Hazard Identification, Risk Assessment and Risk Control for Static and Rotating Lab Works

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ABSTRACT

The hazard identification, risk assessment, and risk control (HIRARC) techniques were utilized in this study to reduce the risk of Static and Rotating Laboratory engineering practice. This research has been conducted in the Department of Petrochemical Engineering, Politeknik Tun Syed Nasir, Pagoh. This study began by identifying possible hazards through working practice observations and workplace inspections, then proceeded on to risk assessment, which is used to quantify the risk level, and then, if necessary, risk management implementation. According to the data, there were eight key everyday activities in this workshop. The greatest risk level value was 8, which was contributed by hazards associated with the electrical, rotating parts and ergonomic due to unsuitable workstation set up during start-up ignition combustion engine lab work activities. There are another five applicable hazards relating to machinery and equipment that are being utilized in the workshop operations, including employing powered rotating equipment, non-powered equipment such as compressors, vibration, moving parts, and noise or fumes produced by static and rotating exhaust machinery. Some recommended control actions must be followed to ensure that the risk level can be lowered in the future such as the combination of engineering control, administrative control, and personal protective equipment (PPE). The HIRARC methodology used in this research is a beneficial technique for assessing potential hazards to reduce the accident rate.

INTRODUCTION

The Occupational Safety and Health (OSH) Act of 1994 applies to both public and private academic institutions [1-2]. However, OSH in the field of education remains inadequate because individuals in higher learning institutions believe they are not exposed to danger, or that the risk is minimal or non-existent due to two considerations. Firstly, there has been no recent loss or serious difficulty, and secondly, it is solely service-oriented employment [3]. There have been several engineering labs or workshop incidents. Mercury spills and a minor electrical fire have recently occurred in Politeknik Sultan Azlan Shah's engineering facility [4]. [5] reported that some accidents occurred in their chemical laboratory in 2016 owing to a lack of maintenance and safety testing performed by competent personnel. The accident was caused by a chemical leak accompanied by a waterflood. This accident was caused by a clogged sink, which had been pouring water for at least 19 hours before the accident. While, a fire in July 2018 destroyed 60% of the general education administration office on the fourth floor of the Port Dickson Polytechnic Academic Building [6]. Although there were no significant injuries or fatalities, these incidents highlighted concerns about the need for greater safety management at the engineering workshop as well as in academic institutions in general. Currently, the Malaysian OSH management system has improved the performance of enforcement and ongoing promotion by federal agencies such

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as the Department of OSH, among others. Employers are required by the OSH Act to offer a workplace free of severe recognized dangers and to adhere to the OSH Act's standards, rules, and regulations, as well as to inspect working conditions to ensure they correspond to applicable OSH Act requirements [1-2]. It must comprise all of the organization's actions, including personnel, equipment, and materials selection, work processes, risk assessment in the workplace, working practices, and working conditions [7]. More than half of all publications utilize Identification of Hazards and Risk Assessment and Determination Control (HIRADC) or Hazard Identification, Risk Assessment, and Risk Control (HIRARC) to identify the hazard and estimate the risk. HIRARC or HIRADC is frequently used for risk assessment due to its simplicity and clear methodology [3]. HIRARC involves four basic steps: classifying work activities; identifying hazards; conducting risk assessments; and deciding if the risk is acceptable or requires management measures. [7, 9-10] utilize HIRARC to assess the risk posed by laboratory users. Hazard identification has been accomplished through a variety of methods, including observation [11], and an interview session [12]. The engineering workshop, as the workplace at PTSN Pagoh, has operations that contain hazards and pose significant risks to the health and safety of employees and other related people. So, procedures involving the identification and evaluation of major hazards are necessary. For instance, in the present predicament of the Mechanical Engineering Program (DPC) in Tun Syed Nasir Syed Ismail Polytechnic (PTSN), Pagoh has introduced DGM50133 Static and Rotating Equipment.

This course introduces students to the understanding of static and rotating equipment that is frequently used in petrochemical plants. This course provides basic knowledge of the classification, types, and specific functions of the components of several systems. During this course, the student will also be exposed to practical skills regarding valves, belts, chains, bearings, pumps, gears, and clutch maintenance through practical work. There are three structured combinations implemented in DGM50142 Static and Rotating Equipment workshop practice: (1) Perform maintenance procedures according to the standard operating procedure; (2) Organize proper procedures for using tools and equipment according to the standard operating procedure; and (3) Arrange ethical skills effectively on well-defined engineering activities based on related static and rotating equipment practice. To date, extensive HIRARC procedures developed through engineering practical work or practical work-related investigations focusing on static and rotating in polytechnic, or a combination of the two, are insufficient or excluded from assessments. The implications of practical pedagogy only focused on one mode of communication for mechanical engineering students, such as academic achievement, without demonstrating the interconnection between procedures, processes, and resources required for the development of occupational safety and health policies, implementation, and achievement, assessment, and maintenance. Besides, there is a lack of HIRARC development for practical work series that best provides a more complete understanding of assessment towards the applicability of engineering lab work teaching methods in the framework of controlling risks related to working activities to create a safe, efficient, and productive workplace [7, 9].

