Risk Analysis of Operation Igniter Technology System for Rocket Motor X

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Abstract

This study discusses risk assessment and the results of the analysis of the ignition system used on the X rocket. The purpose of this study was to obtain a risk analysis obtained when operating the ignition system on the X rocket. This study used HIRADC (Hazard Identification, Risk Assessment and Determining Control) with a qualitative explanation. The results of the risk assessment in the X rocket motor testing process on the application of the ignition system, there are 10 risks in activities consisting of 8 activities that have a "low" risk level, while the other 2 have a "High" risk level. Caused by probability 1 and severity 4 which can result in device explosion as well as the death of the user. The scope of the next assessment is instruments risk assessment. Based on the research conducted, the results obtained from the risk assessment are 13 risks of instrument failure, consisting of 9 risks with a "low" risk value. Meanwhile, there are 2 "moderate" risks, namely a short circuit in the cable and the casing does not catch fire which can result in serious injury. The other 2 sectors that have high risks are found to be at risk of not being grounded which can result in static electricity not going to ground, premature ignition during installation, and explosion, which can cause death.

Keywords: Rocket, Ignition, Risk, Assessment.

1. Introduction

The development of military technology is increasingly being intensified. Procurement of missile and rocket munitions in stages is a form of minimum basic strength or better known as Minimum Essential Force (MEF) (Ministry of Defense of the Republic of Indonesia, 2012). Based on research by Ganda Samosir in 2012 on the propulsion of the RX.320 rocket, although it has a high flash point, this is quite vital considering the speed of the combustion process in the propellant, which is 7mm/s. The propellant flash point is supported by a squib as a conductor of electricity to the initial igniter which will then conduct heat to the propellant in the rocket motor.

An example of the risk posed is that in 2010, at least 200 people died as a result of rocket explosions during the process, testing, launch preparation, and rocket launch operations. Some cases also involve launches, where the spacecraft fails to orbit and falls back to earth. Several cases that are relatively new, namely the China Great Wall Industry Corporation which processed the launch of the Long March-3B/G2 (Chang Zheng-3B / G2) rocket carrying the Nusantara 2 satellite payload, failed at the launch stage. Although there are already standards available as a reference, this event proves that launch activities require the appropriate level of safety supervision in each country (Damayanti, 2020).

There is a need for effort in reviewing the risk assessment on the operation of the igniter technology system for the X rocket, so that the potential risk sector can be known to be able to save an igniter from failure. Thus, this study aims to make a risk assessment in the X rocket motor testing process in the application of the ignition system.

2. Methodology

2.1. Related works

When it comes to rockets and their testing, the rocket launch system requires an initial ignition system for the propulsion system to work properly. This has become the focus of research, which according to (Supriyatno, 2009) the initial igniter is an element in the rocket which is also composed of: squib, pyrotechnic stuffing and tube. By definition, Risk is an event that if it occurs could jeopardize the successful completion of the project including the launch and combustion of propellant. Risks must be identified and assessed for their likelihood of occurrence and impact on the project. In general, according to (INCOSE, 2006) risk has been defined as the probability of an event occurring plus the negative consequences of the event occurring. In other words, risk is a potential problem, something to be avoided if possible, or a possibility and/or a consequence faced.

This study focuses on making an assessment of the igniter system for combustion on the rocket motor X. The initial ignition mechanism that is operated is starting with a squib which is electrified, will be activated so as to produce a spark or flame that burns the fuse head, the fire will ignite the pyrotechnic raw materials contained in the ignition tube, and emits a flame that will burn the propellant in the rocket motor tube.

2.2. Types of igniter

When talking about the type of igniter that is considered from its installation position, according to (Supriyatno, 2009) igniters in a combustion process in a rocket can be divided into 3 types, namely:

a. Igniter mounted on the front side of the rocket (cap)
b. Igniter mounted on the side of the nozzle (rear of the rocket)
c. Igniter mounted in the middle of the propellant in the combustion chamber, which serves to burn the propellant from the inside.

For this study, the author focuses on the ignition system which is positioned on the front side of the rocket (Cap). Considerations are made based on user needs, and risk assessment in the testing and technical process.

2.3. Method

In identifying and analyzing hazard risks, it can be done using Hazard Identification, Risk Assessment and Determining Control (HIRADC) method. HIRADC is one of the requirements that must exist in implementing SMK3 based on ISO 45001:2018. In this study, HIRADC is divided into 2 stages, namely: Hazard Identification, and Risk Assessment. (Saputro & Lombardo, 2021)

