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Design of Risk Mitigation Strategy for Procurement of Raw Materials to Glass Melting Furnace at PT AMFG

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ABSTRACT

Raw materials procurement is crucial in the sustainability of the glass manufacturing industry, including at PT Asahimas Flat Glass Tbk (AMFG). Procurement of raw materials that are not smooth can cause a significant loss and can cause production failure (unproduct) or shut off factory operations. The glass factory has the characteristics of a continuous factory where the smelting materials must be fed continuously because the smelting furnace operates continuously. There is no holistic research on raw material procurement risk management at PT AMFG. This research uses the House of Risk (HoR) approach to manage risk, which consists of 2 phases. The first phase is identifying risks in which risk events and agents are identified and measurement of severity and occurrence, also carried out levels and calculation of the aggregate risk potential (ARP) value. The second phase is risk management. The phase 1 HoR analysis result was carried out by direct discussion at PT AMFG or material supplier in the mine through scoring for each risk event, namely 65 risk events that can be identified through the planning, purchasing, mining/production, inspection, delivery and treatment process. From the Pareto chart, 9 potential risk agents must be prevented by evaluating using HoR stage 2, so that 17 preventive actions are obtained, of 10 preventive actions will be prioritized. One of the priority actions is the creation of an online monitoring dashboard application (Raw Material or RM-One) that can quickly update and monitor risk management from upstream (mining materials and other crucial raw materials) to downstream (factories). RM-One will help facilitate supply chain coordination, especially in preventive efforts against risks.

KEYWORDS: Risk Management, Continues Factory, Procurement, Mitigation Strategy, House of Risk and Online Dashboard Monitoring.

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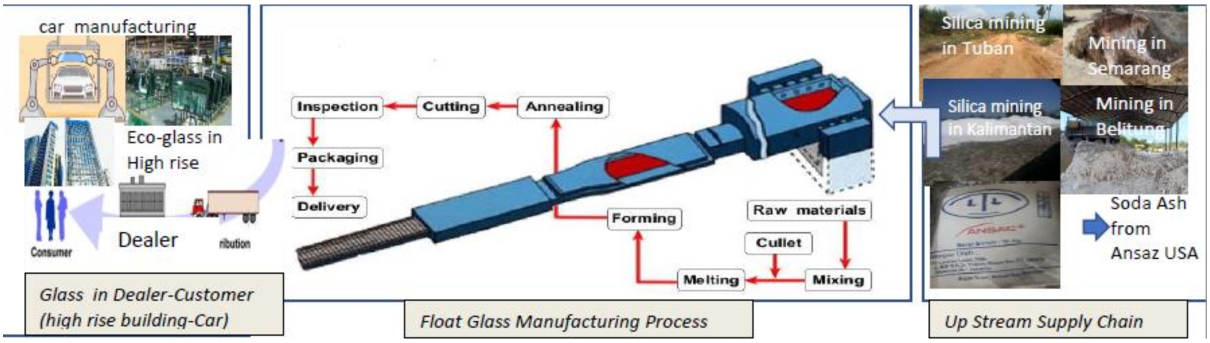
1. INTRODUCTION

PT Asahimas Flat Glass Tbk or AMFG (Asahimas name on the stock exchange starting in 1995) is a joint venture between Asahi Glass Co (AGC) Ltd (Now AGC Inc) and PT Rodamas, a trading company that later turned into a manufacturer of industrial and consumer products. Both companies officially established PT AMFG in April 1973. AGC Inc, the largest shareholder, is the world's largest global supplier of glass. The float glass-making process, whose main process is the melting of materials such as silica sand (SiO2), Dolomite (CaCO3), colorant (Cobalt Oxide, Nickle Oxide, Sodium Selenite) and natural gas fuel for the melting process are some of the materials that must always be supplied continuously. These materials are obtained from domestic Indonesia (local mines in Central Java, Belitung and Kalimantan) or abroad, such as Soda Ash (Na2CO3) imported from America or China. All these materials are needed to continuously melt the material in the glass melting furnace for 10-20 years. The condition of the COVID-19 pandemic in 2020 has made all manufacturing plants review their Business Contingency Plan (BCP), including the existing supply chain risk mitigation (Raj et al., 2022; Sajid, 2021)

