


## HIRADC Analysis for Rolling Stock Body Lifting Ngrombo Railway Maintenance Center

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### Abstract

The Railway Maintenance Center as stated in the Regulation has the duty and function of carrying out the maintenance of state-owned railway facilities. The part of rolling stock heavy maintenance with high potential hazard is Lifting Body Activities Using OHTC in Maintenance of Hydraulic Diesel Locomotive Facilities activity. It so there is a need for a risk assessment which is a process to determine control priorities for the level of risk work accident or occupational disease. Part of OHSAS 18001:2007 Clause 4.3.1. recommendation HIRADC method for can support a safety system with 3 stage analysis (hazard identification, risk assessment, and control determination) The Hazard Identification results obtained 3 aspects of hazard risk in OHTC Rolling stock Body Lifting operations with the following analysis results Crane toppling, Equipment failure, Load falling with Death & asset / property damage impact factor. Risk Assessment analysis of Rolling stock Body Lifting using OHTC obtained results action taken when resources are available regarding handling which in general were Administrative Control. Determine Control relevant steps to minimize potential hazards immediately (1) Evaluating SOP Rolling stock Body Lifting and conduct outreach to all employees related to the work, (2) Making and or adding hazard signs and (3) Human development by conducting Training/Refreshment Crane Operator and Signal man. (4) Strictness of the rules for using PPE for all employees related to the work as the last step in minimizing the risk of occupational hazards.

Keywords: Railway, Rolling Stock, Maintenance, Building, HIRADC, Safety



Figure 1. Ngrombo Railway Maintenance Center Workahop, Directorate General of Rail Transportation, Ministry of Transportation (Indonesia)

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### 1. Introduction

The total number of main causes of train accidents investigated by the Indonesian Transportation Safety Committee (KNKT) from 2017 - 2021 are 18 causes, consisting of 7 accident causes for facilities, so it is necessary to evaluate the operational standards and maintenance of railway facilities to minimize accident rates [1]. A rolling stock failure may be very costly in terms of monetary loss and/or passenger

inconvenience. It can also cause train service delays or even result in a very serious derailment accident. Planning a cost-effective preventive maintenance (PM) program for various rolling stock components is a wise choice [2]. Government Regulation Number 56 of 2009 concerning the Implementation of Railways Article 229 regarding the obligations of railway facility operators in maintaining railway facilities so that they remain operationally viable [3], The Railway Maintenance Center as stated in the Regulation of the Minister of Transportation of the Republic of

Indonesia Number PM 65 of 2014 concerning the Organization and Work Procedure of the Railway Maintenance Center has the duty and function of carrying out the maintenance of state-owned railway facilities [4]. Maintenance performed on state-owned facilities can be categorized into 2 (two), namely periodic maintenance and heavy maintenance. [5] Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 18 of 2019 concerning Standards for Places and Equipment for Maintenance of Railway Facilities, Periodic maintenance consists of daily maintenance; monthly maintenance; 6 (six) monthly maintenance; annual maintenance; 2 (two) annual maintenance; and maintenance 4 (four) years. Operation of the rolling stock is associated with a number of risks. The consequences of failures are sometimes very serious - safety or the environment, sometimes only economic. A significant factor affecting the safe operation of railway vehicles is maintenance. [6] Methods of risks assessment and possibilities of their reduction in design, operation and maintenance of railway vehicles. There are strict rules to be kept in operation and maintenance to avoid unacceptable damage and to prevent accidents, which usually end in serious consequences. Carried out on the facility body with provisions for Maintenance Equipment for lifting components and lifting equipment for facilities [7] Cranes the most common load-lifting machines. Commonly used in facilities industry, supported by overhead rails, Components (1) Bridge (2) Trolley (3) Hoist, Many operate with remote control, Easy to use, required little training, nothing. stability problem [8]. The OHTC with a capacity of 15 tons has gone through a commissioning test from the Labor and Migration Service to ensure operational feasibility on August 13, 2020 [9].



Figure 2. The Ngrombo OHTC

Their structures consist of a mobile platform along the hall with hoisting winch or a trolley moving along girders OverHead Traveling Crane (OHTC) as lifting maintenance equipment specifically in this research in Lifting Body Activities Using OHTC in Maintenance of Hydraulic Diesel Locomotive Facilities has a

potential hazard when using it so there is a need for a risk assessment which is a process to determine control priorities for the level of risk work accident or occupational disease. One that can support a safety system is a recommendation for hazard identification, risk assessment, and control determination or HIRADC is part of OHSAS 18001:2007 Clause 4.3.1 [10].

