Integration of Risk Engineering by ISO 31000 and Safety Engineering:
A Case Study in a Production Floor of Sport Footwear Industry in Indonesia

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Abstract **- ISO 31000 has become essential for the practical implication of risk engineering to industry in Indonesia. The National Standardization Body has decided to make ISO 31000 the National standard for the principle and guidance of risk engineering in industry. Meanwhile, the reference for implementating ISO 31000 is very limited, especially in the footwear industry which has significant volume in Indonesian industry. This article gives a description of the implementation and impact of ISO 31000 with respect to a company's risk engineering strategy on the production floor in the footwear industry. The implementation of risk engineering begins with establishing a context to determine any analysis consideration. The next step is the execution of the risk engineering process, which consists of four major steps: risk identification, risk analysis, risk evaluation and risk treatment. Some techniques used in the risk engineering process are semi-structured interview, root cause analysis, consequence/probability matrix, and cost benefit analysis. Fourty five risks are identified from the company studied. From the risk evaluation, 14 risks are identified as risks that require special treatments. Those risks shall become the priority of management. The process of risk engineering discovered risk in safety. Therefore, safety engineering was implemented to improve the system.**

Keywords - risk engineering, ISO 31000, footwear industry, risk analysis

I. INTRODUCTION

Industrial Engineering is one of the disciplines of engineering. The object studied in this discipline is the system, or rather, the integrated system. It is called an integrated system because the first, and the most important, component is the human. Other components include materials, information, equipment and energy. It is through the discipline of Industrial Engineering that this integrated system is designed, improved, or implemented. Through this discipline the performance of the integrated systems is estimated.

Uncertainty is a matter that often arises in many situations, places, and moments. This uncertainty can have an impact on the performance of an integrated system, which in turn will have an impact on the targets set for the system. The impact of this uncertainty to an organization's objective is called risk (ISO 31000: 2009), so in an integrated system there is often a risk. The term impact is defined as the deviation from a predetermined objective. Impact can be positive or negative (ISO 31000: 2009). Thus, risk must be considered as neutral. Positive risks to an integrated system must be developed its occurances. However, negative risks must be managed in such a way, so that it becomes clear what sort of treatment should be given to those risks. Risk treatment options include (Susilo and Kaho, 2011):

1. Avoiding risk, which is done by not doing activities that allow the occurrence of such risks,
2. Eliminate all causes or sources that trigger risk,
3. Change the level of possibility or opportunity of risk,
4. Change the impact of a risk,
5. Share risk with, or transfer it to, other parties.

Risk is defined as the size of probability and consequences of uncertain future events (Yoe, 2011). Risk is naturally embedded in every uncertainty that impacts the goal of a system (Susilo and Kaho, 2011). The worst impact of an uncertainty is an undesired result such as cost or losing opportunity. Even though the uncertainty may give better result than a prediction, the possibility of worse case is a challenge that management should overcome. The ability of management overcoming the possibility of risk shows the quality of the management process. One process to enhance management's ability to overcome the uncertainty and dynamicity is through the risk engineering process.

Risk engineering is a decision making process that overcomes the uncertainty and dynamicity (Yoe, 2011). Risk engineering practise in companies vary according to the needs of each organization. The needs are mostly determined by the characteristics of each system, the system dynamics and its uncertainties.

The applications of risk engineering are much closer to safety engineering. During the risk engineering process, management may discover a risk which is related to safety. If so, safety engineering shall be performed to overcome the risk related to safety.

Rasmussen and Svedung (2000) stated that risk engineering must apply an adaptive and closed loop feedback control strategy to cope with the dynamics process. ISO 31000 is a framework of risk that is allowing feedback control strategy through out its process (Risk Management Principle and Guideliness ISO 31000, 2009). However, not many companies have implement ISO 31000 for risk management in the production process. Therefore, this article is proposing to implement ISO 31000 as risk management tool to improve the production system.

This article is devided into five major sections. The first section, the introduction section, describes the background of this research. The second section is a description of literature survey and research gap. Third section is discussing the proposed integrated system, while the methodology used in the research is written in section four. Section five, results and discussion, reflects the data processing and analysis. The final section, the conclusion, presents a summary of the article and suggests further potential areas of research.

II. LITERATURE SURVEY

Gjerdum and Peter (2011) stated that ISO 31000 had established framework that is more flexibile and provided more control than the COSO ERM framework. Alignment of principle, framework and the process of risk engineering in ISO 31000 is as shown in Figure 1. The flexibility of ISO 31000 can be seen in the principles that can be fit to any organization, while the control can be seen in the process, which involves monitoring and reviewThis is done through close communication and consultations in the team.

