

Manufacturing Risk Identification in the Steel Industry

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Abstract. The steel manufacturing industry is an inseparable part of the nuclear power plant construction project. This industry is a business full of dynamics, risks, and challenges. The implementation of risk management becomes an obligation that must be executed in managing this very complex project. In general, risk management in manufacturing includes steps to understand and identify potential problems that may occur, evaluate, monitor, and handle risks. The main risk management objectives are to prevent or minimize adverse effects due to unforeseen events through risk aversion or preparation of contingency plans related to those risks. This paper describes the identification of risk factors and assessments using the Boston Matrix. The results of the analysis show that unrealistic schedules, skill not appropriate, not available equipment, transportation barriers to the workshop, fluctuations in steel material prices, wrong specifications from owner, incorrect interpretation of specifications, misinterpretation of drawings, incorrect volume, material storage, wrong cutting, incorrect installation, and wrong order are factors with moderate and high risk.

Keywords: Industries, nuclear power plant, risk management, steel manufacturing.

1 Introduction

The steel manufacturing industries are a part of the supply chain in the Nuclear Power Plant (NPP) Construction Project. Indonesian National Steel Industries can manufacture steel production, especially steel structures. Steel structures can be used for civil construction at the NPP project. These steel industries consist of PT. Krakatau Steel, PT. Gunung Garuda, PT. Krakatau Wajatama, PT. Gunawan Dian Jaya Steel, PT. Jagat Baja Prima Utama, etc. Some of these national steel industries use ASTM A 572 and ASTM A 36 standards, which have potency and capability to be used as steel structures for nuclear power plant construction type Light Water Reactor (L.W.R.) in Indonesia [1]. National steel industries

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need to develop product innovation for the size dimension and prescribed specifications, codes, and standards. Risks identification is very important in the steel manufacturing industries because it can influence the performance of steel industries and also for NPP project performance. Risk identification consists of determining risks to affect the process and results of the production. The aim of risk identification is to generate a comprehensive list of risks based on the events that might create, enhance, prevent, degrade, accelerate, or delay the achievement of objectives. It is important to identify the risks associated with not pursuing an opportunity. In the manufacturing area it is possible to identify operational risk associated with: i) manufacturing process management, ii) maintenance, iii) the operation methods and tools used, iv) material, v) human sources, vi) machines and manufacturing technologies, vii) machine environments [2].

To reduce the operational risks, need quality control in the steel manufacturing industries. Many authors have proposed various statistical methods for quality control in the steel industry. The problem of determining which factors influence the correct manufacture of parts has been considered from different perspectives and statistical methodologies [3]. Larson and Kursiak develop a risk assessment methodology. The methodology, for the most part, draws on materials regarding risk estimation from Larson and Kusiak risk assessment approach and extends to integrate risk identification and evaluation mechanisms in order to be used as a decision-making tool in the risk assessment of processes [4].

The number of safety-related tasks in any organization is enormous, so are the responsibilities accompanying the decisions and choices that have to be made. Well-known (technical) aspects of safety in companies, that is, hazard identification, risk analysis, and risk assessment, are only one part of the larger domain of dealing with risks by company safety managers. Meyer and Reniers define operational risk management as “the systematic application of management policies, procedures, and practices to the tasks of identifying, analyzing, evaluating, treating and monitoring risks” [5].

Risk management activity was designed to assist the practitioner to observe the type of risk and to determine the best solution of the risk. It is a tool to identify the source of risk as well as to predict the impacts and to find the implementation of the ways to overcome the risk. Uncertainty is a condition that can be found in its daily activities. This uncertainty causes several risks that could have an impact on manufacturing performance [6]. Managing risk is not an easy task for every company. Top management needs decision-making tools to support them in identifying, analyzing, and evaluating potential risks [7]. The potential risks are taking into account manufacturing risks that may arise in company production. Identify workers in the steel manufacturing industry face many safety risks due to the nature of the job. Steel manufacturing is an industry where safe working procedures are important, as workers face many risks due to the nature of the job. The work environment is often hot and noisy, and work tasks regularly dense and demanding on the body, and there is an always present risk for crushing injuries and burns. The steel industry workers experienced that communication is needed for safety actions to be practical, through experience and training, taking responsibility for collaboration, and making sure to communicate incidents that happen [8].