[11] in Measuring and Modeling Work Stress of Electric Traveling Crane Operators found 4 main factors: (1) five subscales can be used to measure work stress; (2) employees empowerment is the most significant factor followed by role overload; (3) workplace characteristics contribute more to work stress than operator characteristics; and (4) workplace characteristics, crane height is the main contributor. The issues related to crane height and cabin feature can be fixed by providing engineering or foolproof solutions than relying on interventions related to the demographic factors. [12] the management must review collaborative community safety resources, consider the continuing challenges and barriers to sharing safety information effectively, and suggest that the management is ideally positioned to help reduce those barriers, and develop a strong positive safety culture through safety data sharing and collaboration. Occupational Health and Safety really needs to be a consideration for industry in order to avoid work accidents. [13] the significant risks need to be considered by management and take corrective action. Recommended improvements are engineering, administrative controls, and use of Personal Protective Equipment. The most common hazards are falling, punctured, scratched, tripped, bumped, inhaled dust, electric shock, exposed to concrete splashes with extreme risk of risk of injury, disability and even death [14]. In other studies, similar results were obtained the highest level of risk is substantial in the activity of moving cargo to temporary storage or inspection areas with a potential danger of crashing into workers which has an impact on limb injuries, fractures, and even death, so this activity is a concern to avoid work accidents [15]. There are 4 factors that cause work accidents that are analyzed: attitudes, materials & equipment, work environment, and work procedures [16].



Figure 3. OHTC 3D Detail

The model demonstrates that for a representative rolling stock circulation from The Netherlands Railways a substantial amount of maintenance activities can be performed during daytime. Also, it is shown that the location choice delivered by the model is robust under various time horizons and rolling stock circulations. Moreover, the running time for optimizing the model is considered acceptable for planning purposes [17]. The job-composition model creates a path for each train unit such that the train units that require maintenance are on time for their maintenance appointments. All models are tested on instances of Netherlands Railways. The results show that especially the shadow-account model and the job-composition model are effectively able to take maintenance appointments into account during real-time rescheduling. It depends on the characteristics of an instance whether the shadow-account model or the job-composition model performs best [18]. The results indicate that the proposed model has a substantial potential to reduce the M&R costs while ensuring a higher level of safety and service quality compared to the currently used inspection methodologies. Practical implications The railway rolling stocks should be regularly inspected and maintained so as to ensure network availability and reliability, passenger safety and comfort, and operations efficiency. Despite the best efforts of the maintenance staff, it is reported that a considerable amount of maintenance resources (e.g. budget, time, manpower) is wasted due to insufficiency or inefficiency of current periodic M&R interventions. The model presented in this paper helps the maintenance engineers to assess the current maintenance practices and propose or initiate improvement actions when needed. Originality/value There are few studies investigating the application of risk-based tools and techniques to inspection and maintenance decision making of railway rolling stock components. This paper presents a modeling approach aimed at planning the preventive repair and maintenance interventions for rolling stock components based on risk measures. The author's model is also capable of incorporating real measurement information gathered at each inspection epoch to update future inspection plans [19]. The results revealed that 27 variables have contributed to the rolling stock maintenance costs. The highest among the influential costs are 13.8% spare part cost, 11% life cycle cost, 6.4% preventive maintenance cost, and 4.6% for the workforce, corrective maintenance, and cost of ownership, respectively. The interrelationship between influential costs and their effects on rolling stock costs is further discussed. More importantly, the paper is intended to provide a comprehensive view of influential costs affecting rolling stock maintenance and give useful references for personnel working in the industry as well as researchers. This research has highlighted the possibility of future major studies to minimize the

identified maintenance cost and industry to optimize its operational cost [20]. the algorithm of operation of the system for automatic stopping of the moving parts that have gone away on their own is given of this system safety to determine semi-Markov chain for based on the system a mathematical model of safety was created. Microprocessor to the system based on by itself gone the rest movement contents to stop intended automated from devices use there is a niche in the station ways account received devices without work to algorithms and trains movement speed mutually dependence provided without by itself moving gone movement units safety provide through accidents took is taken. This prevents potential accidents, increases the reliability of system use, and leads to cost-effectiveness in system use [21].

## 2. Research Method

HIRADC stages for Rolling stock Body Lifting activities include 1) Hazard identification is carried out to find, recognize and describe risks, from observing the company's activities, potential hazards can be identified. The companies that know and understand this level of risk can carry out adequate controls to prevent work accidents [17] 2) Risk Analysis to understand the nature of risks and to determine the level of risk. 3) Risk Evaluation Analysis, this analysis is to assist in making decisions, based on the results of risk analysis. Assessments should be reviewed periodically to identify changes in context or assumptions, and new information and new methods [18].

## 3. Result and Discussion

By using the HIRADC Analysis Method as the basis for the analysis, it is divided into three stages, namely Hazard Identification, Risk Assessment, and Determine Control.

### 3.1. Specification Hazard Identification

Frank E. Bird defines hazard as follows: A hazard is a source of potential harm in a combination of these. Hazards and risks have a close relationship. Hazards are sources of accidents or incidents involving people, property and environment. Risk describes the possibility that a hazard can cause an accident and the severity that can be caused. Considering the domain of analysis, this stage must present tools and procedures, how to identify the source of the hazard, to determine the main hazard [19]. The observation results obtained 3 aspects of hazard risk in OHTC Rolling stock Body Lifting operations with the following analysis results, Crane toppling If the crane is not properly set up or overloaded, it can topple over, potentially causing serious injury or death. Equipment failure, Equipment failure can occur due to a lack of maintenance or faulty parts, leading to accidents and injuries, for example The wire rope is broken, Sling/Webbing broke up, Shackle broken. Load falling, When lifting a load,

there is a risk of it falling, which can cause injuries to people and damage to property.