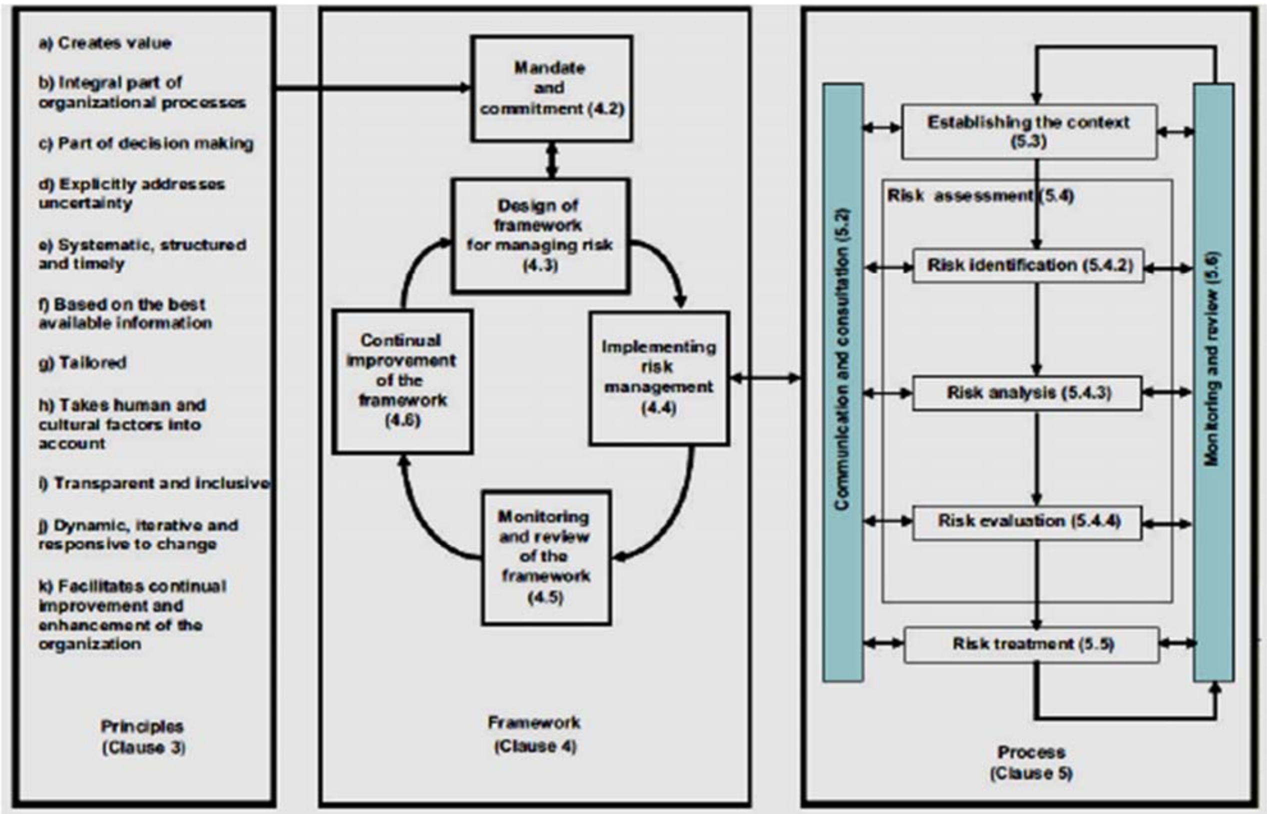

Figure 1. Alignment of principles, framework and process of risk management in ISO 31000 (Risk Management Principle and Guideliness ISO 31000, 2009)

IEC/ISO 31010 (2009) listed 31 techniques are suited to the process of risk engineering. Listed techniques include qualitative, quantitative or a mixture of qualitative-quantitative methods. Each technique has different practicalities. All techniques are common techniques for risk engineering practices. These techniques are: brainstorming, structured interviews, delphi, check-lists, preliminary hazard analysis, hazard & operability studies, hazard analysis and critical control points, environmental risk assessment, structured what-if analysis, scenario analysis, business impact analysis, root cause analysis, failure mode effect analysis, fault tree analyisis, cause and consequence analysis, cause and effect analysis, layer protection analyisis, decision tree, human reliability analysis, bow tie analysis, reliability centered maintenance, sneak analysis, Markov analyisis, Monte Carlo simulation, Bayesian statistics, fn curves, risk indices, consequence/probability matrices, cost benefit analysis, and multi criteria decision analysis. Most of the techniques are also listed as prevalent tools in safety engineering.

ISO 31000 framework gives only generic standard guidance (Susilo & Kaho, 2011). Therefore, to implement it company must fit the implementation with their needs and circumstances. A case study reference can act as a simulation on a system that is compatible with the case study object. This is because the reader can see the probability of output generated by a system from a certain input and scenario of the designated system treatment without having to implement it directly. This is very important considering the amount of cost involved for direct implementation. Moreover, the Indonesian Standardization Body has determined ISO 31000 as the national standard of reference and principle risk engineering process through a policy named: Keputusan Kepala Badan Standarisasi Nasional No. 173/KEP/BSN/10/2011.

Therefore, study cases to research the implementation references of ISO 31000 are very important for business practices in Indonesia or other similar countries.

Mariana (2017) has shown the powerfulness of ISO 31000 in a low-cost carrier company. Anggraini and Pertiwi (2017) have shown the ability of ISO 31000 in executing risk engineering for a case of the implementation of information technology in an organization. While a case study of implementation of ISO 31000 in procurement management has been described by Mursyid and Sutopo (2017).

As resulted by the literature survey, a reference of ISO 31000 implementation in manufacturing activity or in a production floor application is not yet available, while the implementation of ISO 31000 as risk management tools can be seen as powerfull and integrated approach towards risk engineering . Therefore, this article is addressed to close the gap of research: to give references and description of ISO 31000 implementation in manufacturing activity or in a production floor.

III. PROPOSED INTEGRATED SYSTEM

This article describes the implementation of ISO 31000 as risk engineering and its integration with safety engineering on the production floor. The implementation takes place in the sport footwear industry. The footwear industry was elected to be studied because it is amongst Indonesia's top 5 manufacturing industries with a trade surplus in January 2017 (Kementrian Perindustrian Republik Indonesia, 2017).

The object of this research is PT Primarindo Asia Infrastructure Tbk, which is located in Bandung, West Java. This company is engaged in the footwear industry with the brand Tomkins and is a well-known subcon for other brands. This company operates on an international scale and is one of the medium-sized companies in Indonesia. To be able to excel in competition, PT Primarindo Asia Infrastructure Tbk must perform every duty in every function as best as possible, especially in the production section which is a very important part of a manufacturing company.

The production section of PT Primarindo Asia Infrastructure Tbk has principles covering the maximization of utilization of production facilities, minimizing production errors, increasing capability and quality of workers, minimizing low-productivity workers, and improving the organizational structure as well as working procedures. These principles are implemented with the help of medium-tech machines and computerized system assistance so that they will be more accurate. PT Primarindo Asia Infrastructure Tbk certainly hope that these principles can be executed properly so that the goals and objectives of the company can be achieved. In reality, there is uncertainty in all of the plans that have been implemented, which have the potential to adversely impact the company's goals or objectives.