1. Hazard identification
   Hazard identification is carried out with the aim of knowing the potential hazards faced by workers at work. This hazard identification stage can be done by conducting interviews, direct observations in the field and through historical data.
2. Risk Assessment
   Risk Assessment is a process to determine the priority of control over the level of risk of accidents or occupational diseases. In this method, risk assessment is taken based on:

$$R \text{ (Risk)} = C \text{ (Consequence)} \times P \text{ (Probability)}$$

Tabel 2.1. Risk Level

KESERINGAN / *LIKELIHOOD* (K1)						
Almost Certain (Sering Terjadi)	5	T (5)	T (10)	E (15)	E (20)	E (25)
Likely (Kemungkinan Besar Terjadi)	4	S (4)	T (8)	T (12)	E (16)	E (20)
Possible (Mungkin Terjadi)	3	R (3)	S (6)	T (9)	E (12)	E (15)
Unlikely (Kemungkinan Kecil Terjadi)	2	R (2)	R (4)	S (6)	T (8)	E (10)
Rare (Jarang Terjadi)	1	R (1)	R (2)	S (3)	T (4)	T (5)
	Skor	1	2	3	4	5
		Insignificant (Tidak Signifikan)	*Minor* (Cidera Ringan)	*Moderate* (Cidera Berat)	*Major* (Kematian / Cidera Tetap)	*Catastrophic* (Bencana)
		KEPARAHAN / *SEVERITY* (K2)				

Source: HIRADC (Emilia, Wilson, & Doaly, 2018)

In determining the level of risk, risk analysis techniques are needed, risk analysis is a technique to determine the magnitude of a risk which is reflected in the possibilities and impacts that arise based on the aspects of threats and opportunities.

3. Result and Analysis

The risk assessment data obtained, described in the table below is divided into two parts. Table 3.1 discusses occupational risk assessment on human health, while Table 3.2 discusses risk assessment of the device. The intended table is described as follows:

Table 3.1. Occupational risk assessment on human health

NO	Risk Identification		Risk Assessment									
	Activities/Products/ Services/ Facilities	Hazard description	consequence	In Charge	regulations and policies	Control	Risk: likelihood	Risk: Severity	Risk: Score of risk	Risk level	Risk Cost	Risk Schedule
1	Initial igniter installation process on test	Bad weather & hurricane	Dizzines and flu	The team involved in the static test	UU 01/1970	Wear an umbrella / raincoat	1	2	**2**	Low		+
		The weather too hot	Dizzy, tired quickly, dehydrated			Wear a hat and wear protective goggles	1	2	**2**	Low		+
		Strong wind	Dust particles get into eyes			Wear protective glasses	1	2	**2**	Low		+
		Falls due to slippery roads	Physical injuries, sprains			Wear safety shoes	1	2	**2**	Low	+	+
		Stuck on the test bed due to carelessness	Physical injury			Work supervision	1	2	**2**	Low	+	+

		Stumbling on a cable that is about to be installed or has been installed	Physical injury			Making cable routing arrangements	1	2	**2**	Low	+	+
		Unergonomic body position	Muscle injury, physical injury		Permenaker 05 / 2018	Work supervision	1	2	**2**	Low		+
		Explosion at the start of testing	Burns, and death		Kepmenaker 186 / 1999	Observing from afar, and take shelter in the bunker	1	4	**4**	High	+	+
		Explosion due to premature ignition	Burn, and death		Kepmenaker 186 / 1999	n/a	1	4	**4**	High	+	+
		Electrocution	Physical injury, health problems, death	operator	Permenaker 12 / 2015		2	2	**4**	Low	+	+

Source : (Authors. 2021)

Table 3.2. Risk assessment of the igniter system device

NO	RISK IDENTIFICATION		RISK ASSESSMENT								
	Activities/Products/ Services/Facilities	Hazard description	Consequence	In Charge	Control	Risk			Risk level	Risk Cost	Risk Schedule
						Likelihood	Severity	Score of risk			
1	Power supply	Current is not as required (less than)	Squib does not receive electricity, and the igniter does not turn on	Firing team & Operators	Supervision of work	3	1	3	Low		+
2	Switch connector	Switch connector not working properly	Electrical current is not connected properly, and the igniter does not turn on,	Firing team	Adjustment of connectors and wiring before testing	2	1	2	Low		+
3	Cable	Exfoliated cable	Reduced cable cross-sectional area, Electrical short circuit	Firing team & Operators	Inspect and replace equipment	2	2	4	Low		+
		Incorrect cross-sectional area	High delay time		Cable resistance measurement and cable adjustment	3	1	3	low		+

		High resistance	High delay time		Cable resistance measurement and cable adjustment	3	1	3	low		+
		Short circuit	Burnt wires, ignition failure, premature ignition, explosion		Team avoid field, tracing and device switching	2	3	6	Moderate		+
4	Grounding	Grounding not connected	Static electricity not going to ground, premature ignition, explosion	Firing team	Team avoid field, Grounding system check	1	4	4	High		+
		High resistance	Static electricity does not go to Ground, premature ignition, explosion		Team avoids field, Grounding system check	1	4	4	High		+
5	Casing	Case not burning	Nozzle Clogging, Explosion	Team Igniter & Operator	Team dodging the field, waiting for combustion to finish	2	3	6	Moderate	+	+
		Case burns too fast	Burns unevenly		Team avoids the field, waits for burning to finish	3	1	3	Low	+	+
6	Squib	Squib not burn	There is no ignition of the Igniter		Wait 10 minutes, disconnect the power supply, confirm the case, security measures according to Standard of procedure	3	1	3	Low	+	+
7	Igniter material	Pyrotechnic does not turn on	Igniter does not occur		Waits 10 minutes, disconnects power supply, confirms case, safety measures according to standard of procedure	3	1	3	Low	+	+