The risks are very important for safety in steel manufacturing. If risks are identified early on, the risk potential can be reduced by taking suitable measures, and proactive risk management is rendered possible [9]. All sources of risks need to identify, so the determination of the project activities in the steel manufacturing are high risks, moderate risks, or low risks.

2 Method

The methodology of this study is technical consultation with interviewees from the steel industry based on experienced project stakeholders in this industry and helps to identify risks. This method was also based on the purpose sampling test method with the determination of one industry of existing steel industries.

3 Literature review

The risk-based approach introduced by the latest standard of ISO 9001:2015 requires organizations to categorize process outputs as either acceptable or unacceptable outputs and take specific actions to determine and address risks and opportunities in order to minimize undesired effects and achieve process improvement [10]. Risk is defined as an uncertain event or condition that, if it occurs, can have either a positive or negative effect on the project objectives. Known risks have been identified, analyzed, and can be managed using the processes in this knowledge area. Known risks may be assigned a contingency reserve as part of managing them. Unknown risks cannot be ascertained or managed adequately in advance. A common method for dealing with unknown risks is to allocate management reserves in the form of extra money, time, or resources. Risk management is a process comprising the following main step: risk management, planning, risk identification, risk assessment, risk analysis, risk response, risk monitoring, and risk communication [11].

Risk management is a complex activity that is developed from the top management to the executives. The literature mentions a long list of ideas, opinions, techniques, and methods regarding risks, uncertainty, and efficiency for risk evaluation and risk management that are useful for managers [12–18]. The overall process of risk assessment can be summarized as an overall process of hazard identification, risk analysis, and risk assessment, forming part of that process of a risk management structure. The risk identification process includes identifying the causes and the source of risk, that is, the hazard in the context of physical damage. The definition “source of risk” consists of some definitions from some researchers. Source of risk (S.R.) are hazard leads to a source of potential damage; maybe the source: materials, equipment, methods, or work practices. Also, it is understood as damage: human damage or deterioration of health, or a combination thereof, besides being able to fall on someone, it could also do it something [19]. Sources of risk or hazards are elements that alone or in combination, have the intrinsic potential to give rise to risk. A systematic approach to identifying these is required to ensure all relevant sources of risk and hazards are identified. One such approach is the Hazard Identification (HAZID) [20].

Risk identification should address both internal and external risks. Internal risks are things that the project team can control or influence. External risks are thought beyond the control or influence of the project team. Risks identification is also concerned with opportunities (positive outcomes) as well as threats (negative outcomes). Risk identification may be accomplished by identifying causes and effects (what could happen and what will ensure) or effects and causes (what outcomes are to be avoided or encouraged and how each might occur) [21].

3.1 Qualitative risk analysis

Qualitative analysis in risk management is the process of assessing the impact and likelihood of identified risks. This process is carried out by arranging risks based on their

impact on project objectives. This analysis is a way of prioritizing risks to form a picture of risks that should receive individual attention and how to respond to these risks should they occur. Qualitative risk analysis can also be done with a 5×5 matrix called the Boston Square Matrix. This method is useful for visualizing risks in the form of a dominant risk priority matrix. The risks that have been identified are categorized as high, moderate, and low risks, which are sequentially represented in red, yellow, and green. These risks are ranked based on their probabilities and impacts. An example of a Boston rectangular matrix can be seen in the following in Table 1.

Table 1. Boston rectangular matrix.

Factor Probability	Very Likely	5	10	15	20	25
	Likely	4	8	12	16	20
	Possible	3	6	9	12	15
	Unlikely	2	4	6	8	10
	Very Unlikely	1	2	3	4	5
		Slight	Minor	Significant	Severe	Major
Impact Factor						

4 Results and discussion

Production risks can be categorized into production factor risks, production process risks, and product risks. Reliable production is fundamentally important for an industrial company attempting to address these challenges. An effective risk management system helps to ensure such production. The evaluated risks have to be integrated into the planning procedures to reduce the risk level in a manufacturing system. Companies are also faced with different challenges due to the increasing complexity of their own production processes [22]. Existing risks have to be identified first—the identified risks than having to be assessed. Production factor risks depend on resources, raw materials, and labor. The production process consists of a production program, machine scheduling, lot size, operation times. Product risks were categorized as quantity and quality table 2 shows production risks based on data from Klober-Koch, Braunreuther, and Reinhart [22].

