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Comparative Analysis of Hazard Identification and Risk Assessment Methods in Ağrı Cement Factory: Fine-Kinney vs. 3T Approach

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Abstract

Occupational health and safety is essential to protect, maintain and improve the physical, psychological and social well-being of employees and to prevent harmful factors. One way to prevent occupational hazards is to identify them in the workplace. Therefore, providing information to assist in making the necessary decisions to reduce occupational hazards, and conducting hazard identification and risk assessment will contribute significantly. In this study, the risks identified at Ağrı Cement Factory were classified using the Fine-Kinney method and the 3T risk assessment method, and the results were compared. The 3T method is superior to the Fine-Kinney method because of its modular structure. The high risks that require immediate action in the Fine-Kinney method appear to be prioritized similarly in the 3T method as well. However, in the Fine-Kinney method, significant, possible, and risks are considered among the top 3 priority risks, while in the 3T method, they are considered among the top 2 priority risks. It has been observed that a risk assessment utilizing the Fine-Kinney method will be successful if continuously updated. Difficulty in selecting the probability component has led to elevating risk values in the Fine-Kinney risk assessments by selecting a higher level of risk. Although both methods exhibit different approaches, the 3T methodology has been understood to provide a comprehensive perspective by considering risk in terms of threat, performance, and harm. This approach has addressed different dimensions to understand the origins, impacts, and consequences of risks. On the other hand, the Fine-Kinney Risk Assessment Method, relying on weighting and scoring factors specific to project characteristics and factors, has been reported to evaluate risk in a more analytical manner. It has been concluded that this methodology will be successful in calculating risk scores by considering specific project characteristics and risk profiles.

Keywords: Fine-Kinney, 3T, Risk Assessments, occupational health and safety.

Ağrı Çimento Fabrikası'nda Tehlike Tanımlama ve Fine-Kinney ile 3T Risk Değerlendirme Yöntemlerinin Karşılaştırılması: Bir Kritik İnceleme

Öz

İş sağlığı ve güvenliği, çalışanların fiziksel, psikolojik ve sosyal iyilik hallerinin korunması, sürdürülmesi, geliştirilmesi ve zararlı faktörlerin önlenmesi açısından şarttır. Mesleki tehlikeleri önlemenin bir yolu onları işyerinde tanımlamaktır. Bu nedenle mesleki tehlikelerin azaltılması için gerekli kararların alınmasına yardımcı olacak bilgilerin sağlanması, tehlike tanımlama ve risk değerlendirmesinin yapılması önemli katkı sağlayacaktır. Bu çalışmada Ağrı Çimento Fabrikasında tespit edilen riskler Fine-Kinney yöntemi ve 3T risk değerlendirme yöntemi kullanılarak sınıflandırılmış ve sonuçlar karşılaştırılmıştır. 3T yöntemi modüler yapısından dolayı Fine-Kinney yöntemine göre daha üstün olduğu görülmüştür. Fine kinney metodunda hemen önlem alınması gereken yüksek riskler 3T yönteminde de öncelikli olarak görünmektedir. Ancak Fine-Kinney yönteminde önemli, olası ve riskler ilk 3. öncelikli risk arasında değerlendirilirken, 3T yönteminde ise ilk 2. öncelikli risk arasında değerlendirilmektedir. Fine-Kinney yöntemini kullanan risk değerlendirmesi, sürekli güncellendiği takdirde başarılı olacağı görülmüştür. Olasılık bileşeninin seçiminde zorluk yaşandığında bir üst düzeyde bir risk değeri seçilmesi fine kinney risk değerlerini yükseltmiştir. Her iki yöntem de farklı yaklaşımlar gösterseler de 3T metodolojisi, riski tehdit, performans ve zarar açısından ele alarak kapsamlı bir bakış açısı sağladığı anlaşılmıştır. Bu yaklaşım, risklerin kökenini, etkilerini ve sonuçlarını anlamak için farklı boyutlarını ele almıştır. Fine-Kinney Risk Değerlendirme Yöntemi ise proje özelliklerine ve faktörlere özel ağırlıklandırma ve puanlama faktörlerini temel alarak riski daha analitik bir şekilde değerlendirdiği rapor edilmiştir. Bu metodoloji, projelerin belirli özelliklerini ve risk profillerini dikkate alarak risk puanlarını hesaplamada başarılı olacağı kanaatine varılmıştır.

Anahtar Kelimeler: Fine-Kinney, 3T, Risk Değerlendirme, İş sağlığı ve güvenliği.

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1. Introduction

The cement industry is closely linked to natural resources, making geological surveys more important than in other fields of science and technology. This is because even the most modern cement plant established without suitable raw materials or without finding raw materials with the desired properties would be an investment in vain. The cement industry aims to create a chemical mixture from carefully proportioned raw materials and produce it through processes that alter it to some degree. The fundamental factors that determine the quality of cement are the raw materials (Engin and Kumbaracıbaşı, 2013). Changes in raw material properties result in variations in cement quality. In addition, the maintenance of consistent product quality throughout the production process is dependent on changes in the quality of raw materials during this period.