IV. RESEARCH METHODOLOGY

The implementation of ISO 31000 was done following the steps of ISO 31000, as depicted in Figure 2. In Figure 2, the implementation begins with an initial study and problem identification. Both actions are taken to make sure that the management risk team members have enough knowledge and skill to execute the project firmly before commencing. The knowledge and skill required includes mastering the system that shall be implemented and mastering ISO 31000.

The next step is performing the risk engineering process, as guided by ISO 31000:2009. The risk engineering process consists of three major steps: establishing the context, risk assessment, and risk treatments. Three steps of risk assessment are: risk identification, risk analysis and risk evaluation. When a company has enough historical data records to be analysed through quantitative methods, a quantitative analysis is suggested. However, if a company lacks historical quantitative records, it may analyse with qualitative methods (Sekaran and Bougie, 2013). In this research, due to a lack of quantitative data, discussions and quantitative analysis are used. The methods used are the cons/prob matrix, the RCA matrix and cost-benefit analysis.

Each step of the risk engineering process, as required by ISO 31000, shall be monitored and reviewed through communication and consultations.

V. RESULTS AND DISCUSSION

The study case considered took place in a sport footwear production floor of PT Primarindo Asia Infrastructure Tbk. One specific area was selected to make the implementation more effective (menurut). The production consists of five processes: cutting, sewing, rubber pressing, stock fitting, and assembling. Each process is lead by a sub-department head. In the sub-section below, the results and analysis for each step of risk engineering is presented.

Establishing the Context

Context analysis of risk engineering in PT Primarindo Asia Infrastructure Tbk is made based on the consensus of the entire risk engineering team. The risk engineering team shall act based on the context agreed. Table I displays in detail the contexts of the risk engineering implementation.

