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Improvement Of Safety Analysis Form (HIRARC) For Manual Tamping Works In Keretapi Tanah Melayu Berhad (KTMB)

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Abstract Maintenance activities consist of routine servicing or heavy mechanical maintenance, such as tamping works[1]. These critical aspects must be completed properly with full concentration and dedication by the workers who have been assigned the task of maintaining the railway track to prevent injuries and accidents. In this study, the existing safety analysis form (HIRARC) of manual tamping works in KTMB was improve to make sure to ensure it meets current needs. HIRARC is a systematic approach to identifying and controlling hazards in the workplace. It is a valuable tool for improving workplace safety and reducing the risk of accidents and injurie. analysis and review for tamping manual works can be carried out to see the current safety situation and to identify the hazards that exist when these works are carried out. The level of risk will use risk assessment where likelihood and severity are used to get the risk level value. Results of the safety review, Improvements has be made to the existing HIRARC form with the addition of resources of hazard. This enhancement will make the HIRARC form more detailed and easier to determine the control measure to be used. The improved HIRARC has be brought to the interview session for validation and review by KTMB track engineering staff.

Keywords: Safety, HIRARC, KTMB, Tamping Manual

1. Introduction

Manual tamping work exposes workers to vibration and noise. Exposure to noise above the permissible exposure limit and over the daily allowable duration can cause noise-induced hearing loss. In addition, vibration can cause a variety of health problems, including musculoskeletal disorders, fatigue, and headaches.

Tamping work in the KTMB is usually carried out at night after the closing time of train operations, except in project areas where it can be done during the day. The dark environment inevitably poses a hazard as vision is limited and unclear. This can lead to accidents. To mitigate these risks, tamping workers must take extra precautions, such as wearing high-visibility clothing and using spotters to help them stay aware of their surroundings.

Implementing Hazard Identification, Risk Assessment and Risk Control (HIRARC) has become fundamental to providing a safe workplace to employees and other related persons. persons (Kabul et al., 2022). It helps to identify potential hazards. The first step in any risk management process is to identify the hazards that exist in the workplace. HIRARC provides a systematic way to do this, by considering all aspects of the workplace, including the physical environment, the equipment used, the materials handled, and the work activities performed. It assesses the risks associated with hazards. Once the hazards have been identified, they need to be assessed to determine the level of risk they pose. HIRARC uses a simple scoring system to assess the risk of each hazard, taking into account the likelihood of the hazard occurring and the severity of the consequences if it does occur. It helps to control risks. Once the risks have been assessed, they need to be controlled. HIRARC provides a systematic way to do this, by identifying and implementing appropriate control measures. Control measures can range from simple things like warning signs and procedures, to more complex engineering controls such as guardrails and machine guards

The existing HIRARC is fragmented and could be improved with a new study to ensure the safety of workers. Based on the issues in track maintenance activity, there is a need to improve and evaluate a new safety analysis for the safety of workers. Additionally, the HIRARC form used by KTMB at this time needs to be updated to meet current needs[2]. A HIRARC form that is compiled and fulfills current needs can save workers and avoid injuries while carrying out tasks. Improvement also for the ISO45001 certification application process, the HIRARC form used needs to fulfil the criteria set out in the ISO45001 certification process.

2. Tamping maintenance work

In the past, track alignment was manually maintained by teams of workers using traditional tools and techniques. This process involved using sighting board levels and small cans filled with half-inch stones to manually adjust the track's lateral position. This was achieved by using skills, string lines, and sighting boards to align the track with bars. This method was labour- intensive and required a high level of skill and expertise to achieve accurate results. Throughout the years, KTMB eventually replaced manpower with tamping machines.

Nowadays, the use of tamping machines has become the norm to ensure a smooth and even track surface since it performs efficiently well and precise. Tamping can be explained as compaction of the ballast in the railway track to increase the supportive effect from the ballast on the sides of and under the sleepers[2]. The tamping machine will lift each sleeper and the rails up then packs ballast underneath.