Cement is considered an important raw material, especially in developing countries, due to its technological and economic characteristics, and is therefore of particular importance to governments. The cement industry is primarily a capital-intensive sector; however, the various secondary uses of cement have greatly contributed to the emergence of new business opportunities in countries like Turkey. As a result, during Turkey's development plan periods, governments have provided significant support for the growth of this sector (Tüzemen and Yıldız, 2018).

The cement industry in our country has a highly developed structure compared to other modern industrial sectors. It surpasses many countries in terms of both applied technology and experienced technical knowledge, reaching the level of developed countries. The adoption and implementation of a planned development approach in our country requires the highest level of planning in the cement industry. Since 1900, the cement raw material resources of our country have been the subject of numerous direct or geological studies. Following the establishment of the first cement plant in Turkey in 1911, efforts to establish cement plants in different regions rapidly continued. Particularly after World War II, investment and development goals that affected the world made growth in the cement sector in Turkey an inevitable outcome of investments (Polat, 2007).

Since 2001, the Turkish cement industry has achieved great success by ranking first in cement and clinker exports to Europe. In 2003 and 2004, it maintained its position as the leading cement exporter in Europe and the second largest in the world. Currently, the cement industry is able to meet the country's needs and ensure a reliable supply of raw materials for production. With a small share of imports, the sector is continuously increasing its share of exports, selling products to about 90 countries (Çağatay, 2021). Therefore, the Turkish cement industry is of great importance in terms of employment and its contribution to the national economy. However, the cement sector is structurally classified as heavy and hazardous work, which presents challenges in ensuring a safe working environment. The low proportion of skilled and trained workers in Turkey is also one of the main

factors influencing this situation. In this context, efforts must be made to ensure safe working conditions in the sector (Umutlu and Karcıoğlu, 2021).

The cement manufacturing process creates significant dust issues due to the product produced and the raw materials used. These issues require environmental and occupational health and safety measures and arise at various stages of the production process (Özkan, 2021). Equipment such as fans, generators, motors, and grinding mills are significant sources of noise in cement plants. In addition, heavy haul trucks and drilling and blasting operations generate noise at cement plants located near raw material sources in quarries (Yıldız, 2019).

For these reasons, dust and noise issues in cement production are of significant environmental and occupational health and safety importance and require the necessary precautions to be taken. The cement sector should strive to provide an environmentally friendly and safe working environment by implementing appropriate measures to address these challenges. Explosions and fires are among the most serious risks in cement plants, especially in coal-fired operations. Hazards such as fires, dust explosions, or gas explosions can occur during processes such as coal storage, grinding, and combustion in mills (Yıldız, 2022). In addition, there are common risks in cement production during plant overhauls, maintenance and repairs. The production of clinker and exposure to hot cement dust can result in occupational injuries and significant health hazards. Rotating parts of frequently used machinery, especially when used without protection, can cause accidents and loss of limbs. Such accidents may occur, especially during maintenance and repair work. Cement plants must take precautions against these risks and strictly enforce occupational safety measures (Delibalta and Türkmen, 2022).

In the period from 2007 to 2021, work accidents in Turkey were most frequently observed in sectors such as mining, construction, manufacturing of fabricated metal products, primary metal industry, and non-metallic mineral products. According to the data from the Social Security Institution (SGK), work accidents in the cement industry also increased during this period, reaching a significant point with 18,957 incidents in 2021 (Yıldız, 2019). This highlights the need to review occupational health and safety measures, particularly in the cement sector. The fact that the cement industry is one of the high-risk sectors for occupational accidents, along with other industries, underscores the need for the cement industry to focus more on worker safety and health. Taking effective measures to prevent workplace accidents and ensure safe working conditions is a critical step in protecting the well-being and safety of employees (Çavuş, 2016).

The purpose of this study is to identify the risks faced by workers in a cement plant, analyze the risks using the Fine-Kinney Method (FKM) and 3t methods, and compare the two methods. The reasons why they have advantages over each other and why both are used in many industrial organizations are to be questioned with the data obtained. To this end, it shall contribute to

improvement activities related to occupational health and safety. Given the importance of the cement sector and the level of risk in the industry, it is clear that the likelihood of workplace accidents is high. Therefore, employees must act by occupational health and safety guidelines. Risk assessment studies conducted in the context of occupational health and safety not only make workplaces safer, but also contribute to achieving quality, reliability and international reputation. Such efforts are an important step in identifying workplace hazards and taking appropriate precautions to protect the health and safety of workers. As a result, the cement industry can achieve a respected position at the international level and earn the trust of its employees and customers.

2. Materials and Methods

During the research process, different departments and work processes of Ağrı Cement Factory were identified and field work was conducted. Observation, interview, and documentation methods were used to collect data. First, each work process was described in detail and potential risks were identified. Factors such as the severity, likelihood and frequency of recurrence of these risks were then evaluated. In the final stage, appropriate measures were proposed to reduce or eliminate the risks. The data obtained through these methods helped to understand the existing risks in the cement plant and to develop effective preventive measures and regulations. The results of the research can be used to identify significant areas of occupational health and safety risk and to plan measures to protect the health and safety of employees.

The research included both qualitative (observation, interviews) and quantitative (risk scores, data analysis) data collection and analysis techniques. The combination of these methods provided a comprehensive risk analysis and assessment. The FKM and the 3T method were used to rank the risks, and the data obtained from these two methods were compared.