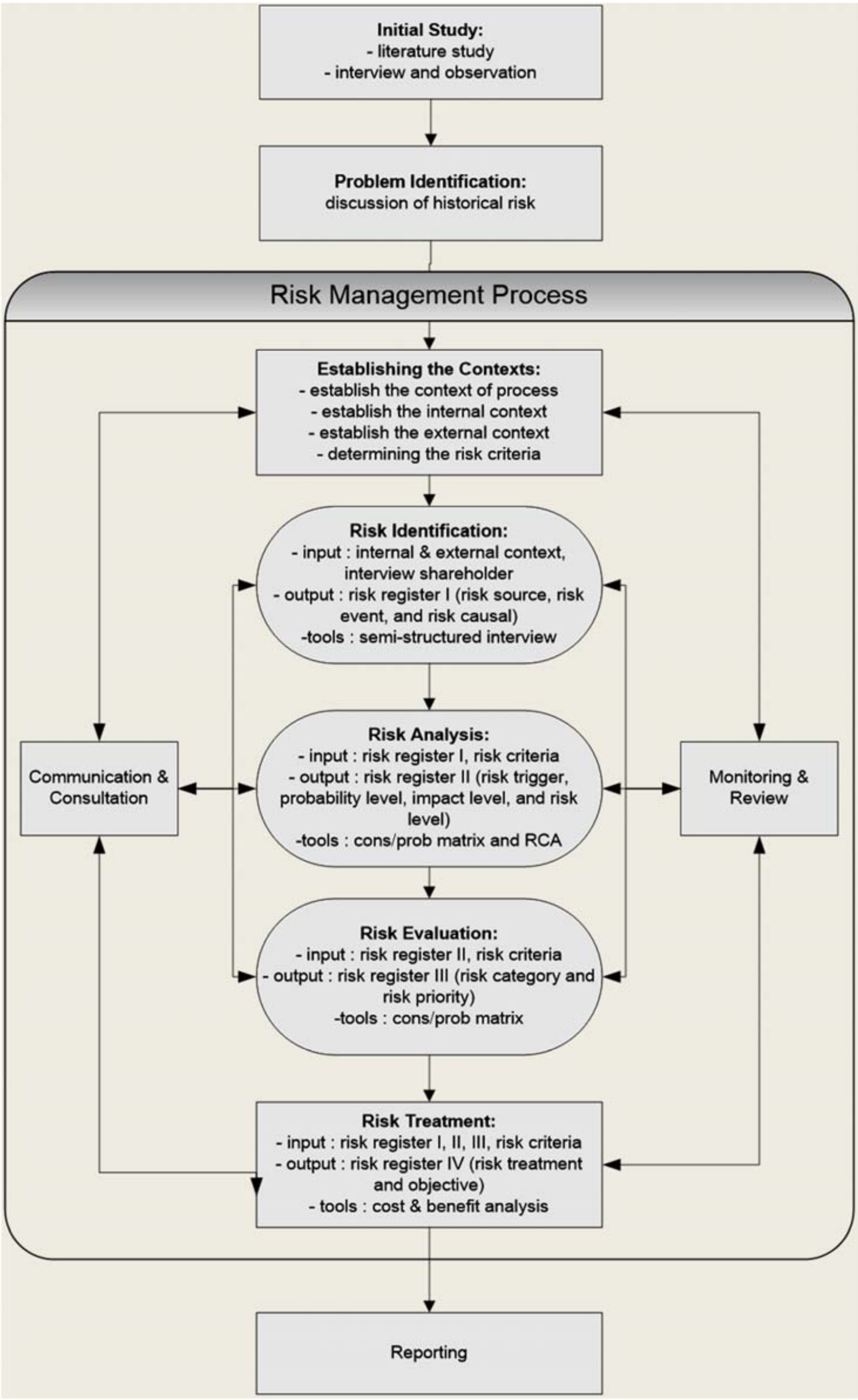

Figure 2. Research Methodology

TABLE I. RISK ENGINEERING CONTEXT IN PRODUCTION FLOOR OF PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

No.	Contexts	Result of Establishing the Context
1	Implementation scope of risk engineering	Production department of PT. X
2	Goal of implementation of risk engineering	Execution of ISO 31000 in production department of PT. X
3	Responsibility of the implementation of risk engineering	Responsibility lies on management risk team, including head of production department, sub department head, consultant (if any)
4	The target of risk engineering	Identification, analysis, evaluation, and planning the treatment for each risk found in production department to create the smooth and efficient production process
5	Implementation of risk engineering	Implementation of communication and consultation, establishing the context, risk identification, risk analyisis, risk evaluation, and risk treatment.
6	Risk assessment method	Qualitative and semi-qualitative methods as written in ISO 31000: semi-structured interview, root cause analysis, consequences/probability matrix, cost benefit analysis.

An external context shall be established to identify the stakeholders and to understand their interest. The method used by the risk engineering team is stakeholder analysis, which generates the relationship map of the production department and external stakeholders and also the list of conflict of interests amongst the stakeholders, as depicted in Table II.

TABLE II. STAKEHOLDERS ANALYSIS OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Stakeholder	Interests	Potential Conflicts
Purchasing Department	Procure the raw and supporting material needed by production department	Specification discrepancy
PPIC Department	Planning, instructing, and controlling the production process	Sudden change in the instruction or production which does not comply with the instruction
Development Department	Development of samples, generating standards, pattern and specifications	Specification change, or the production which does not comply with the standards and specification
Supplier	Providing goods or services as needed by production department	Specification discrepancy
Distributor	Selling finishing products according to sales order	Quantity or specification discrepancy
Transportation Vendor	Renting a transporation mode to send the finish goods to distributors	Delay in delivery that causes rescheduling, or a missed delivery that causes re-delivery

The internal context establishment generates the list of main responsibilities and a detailed work breakdown structure per sub-department. Work breakdown structure is a good method to be used to identify all activities inside the implementation system in addition to identifying the job desk of the stakeholders.

Based on the consensus of all risk engineering teams, three criteria are set: impact, measurement of risk possibility, and risk level criteria. The financial impact is counted based on the lost impact cost, meanwhile production impact is considered based on the production delay. The frequency of risk is considered as a measurement criterion. Risk level criteria can be separated into three risk levels: low, medium, and high. The team had decided that low risk can be accepted without any treatments. The sensitivity of each risk that can be accepted by team is as depicted in Table III. By having risk sensitivity, the team would be focused on the middle and high risk for the next step.

TABLE III. RISK SENSITIVITY OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Failure impact	Failure tolerance	Type of treatments	Supervision and Accountability Authorization
Low	High	Accepted	Sub Dept. Head
Medium	Medium	Management control and supervision	Sub Dept. Head
High	Low	Special meeting with director board to determine and plan the control	Dept. Head

Risk Identification

The team performs semi-structured interviews to identify the risk for each of the activities in the system. Interviews are conducted with each sub-department head where the activities are conducted. The semi-structured interview gives flexibility to the interviewer to explore the responses of interviewee (Sekaran & Bougie, 2013). Thus, the result of the identification process would be more effective. As result of risk identification, risk register I is designated fully. Risk register I is a list of all descriptions of risk, source of risk, the impact of, and the person in charge of, each risk.

Table IV describes the 35 risks listed in risk register I for each sub department on the production floor of PT

Primarindo Asia Infrastructure Tbk. In Table IV, it can be seen that the risk listed is a general risk which is not yet analysed deeply. This can happen because PT Primarindo Asia Infrastructure Tbk is just initiating the implementation of ISO 31000. In the companies that have previous experience of ISO 31000, the risks found by the risk engineering team might have more detailed cause and effect descriptions.

TABLE IV. RISK REGISTER I OF PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Code	Source	Description	Impact
Location : Raw Material Warehouse PIC : Sub Departement Head of Raw Material Warehouse			
RGB1	Sudden change on the production quantity instruction from PPIC	Sudden modification of production schedule, quantity of material, and administration	Extra production cost on producing un-used footwear outsoles
RGB2	Inaccuracy workers during providing the correct color of a particular canvas material	Color discrepancy in supplying the canvas material to production	Product rejection or re-manufacture due to wrong canvas material being used
RGB3	Lack of worker alertness during laminating process	Late laminating (foam and cloth) processes	Delay in production process
RGB4	Suppliers careless in ensuring the accessory corresponds to the order	Discrepancy in quality or quantity of accessories with order	Return goods to supplier which may cause production delay
RGB5	Suppliers careless in conforming the fabrics/leather with the order	Discrepancy in quality or quantity of fabrics/leather with order	Return goods to supplier which may cause production delay
RGB6	Worker inaccuracy in delivering the information of inventory or quantity	Stock unbalancing because provision of the raw materials exceeds the requirement	Wasting the material for providing the exceeding quantity
RGB7	Un-collected rejected goods by supplier	Stack of unrecorded raw material	Additional inventory cost due to stacks of inventory
Location : Upper PIC : Sub Departement Head of Upper			
RU1	Inaccurate calculating of the quantity of particular material by worker	Quantity of fabrics or leather does not correspond with requirements	Waiting for material to arrive, causing production delay
RU2	Sudden change in specification or production instruction of a particular good	Sudden change in standard cutting patern	Re-cutting to fit the new standard, causing production delay and waste of material
RU3	Error of cutting machine: ability to be operated with pressing one button	Working accident in cutting machine	Production delay and cost for health care of the affected operator
RU4	Inaccuracy of cutting worker for giving the incompatible cutting desk	Error in adjusting the cutting desk and the footwear to be printed	Reprocessing and production delay
RU5	Worker error by placing the paint inside unclear container or changes of paint colors due to time	Paint discrepancy during printing a particular footwear	Unreprocessed, rejected footwear that cause major waste
RU6	Worker does not follow the standard instruction during printing a particular footwear	Method or tooling process discrepancy during printing a particular footwears Ketidaksesuaian metode	Reprocessing footwear and rejected products
RU7	Worker error in operating the machine and worker does not follow the procedure	Working accident (electric shock) in operating the printing machine	Production delay and cost for health care of the affected operator
RU8	Worker error in operating the machine and worker does not follow the procedure	Working accident in skiving machine	Production delay and cost for health care of the affected operator
RU9	Worker error in operating the machine and worker does not follow the procedure	Working accident in buffing machine	Production delay and cost for health care of the affected operator
RU10	Worker error in operating the machine and worker does not follow the procedure	Working accident in punching machine	Production delay and cost for health care of the affected operator
RU11	Worker error in operating the machine and worker does not follow the procedure	Working accident in buttoning machine	Production delay and cost for health care of the affected operator
RU12	Worker error in operating the machine and worker does not follow the procedure	Working accident in D-ring machine	Production delay and cost for health care of the affected operator
RU13	Worker error in operating the machine and worker does not follow the procedure	Working accident in sewing machine	Production delay and cost for health care of the affected operator
Location : Bottom PIC : Sub Departement Head of Bottom			
RB1	Worker does not use the PPE (personal protective equipment) during transfer material and worker error	Working accident and wasting of chemical material during transfer to container	Production delay, material wasted, and cost for health care of the affected operator
RB2	Worker does not follow procedure of storing the chemical container	Damage (leak) in chemical material container	Production delay due to supplier needs to resupply the chemical that can not be used, therefore supplier.