Table 2. Production risks [22].

Production Risks		
Production Factor	Production Process	Product
i. Resources ii. Raw materials iii. Labor	i. Production program ii. Machine scheduling iii. Lot size iv. Operation size	i. Quantity ii. Quality

The output of a manufacturing process is dependent on the performance of machinery, as defective products from the previous machinery can accumulate or disturb the subsequent process and overall quality. Naturally, the equipment or machinery gets older and deteriorates with time and/or with the level of usage in a manufacturing process, which

has a direct/indirect impact on the overall quality of the manufactured products. Naturally, the equipment or machinery gets older and deteriorates with time and/or with the level of usage. In the manufacturing process, which has a direct/indirect impact on the overall quality of the manufactured products [23].

This paper describes risk identification in the steel industry and assessment using the Boston Matrix. Boston matrix is a popular tool used in marketing and business strategy. Case study for the steel industry in this paper, namely P.T. X.Y.Z. Company. The methodology of the study is a purposive sampling test. The number of respondents is one company. The name of P.T. X.Y.Z. is not the original name. This industry as one of steel manufacturing industries in Indonesia that produces steel structures, plate works, tanks and silos, piping, material handling and structures, and equipment installations services. A probability and impact matrix is a grid for mapping the probability of each risk occurrence and its impact on project objectives if that risk occurs. Risks are prioritized according to their potential implications for having an effect on the project’s objectives. A typical approach to prioritizing risks is to use a look-up Table 3 or a probability and impact matrix. The specific combinations of probability and impact that lead to a risk being rated as “high,” “moderate,” or “low” importance are usually set by the organization [21]. The use of the risk matrix as a hazard management tool is a significant issue for the industry due to (i) documented pitfalls and (ii) attention to adverse outcomes [24]. Personnel that is involved in risk identification activities may include project manager, project team members, risk management team, stakeholders, risk management experts, and customers.

Table 3. Risks identification in P.T. X.Y.Z. Industry.

No.	Activities	Risk Factors	Probability	Impact	Risks
1.	Schedule arrangement	The schedule is no realistic	3	3	9
2.	Human resources development plan arrangement	Skill in not appropriate	2	4	8
3.		H.R.D. is inadequate	1	3	3
4.	Facility arrangement	The workroom is inadequate	1	3	3
5.	Preparation of equipment plan	Equipment is not available	3	4	12
6.	Preparation on material plan	Bill quantity is wrong	2	3	6
7.		Management Representative is the wrong specification	2	2	4
8.		Purchase Order is wrong volume and specification	2	2	4
9.		Transportation to the workshop is hampered	2	4	8

Table 3. continue to the next page.

Table 3. continued

No.	Activities	Risk Factors	Probability	Impact	Risks
10.		Material retrieval is wrong	2	3	6
11.		Fluctuations in steel material prices	3	5	15
12.	Receipt of Specification Document	Wrong specification from owner	3	4	12
13.		Incorrect interpretation of specifications	2	4	8
14.	Acceptance of construction drawings	Wrong drawings from the owner	2	3	6
15.		Misinterpretation of drawing	2	4	8
16.	Material Calculation	Incorrect volume	2	4	8
17.	Making Shop drawing	Wrong shop drawing	2	4	8
18.	Material Procurement	Wrong purchase	1	4	4
19.	Material Storage	Material storage	2	4	8
20.	Expediting	Less expediting	2	3	6
21.	Material Quality Control	Incorrect quality of raw materials	1	4	4
22.	Workshop Preparation	Wrong shop set up	2	2	4
23.	Material Cutting	Wrong cutting	2	4	8
24.	Assembling	Incorrect installation	4	3	12
25.	Welding	Wrong welding	1	3	3
26.	Surface Preparation	Wrong surface preparation	1	3	3
27.	Painting	Wrong paint	1	4	4
28.	Quality Control	Rejected	1	4	4
29.	Product delivery	The sequence of order is wrong	2	4	8
30.	Man, Power, and subcontractor	Underestimated productivity	3	2	6

Each risk has rating rules on its probability of occurrence and impact. The organization determines combinations of probability and impact result in a classification of high risk, moderate risk, and low risk. In Table 4 and Figure 1, the red area represents high risk: yellow area represents moderate risk, and green area represents low risk. These risk-rating

rules are specified by the organization in advance of the project and included in organizational process assets. Risk rating rules can be adjusted to in the plan risk management process.