2.1. 3T Risk assessment method

The 3T risk assessment method is a process used to identify potential workplace hazards, analyze exposure levels, rank risks and determine risk control measures. This methodology is widely used in the field of occupational health and safety to help employers identify and manage risks in the workplace. The 3T method consists of three main steps: Hazard (T), Exposure (E), and Tolerance (T). The first step is to identify potential hazards and assess the severity and likelihood of each hazard. The second step is to analyze the extent to which workers are exposed to these hazards and determine exposure levels. In the final step, the hazard and exposure information obtained is used to rank the risks and determine appropriate measures to control the risks (Topuksak, 2018).

The 3T Risk Assessment methodology helps improve occupational health and safety standards and facilitates the implementation of effective measures to ensure employee safety. This method provides a better understanding of the hazards and risks in the workplace and allows for more informed planning of preventive measures. This in turn enables the implementation of effective and appropriate measures to protect the health and safety of employees. The 3T risk assessment method is a 3x3 matrix-based approach supported by specific guidelines to help conduct effective occupational health and safety analyses. It consists of two main modules: basic and specific. Through the specific modules, it can be customized and used for different companies (Ayan et al., 2013).

The assessment process involves both top-level and lower-level employees. If the "appropriate" option is selected during the assessment, it is assumed that there is no specific risk for that company. However, if the "inappropriate" option is selected, it indicates that there is a risk for this company and it needs to be calculated. Calculations are made quickly and then the necessary actions are taken. The 3T module offers great benefits to companies by providing convenience and speed to support the process (Köşek, 2016).

Table 1. 3T Risk Assessment 3x3 matrix

Decision Matrix		**Severity**		
Control Scale		1	0	-1
Control Sufficient	1	0	1	2
Needs Improvement	0	2	3	4
Significant Improvement Required	-1	3	4	5

This method is an important tool in occupational health and safety, helping to better understand potential risks in the workplace and to implement effective measures. The 3T risk assessment method provides employers with an appropriate and customizable approach to protecting the health and safety of employees, and helps improve the safety culture in the workplace (Şenyurt, 2019).

2.2. Fine-Kinney method (FKM)

The FKM is an effective tool for assessing workplace health and safety risks and business project risks. In particular, it is used to inform decision makers by analyzing the costs and risks of projects. This method considers various critical factors to identify potential risks of a project and evaluate their impacts. These factors include project size, complexity, technological innovation, market stability, organizational capabilities, and execution risk. The FKM plays a significant role in understanding the likelihood of future project success for projects and optimizing the strategic management of business processes. It helps decision-makers make more informed and sound decisions by analyzing risks and evaluating projects. This method is considered to be a valuable tool

to overcome uncertainties in the business world, aiming to help deal with uncertainties (Birgören, 2017).

This method allows a risk score to be calculated using predefined weighting and rating factors. The resulting risk score (Risk value = Likelihood x Frequency x Severity) helps to determine the level of risk in the project and to prioritize it (Table 2). It provides decision makers with important guidance in understanding the risk status of projects (Table 3). The FKM is an extremely useful tool for better understanding the risks of business projects and effectively managing resources (Şimşek, 2020). It helps decision-makers determine the risk level and priorities of projects and helps develop strategies for effectively managing risk. This method provides valuable contributions to putting business projects on a stronger foundation and increasing their chances of success.

Table 2. FKM likelihood, frequency and severity evaluation tables

LIKELIHOOD	Likelihood	Likelihood (%)	Likelihood (Qualitative)
	0,2	2/100	Practically Impossible
	0,5	5/100	Weak Likelihood
	1	10/100	Quite Low Likelihood
	3	30/100	Rare but Possible
	6	60/100	Strongly Likely
	10	100/100	Very Strong Possibility
FREQUENCY	Frequency	Quantitative Frequency	Qualitative Rating
	0,5	Very Rare	Once a year or less
	1	Fairly Rare	Once or several times a year
	2	Rare	Once or several times a month
	3	Now and again	Once or several times a week
	6	Often	One or more per day
	10	Continually	Continuously, more than once per hour
SEVERITY	Severity	Severity	RATING
	1	Should Be Considered	Harmless or insignificant
	3	Important	Low job loss, minor damage, first aid
	7	Serious	Significant Damage, External treatment, lost workday
	15	So serious	Disability, loss of limb, environmental impact
	40	Bad	Death, Complete disability, Severe environmental impact
	100	Catastrophe	Multiple deaths, major environmental disaster

Quantitative assessment and qualitative assessment are two different approaches to risk analysis, each providing a different focus and method for determining the frequency of risk. Quantitative assessment focuses on determining the frequency of occurrence of the risk in numerical terms. This method uses numerical values to assess the likelihood of a risk occurring, its probability of recurrence, and its frequency within a specified time frame. For example, the likelihood of a risk occurring once a year or three times a month can be expressed as a specific quantitative value. On the

other hand, qualitative assessment evaluates the frequency of risk in a broader scope. This approach defines the frequency of risk using terms such as infrequent, occasional, frequent, or continuous (Cündübeyoğlu and Kayabaşı, 2022). Qualitative assessment is generally representing a more general and qualitative approach. Depending on the frequency and significance of the risk, both quantitative and qualitative assessments can be used in different situations. In some cases, a comprehensive risk assessment can be performed by combining both quantitative and qualitative approaches. It is important to conduct these assessments according to the specific needs and circumstances of the project or organization, and to follow a consistent assessment process. In this way, risks can be better understood and appropriate measures can be taken to minimize their impact.