Both supply chains start from mining materials, domestic raw material suppliers and imported materials. In these difficult conditions, the main material needs for manufacturing, especially continuous factories that require materials for continuous smelting, are very critical. The smelting process in high-temperature furnaces must always be kept stable and have a minimum operational temperature so that the refractory stone furnaces do not experience damage or cracks. To anticipate operational risks that can hinder production and even interrupt the business. A decrease in temperature that reaches the minimum thermal expansion of each type of refractory stone in the furnace will turn the furnace off. This condition will require a long time to off the furnace operation before it has to start up again. The total time required for the cycle is a minimum of 12-14 months, with a very high cost, including the costs that must be borne when there must be a sudden stop of operations and other safety and social impact factors. Procurement is a key supply chain management activity with a very strategic function. In the Supply Chain Operation Reference framework, procurement is at the source stage, which is the process associated with ordering, delivering, receiving, and transferring raw materials, products, and services. Procurement is one of the main activities in a manufacturing company related to the main functions of a supply chain (Pujawan & Geraldin, 2009)]. Materials for glass melting are sourced from mining and industrial products and come from local Indonesia and imports from abroad because no suppliers from Indonesia meet specifications or due to considerations of supply ability or material quality. In addition to the supply of materials and goods that must be safely conditioned, fuel availability to melt the "Batch" (mixture of glass materials ready for feeding) into the furnace is a vital factor that must always be conditioned available. The process of melting glass in the furnace requires considerable energy using natural gas fuel with a back. The following is the supply chain flow of the glass business process.



Source: PT AMFG

FIGURE 1. Supply Chain Flow in Float Glass Manufacturing

There are three supply chain components: upstream or upstream, internal supply chain and downstream supply chain (Turban et al., 2008). Learning from the unexpected conditions of COVID-19, where the normal supply chain cannot fully anticipate shortages or disruptions in the supply chain from material suppliers to factory operations (Orlando et al., 2022). A resilient supply chain and many innovations are needed to deal with unexpected disruption (Geraldin, 2010; Govindan & Fattahi, 2017; Suryawanshi & Dutta, 2022). The company needs to design a risk mitigation strategy for the supply chain of materials & fuel to the melting furnace with the House of Risk method to avoid interruption problems in the melting process or quality problems in the glass production that will be produced. The risk management design process includes the stages of risk identification, risk analysis, risk evaluation, risk treatment, control and monitoring. (Anggraini, 2021). This research aims to create an upstream supply chain risk management plan, which includes identifying each material's risk and fuel for the smelting process in the furnace, the source of risk, the relationship matrix, and the aggregate risk potential. Also, to design appropriate mitigation strategies for the evaluated risks and design a dashboard monitoring upstream supply chain materials as one of the digitalization implementations to be able to monitor in real-time the conditions that occur at the mining supplier in the form of material quality parameters that can be anticipated more quickly in the smelting process at the factory (moisture content, grain size, etc.) (Jha et al., 2022). In this research, no research and risk identification was conducted on the existing process equipment due to the lower risk factor with the "back up" or use of UPS (Uninterruptible Power Supply) in each of the main equipment. Also, no research was conducted on residual risk, which refers to the level of risk remaining after risk control efforts are made. The Business Contingency Plan contains risks that remain after implementing mitigation and risk control. One example of residual risk is if the preventive action is unsuccessful, such as the material cannot be supplied to the melting furnace. In our risk management process, three major processes must be gone through. These processes are as follows:

Establishing The Context

It was establishing the context or determining the part of a description or sentence that can support or add clarity to the meaning of the situation concerning an event. It is established by identifying the organization's or company's targets and objectives. The steps that must be taken are to set the context, set objectives, and formulate internal and external parameters to be considered in risk management. It also establishes the scope and risk standards of the ongoing process.

Risk Assessment

There are several processes, such as risk identification, which is an activity to identify the organization to determine what risks can affect the achievement of organizational goals (Nimmy et al., 2022). After that, there is risk analysis and knowledge about risk. Risk analysis considers the root cause or cause and the source of risk, regardless of whether there will be negative or positive consequences and the possibility of risk occurrence. The next process in risk assessment is risk evaluation, which aims to assist in making decisions based on risk analysis results, which risks should be improved and prioritized for improvement.

Risk Management

The improvement process in supply chain risk management is an effort to create a supply chain organization resilient to the emergence of risks in existing business activities(Ammar et al., 2021). The risk management approach is expected to provide awareness for business people to make risk one of the considerations that must be considered to prevent the emergence of fragility in the supply chain. Finally, risk control and monitoring is a process to identify, analyze and plan for emerging risks, keep an eye on the list of risks that have been identified, re-analyse existing risks, monitor trigger conditions against possible plans, control residual risks and evaluate the effectiveness of the implementation of risk management. The following is the upstream supply chain flow of the float glass manufacturing process.