		Pyrotechnic ignites but propellant does not ignite	No combustion of propellant occurs		Waits 10 minutes, disconnects power supply, confirms case, safety measures according to standard of procedure	3	1	3	Low	+	+

Source : (Authors. 2021)

Based on Table 3.1 and Table 3.2, an analysis was described that could describe the situation obtained in the form of a work safety risk assessment and initial ignition system device, namely:

3.1. Work safety risk assessment

In the depiction that is seen based on Table 3.1 above, there is a risk identification that begins with the activity of the initial igniter installation process in the test. Where, we get a description of the dangers such as the influence of weather which discusses in general, the danger of electric shock. The description of the hazard that is influenced by the weather, the result is "Low" which is seen based on the consequences that have an impact on humans who serve as field operators. This is also supported by the probability of the possibility. This activity indicates that it is very rare (1x in more than 1 year), and the severity level is found at number 2 which means medium level. So the impact given by sequential weather is at a value of 2 (Low).

Another thing that is considered in the installation of the initial igniter when carrying out the test, obtained a description of the technical hazards which include, explosion during testing, explosion due to premature ignition, and also electric shock. Based on the three descriptions of these hazards, the consequences if these hazards occur are, they can have an impact on the operator and also the software that is in the testing area. In this case, the type of consequences that can result in burns, physical injuries, health problems and also death.

Based on the three hazard descriptions, although the failures found are very rare, the potential for these failures can cause death with a severity level that reaches "major" so that the risk level is "High".

3.2. Risk assessment of the ignition system device

In the depiction that is seen based on Table 3.2 above, there is an identification of risks in the initial ignition system device used. Activities carried out on the system include power supply, switch connectors, wiring, grounding, casing, Squib, and initial ignition (Igniter).

The potential risk in the assessment carried out, the results obtained in the form of "Low" were obtained on power supply devices that had potential electric currents that did not match the needs (less than), switch connectors that had the potential not to function properly, and wiring that had potential risks in the form of chipped wires, inappropriate cross-sectional area, and high resistance.

The potential risk in the assessment carried out, also obtained results in the form of "low" or in other words minimal risk assessment results. The system devices that get a "low" value in the initial igniter are in the form of a casing that has the potential to burn too quickly, a squib that does not turn on and can cause ignition failure, and an initial igniter that has a risk that the pyrotechnic does not ignite and cannot ignite the propellant filling. . The results of the "low" assessment were obtained because the probability/frequency value of the potential risk described had a low value or <3 with an indication (possible) which means it is likely to occur, and the severity level (severity) has a low value or < 4 or with Minor indications and has a minor impact.

Meanwhile, the risk assessment on the initial ignition system device also obtained a "moderate" value in two parts. Moderate is a medium / moderate risk assessment level that can occur at any time and can cause serious injury, even though the probability level is quite low or <3. This happens in the wiring that has the potential for a short circuit and can cause the cable to catch fire, fail to start, premature ignition, explosion or with a potential value > 3 which can result in serious injury to humans. In addition, a "moderate" value is obtained in other parts such as the casing which has the potential not to burn out. As a result of a casing that cannot be burned out, it can cause a blockage of the fire output at the nozzle, and it can trigger an explosion during the rocket ignition process, or with the results of an assessment in the form of likelihood 2, and the severity value that can be caused is 3 (medium).

The risk assessment on the initial ignition system device also obtained a "High" value. The value of the potential risk of "High" occurs in the part of the ground system that is considered vital for its existence. The system ground has two potentials i.e. if the ground is not properly connected, and when the resistance is high on the ground. Failure of the ground system can result in static electricity that does not go to the ground, premature ignition of the initial igniter, and can also trigger a direct explosion in the installation process in the testbed room. This situation is described as not frequently occurring, or having a likelihood value of 1 or very rare. However, the consequences of this failure have a severity of 4 with an indication of "major" which can cause permanent injury to death due to explosion. So far, the control carried out for this case is by following the applicable standard operating procedures, namely, the team avoids the field, and checks the grounding system.

4. Conclusion

The results of the risk assessment in the X rocket motor testing process in the application of the initial ignition system, there are 10 risks to activities consisting of 8 that have a "low" risk level, while the other 2 have a "High" risk level caused by likelihood 1 and severity level. 4 which can result in an explosion of the device and also the death of the user. The scope of the next assessment is the product risk assessment, based on the research conducted, the results obtained from the risk assessment of 13 risks of product failure, consisting of 9 with a low-risk value of "low". Meanwhile, there are 2 “moderate” risks, namely the cable short circuit and the casing does not burn which can result in serious injury. Other sectors that have 2 high risks "High" are found at the risk of not being connected to the ground which can result in static electricity not going to ground, premature ignition during installation, and explosion, which can cause death.

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All authors have the same proportional contributions. WN, HT, YHY, and EL are contributed for risk analysis of operation of igniter technology system for rocket motor X . EL and WN are contributed for introduction and to do risk assessment. WN, HT and YHY are contributed for results, analysis and reviewing the article.

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