Table 3. FKM risk value decision table

Risk Value	Decision	Action
Less than 20	Acceptable Risk	No immediate action may be required
20-70	Possible Risk	It should be included in the action plan
70-200	Significant Risk	It should be carefully monitored and resolved by taking it into the annual action plan.
200-400	High risk	It should be resolved by taking it into a short-term action plan.
400+	Very High Risk	Immediate action should be taken by suspending work

The FKM and the 3T methods are two main strategies commonly used in identifying and managing industrial risks. Both methods have unique advantages and limitations, which influence their preference in different contexts. The 3T method stands out as a simpler and easier-to-use approach compared to the FKM. Particularly, its ease in estimating the likelihood of potential hazards becoming risks provides a significant advantage in practice (Vahapassi et al., 2012). In this method, the adequacy of existing controls for each hazard is assessed in accordance with laws, standards, and best practices. For example, control measures taken in accordance with occupational health and safety procedures and standards regarding fire risk reduce the probability of risk occurrence (Gunduz and Laitinen, 2018).

The FKM, on the other hand, focuses on the probability of unwanted events occurring and the magnitude of the consequences if they occur. In this method, estimating probabilities and determining frequencies often require a difficult and time-consuming process (Dogan, et al., 2022). This can adversely affect risk assessment and make it challenging to determine acceptable risk levels (Birgören, 2017). In contrast, in the 3T method, the adequacy of control measures and the assessment of requirement conditions are conducted through a simple and non-specialized approach (Yaşar et al., 2013). This method offers a faster and more practical approach since it does not require expertise (Laitinen et al., 2012). However, it does not provide a thorough analysis like the FKM.

The FKM is an approach that requires expertise and is typically carried out by experienced individuals. In cases where probabilities cannot be determined, a higher probability level is generally accepted, which can affect risk assessment (Kuleshov et al., 2021). Consequently, both methods have their advantages and limitations. Selecting the appropriate method in the workplace is a crucial factor in effectively managing risks.

3. Results and discussion

In this study conducted with occupational safety and health (OSH) experts at Ağrı Cement Factory, all processes from raw material procurement to final product have been comprehensively examined. Each section of the factory poses different risks. For this purpose, risks in general working areas of the factory as well as in Warehouses, cement silos, cement dosing and cement delivery line, Switchyard and stockyard, Cement mills, Main and auxiliary crusher unit, Raw mill, dosing and silos, Construction equipment and machinery maintenance, Raw material and Raw Material quarries, and Packaging departments have been analyzed. The determination of risks relied on workplace accident reports, expert opinions, and literature review.

The 3T method and the FKM are two approaches to performing risk assessment using different approaches. Some points of comparison between these two methods can be listed as follows: The 3T method focuses on three fundamental dimensions in risk assessment: threat, treatment, and damage. This approach emphasizes the dimensions of hazard (threat) and risk acceptance (treatment), while also assessing the outcome dimension (damage) of risk. The threat dimension focuses on identifying potential hazards and determining the source of risk. The treatment dimension addresses the measures and precautions to be taken to manage and control the risk to an acceptable level. These actions include the steps necessary to reduce or eliminate the risk. Finally, the damage dimension analyzes the magnitude of potential harm by assessing the outcome and impact of the risk.

The FKM is an analytical tool that performs risk assessment based on the characteristics, factors, and risks of the project using a weighting and scoring method. This method is used to calculate risk scores by considering various project attributes such as cost, complexity, technological innovation, and other critical factors. The FKM offers an effective approach to better understanding the risks of projects and managing resources effectively. By identifying potential project risks and determining the risk level of projects through risk scores, it helps develop strategies for project prioritization and effective risk management (Koçak, 2022).

3.1. Factory wide and general working environment

Conducting risk assessments throughout the plant and in the general working environment is critical to ensuring the safety of employees and the protection of the environment. Two different risk assessment methods, FKM and 3T, can be used with their different approaches to identifying and managing risk.

The failure to implement the TLVT (Tag, Lock, Verify, and Test) procedure for equipment interventions and the lack of general occupational health and safety measures at the Ağrı Cement Factory were rated as high risk according to the FKM (Table 4). The TLVT is a safety procedure used in industrial and construction settings to ensure proper shutdown of hazardous machinery and prevent their reactivation until maintenance or repair work is completed. The TLVT aims to protect workers from accidents that may occur due to unexpected activation of equipment or release of stored energy, while also facilitating maintenance or service operations (Ateş, 2022). When assessed using the 3T methodology, it is considered a top priority hazard, indicating that it is a high priority risk of significant importance and urgency. Spontaneous working at heights and the presence of compressed air tanks have been identified as important risks according to FKM, but when assessed using the 3T method, they fall into the category of second priority hazards. This indicates that the importance and urgency of the risk are at a moderate level. Conveyor belt cleaning and the presence of electrical cables in the work area are considered potential risks with a low probability of occurrence and limited potential consequences in FKM, while the 3T method classifies this situation as a third priority hazard. Emergency situations and noisy work environments are rated as very high risks in FKM, indicating a high probability of risk occurrence and serious potential consequences. However, the 3T method classifies this situation as a top priority hazard, indicating high importance and urgency of the risk. These different assessments show that the methodologies approach risk in different dimensions and priorities.