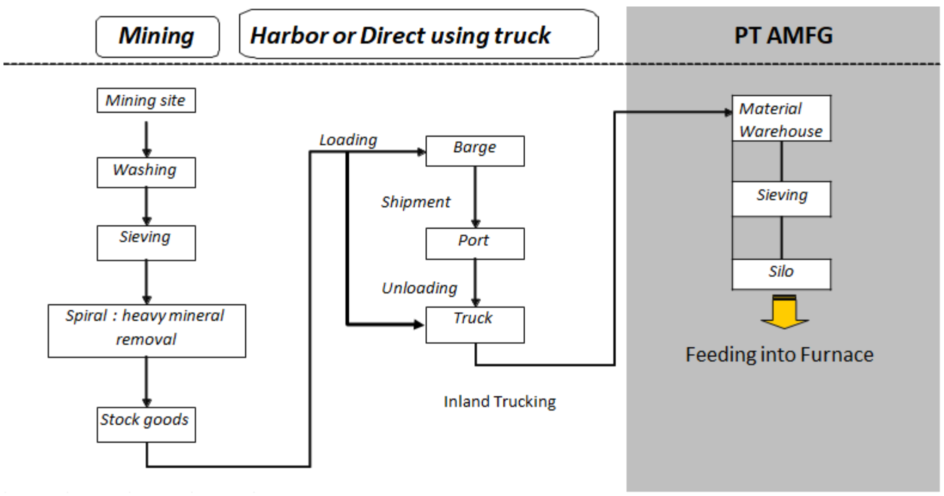


FIGURE 2. Up Stream Supply Chain Flow in Float Glass Manufacturing

2. METHODS

Data Collection Risk Identification and Risk Sources

This study uses the House of Risk (HoR) method for the risk identification stage. The risks identified are seen from risk events in the purchasing, raw material, procurement sections, department, division or factory level. For some mining suppliers, interviews or discussions are conducted directly with the owner or site manager at the mine. The respondent is someone who is directly involved and has a background experience of more than 12 years. The selection of respondents from people with considerable experience in their fields will help formulate risk identification using SCOR, which includes the Plan, Source, Make, Deliver and Return sub-processes. After identifying risks, the identification of risk triggers (risk agents) is then carried out. This identification is to determine what factors can cause risk events. Abnormal conditions that occur can cause risks to be identified. Risk identification is made from data obtained from discussions, brainstorming, direct interviews with respondents, literature studies, field observations, and various other sources of information both internal to the supply chain, internal to PT AMFG or AGC Inc. as a group corporation and the external environment.

Creating Relationship Metrics

At this stage, metrics are developed for the relationship between each risk event and risk agent variable. These metrics are identified with a predefined score.

House of Risk 1 (HoR1) and House of Risk 2 (HoR 2)

Study Literature HoR

There is a relationship between HoR and FMEA (Failure Modes and Effect of Analysis), but HoR is not a direct development of FMEA or HoQ (House of Quality) (Febrianto, 2017; Pujawan & Geraldin, 2009). HoR is a comprehensive model or framework that covers various aspects of risk management in a company or organization (Pujawan & Geraldin, 2009). FMEA is a method used to identify and analyze possible failures, their causes, and their effects on existing systems or processes. HoQ is a method used to identify and give priority to customers in designing a product or service.(Braglia et al., 2018). HoR evaluates more than failure identification and customer preferences. This model involves organizational structure, risk policy, risk culture, organizational goals and overall risk management. In HoR implementation, FMEA and HoQ can be tools that support risk identification and understanding customer preferences. FMEA can help identify potential failures and their impacts, and HoQ can help understand customer desires related to risks related to products or services.(Braglia et al., 2018) .Therefore, with the HoR method, organizations or companies can integrate various relevant risk management tools, techniques, and approaches to gain a more holistic and structured understanding of the risks and how to manage them. HoR is also a model based on the need for risk management that focuses on preventive action to determine which causes of risk are prioritized, which will then be given risk mitigation or countermeasures (Pujawan & Geraldin, 2009). In this study, two deployment models called HoRs are proposed, both of which are based on a modified HoQ. HoR 1 determines which risk sources are prioritized for preventive actions, while HoR 2 prioritizes actions by considering cost-effective resources.(Pujawan & Geraldin, 2009)

HoR Implementation

In this stage, the identification of risks that may occur in each business process is carried out. This stage can be started by mapping each stage of the business process. HoR 1 focuses on ranking the ARP, which consists of 3 factors: occurrence, severity and interrelationship. In other words, this phase focuses on the risk identification process, including risk agents and events.(Pujawan & Geraldin, 2009). This phase consists of several working steps, namely:

1. Identify the division of business processes/company activities that aim to find out where these risks can arise.
2. Identify risk events (Ei) for each business process identified in the previous stage.
3. Measure the level of impact (Si) of a risk event on the company's business processes. This severity value states how much disruption a risk event causes to the company's business processes, where a 1-5 scale assessment can be given regarding severity.
4. Identify the causative agent (Aj), which is any factor that causes the occurrence of the previously identified risk event.
5. Measure the probability of occurrence (occurrence) of a risk agent. Occurrence expresses the probability of a risk agent's frequency of occurrence resulting in one or more risk events that can disrupt business processes with a certain impact. Identify the risk agent by providing a scale of 1-5, where scale 1 indicates that the risk has never occurred, while number 5 indicates that the risk will almost certainly occur.
6. Prepare a matrix to link each risk agent with risk events.
7. Measure the correlation value between a risk event and the risk agent. If a risk agent causes a risk to occur, it is said that there is a correlation. The correlation value (Rij) consists of (0,1,3,9) where 0 indicates no correlation, 1 describes a small correlation, 3 describes a medium correlation, and 9 describes a high correlation.