The control system of the tamping machine commonly uses a three- or four-point measuring system for identifying the geometry. The tamping machine may contain both mechanical and digital features. Using the indicated relationship between measurement points comprised of tracking wheels, horizontal and vertical deviations from a line connecting the points are determined. The efficiency of this method depends on the length of the measurement standard for the tamping vehicle[3]. Greater accuracy is achieved by increasing the distance between measurement points.

2.1 Type of tamping works

Tamping usually carried out by machine but local manual tamping also can be used. The tamping vehicle lifts the track, and vibrating tines then compact the ballast beneath the sleepers (Figure 1 (a)). Another method, manual tamping, can also be employed where the track is lifted using jacks, and ballast is compacted under the sleeper using vibrating packing tools (Figure 1 (b)).

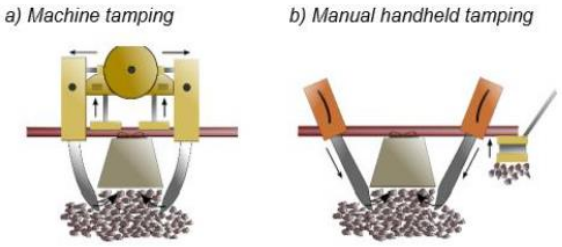

Figure 1: Type of tamping [4]

Plasser & Theurer tamping machine commonly used for railway track maintenance in Malaysia especially in KTMB. The reliability of Plasser & Theurer tamping equipment is impressively proven by countless problem-free operations throughout the world. Plasser & Theurer offers a variety of tamping unit designs that meet the needs of the whole turnout and track maintenance industry. The tamping equipment can also be used for tamping double sleepers. Moreover, a handheld ballast tamper is made to construct a track bed fast and efficiently when it is not possible or cost-effective to use large tamping machines due to the minimal amount of work.

2.3 Manual tamping Works

Manual tamping is the process of compacting the ballast under railway sleepers using a handheld tamper. This is a traditional method of tamping that is still used in some railways, especially in remote areas where access to power or other equipment is limited.

A handheld tamper is a simple tool that consists of a long handle and a heavy head. The head is usually made of steel and has a flat or pointed tip. The operator uses the handle to apply force to the head, which is then used to compact the ballast. During manual tamping activity, railway workers use specialized tools such as tamping machines, picks, and shovels to manually compact the ballast around the sleepers. This process helps to ensure that the ballast is evenly distributed and tightly packed, providing a stable foundation for the track. Here are some of the benefits of manual tamping by using handheld tamper in railway:

- It is a simple and effective way to compact the ballast.
- It is a relatively inexpensive option.
- It can be used in remote areas where access to power or other equipment is limited.

Although manual tamping activity can be a physically demanding and time-consuming process, it is still commonly used in railway maintenance today, particularly in areas where access is difficult for machinery. However, new technologies such as automated tamping machines are increasingly being developed to help improve the efficiency and safety of railway maintenance operations.

3. Research method

3.1 Interview session

A staff member from the KTMB track engineering department will be interviewed to obtain endorsement regarding the new safety analysis form template. The selection of staff to be interviewed takes into account several aspects such as position, length of service, and experience with tamping activities.

There is a set of questions that will be asked to the selected panel. This question set contains 3 sections. The questions for the first section are about the background of the selected KTMB staff panel. Among the questions are name, position in KTMB, and also the period of service in KTMB. For section 2, is the most important section because the questions focus on the new safety analysis (HIRARC) template. The questions will prompt the panel to give their feedback and endorsement of the template. In this section, the panel will also be asked to endorse the new template to determine whether it can be used or needs to be revised. Lastly, the third section contains only one question. It is a question of opinion and recommendation from the panel for future improvement. The complete set of questions will be placed in the appendix section.