To ensure a safe working environment throughout the factory, strict adherence to work permit procedures and compliance with TLVT requirements is crucial. Safety measures such as certified temporary horizontal lifelines in accordance with EN 795 standards should be carefully provided for when working at height, and care should be taken when cleaning roofs. In addition to implementing the necessary procedures for employee training and qualification, regular drills and continuous monitoring should be conducted in these areas (Kara et al., 2023).

Field inspections for occupational safety should be conducted periodically, and the results obtained should be reported. The cleanliness, order, and tidiness of the work area should be carefully maintained. Personal Protective Equipment (PPE) should be selected according to specifications and its use should be strictly controlled (Karahan, 2016). Regular training should be provided and warning

and information signs should be posted in appropriate locations in the workplace. These measures should be taken to ensure that employees work conscientiously and safely.

Table 4. Factory and General Working Environment Risk Assessment Comparison

No	General Working Environment	Fine Kinney	3T
1	Interfering equipment is stopped and TLVT is not applied.	HIGH RISK	I. Primary Hazards
2	Spontaneous Studies at Height	SIGNIFICANT RISK	II. Primary Hazards
3	Failure to take general OHS measures	HIGH RISK	I. Primary Hazards
4	Emergencies	VERY HIGH RISK	I. Primary Hazards
5	Compressed air tank	SIGNIFICANT RISK	II. Primary Hazards
6	Noisy Work Environments	VERY HIGH RISK	I. Primary Hazards
7	Conveyor Rubber Band Cleaning	POSSIBLE RISK	III. Primary Hazards
8	Presence of power lines in the work area	POSSIBLE RISK	III. Primary Hazards

3.2. Warehouses, cement silos, cement dosing and cement delivery line

There is a high probability of hazards such as electric shock from contact with other electrical equipment and cables in the silo and conveyor line, and failure to implement the TLVT procedure when entering the mill and separator. These hazards have been classified by the FKM as high risk with potentially significant consequences. In the 3T Risk Assessment, these hazards fall into the first priority category, indicating that they are high-priority risks of significant importance and urgency (Table 5).

Working at heights during silo and bunker cleaning, slipping, tripping and other hazards due to uneven working surfaces during ball loading, and working at heights during elevator control have been identified as important risks in FKM. In the 3T, however, they fall into the category of second priority hazards. This indicates that the significance and urgency of the risk are moderate.

Hand tools used should be inspected regularly to eliminate potential hazards, and particular attention should be paid to the use of lanyards when working at height. Appropriate personnel should be assigned and working hours should be regulated within legal requirements. The work area should be kept clean and tidy at all times (Şardan, 2005).

Table 5. Comparison of 3T and Fine Kinney Risk Assessments of Warehouses, Cement Silos and Cement Mills, Cement Dosing and Cement Conveying Line

No	Warehouses, Cement Silos and Cement Dosing and Cement Delivery Line	Fine Kinney	3T
1	Electric shock from contact with other electrical equipment and cables	HIGH RISK	I. Primary Hazards
2	Failure to apply TLVT while entering the mill	HIGH RISK	I. Primary Hazards
3	Failure to apply TLVT while entering the separator	HIGH RISK	I. Primary Hazards
4	Working at height during silo and bunker cleaning	SIGNIFICANT RISK	II. Primary Hazards
5	Dangers such as slipping, tripping etc. due to the unevenness of the working area during ball charging.	SIGNIFICANT RISK	II. Primary Hazards
6	Working at height during elevator control	SIGNIFICANT RISK	II. Primary Hazards

3.3. Switchyard and stockyard

Working in electrical control rooms and general electrical and electronics maintenance on the factory floor poses potential hazards, such as the operator being caught in rotating machinery or being injured by sharp objects or being trapped between them. In the FKM, these hazards are assessed as possible risks with a low probability of occurrence and limited potential consequences. In the 3T, however, these situations are classified as category III priority hazards (Table 6). This means that they are hazards with a low probability of occurrence and limited potential consequences. On the other hand, conditions such as undefined storage areas (lack of warning signs and labels), inadequate dust suppression in storage areas and roads, and hazards during loading and unloading of coal stock are considered high risk levels in the FKM, but are classified as category I hazards in the 3T method. This indicates that they are hazards of high importance and urgency. Hazards associated with the absence of stock area markings and lack of suitable ground are considered significant risks with medium probability of occurrence within the FKM, while they are categorized as hazards of category II priority in the 3T. In other words, they are hazards with moderate probability of occurrence and moderate potential consequences.

Proper installation of doner equipment enclosures and assignment of appropriate personnel helps reduce risks in the work environment. In particular, dust control methods such as a continuous watering system should be used to prevent dusting in charcoal storage areas. It is important to properly inspect the PPE to be used in these areas and organize continuous training programs for employees. For storage areas, a separate configuration should be defined and included in the employment contracts, and safety measures such as warning signs, deceleration measures, and flagmen should be taken for road and traffic safety in the area. This provides a safe working environment for employees and visitors (Özkan, 2021).