Calculating ARP (Aggregate Risk Potential)

A risk matrix is created after determining the risk event variable (risk event, Ei) and the risk trigger (risk agent, Aj). A matrix is created that connects the risk event (risk event) and the risk trigger (risk agent). The aggregate risk potential or ARP (Aggregate Risk Potential) calculation can be determined from the risk trigger variable (risk agent) and the impact resulting from the risk trigger. The results will then determine the level of risk probability (occurrence, Oj) and risk impact (severity, Si). The ARP value is obtained by multiplying the severity and occurrence levels. The ARP (Aggregate Risk Potential) calculation process involves several elements as described above, namely the level of impact of a risk event (Si), the level of chance of occurrence of a risk agent (Oj), and the level of connection between the risk agent and the risk event (Rj). Risk agent ranking is based on the ARP value. The result of this stage is the prioritization of risks, which is then used as a reference for preparing the risk-handling plan. The following is the impact of supply chain risks from suppliers to factories, which can affect the production process because the availability of materials or raw materials in inventory is not fulfilled properly. The impact (severity) and correlation (correlation) between risk events and risk agents, as well as the likelihood of these impacts arising (occurrence), combined to determine the level/rating of risk by analyzing the causes of the identified risks to then calculate the Aggregate Risk Potential (ARP) value using the HoR1 Model as previously explained.

$$\mathrm{ARP\ j} = \mathrm{0j} \sum \mathrm{Si\ Rj} \tag{1}$$

This ARP value is obtained from the sum by multiplying the severity and occurrence levels. This risk analysis stage results are in the form of risk prioritization, then used as a reference for preparing risk handling plans.

Identification of Mitigation Strategies

Risk mitigation strategies are carried out to reduce potential risks in the future or reduce the impact of Risk Events (Kraude et al., 2022). In other words, mitigation control is an action to minimize potential risks based on events that have occurred before(Mishra et al., 2016). At this stage, a list of variables related to what strategies will be carried out for risk mitigation is made using the risk variables obtained from the questionnaire and the results of interviews with managers, section heads, and suppliers in related sections. After that, discussions were held with several people with experience and expertise in the field.

Risk Evaluation

Risk evaluation aims to determine the selection of risk agents from the highest priority level based on phase 1 (HoR) results to phase 2 (HoR). In phase 2, the focus is on determining the most appropriate step to take by considering the effectiveness of the resources used and the level of performance of the object concerned. (Pujawan & Geraldin, 2009) Several stages in HoR 2:

1. Select the risk agent with a high priority level based on the output of HoR phase 1.
2. Identify relevant actions to prevent the risk.
3. Determine the relationship between each preventive action and each risk agent.
4. Calculate the effectiveness of each action as follows:

$$TE_k = \sum_j ARP_j \, . \, Ejk \tag{2}$$

5. Measure the level of difficulty by presenting each action.
6. Calculating the total effectiveness to determine the ratio amount with the following formula:

$$ETD_k = TEk \ / \ Ejk \tag{3}$$

7. Prioritize ETD from the highest to the lowest. The highest priority value is given to mitigation actions with the highest ETD value.

Determining Mitigation Strategies

Actions considered relevant or related to reducing risk triggers (risk agents) are identified to determine mitigation strategies. For one risk agent variable, more than one action can be taken to mitigate the risk that will occur. At this stage, the focus is on determining the most appropriate step, considering the effectiveness of the relevant performance objects. It is also applied to long-term mitigation strategies, namely 20 years (Concession for mining), 12 months (1 year) and 24 months (2 years) and short-term, namely 1 month, 4 months and 6 months. [14].

Risk Analysis and Control

At this stage, the data that has been collected is further analyzed so that conclusions can be drawn that can answer the objectives of conducting risk management research (Hofmann & Rutschmann, 2018) in the procurement department. Risk control is carried out periodically; the company must monitor and review risks at time intervals determined by the company. At this stage, keep an eye on the list of risks that have been identified, re-analyse existing risks, and monitor trigger conditions against possible plans. These control risks still occur, and evaluate the effectiveness of implementing these activities.