Table IV continues on the next page

RB3	Worker inaccuracy in mixing the material	Mistakes made in mixing chemical compound	Remixing, causing production delay and material to be wasted
RB4	Worker does not use the PPE (personal protective equipment)	Worker inhales the odor of unhealthy chemical	Reduces the worker's concentration (health problem)
RB5	Sudden temperature change which is not realized by operator	Sudden temperature change in outsole heat control machine	Rejection and re-processing work in process material
RB6	Operator negligence for using pressing machine with inappropriate procedure	Working accident in rubber processing area caused by pressing machine	Production delay, and cost for health care of the affected operator
RB7	Operator negligence for using solder with inappropriate procedure	Working accident during soldering	Production delay, and cost for health care of the affected operator
RB8	Sudden temperature change which is not realized by operator	Sudden temperature change in pressing machine	Rejection of work in process material
RB9	Operator negligence for using grinding machine with inappropriate procedure	Working accident in stocking fit processing due to grinding machine	Production delay and cost for health care of the affected operator
Location : Assembly **PIC : Sub Departement Head of Assembly**			
RA1	Operator unreadiness in preparing the upper and bottom result	Lateness in preparation of set balance	Faltering upper and bottom assembly
RA2	Operator negligence in choosing appropriate match of upper and bottom part	Incompatibility upper and bottom part which are supposed to be assemblied	Reprocessing the rejected footwear
RA3	Operator insolence in choosing the appropriate tools to process a particular footwear	Inappropriateness tools during upper and bottom assembly	Reprocessing the rejected footwear
RA4	Sudden temperature change which is not realized by operator	Sudden temperature change in outsole heat control machine	Rejection because the product is unable to be reprocessed
RA5	Sudden temperature change which is not realized by operator	Sudden temperature change in cooling chamber machine	Rejection because result of cooling process is unable to be reprocessed
RA6	Operator negligence during using lasting machine	Working accident in lasting machine	Production delay, and cost for health care of the affected operator
RA7	Operator negligence during using universal pressing machine	Working accident due to universal pressing machine	Production delay, and cost for health care of the affected operator
RA8	Operator negligence during using insole pressing machine	Working accident due to insole pressing machine	Production delay, and cost for health care of the affected operator
RA9	Compound worker do not use the PPE (personal protective equipment)	Working accident in mixing room due to chemical exposure	Production delay, and cost for health care of the affected operator
Location : Finished Goods Warehouse **PIC : Sub Departement Head of Finished Goods**			
RGJ1	Worker carlessness in fitting the footwear and footwearbox	Wrong Packing or discrepancy label with the footwear specification	Resend the correct footwear to distributor
RGJ2	Worker carelessness in arrange the footwears accoding to the storing plan	Mistakes in storing process	Distributors receive the wrong footwear
RGJ3	Worker carelessness in confirming the quantity with the sales order	Discrepancy in quantity of ordered footwear	Resend the correct footwear to distributor
RGJ4	Worker carelessness in conforming the sales order with the distributor, or the transportation vendor error on delivery	Delivery to the wrong distributor	Resend the footwear to the right distributor
RGJ5	Delay vehicle arrival from transportation vendor	Late tracking process	Additional overtime cost
RGJ6	Worker not ready to respond the transferred sales data	Delay response on processing the sales order	Delayed order, or loss of opportunity cost
RGJ7	Lack of security inside the warehouse	Missing finished goods	The process business is useless

Risk Analysis

During the risk analysis process, the team begins with the determination of the consequences and probability levels. The consequences and probability levels then become input for the consequences and probability matrix. The consequences level and probability level developed are as seen in Table V and Table VI, while the consequences and probability matrix is depicted in Figure 3.

The financial and delay impact is used to determine the scale (level) of the consequences of probability. Here, because of the lack of qualitative data, the risk engineering team decides to use a consensus scale based on their expertise and experiences in building the subjective consequences/probability matrix. As a result, the matrix produces a more accurate prediction. In the matrix, the team had decided on three categories: high risk, medium risk, and low risk. The team would focus on mitigating the high risk as unavoidable risk, and treating the medium risk based on the cost-benefit analysis of each risk.