Table 6. Comparison of 3T and Fine Kinney Risk Assessments of Switchyard and Stockyard Switchyard and Stockyard

No	Switchyard and Stockyard	Fine Kinney	3T	
1	During work in electrical switchgears and general factory electrical and electronic maintenance work, the worker is caught in rotating equipment and injured by sharp objects or jamming.	POSSIBLE RISK	III. Hazards	Primary
2	Inadequate dust suppression in stockyards and roads	HIGH RISK	I. Hazards	Primary
3	Inappropriate ground due to not figuring the stock areas	SIGNIFICANT RISK	II. Hazards	Primary
4	Coal Stockyard Loading Unloading	HIGH RISK	I. Hazards	Primary
5	Not defined stock areas (no warning signs and plates)	POSSIBLE RISK	III. Hazards	Primary

3.4. Cement mills

During silo and bunker cleaning operations, working at heights and the need to work at heights to open mill covers are considered by FKM to have a moderate probability of occurrence and significant potential consequences. In the 3T, these situations are classified as hazards of secondary priority (Table 7). In other words, they are among the hazards with moderate levels of risk importance and urgency. Failure to implement lockout procedures, failure to perform TLVT when entering the mill and separator are considered high risks in the FKM, while in the 3T they are classified as high priority hazards. This indicates that these are hazards with a high level of risk significance and urgency.

Company policies and procedures should be followed in plant operations, and the lockout/tagout procedure should be effectively implemented. Working at heights and confined space work permit forms are of great importance in eliminating hazards. Training in the use of safety belts and the proper selection of anchorage points will make working at height safer. It is recommended that a walking platform and/or guardrails be constructed when working on the mill (Şardan, 2005).

Table 7. Comparison of Cement Trainers' 3T and Fine Kinney Risk Assessments

No	Cement Mills	Fine Kinney	3T
1	Failure to follow the lockout procedure	HIGH RISK	I. Primary Hazards
2	Failure to apply TLVT while entering the mill	HIGH RISK	I. Primary Hazards
3	Failure to apply TLVT while entering the separator	HIGH RISK	I. Primary Hazards
4	Working at height during silo and bunker cleaning	SIGNIFICANT RISK	II. Primary Hazards
5	Working at height so that the mill covers can be opened	SIGNIFICANT RISK	II. Primary Hazards

3.5. Main and auxiliary crusher unit

Failure to implement the lockout/tagout procedure on crusher units, the risk of falling objects during infeed, and the failure of system start and stop warning signals were assessed as high risks in the workplace risk assessment. 3T has reported this situation as a priority I threat with high urgency (Table 8).

In the maintenance and repair of crushers, operating instructions and procedures are of great importance. However, in addition to operating instructions and procedures, the implementation of the lockout/tagout procedure is also required. The lockout/tagout trial procedure is a critical step to ensure the safety of employees. This procedure involves shutting down the power source to the crushers and making them safe using the lockout/tagout method. This prevents unexpected operation of the crushers and ensures operator safety. The effective use of PPE in crusher maintenance and repair is also critical. The PPE is equipment that helps protect employees from serious injuries and hazards. Therefore, it is important that employees use this equipment correctly and that it is inspected regularly (Karahan, 2016).

Table 8. Comparison of 3T and Fine Kinney Risk Assessments of Main and Auxiliary Crusher Unit

No	Main and Auxiliary Crusher Unit	Fine Kinney	3T
1	Failure to follow the lockout procedure	HIGH RISK	I. Primary Hazards
2	Pieces falling out during feedings	HIGH RISK	I. Primary Hazards
3	System start and stop warning signals not working	HIGH RISK	I. Primary Hazards

3.6. Raw mill, dosing and silos

Hazards such as falls and injuries resulting from work at heights in mills and work at heights on equipment, performing belt under cleaning and environmental cleaning while the system is operational, accidental material feeding during bunker cleaning, and workers being affected by pressure during silo cleaning (Table 9) are evaluated as potential risks in the FKM, and they are classified as hazards of medium importance and urgency. This indicates that they are among the hazards with moderate risk priority in the 3T. The risk of vibrations occurring in the body of the mill during the grinding process is assessed as low in FKM and its possible consequences are considered to be within acceptable limits, while 3T assesses this situation as a hazard of the III. degree. Hazards such as hand injuries due to entrapment when the mill cover is opened, working in a dusty environment due to residual dust inside the mill, filters being blocked or affected by ambient dust during operation of the mill and conveying lines, and the body being affected by noise caused by the

operation of the mills are considered significant risks in the FKM and are accepted as priority hazards in the 3T.

Physical changes made to machinery and equipment should be carefully monitored through change management processes, and other employees should be informed about these changes. PPE should be selected according to PPE specifications and its use should be closely monitored. In addition, noise levels in the work environment should be measured regularly and necessary precautions taken. Personnel working hours should be regulated within the framework of legal requirements, and work areas should be constantly kept clean and organized. In particular, procedures for working at heights should be properly implemented and necessary precautions taken for the safety of employees. Controlling changes made in the work environment and informing employees about them are important in terms of occupational health and safety. The correct selection and use of PPE is a critical factor in ensuring employee safety. Measuring noise levels and taking the necessary precautions is necessary to maintain hearing health in the workplace (Çankaya and Çankaya, 2015).