Table 4. Risk mapping of P.T. X.Y.Z. industry.

No	Risk Factor	Index		Score (PxI)	Risk
		Probability	Impact		Status
	Schedule arrangement				
1.	Schedule is no realistic	3.00	3.00	9.00	Moderate
	Human Resources Development (H.R.D.) plan				
2.	Skill is not appropriate	2.00	4.00	8.00	Moderate
3.	HRD is inadequate	1.00	3.00	3.00	Low
	Facility arrangement				
4.	Work room is inadequate	1.00	3.00	3.00	Low
	Preparation of equipment plan				
5.	Equipment is not available	3.00	4.00	12.00	Moderate
	Preparation on material plan				
6.	Management representative is wrong specification	2.00	3.00	6.00	Moderate
7.	Purchase order is wrong volume and specification	2.00	2.00	4.00	Low
8.	Transportation to the workshop is hampered	2.00	2.00	4.00	Low
9.	Material retrieval is wrong	2.00	4.00	8.00	Moderate
10.	Fluctuations in steel material prices	3.00	3.00	9.00	Moderate
	Receipt of specification documents				
11.	Wrong drawings from the owner	3.00	5.00	15.00	High
12.	Incorrect interpretation of specifications	2.00	4.00	8.00	Moderate
	Acceptance of construction drawings				
13.	Wrong drawings from the owner	2.00	4.00	8.00	Moderate
14.	Misinterpretation of drawings	2.00	3.00	6.00	Moderate
	Material calculation				
15.	Incorrect volume	2.00	4.00	8.00	Moderate
	Making shop drawing				
16.	Wrong shop drawing	2.00	4.00	8.00	Moderate

Table 4. continue to the next page.

Table 4. continued.

No	Risk Factor	Index		Score (PxI)	Risk
		Probability	Impact		Status
	Material procurement				
17.	Wrong purchase	1.00	4.00	4.00	Low
	Material storage				
18.	Material storage	2.00	4.00	8.00	Moderate
	Expediting				
19.	Less expediting	2.00	3.00	6.00	Moderate
	Material quality control				
20.	Incorrect quality of raw materials	1.00	4.00	4.00	Low
	Workshop preparation				
21.	Wrong shop set up	2.00	2.00	4.00	Low
	Material cutting				
22.	Wrong cutting	2.00	4.00	8.00	Moderate
	Assembling				
23.	Incorrect installation	4.00	3.00	12.00	Moderate
	Welding				
24.	Wrong welding	1.00	3.00	3.00	Low
	Surface preparation				
25.	Wrong surface preparation	1.00	3.00	3.00	Low
	Painting				
26.	Wrong paint	1.00	4.00	4.00	Low
	Quality control				
27.	Rejected	1.00	4.00	4.00	Low
	Product delivery				
28.	Wrong sequence delivery	2.00	4.00	8.00	Moderate
	Workforce and subcontractor				
30.	Under estimated productivity	3.00	2.00	6.00	Moderate

Table 4 and Figure 1, risk status can be classified as follow:

- i. High risks can take place to wrong drawings specification document from the owner.
- ii. Moderate risks can take place to: a) Equipment is not available, b) Incorrect installation, c) Schedule is no realistic, d) Skill's H.R.D. is not appropriate, e) fluctuation in steel material price, f) Material retrieval is wrong, g) Incorrect interpretation of specifications, h) Wrong construction drawing from the owner, i) Incorrect volume of material, j) Wrong shop drawing, k) Material storage, l) Less expediting, m) Wrong cutting of material, n) Wrong sequence delivery.
- iii. Low Risks can take place to: a) H.R.D. is inadequate, b) Work room is inadequate, c) Purchase order is wrong volume and specification, d) Transportation to the workshop is hampered, e) Wrong purchase of material, f) Incorrect quality of raw materials, g) Wrong Shop set up, h) Wrong welding, i) Wrong Surface Preparation, j) Wrong paint, k) Rejected quality control.