Risk register II are then developed based on root cause analysis by using five-whys and a subjective cons/prob matrix. The root cause analysis would help the risk engineering team to verify (monitor and review) the source of risk listed in risk register I. The root cause of each risk will then become the risk trigger. Risk trigger will be an input for risk register II. List of risk register II is depicted in Table VII. In table VII, the risk level is calculated by multiplying the consequences and probability of each risk.

TABLE V. PROBABILITY LEVEL OF PRODUCTION FLOOR PT PRIMARINDO ASIA INFRASTRUCTURE TBK

Criteria	Probability	Description	Frequency (yearly)
very low	0.1	only happens once in the last 10 years	1event in 10 year
low	0.3	little possibility to happen	1 - 6 events in 1 year
medium	0.5	medium possibility to happen	7-12 events in 1 year
high	0.7	high possibility to happen	13-48 events in 1 year
very high	0.9	almost certain to happen	more than 48 events in 1 year

TABLE VI. CONSEQUENCES LEVEL OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Description	Risk Score	Financial consequences	Delay consequences
Very low	0.1	less than Rp 1 Mio	less than 1 day
Low	0.3	Rp 1 Mio – Rp 1.99 Mio	1 – 3 days
Medium	0.5	Rp 2 Mio– Rp 9.99 Mio	4-7 days
High	0.7	Rp 10 Mio – Rp 50 Mio	8-30 days
Extreme	0.9	above Rp 50 Mio	more than 30 days

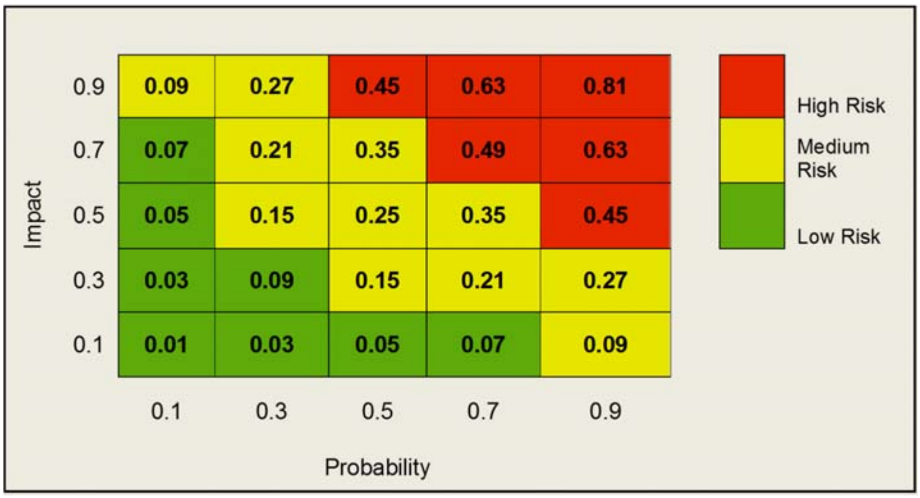

Figure 3. Cons/Prob Matrix

TABLE VII. RISK REGISTER II OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Code	Risk Trigger	Probability Level	Consequences Level	Risk Level
RGB1	A particular footwear is suddenly discontinued	0.3	0.7	0.21
RGB2	High similarity of black and dark blue canvas roll	0.3	0.5	0.15
RGB3	Operator catching up to the production target so that the result is not as standard	0.7	0.1	0.07
RGB4	Discrepancy in methods used by raw material warehouse and supplier in weighting the raw material	0.7	0.5	0.35
RGB5	Supplier is not given enough information regarding to the specification intended	0.7	0.5	0.35
RGB6	The quantity of raw material needed by the other process is difficult to be fulfilled in precise number	0.9	0.1	0.09
RGB7	Reject raw material from supplier is stacked as inactive raw material even though it still has benefits	0.5	0.3	0.15
RU1	Numerous fabrics and leather types are so similar that it is difficult for operators to differentiate them	0.3	0.1	0.03
RU2	Shifting the consumer trends following latest fashion	0.3	0.1	0.03
RU3	Operator fails to ensure the fluency of cutting machine	0.1	0.5	0.05

Table VII continues on the next page

RU4	Operator lack of concentration during choosing the appropriate cutting	0.3	0.1	0.03
RU5	Lack of coordination between operator and the sablon sub department head	0.5	0.1	0.05
RU6	Lack of coordination between operator and the sablon sub department head	0.3	0.1	0.03
RU7	Lack of operator's working concentration	0.1	0.1	0.01
RU8	Lack of operator's working concentration	0.3	0.1	0.03
RU9	Lack of operator's working concentration	0.3	0.1	0.03
RU10	Lack of operator's working concentration	0.5	0.1	0.05
RU11	Lack of operator's working concentration	0.3	0.1	0.03
RU12	Lack of operator's working concentration	0.3	0.1	0.03
RU13	Lack of operator's working concentration	0.5	0.1	0.05
RB1	The non-awareness of operator about the danger of conveyor that is operating	0.3	0.1	0.03
RB2	The chemical container is expired	0.3	0.1	0.03
RB3	Mixing operator is working in hurry to fulfill the production target	0.3	0.3	0.09
RB4	The non-awareness of operator about the danger of conveyor that is operating	0.3	0.1	0.03
RB5	Machine is fully loaded with pulp that clogs the incoming supply boiler	0.3	0.5	0.15
RB6	Lack of operator's working concentration	0.3	0.3	0.09
RB7	Lack of operator's working concentration	0.5	0.1	0.05
RB8	The standard processing time executed by operator is too short	0.9	0.1	0.09
RB9	Lack of operator's working concentration yang tidak diinginkan	0.3	0.1	0.03
RA1	Numerous footwear types and specifications that complicate the operator's ability to choose the appropriate upper and bottom	0.7	0.1	0.07
RA2	Operator assembling choose the pair in hurry to fullfull the production target	0.7	0.1	0.07
RA3	Lack of coordination between operator with assembly sub department head	0.7	0.1	0.07
RA4	Machine is fully loaded with pulp that clogs the incoming supply boiler	0.3	0.5	0.15
RA5	Machine is fully loaded with pulp that clogs the incoming supply cooler	0.3	0.5	0.15
RA6	Lack of operator's working concentration yang tidak diinginkan	0.1	0.1	0.01
RA7	Lack of awareness of the operator about the danger of conveyor that is operating	0.1	0.9	0.09
RA8	Lack of operator's working concentration	0.3	0.1	0.03
RA9	Lack of operator's concern in the importance of personal protective equipment	0.3	0.1	0.03
RGJ1	Operator packs the footwear in a hurry to fullfill the production target	0.3	0.3	0.09
RGJ2	Lack of coordination between operator with finished good sub department head	0.3	0.1	0.03
RGJ3	Operator pack the footwears in hurry to fullfill the production target	0.3	0.3	0.09
RGJ4	Lack of coordination from finished good warehouse with transportation vendor	0.3	0.3	0.09
RGJ5	Lack of management attention in external driver such as congestion and traffic jam	0.5	0.3	0.15
RGJ6	Information network damage	0.3	0.7	0.21
RGJ7	Facility of security in finished goods warehouse is not adequate enough	0.1	0.9	0.09