Table 9. Comparison of 3T and Fine Kinney Risk Assessments of Raw Mill, Dosing and Silos

No	Raw Mill, Dosing and Silos	Fine Kinney	3T	
1	Injury due to human fall due to work at height in raw mills and work at heights on equipment	POSSIBLE RISK	III. Hazards	Primary
2	Cleaning the underbelts and the environment while the system is on	POSSIBLE RISK	III. Hazards	Primary
3	Injury due to handshake while opening the raw mill cover	SIGNIFICANT RISK	II. Hazards	Primary
4	Working in a dusty environment due to dust remaining in the mill	SIGNIFICANT RISK	II. Hazards	Primary
5	During the operation of the Raw Mill and the delivery lines, the filters are out of order or the body is affected after dust caused by the environment.	SIGNIFICANT RISK	II. Hazards	Primary
6	The body is affected by the noise due to the noise caused by the operation of the mills.	SIGNIFICANT RISK	II. Hazards	Primary
7	Vibration in the body of the Raw Mill during the grinding process	ACCEPTABLE RISK	III. Hazards	Primary
8	Accidental feeding of material to the bunker while cleaning is being done in the bunker	POSSIBLE RISK	III. Hazards	Primary
9	Operation of air blasts during silo cleaning and workers being affected by pressure	POSSIBLE RISK	III. Hazards	Primary
10	Accidental feeding of material to the bunker while cleaning in the silo	POSSIBLE RISK	III. Hazards	Primary
11	Sliding of the material inside and collapsing of the workers into the material during cleaning	POSSIBLE RISK	III. Hazards	Primary

3.7. Construction equipment and machinery maintenance

The use of negative and worn-out tires in construction machinery, as well as the high vibration generated during machine operation, has been identified as a high-risk factor according to Table 10

and the FKM. In this case, it has been determined that the likelihood of the risk occurring is high and the potential consequences are significant. In particular, the presence of underinflated or worn tires on construction equipment can negatively impact safe and healthy working conditions and pose serious risks. Therefore, eliminating or mitigating these hazards is considered a high priority. Injuries resulting from the use of cranes and hand tools, as well as hazards resulting from failure to follow work instructions when changing machine tires, are rated by FKM as risks with a moderate probability of occurrence and significant potential consequences. In other words, the likelihood and impact of these hazards are moderate compared to other hazards. In the 3T, this situation falls among the second-priority hazards. Thus, the importance and urgency of these hazards are considered slightly lower than those of high-priority hazards. This does not diminish the significance of these hazards; it only creates a distinction in priority order.

Regular maintenance and inspections of machinery and vehicles are critical to occupational health and safety and must be performed with care. Work equipment should be subjected to scheduled periodic inspections and carefully inspected for abnormalities. These inspections should be performed periodically to ensure the functionality and safety of the equipment. Timely and accurate periodic inspections allow for continuous monitoring of the condition of work equipment and the implementation of necessary precautions. Any adverse condition or malfunction found during these inspections should be promptly documented and repairs initiated immediately (Khaviya et al., 2017).

Table 10. Comparison of 3T and Fine Kinney Risk Assessments of Construction Equipment and Machinery Maintenance

No	Construction Equipment and Machinery Maintenance	Fine Kinney	3T
1	Using very bad and worn tires	HIGH RISK	I. Primary Hazards
2	High vibration	HIGH RISK	I. Primary Hazards
3	Injuries during working with cranes and hand tools.	SIGNIFICANT RISK	II. Primary Hazards
4	Non-compliance with the work instructions in the tire changes of the construction equipment	SIGNIFICANT RISK	II. Primary Hazards

3.8. Raw material and raw Material quarries

The risk of material falling from the slope, injuries caused by trucks overturning or colliding in storage areas, injuries to employees caused by landslides, and soil collapse that may occur in the environment due to weather conditions (see Table 11) have been assessed by FKM as high-risk hazards. They are recorded as Priority 1 hazards in the 3T system. Hazards such as injuries caused by incorrect detonation during blasting operations and the failure to conduct periodic inspections of detonators, magnetos, and resistance meters have a low probability of occurrence according to FKM,

but their potential consequences can be serious. These hazards are included as Priority 3 hazards in the 3T system, which means they are among the hazards with low significance and urgency.

Obtaining a work permit is important from an occupational health and safety perspective. A work permit refers to the process of obtaining the necessary permits to safely perform a specific job. This permit requires employees to complete certain procedures before starting work and ensures their approval based on the employer's risk assessment. The TLVT procedure is used to isolate the energy of equipment to be worked on and ensure that the work is done safely. The TLVT procedure is crucial in preventing equipment from unexpectedly starting up and avoiding hazardous situations (Etim et al., 2021). Training and competency procedures are implemented to ensure that employees have the knowledge and skills to perform their work safely. Employees should receive the necessary training and demonstrate their qualifications before starting their jobs. These procedures are critically important in minimizing workplace accidents and risks. Ensuring the safety and health of employees is the responsibility of the employer, and the meticulous implementation of these procedures is vital for providing a safe and healthy working environment.