3.2 HIRARC report

3.2.1 Hazard Identification

Hazard identification is the important part in HIRARC analysis. It is the process of identifying potential hazards in a workplace or environment. It provides a framework for defining safety working processes, implementing prevention strategies, and taking other measures to eliminate or control risks. The goal of hazard identification is to find and record all possible hazards that may be present in the workplace.

Every employer is obliged to recognize and control hazards in their workplace[5]. This is to maintain the safety of workers who will carry out work in the area. Employers also need to provide training and safety briefings to workers on how to control hazards and the procedures that need to be followed if an accident occurs.

The best method for identifying hazards will vary depending on the specific workplace and the nature of the work being done. However, by using a combination of methods, it is possible to identify most of the hazards that exist in the workplace.

In this research, the sources of hazards will be divided into 4 points. this will be included in the new HIRARC form that will be proposed given that it was not used previously in the KTMB. This addition will allow for the identification and classification of causes that have a particular effect

3.2.2 Risk assessment

A risk assessment is a systematic process of identifying, analyzing, and controlling hazards and risks present in a situation or a place[6]. The goal of a risk assessment is to determine the likelihood and severity of a hazard, and to implement controls to reduce the risk to an acceptable level and also

Risk can be presented in a variety of ways to communicate the results of analysis to make decisions on risk control. For risk analysis that uses likelihood and severity in the qualitative method, presenting results in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace. To estimate the likelihood and severity classification, this method relies on expert knowledge and experience.

There is no precise answer how to assess the likelihood. Normally, it may depend on the industry, company, and situation. By following the guidelines from DOSH, Likelihood levels range from "most likely" to "inconceivable". Table 1 shows the likelihood using following value.

Table 1: The likelihood using following value [11]

No	Likelihood (L)	Example	Rating
1	Most Likely	The most likely result of the hazard/ event realized.	5
2	Possible	Has a good chance of occurring and it is not unusual.	4
3	Conceivable	Might be occur at sometimes in future.	3
4	Remote	Has not been known to occur after many after.	2
5	Inconceivable	Is practically impossible and has never occured	1

Severity is divided into 5 levels which are from level 1 to level 5. The determination of the level is seen against the effect on human health, the effect on the surrounding nature and the effect on property. Table 2 shows the classification of severity.

Table 2: Severity classifiaction [11]

No	Severity (S)	Example	Rating
1	Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
2	Fatal	Approximately one single fatality major property damage if hazard is realized	4
3	Serious	Non-fatal injury, permanent disability	3
4	Minor	Disabling but not permanet disability	2
5	Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

3.2.3 Risk control

Risk can be presented in a variety of ways but, for risk assessment that utilises qualitative methods, the matrix form is the best approach to provide a decision to explain the risk billing to the entire lodge and workplace area[7]. Table 3 shows the schedule of risk matrices used in this study:

Table 3: Risk matrix [11]

	Severity (S)				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

4. Result and discussion

4.1 Hazard identification on manual tamping works

Manual tamping works are strenuous and exposed to various types of hazards. The hazard identification process is essential to ensure workers can carry out their tasks safely. However, the safety of the workers depends on the workers themselves. Workers need to follow procedures and always be careful in carrying out tasks[8]. In addition, they also need to follow the rules set by their company.

At KTMB, there are several hazards that have been recognized during manual tamping work. These hazards are recognized through procedures that have been established by KTMB. Some hazards that have been identified in this procedure are shown in table 4.1 below.