Risk Evaluation

The risk register II is evaluated by the risk engineering team by following the consequences/probability matrix. The result is as illustrated in Figure 4. Based on the consequences/probability matrix, only 14 risks should be evaluated and prioritized.

Based on the consequences, the risk engineering team can then categorize the risk into four priorities as listed in risk register III (Table VIII). From Table VIII, it is clearly seen that only 4 risks are in the first priority, 2 risks are in the second priority, 2 risks are in the third priority and 6 risks are in the fourth priority.

Risk Treatment

As depicted in Figure 4, only four risks are categorized as high risk: RA7, RGJ7, RGB8, and RB8. For all those risks, the team management would design a special risk treatment to handle the risk. However, for the remaining risks categorized as medium risk, which means that handling of the risk is not urgent, management shall understand if handling a particular risk by a designated risk treatment would create an equivalent benefit to the system. Therefore, the risk engineering team shall generate the cost benefit analysis for medium risk after designing the treatments. Cost/benefit analysis is done by comparing the benefit and total implementation cost. Benefit is calculated by subtracting baseline cost with residual cost (Susilo & Kaho, 2011).

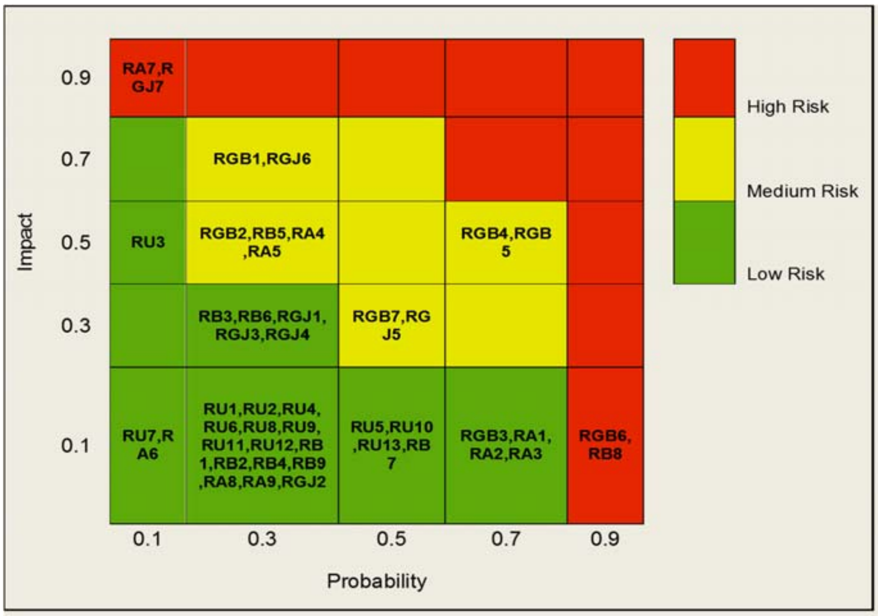

Figure 4. Cons/Prob Matrix of Risk Register II in PT. Primarindo Asia Infrastructure Tbk

TABLE VIII. RISK REGISTER III OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Code	Risk Level	Description	Risk Category	Risk Priority
RA7	0.09	Working accident due to universal pressing machine	High	I
RGJ7	0.09	Missing finished goods	High	I
RGB6	0.09	Stock unbalancing because provision of raw materials exceeds the requirement	High	I
RB8	0.09	Sudden temperature change in pressing machine	High	I
RGB4	0.35	Discrepancy in quality or quantity accessory with order	Medium	II
RGB5	0.35	Discrepancy in quality or quantity of fabrics/leather with order	Medium	II
RGB1	0.21	Sudden modification of production schedule, quantity material, and administration	Medium	III
RGJ6	0.21	Delay response on processing the sales order	Medium	III
RGB2	0.15	Color discrepancy in supplying the canvas material to production	Medium	IV
RGB7	0.15	Stack of unrecorded raw material	Medium	IV
RB5	0.15	Sudden temperature change in outsole heat control machine	Medium	IV
RA4	0.15	Sudden temperature change in outsole heat control machine	Medium	IV
RA5	0.15	Sudden temperature change in cooling chamber machine	Medium	IV
RGJ5	0.15	Late tracking process	Medium	IV

Table IX shows the design of the risk treatment for fourteen focused risks and the cost/benefit analysis. The treatment design for each risk is developed by the risk engineering team. As seen in Table X, the cost/benefit analysis has stated the value over 100% for all medium risks. Therefore, the benefit received by the system is bigger than the cost, and the implementation of all risk treatments for medium risks is worthwhile.