Online Dashboard Supply Chain from Mining Supplier to Factory

Currently, supply chain information from downstream (mining) or fuel suppliers is still lacking, and information is always obtained late (Kraude et al., 2022), so upstream (factories) often find it difficult to anticipate abnormal conditions from downstream. Designing a supply chain dashboard that is easily accessible will be very useful for both downstream and upstream processes. It greatly minimizes the risks arising from the information obtained quickly. The dashboard display will be based on the risk analysis and control results examined and obtained during the research. We call the name RM-One (Raw Material One).

3. RESULTS

Business Process Identification

Business process identification aims to understand the sequence of existing business processes and map the analysis of potential risks (Keilhacker & Minner, 2017). It can be done by discussing with material and gas suppliers and taking references from working instructions in the company's ISO documents. From the activities carried out, the supply chain reference of the company will be obtained.

Risk Event Identification

There are 65 risk events at PT AMFG that were identified from several sub-processes. The determination of risk events is adjusted to conditions that often occur, such as uncertain weather conditions, the COVID-19 pandemic, environmental issues that are increasingly important at the mine, conflicts in the mining area and daily operational problems that arise in each sub-process.

Determination of the Severity Level of the Risk Event

Risk Agent is a trigger factor that will cause risk events. Determination of Risk Agent is done by conducting interviews with several Department Managers, related Division Managers and material suppliers, which then obtained 29 risk causes starting from the planning process, mining process, mining material processing, receiving process at the factory and feeding process into the melting furnace at the factory. One risk cause (Risk Agent) can result in one or more risk events.

Determination of the Severity Level of the Risk Event

To determine the risk event score for severity or impact, obtained from interviews conducted by the manager and the manager or owner of the related material supplier based on criteria 1-10. After that, Risk Event grouping is carried out based on the priority level where preventive action will be taken. Assessment of the severity value of risk events through interviews and discussions to determine the score for each sub-process where Risk Events that appear more frequently, especially during the COVID-19 pandemic or weather during the extreme rainy season, have a high severity value because they will have a serious impact on company targets and goals. Other Risk Events or Risk Events correlated with severity values, the result for moderate to severe (>5) have 52 items and moderate to low (<5) any 13 items.

Determination of Occurrence Rate of Risk Agent

The meaning of determining the level of Occurrence of Risk Agents is how often the frequency of occurrence of risk events is due to the presence of risk agents. Something that causes a risk with a high Occurrence value must be minimized so as not to cause a risk event due to a risk agent with a high occurrence value. Determination of the occurrence rating is done by filling out a questionnaire conducted by the manager from the Raw Material, Purchasing / Procurement, Purchase Logistics, Quality, Production and the owner or Manager of the material supplier by filling in a scale of 1-10 in the table below. After filling out the questionnaire, an interview was also conducted regarding the occurrence assessment. Some risk agents at that time were closely related to the pandemic conditions (lockdown, Regional Restrictions or PPKM, etc.). These central and local government regulations or uncertain business conditions were set at that time. The order or ranking of the occurrence risk agents correlated with occurrence values; the result for moderate to high (>5) has 5 items and moderate to low (<5) any 24 items.

Creation of Relationship Matrix

Determination of severity criteria for risk events and occurrence of risk agents has been carried out. Therefore, the next step is to classify the correlation level between risk events and risk agents. From the results of communication at the factory, the level of correlation between risk event and risk agent is made into four levels: score 9 with the highest correlation, score 3 with medium correlation, score 1 with low correlation, and score 0 if there is no correlation. After discussions, the correlation of risk events and risk agents and the correlation value of risk event and risk agent with factory members & material suppliers resulted in a high correlation of 17 items, a medium correlation of 23 items and a low/no correlation of 25 items.

Calculation of Aggregate Potential Risk (ARP) Value And Rating

Determining the relationship between the risk event and risk agent will result in an ARP value for each risk agent

Ranking of ARP Values

ARP values are sorted from the largest to the smallest, and the table from this is sorted. After that, it is converted into a Pareto Chart or Pareto diagram. The ranking of risk agents against the largest ARP value is on the left position, and the one with the smallest value is on the right side.

The Pareto Chart determines which risk agents we should prioritize for preventive action or handling. Not all risk agents will be handled but selected based on priority or those with a large impact or influence on risk events. It must be done considering the efficiency of activities regarding human resources and costs that will be affected.

Strategy Identification

The results of the Pareto Chart, where risk agents will be prioritized, will be identified with preventive action (PA) to prevent the occurrence of risk events. The analysis will use HOR 2 to obtain the priority order of the preventive action (PA), which is the solution to the problem to be implemented at PT AMFG. The determination and discussion on this matter involve the Division Manager and assistant Factory Manager as senior Management at the company. These senior Management have a long working experience (15-28 years) and are highly competent in their fields. The discussion included the selection of risk agents that would be prioritized for mitigation. The discussion results determined that as many as 80% of the total risk agents, or 9 risk agents, have the possibility of risk events with the greatest impact. The results of the Pareto chart show a list of risk agents selected according to the score of 80% of the ARP value, which has the potential to cause the impact of risk events as many as 9 risk agents. By selecting 9 priority risk agents for countermeasures or preventive actions, risk agents' potential influence or impact can be minimized or even eliminated. Interviews and discussions conducted with senior Management at the Factory, Management or Owner of raw material suppliers at the mine, Manager of Natural Gas Supplier and previous journal studies have identified 17 items of countermeasures and preventive actions that can be done.