Table 4: Hazard identification for Manual tamping works

Item	Work Activity	Hazard	Effect
1	-Lifted the track using jacks to align the track level precisely to the requires level.	-Struck by something slip, trip fall, or electrocution. -Collapsing of rail due to inadequate capacity or any other external factor.	-fatality or permanent disability, or irreversible illness. -prains, strains, bruises, concussions, and fractures. -serious injuries
2	-Pushed the ballast underneath the sleeper using handheld tamper until the ballast compacted approximately 1 minutes.	-Loud noise generated by the machine -Vibration from handheld tamper. -Struck by moving object due to unstable ground or mishandling.	-Hearing loss, tinnitus, and other hearing problems. -Hand-arm vibration syndrome. -Head injuries, broken bones, and internal injuries.
3	-Add more ballast using the showel when the previous ballast already sank until the requires level achieved	-Flying object. -Exposed to hard and sharp objects.	-Eye injuries -Physical injuries
4	-Routine inspection after done works activity.	-Lying object. -Slip and fall on the track. -Exposed to hard materials (track)	-Physicals injuries. -Broken bone, internal injuries. -Fatality.

4.2 Risk assessment

Risk assessment in study was measure by considering the likelihood and severity. Likelihood and severity value in this study was based on the hazard identification on table 4

In the existing HIRARC report template used by KTMB, the risk level is still determined by a qualitative method using a formula below. The ratings used range from 1 to 25 and are broken down into sections according to the category effect for each hazard. The formula to determine the risk level is shown in Equation 1

$$Risk\ level = Likelihood\ (L) \times Severity\ (S) \qquad Eq.1$$

Table 5: Risk level for manual tamping works

No	Work Activity	Hazard	*L*	*S*	*Risk Level*
1	-Lifted the track using jacks to align the track level precisely to the requires level.	-fatality or permanent disability or irreversible	4	5	20
2	-Pushed the ballast underneath the sleeper using handheld tamper until the ballast compacted approximately 1 minutes.	-Loud noise generated by the machine -Vibration from handheld tamper.	3	5	15
3	-Add more ballast using the showel when the previous ballast already sank until the requires level achieved	-Flying object.	3	3	9
4	-Routine inspection after done works activity.	-Lying object. -Slip and fall on the track. -Exposed to hard materials (track)	4	4	12

4.3 Risk control

Risk control is determined based on the type of hazard that applies. The selection of risk control must be in accordance with the hazard to ensure that it can provide protection to the workers as much as possible[9]. Figure 2 below shows the hierarchy of control that KTMB follow and most companies in Malaysia for the selection of controls to be used. the most effective way to reduce the risk is by eliminating, substituting, engineering control, administrative control, and finally personal protective equipment (PPE).

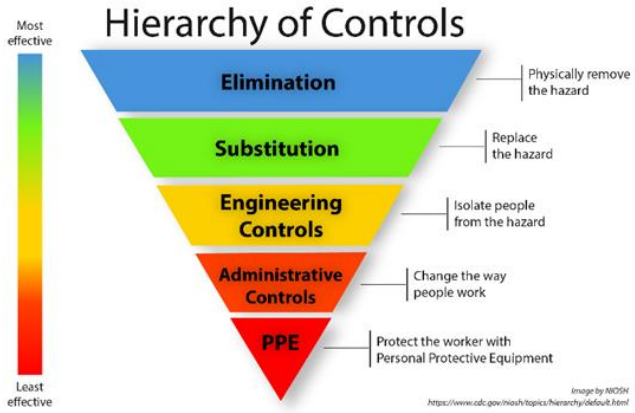

Figure 2: Hierarchy of Control.[10]

The control reserves for the hazards stated in table 4 are shown in table 6 below.

Table 6: Risk Control

No	Hazard	Risk Control
1	-fatality or permanent disability or irreversible	Administration control -provide continuous training -review the method of works.
2	-Vibration from handheld tamper. -Loud noise generated by the machine	PPE -use a correct PPE such as ears muffs Administration control -establishing the rotation between workers
3	-Flying object	PPE -use the correct PPE such as safety glasses.
4	-Exposed to hard materials (track) -Lying object. -Slip and fall on the track.	Elimination -Remove and redirect unrelated items in the work area. PPE -use a correct PPE such as safety glasses, safety helmet.