TABLE IX. DESIGNATED RISK TREATMENT AND COST/BENEFIT ANALYSIS OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Code	Risk Treatment Design	Estimated Risk Probability	Estimated Risk Impact	C/B Ratio
RA7	Development of new SOP for press machine operating because operation process of this machine is considered very dangerous.	0.05	0.10	High risk
RGJ7	Enhancing the security by installing CCTV	0.05	0.90	
RGB6	Developing variance of material size to fulfill the requirement of other department	0.90	0.05	
RB8	Installation of temperature measurement in each machine.	0.70	0.10	
RGB4	Better coordination with supplier on the correct amount of sales and agreement of weighting method	0.30	0.50	4000%
RGB5	Submitting proper sample of a particular order to supplier so that supplier can ensure the correct specification of an order	0.30	0.50	4000%
RGB1	Using the outsole footwear that have been made to the proper type of footwear	0.30	0.10	7560%
RGJ6	Increasing the frequency of networking system maintenance	0.10	0.70	333%
RGB2	Patching stickers of clear raw material information to each raw material, especially to the canvas with similar color	0.10	0.50	920%
RGB7	Risk Avoidance	0.00	0.00	Risk Avoidance
RB5	Inspecting the machine once a week	0.10	0.50	500%
RA4	Inspecting the machine once a week	0.10	0.50	500%
RA5	Inspecting the machine once a week	0.10	0.50	500%
RGJ5	Considering the possibility of traffic congestion of the delivery route in leadtime calculation	0.30	0.30	200%

Risk register IV is made to list all the treatments which pass the cost/benefit analysis and specify the purpose of each risk treatment to convince all stakeholders about the importance of implementation of each risk treatment. The risk register IV of PT. Primarindo Asia Infrastructure Tbk is as seen in Table X.

TABLE X. RISK REGISTER IV OF PRODUCTION DEPARTMENT IN PT. PRIMARINDO ASIA INFRASTRUCTURE TBK

Risk Code	Description	Risk Category	Risk Priority	Risk Treatments	Objective of the treatments
RA7	Working accident due to universal pressing machine	High	I	Development of new SOP for press machine operating because operation process of this machine has considered very dangerous.	By clear SOP, operator will be able to operate the machine correctly. Each of the operators shall get proper training on the press machine operation.
RGJ7	Missing finished goods	High	I	Enhancing the security by installing CCTV	CCTV would prevent footwear thievery. CCTV shall be connected with the central information database, which can be controlled by management.
RGB6	Stock unbalancing because provision of raw materials exceeds the requirements	High	I	Developing variance of material size to fulfill the requirement of other department	Variance of material size would reduce the impact of material waste
RB8	Sudden temperature change in pressing machine	High	I	Installation of temperature measurement in each machine.	Measurement installation in each machine would make the monitoring process easier whenever the temperature drops or increases suddenly.
RGB4	Discrepancy quality or quantity accessory with order	Medium	II	Better coordination with supplier on the correct amount of sales and agreement of weighting method	Clear information to supplier and agreement of weighting method would help supplier to set up proper quantity
RGB5	Discrepancy quality or quantity fabrics/leather with order	Medium	II	Submitting proper sample of a particular order to supplier so that supplier can ensure the correct specification of an order	Sample would help supplier to comply with the desired specification
RGB1	Sudden modification of production schedule, quantity material, and administration	Medium	III	Using the outsole of footwear that have been made to the proper type of footwear	By using the outsole footwear to produce the proper type of footwears would reduce waste and production costs
RGJ6	Delay response on processing the sales order	Medium	III	Increasing the frequency of networking system maintenance	Increasing the maintenance frequency would reduce the networking system error
RGB2	Color discrepancy in supplying the canvas material to production	Medium	IV	Patching stickers of clear raw material information to each raw material, especially to the canvas with similar color	Sticker would reduce the possibility of a particular material being wrongly selected
RGB7	Stack of unrecorded raw material	Medium	IV	Risk Avoidance	Risk shall be avoided because it gives no significant value to the company

Table X continues on the next page

RB5	Sudden temperature change in outsole heat control machine	Medium	IV	Inspecting the machine once a week	Regular machine inspection would prevent rejection of product due to sudden temperature change
RA4	Sudden temperature change in outsole heat control machine	Medium	IV	Inspecting the machine once a week	Regular machine inspection would prevent rejection of product due to sudden temperature change
RA5	Sudden temperature change in cooling chamber machine	Medium	IV	Inspecting the machine once a week	Regular machine inspection would prevent rejection of product due to sudden temperature change
RGJ5	Late tracking process	Medium	IV	Considering the possibility of traffic congestion of the delivery route in leadtime calculation	Congestion possibility would create the realistic delivery lead time.

The risk register IV closes the risk engineering loop. Management shall execute the list in risk register IV according to its priority and control the implementation. Based on the implementation, management can then redo the loop of the risk engineering process.

VI. CONCLUSION

In conclusion, this article has shown that ISO 31000 can be used on the production floor even when the budget allocated for risk engineering is very limited. The implementation in this article is shown in a context of footwear industry based on a case study. The implementation of ISO 31000 method in PT Primarindo Asia Infrastructure Tbk. identified 45 risks which are caused by 45 risk causal. Fourteen risks have been assessed as priority risks through risk evaluation method. Amongst the priority risks, ten risks are middle risks, and four risks are high risks. Each priority risk has been assessed based on the probability and impact. Special treatment for each priority risk had been designed. Cost-benefit analyses were performed for middle risks to further assess the treatments designed in order to make sure that the cost of the designed treatments would be commensurate with the benefit. More research on the implementation of ISO 31000 in different contexts is important. Further research shall also cover the control and maintenance of the implementation ISO 31000.

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