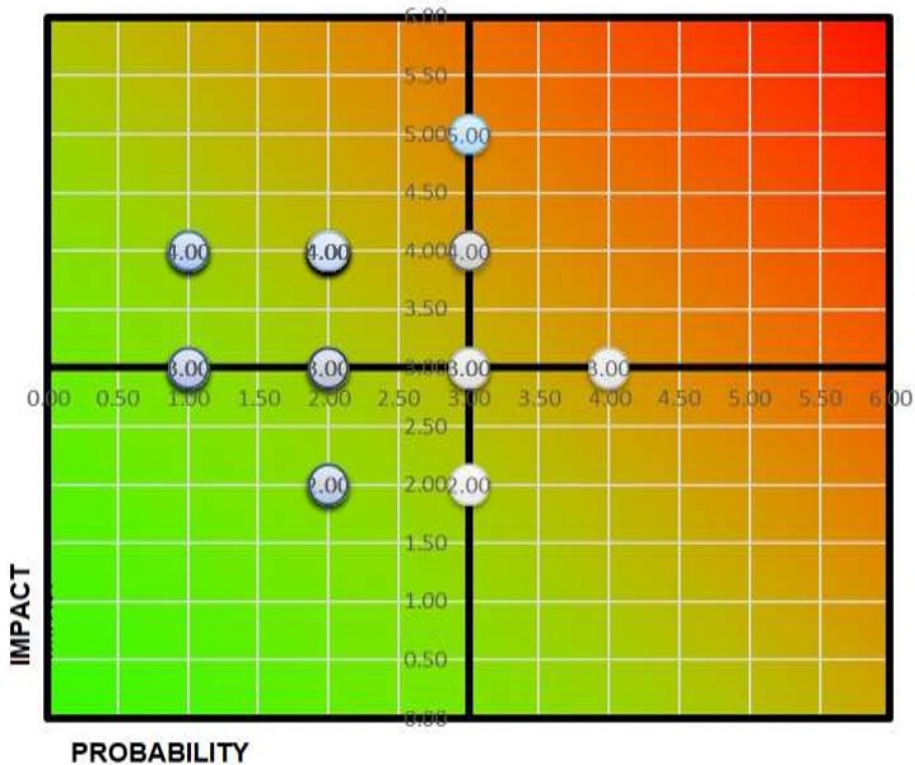


Fig. 1. Risk mapping of the steel industry.

Based on the data above, the results of the study conclude that the source of high risks comes from the wrong drawings specification document from the owner. Source of moderate risks cam from the schedule is no realistic, skill’s HRD is not appropriate, fluctuation in steel material price, etc. Generally, sources of risks include change in specifications/ requirements, design/drawing errors, poorly responsibilities, and insufficiently skilled staff. Human, technology, and organization aspects influencing the production schedule process [25]. The production schedule is one of risks factors which it was evident that there were many organizational factors that significantly affected individual safety behaviour. These factors include role overload, perceptions of performance over safety, socialization influences, safety attitudes, and perceived risks. Perceived risks associated with a job tend to be height-ended when an individual experiences or learns about an injury that occurs within the workplace [26].

Manufacturing risks may raise or reduce in a company manufacturing production. Every steel manufacturing industry has risk factors, and risk status is different depending on the available production facilities, HRD, and good management. Safety is the state in which the risk of harm to persons or property damage is reduced and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management [27]. The steel manufacturing industries are an inseparable part of the nuclear power plant construction project. The Nuclear Power Plants are depending on the supply chain from the steel manufacturing industry, especially steel structure for civil construction. So that

performance of steel industries is very influential in the NPP project. Based on the result of the study conclude that the performance of Indonesian steel manufacturing can be developed and enhanced the facilities and all supporting because they have potency and capability to produce and support the NPP project in Indonesia, especially for steel structures.

5. Conclusions

The Result study concluded that unrealistic schedules, skill not appropriate, not available equipment, transportation barriers to the workshop, fluctuations in steel material prices, wrong specifications from owner, incorrect interpretation of specifications, misinterpretation of drawings, incorrect volume, material storage, wrong cutting, incorrect installation, and wrong order are factors with moderate and high risk.

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