4.4 New proposed safety analysis template

This is a new proposed safety analysis template that has been carefully developed after taking into account several aspects. Like the existing template, it is divided into three main parts: hazard identification, risk assessment, and risk control.

For the hazard identification part, the columns for activity, R/NR/E, and effect have been retained. The column for effect has been renamed to Impact. The type of hazard and source of hazard columns have been added. This is to ensure that the template follows current requirements and makes it easier to conduct analyses to identify underlying hazards and accidents. The addition of these columns applies the 4M 1E, which can identify the source of the hazard. Figure 3 below shows the proposed template. In addition, the risk control part has been unified under the control measure/recommendation column.

This makes it easier for the process to fill in the information, as the two concepts are essentially the same. Table 7 is comparison between existing and new proposed template

Table 7: Comparison between existing and new proposed template

No	Item	Existing Template	New Template
1	Activities	✓	✓
2	Hazard	✓	✓
3	R/Nr/E	✓	✓
4	Legal & Other Requirement	✓	✓(At Upper Colum)
5	Risk Assessment (Likelihood, Severity, Risk Rating	✓	✓(Risk Rating With Colour Code)
6	Risk Control	✓(Existing Control), Proposed Control)	✓(Combine In 1 Colum)
7	Type Of Hazard		✓
8	Source Of Hazard		✓
9	Effect/Impact	✓	✓