Correlation Between Countermeasures, Preventive Action and Risk Agent

The following table shows that preventive actions correlated with risk agents are scored on a scale.

TABLE 1. Identify Countermeasures and Preventive Actions against Risk Agents

Code	Risk Agents	Code	Preventive Action	Rj	Dk
A23	Poor control of quality standard specifications in the mining material area	PA1	Review agreements and educate suppliers on controlling standard material specifications in the mining area.	9	4
		PA2	Add a clause in the agreement regarding the system for changing the location or lot in the mining area.	9	4
		PA3	Evaluate supplier audit check- items by PT AMFG for material suppliers carried out every 6 months.	9	4
		PA4	Prepare a visualization system and dashboard so that abnormalities can be easily identified from the mine to the factory so that action can be taken quickly.	9	5
		PA5	Review working instruction (WI) and procedure (PD) to control quality standard	3	4
A02	Unclear changes in forecasting at the factory	PA4	Set up a visualization system and dashboard so that abnormalities can be easily identified from the mine to the factory so that action can be taken quickly.	9	5
		PA6	Improve communication and coordination between the raw material section, HotCold Section, Production Planning Control Group, Sales and suppliers.	9	4
		PA7	Review forecasting monthly and conduct a coordination meeting after the forecast is finalized.	9	4
		PA8	Refresh training by reviewing working instruction (WI) and procedure (PD), especially for newcomers who are very numerous in PT AMFG, Sidoarjo Factory.	9	4
A27	Contaminants from Nickel or aluminum materials will cause NiS to form, which will cause the glass to break.	PA1	Review agreements and educate suppliers on controlling standard material specifications in the mining area.	9	5
		PA3	Evaluate supplier audit check items by PT AMFG for material suppliers every 6 months.	3	4
		PA9	Educate all material suppliers & PT AMFG employees (especially newcomers) on the Ni contaminants that will cause NiS in the melting furnace and cause sudden glass breakage.	9	4
		PA10	Ensure all material suppliers have been audited by checking by Handy X-Ray (max nickel content: 0.5%) every 6 months.	9	5
		PA11	Immediately replace the material with a replacement material for equipment in the mine that has the potential to become a Ni contaminant from the material in the mine (rotary screen, conveyor line, backhoe/excavator bowl, etc.)	9	5

Code	Risk Agents	Code	Preventive Action	Rj	Dk
		PA12	Control and make agreements with all material transporters always to keep their trucks or vehicles not mixed with materials for PT AMPO (mixed with coal, sulfur and others)	9	5
A29	Uncertain global circumstances influenced by the global recession	PA4	Set up a visualization system and dashboard so that abnormalities can be easily identified from the mine to the factory so that action can be taken quickly.	9	5
		PA6	Improve communication and coordination between the raw material section, HotCold Section, Production Planning Control Group, Sales and suppliers.	9	4
		PA7	Conduct monthly forecasting reviews and coordination meetings after the forecasts are finalized.	9	4
		PA13	Continue to take corrective actions with a target ROCE (Return of Capital Employee) of 0110% and have flexibility in rapidly changing market conditions.	3	5
		PA14	Continue to optimize inventory to control cash flow and unnecessary losses, one of which is raw material stock, with careful consideration in highly volatile conditions.	9	5
		PA15	Prepare future activity and investment plans with carbon-neutral policies for society.	3	5
A07	Mining Process in Supplier, Setup in the factory, and control before entering the smelting process.	PA4	Set up a visualization system and dashboard so that abnormalities can be easily from the mine to the factory for quick action.	9	5
		PA5	Review working instruction (WI) and procedure (PD) to control quality standards.	3	4
		PA6	Improve communication and coordination between the raw material section, hot-cold section, production planning control group and sales.	9	4
A24	Control and Management in receiving material (raw material dept & QC dept)	PA4	Set up a visualization system and dashboard to easily identify abnormalities from the mine to the factory for quick action.	9	5
		PA5	Review working instruction (WI) and procedure (PD) to control quality standards.	3	4
		PA16	Conduct internal quality patrol, specifically in raw materials, by the Factory/Division Manager routinely every month.	3	3
A21	Control of expired permits that are not made by an auto reminder system	PA17	Create auto reminders for all permits & licenses of existing materials, domestic and imported.	3	3
A16	Differences in material specifications that sometimes arise when	PA2	Add a clause in the agreement regarding the system for changing the location or lot in the mining area.	9	4