Figure 4. Hazard identification

Equipment failure, Equipment failure can occur due to a lack of maintenance or faulty parts, leading to accidents and injuries, for example The wire rope is broken, Sling/Webbing broke up, Shackle broken. Load falling, When lifting a load, there is a risk of it falling, which can cause injuries to people and damage to property.

Table 1. Rolling stock Body Lifting Hazard Identification

Aspect	Impact			Aposition
	Human	Environment	Property	
Crane toppling	V	V		Death & asset /
Equipment failure	V	V		property damage
Load falling	V	V		

The Rolling stock Body Lifting activity was conducted at the workshop so that it has a major impact on humans and property.

### 3.2. Risk Assesment

The combination of the likelihood and severity of an event. The greater the potential for an event to occur and the greater the impact it has, the greater the risk of the event is considered to have [20]. The risk formula is as follows:

$$(Risk = Probability \times Consequences)$$

The results of observations and interviews to get a Probability grade with a scale of 1-5 and a Consequence grade with a scale a-e with grade information as follows:

Table 2. Probability Grade

Grade	Probability
1	Rare
2	Unlikely
3	Possible
4	Likely
5	Almost Certain

Table 3. Consequence Grade

Grade	Consequences
a	Catastrophic
b	Major
c	Moderate
d	Minor
e	Insignificat

After analyzing the Probability Grade and Consequence grade, the formula can be operationalized to obtain a Risk Grade with the following interpretation provisions:

Table 4. Risk Grade

Value	Risk Grade	Aposition
I	Extreme	Urgent action is required for managing risk
II	High	Action is required to manage risk
III	Medium	Action Taken If Resources Available
IV	Low	Action Taken If Necessary

In the calculation of the Risk Assessment results of the Rolling stock Body Lifting Hazard Identification, the Grade of Risk results from each aspect show the following analysis results:

Table 5. Calculation Risk Grade

Aspect	Existing Hazard		Grade of Risk		
			Probability	Severity	PXS
Crane toppling	Check	OHTC	2	a	III
Equipment failure	Test & tools help	lift	3	a	III
Load falling	lift		3	a	III

Overall, Rolling stock Body Lifting using OHTC has Consequence grade a (Catastrophic) with Consequence of Death, Very Large Material Losses, Long-term Major Damage but with Probability Grade 3 (Possible) with the final result being Risk Grade III (Medium) with advice justification action taken when resources are available

### 3.3. Determine Control

Risk control is an important and decisive step in overall risk management. If the previous stage was more conceptual and planning, then at this stage is a realization of risk management efforts. Regulation of the Minister of Manpower number 5 of 2018 article 7 paragraph 3 to 8 states that risk control is carried out according to the control hierarchy which includes efforts: (a) Elimination is an effort to eliminate sources of danger originating from materials, processes, operations or equipment. (b) Substitution is an attempt to change materials, processes, operations or equipment from hazardous to non-hazardous. (c) Technical engineering is an effort to separate sources of danger from workers by installing a safety system on tools, machines and/or work areas. (d)

Administrative is an effort to control from the side of the workforce in order to carry out work safely. (e) Personal protective equipment (PPE) is an effort to use tools that function to isolate part or all of the body from sources of danger.

Table 6. Determine Control

Aspect	Hierarchy of Control				
	Elimination	Substitution	Engineering Control	Administrative Control	PPE
Crane toppling				√	√
Equipment failure				√	√
Load falling				√	√

Based on Permenaker No 08/2020 Regarding OHS of Lifting & Transport Aircraft, and Permenaker 08/2010 Concerning Personal Protective Equipment, several Determine Controls can be explained as follows: (1) Crane toppling Crane Operator & signal man training, SOP for Lifting, Hazard Signs, Use of PPE (safety helmet, safety shoes), (2) Equipment failure (The wire rope is broken, Sling/Webbing broke up, Shackle broken) Crane Operator & signal man training, SOP for Lifting, Hazard Signs, Usage, PPE (safety helmet, safety shoes), (3) Load falling Signal man training, Ties, SOP for Appointment, Hazard Signs, Use of PPE (safety helmet, safety shoes)

**4. Conclusion**

The Hazard Identification results obtained 3 aspects of hazard risk in OHTC Rolling stock Body Lifting operations with the following analysis results Crane toppling, Equipment failure, Load falling with Death & asset / property damage impact factor. Risk Assessment analysis of Rolling stock Body Lifting using OHTC obtained results action taken when resources are available regarding handling which in general were Administrative Control. Determine Control relevant steps to minimize potential hazards immediately (1) Evaluating SOP Rolling stock Body Lifting and conduct outreach to all employees related to the work, (2) Making and or adding hazard signs and (3) Human development by conducting Training/ Refreshment Crane Operator and Signal man. (4) Strictness of the rules for using PPE for all employees related to the work as the last step in minimizing the risk of occupational hazards.

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