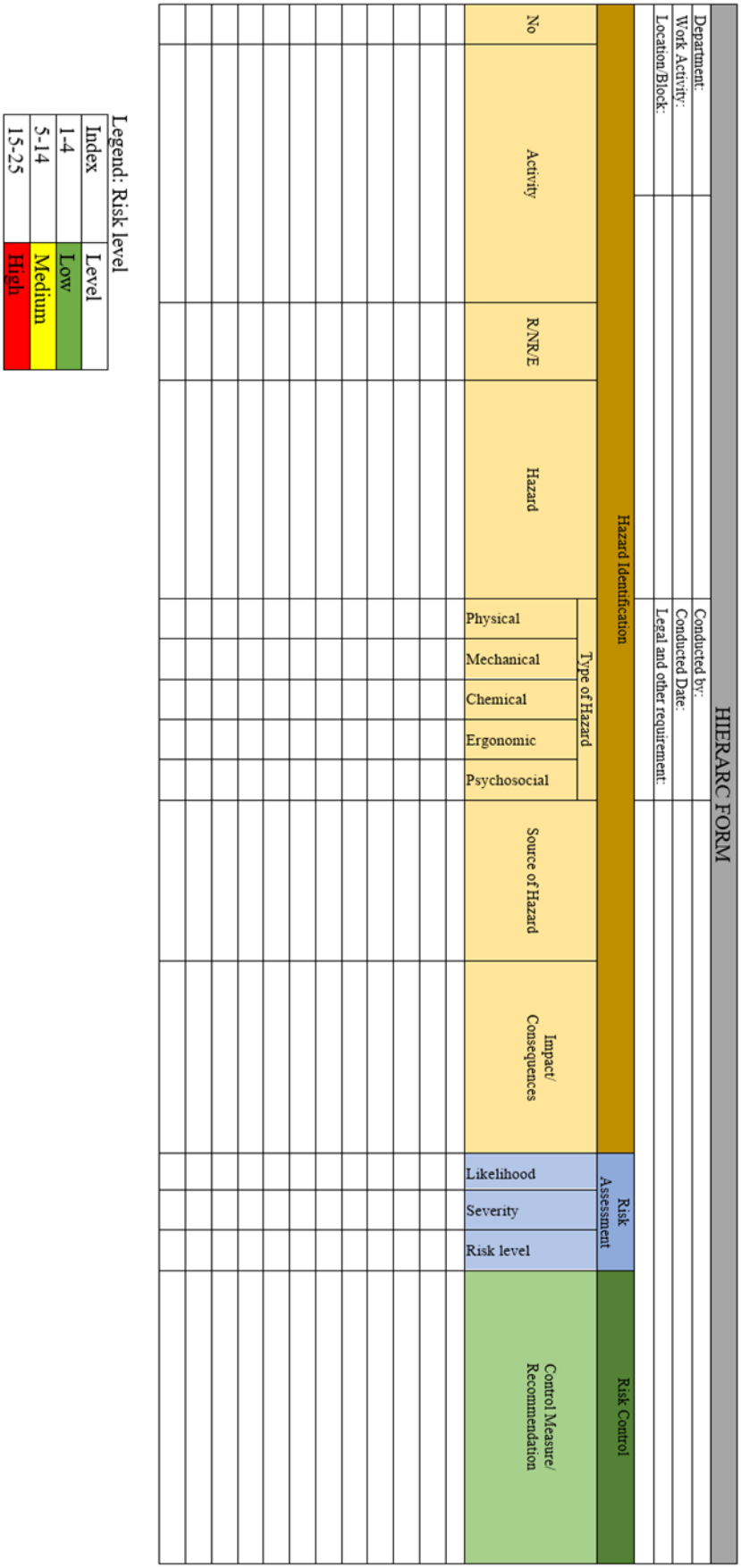

Figure 3: New proposed safety analysis template

4.5 Interview session

The interview session was conducted on 20/6/2023 at the track engineering department office at KTMB HQ. The track engineering department is responsible for carrying out track-related activity, including tamping. This interview involved expert panels from the track engineering department who have experience in the tamping activity. However, there were panels who did not want their information and names included in this study due to several factors. This resulted in only the names of the panels who confirmed that their names and information were included in this studyThe panel is Khairul Shakir bin Hassan. He is a senior engineer for the department of track engineering. He has a lot of experience in KTMB in track engineering. He is involved directly in maintenance works and coordinates a contractor for a project under KTMB. For example, KVDT rehab project phase 1 and phase 2.

The discussion will focus on reviewing and validating the new safety analysis template, which was improved by adding resources on hazards and writing techniques for the HIRARC form. This will help the researcher achieve the third objective of validating and confirming the new safety analysis template with track engineering department staff. There are several questions that need to be answered by the panel at this meeting. The responses and answers from the panel will help to validate and improve the new HIRARC form in the future.

This question set contains 3 sections. The first section asks for the panelist's personal information, such as their name, age, and position in the company. Section B consists of questions about the panelist's information and opinions regarding the new template. This section is important for confirming whether the new template can be used or needs improvement. The last section asks for the panelist's recommendations for improving the new template in the future.

Based on the answers provided, the panel was satisfied with the newly produced template. The insights and answers provided were very helpful and made the validation process easier to run. The table below shows the summarised panel responses for each question.

Before ending the interview session, the panelists also had time to provide input for the improvement of the safety analysis template in the future. One of the inputs given was to make the template more user-friendly. The current template can be a little daunting to complete, especially for people unfamiliar with HIRARC. The template could be improved by making it more visually appealing and by providing clearer instructions. Additionally, new technologies could be incorporated. There are a number of new technologies that can be used to improve HIRARC form templates. For example, the template could be made interactive so that users can click on risks to get more information.

5. Conclusion

There are three main objectives for this study. All three objectives can be achieved through the method that has been determined.

overall safety of workers. There are three main objectives for this study.

All three objectives in this study have been successfully achieved through the method that has been established. Improvements to the HIRARC form template have been made as a result of identifying and analysing the hazards and risks associated with manual tamping activities in KTMB. Improvements made also follow the requirements set by the standard used as reference material. In conclusion, this study has achieved all three objectives that have been set. This study can also be improved for future studies through the use of different methods.

The results of the interview session with experts from the KTMB ground engineering department showed positive results and fulfilled the wishes and needs in the ground engineering department. In conclusion, this study has achieved all three objectives that have been set. This study can also be improved for future studies through the use of different methods.

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