Code	Risk Agents	Code	Preventive Action	Rj	Dk
	changing material lots at the mine	PA4	Prepare a visualization system and dashboard so that abnormalities can be easily identified from the mine to the factory so that action can be taken quickly.	9	5
		PA5	Review working instructions (WI) and procedures (PD) to control quality Reviewing standards.	3	4
A18	Poor communication among suppliers	PA4	Set up a visualization system and dashboard to easily identify abnormalities from the mine to the factory for quick action.	9	5
		PA5	Review working instruction (WI) and procedure (PO) to control quality standards.	3	4
		PA17	Improve communication, coordination and education within suppliers and report in monthly meetings between suppliers and PT AMFG.	9	3

The next step is to evaluate the level of difficulty (Dk) of each countermeasure, preventive action that has been determined by considering the conditions at the operational level in the field both at the supplier, material mining area, investment costs needed, existing equipment, regulations or agreements that have been made, as well as the resources that must be prepared. Furthermore, all assessments (scores) and existing data from discussions and communication with suppliers (supplier owners and managers) and Senior Management in the factory are entered in the HoR 2 matrix.

After the correlation of countermeasures, preventive actions against risk agents are carried out, and then the HoR2 will produce the value of total effectiveness (Tek), difficulties (Dk), the effectiveness of difficulties (ETDk) and ranking (Rk) (Pujawan & Geraldin, 2009)

To be treated risk management		Strategy Preventive Action (PAk)																	Agregate Risk Potensial (APRj)
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	
RISK AGENTS	A_{23}	9	9	9	9	3													594
	A_{02}				9		9	9	9										525
	A_{27}	9		3						9	9	9	9						468
	A_{29}				9		9	9						3	9	3			441
	A_{07}				9	3	9												417
	A_{24}				9	3											3		384
	A_{21}																	3	270
	A_{16}		9		9	3													252
	A_{18}				9	3												9	234
Total effectiveness of action k (TEk)		9558	7614	6750	25623	5643	12447	8694	4725	4212	4212	4212	4212	1323	3969	1323	1152	2916	
Degree of difficulty performing action (Dk)		4	4	4	5	4	4	4	4	4	5	5	5	5	5	5	3	3	
Effectiveness to dificulty ratio (ETDk)		2390	1904	1688	5125	1411	3112	2174	1181	1053	842	842	842	265	794	265	384	972	
Rank of priority (Rk)		3	5	6	1	7	2	4	8	9	11	12	13	16	14	17	15	10	

FIGURE 3. Correlation between PA and RA

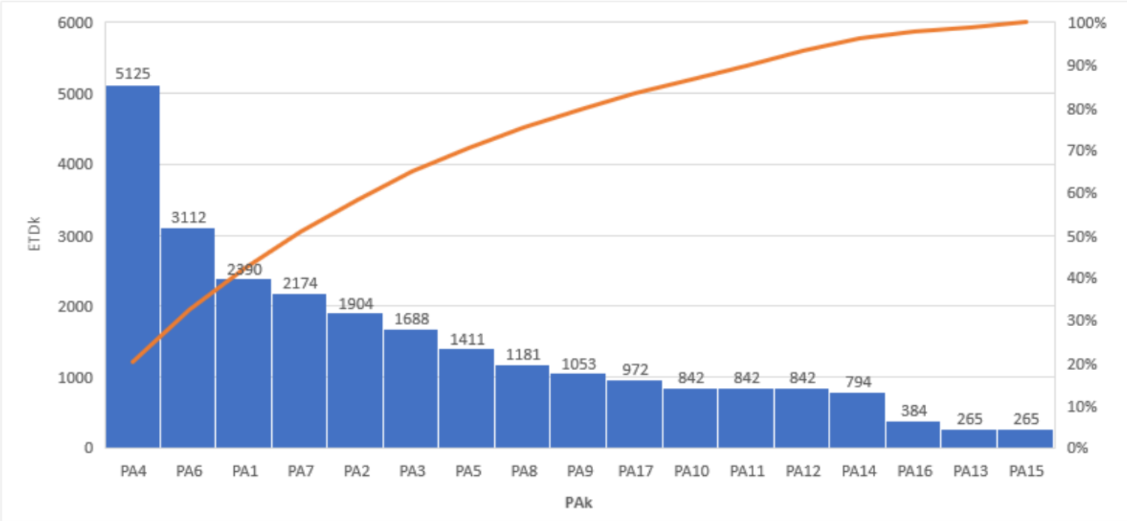


FIGURE 4. Pareto Chart PAk versus selected RA

The right side above is a Pareto chart used to analyze the relationship or correlation between risk agents and countermeasures preventive actions. The correlation between countermeasures, preventive actions and selected risk agents seen from the order of priority starting from countermeasures preventive actions can be seen in Fig.4 as a Pareto chart.