Table 11. Comparison of 3T and Fine Kinney Risk Assessments of Raw Material and Raw Material Quarries

No	Raw Material and Raw Material Quarries	Fine Kinney	3T
1	Fragments falling from the slope steps	HIGH RISK	I. Primary Hazards
2	Danger of falling from slope steps	SIGNIFICANT RISK	II. Primary Hazards
3	Injuries resulting from the overturning or collision of trucks operating in stockyards	SIGNIFICANT RISK	II. Primary Hazards
4	Injury of employees as a result of landslides and soil collapses that may occur in the environment due to weather conditions	SIGNIFICANT RISK	II. Primary Hazards
5	Injuries caused by incorrect blasting during dynamite blasting operations	POSSIBLE RISK	III. Primary Hazards
6	Failure to perform periodic checks of igniter magneto and resistance meters	POSSIBLE RISK	III. Primary Hazards

3.9. Packaging

Failure to implement the lockout procedure is considered a high risk in FKM and a priority I hazard in 3T. The detachment of packaging tape connections and their falling onto the worker (Table 12) is evaluated as a significant risk for FKM. 3T considers this situation as a priority II hazard. The risk of injury or death from being caught in moving equipment on belts and machinery, and the risk of injury or death from intervention in moving equipment during interventions, is considered a potential hazard in FKM and a priority III hazard of low significance and urgency in 3T. Performing

cleaning tasks on operational belts is an acceptable risk in FKM but falls into the priority III risk class in 3T.

All moving equipment within the packaging system is a major potential source of worker safety hazards. Therefore, appropriate enclosures should be installed around them. Regular monitoring and inspection of enclosures should be diligently performed by area supervisors. This will ensure that the enclosure system is operating continuously and effectively and that employee safety is maintained. Site inspections are conducted to determine whether safety rules and enclosure systems are properly implemented in the workplace. Inspection results are reported regularly and necessary adjustments are made. In addition, site cleanliness and organization are critical and should be monitored regularly. A clean and organized work environment helps prevent accidents and injuries (Karahan and Akosman, 2018). Adhesive tapes are another critical safety element in the packaging system. Properly securing these tapes with double security measures is essential to prevent potential safety issues. In addition, the need for a complete overhaul of tape technology should be considered as an important investment. Using tapes that comply with current technology and safety standards is critical to employee safety and increases workplace security.

Table 12. Comparison of 3T and Fine Kinney Risk Assessments of the Packaging Area

No	Packaging	Fine Kinney	3T
1	Failure to follow the lockout procedure	HIGH RISK	I. Primary Hazards
2	Disconnection of packing tongue tapes and falling on employee	SIGNIFICANT RISK	II. Primary Hazards
3	Injury, death as a result of tripping on moving equipment in belts and equipment.	POSSIBLE RISK	III. Primary Hazards
4	Performing cleaning works on working bands	ACCEPTABLE RISK	III. Primary Hazards
5	Injury and death as a result of interfering with moving equipment during the intervention.	POSSIBLE RISK	III. Primary Hazards

4. Conclusion

The 3T and FKM are two approaches that use different methodologies to perform risk assessments. Some points of comparison between these two methods can be listed as follows:

Method and Purpose: The 3T provides a comprehensive risk assessment process that includes hazard identification, diagnosis, and measures. Its purpose is to identify hazards, analyze exposure levels, rate risks, and determine risk control measures. It is commonly used in the field of occupational health and safety. On the other hand, the FKM is preferred for assessing and evaluating risks in business projects. It is used to analyze the costs and risks of projects and to inform decision makers.

Method Content: The 3Ts include steps such as hazard identification, exposure level analysis, risk assessment and determination of risk control measures. The identification of hazards and risk assessment primarily rely on quantitative and numerical data. Conversely, the FKM uses weighting factors that can vary depending on the project's characteristics and organization's priorities. It assesses the risks of projects in a broader and conceptual manner.

Application Areas: The 3T is commonly used in occupational health and safety, while the FKM is preferred for project risk analysis and effective resource management.

Quantitative and Qualitative Aspects: The 3T generally conducts risk assessment based on quantitative and numerical data. The FKM, however, typically involves qualitative and conceptual expressions in conducting risk assessment.

The 3T approach is easy to implement and does not require experienced personnel. However, FKM does require experienced personnel. Determining the probability and frequency of risk occurrence requires significant research and experience. The 3T is a simple and straightforward approach and is an effective tool used for risk assessments. However, FKM is a more complex analysis method and is recommended to be implemented by experts with advanced knowledge and experience. FKM requires the analysis of various data to determine the frequency of events and situations with high risks. These data can include occupational safety records, accident reports, industrial statistics, and other similar sources. Experienced personnel can accurately assess the probability and frequency of risk occurrence based on this data. Additionally, during the implementation of FKM, various factors that affect the probability of a specific event occurring must be taken into account. These factors may include operational conditions, equipment status, employee competencies, and other environmental factors. By analyzing these factors, experienced personnel can determine the probability and frequency of risk occurrence more effectively. In conclusion, the implementation of FKM is an important tool in risk management and safety planning processes. However, the knowledge and experience of experienced personnel in using this method and accurately determining the probability and frequency of risk occurrence are crucial.

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Authors' Contributions

All authors contributed equally to the study.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The author declares that this study complies with Research and Publication Ethics.

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