Preventive Action (PA)

From the table above, the research at PT AMFG limits the ETDk value to above 80% as a prioritized choice for what countermeasures and mitigation strategies should be carried out. Seen from the ETDk table, the priority countermeasure and preventive action strategies are 10 countermeasures, preventive actions attached to the countermeasure priority table, and preventive action below.

TABLE 2. Priority List of Preventive Action (PA)

Code	Countermeasures & Preventive Action	TEk	Dk	ETDk	Rk	Acc (%)
PA4	Set up a visualization system and dashboard so that abnormalities can be easily identified from the mine to the factory so that action can be taken quickly	25.623	5	5125	1	20%
PA6	Improve communication and coordination between raw material section, Hot-Cold. Section, Production Planning Control Group, Sales and suppliers	12.447	4	3112	2	33%
PA1	Review agreements and educate suppliers on controlling standard material specifications in the mining area	9.558	4	2390	3	42%
PA7	Review forecasting every month and immediately conduct coordination meetings after the forecasts have been finalized	8.694	4	2174	4	51%
PA2	Add a clause in the agreement regarding the system for changing the location or lot in the mining area	7.614	4	1904	5	58%

Code	Countermeasures & Preventive Action	TEk	Dk	ETDk	Rk	Acc (%)
PA3	Evaluate supplier audit check items by PT AMFG for material suppliers that have been carried out every 6 months	6.750	4	1688	6	65%
PA5	Review working instruction (WI) and procedure (PD) to control quality standards.	5.643	4	1411	7	71%
PA8	Conduct refresher training by reviewing working instruction (WI) and procedure (PD), especially for newcomers who are very numerous at PT AMFG, Sidoarjo Factory	4.725	4	1181	8	75%
PA9	Educate all material suppliers & PT AMFG employees (especially newcomers) on the issue of Ni contaminants that will cause NiS in the melting furnace and will cause sudden glass breakage	4.212	4	1053	9	79%
PA17	Improve communication, coordination and education within suppliers and report in monthly meetings between suppliers and PT AMFG	2.916	5	972	10	83%

4. CONCLUSIONS

1. The creation of a risk management plan in the upstream supply chain of PT AMFG, Sidoarjo Factory resulted in the identification of risk events arising in the raw material procurement process at PT AMFG using the SCOR method obtained 65 risk events which include starting from the material procurement process from suppliers in the mining area, the material processing process after mining, stock supplier materials in the mine, transportation of materials from the mine to the processing process at the supplier, transportation from the supplier to the factory, receipt, inventory at PT AMFG and quality control from the mine to feeding into the glass melting furnace at PT AMFG.
2. Using the discussion method, interviews through visits to PT AMFG and material suppliers mined, the identification of risk agents from the results of the HOR1 analysis was obtained as many as 29 risk agents. After making a Pareto chart, 9 risk agents were selected to be prioritized for risk event mitigation.
3. For stage 2 HoR analysis, 17 countermeasures and preventive actions were obtained. After processing with a Pareto chart, 10 countermeasures and preventive actions were obtained to minimize the occurrence of risk agents.
4. The results of the analysis of risk mitigation strategies with the application of managerial implications involving all elements in the upstream supply chain of PT AMFG become easier to coordinate with the creation of the RM-One application (Online dashboard monitoring) where every abnormality that occurs in one of the elements of the supply chain can be known quickly so that this support system can be the basis for making quick and accurate decisions in minimizing the existence of risk triggers (risk agents). It is the voice of the supplier owner at the mine, the quality and raw material manager, and the production Manager at the factory because it is very helpful to anticipate the possibility of problems or large losses. Another positive impact for the transporter manager is that the registration of material supplier trucks in the factory has become more transparent (no extortion to

determine which trucks enter PT AMFG first, and the time of arrival loading in the factory is known), the transportation manager can monitor easily from a mobile phone and finally efficiency on the part of the transporter.

5. The House of Risk (HoR) method is a method that can help companies or organizations manage risks in a holistic and structured manner.(Pujawan & Geraldin, 2009) , but it requires considerable resources in terms of time, finance and human resources. It is very suitable for a company or organization like PT AMFG, especially if it is done across all PT AMFG factories in Indonesia or AGC corporations worldwide. Still, it may be difficult for companies or organizations with limited resources to implement this method effectively. Another thing is that it is not always easy to identify the right risks using the House of Risk (HoR) method because it requires a good understanding of the organization to identify the right risks.
6. After risk mitigation using the HoR method and residual risk remains in the upstream supply chain of PT AMFG, a review must be carried out again for the BCP subscription (Business Contingency Plan) to handle the existing residual risk.

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