As a consequence, inadequacies in the research imply that systematic approaches with a special emphasis on static and rotating modules, a range of hazards, and effective usage of control measures such as engineering safety control and laboratory administration are required as a benchmark for the managing of inherent hazards that arise from pedagogical methods in an educational institution [11]. Therefore, the development of HIRARC for engineering practical work procedures must be undertaken in a planned manner [9], focusing on the requirements of DGM50142 Static and Rotating Equipment workshop practice in PTSN. The contribution of this research is an analysis of the risk assessment developed from the implementation of the workshop practice, designed in the domain of the static and rotating module (DGM50142), relating to the maintenance of the belt, chain drives, and compressor. Besides, this paper wants to propose further perspectives on future research requirements on this subject, such as recommending some preventive actions to be taken to reduce the risk level in the future in the static and rotating courses. After analyzing this practical workshop series focusing on static and rotating, it will be able to: (i) Provide new information about the academic workshop's risk assessment, with an emphasis on the risk assessment technique, type of hazard, and control methods used to eliminate the hazard; (ii) Boost mechanical engineering students' confidence and understanding through safe-based experience learning; and (iii) Such approaches to designing systematic and safe systems can be used in other polytechnics with incentives including extra marks and credentials, allowing students to actively participate in engineering studies and improving pedagogical methods among instructors.

BACKGROUND OF STUDY

Static and Rotating Equipment in Polytechnic

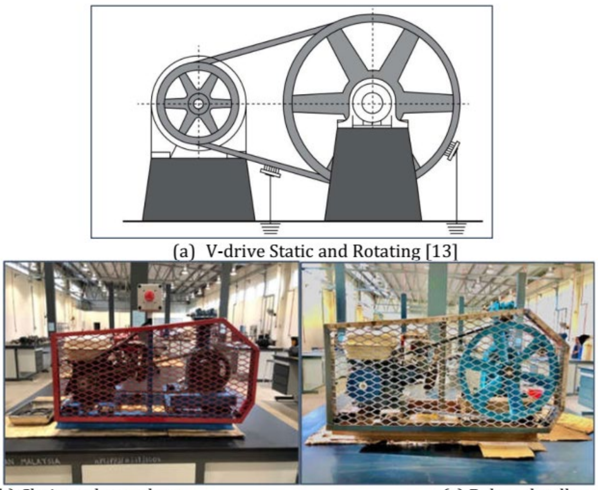
The static and rotating equipment courses present a combination of theoretical and workshop practice. In compliance with the Course Information of DGM50142 static and rotating equipment workshop practice provided by the Department of Polytechnic and Community College Education, Ministry of Education Malaysia, this subject requires the students to study these components to grasp the crucial steps of constructing a fully operating and maintenance belt, chain, and drivers' system (Figure 1). It will help in the performance of interactive learning that is not only according to standard operating procedures but also enhances the skills of ethics effectively.

Year of Study

The semester and year offered for this subject are for semester 5 and year 3, while the credit value is 2 hours. On average, a third-year Diploma Mechanical in Petrochemical (DPC) engineering student will know more as core topics like valve, belt and chain drive, bearing, pump, gears, clutch and coupling are being taught to students. It has been incorporated into the curriculum in a very methodical and project-based way, as opposed to the typical classroom system's monotonous theoretical learning.

Department

The Department of Petrochemical Engineering at PTSN offers four main programs, namely: the Diploma in Process Engineering (Petrochemical), the Diploma in Chemical Engineering, the Diploma in Electrical and Instrumentation Engineering, and the Diploma in Mechanical Engineering (Petrochemical-DPC). The DPC program's goal is to provide knowledge and relevant technical skills in mechanical and mini-plant engineering, particularly in petrochemical engineering. Students are exposed in theoretical and practical forms to plant operation, equipment maintenance, and maintenance problem-solving.



(a) V-drive Static and Rotating [13]

(b) Chain and sprockets (c) Belt and pulleys

Figure 1 (a-c). V-drive installation in potentially explosive settings.

Subject Structure

The course syllabus DGM50142 Static and Rotating Equipment Workshop Practice is organized into five main practical topics: (1) Perform valve routine maintenance service and troubleshooting; (2) Assemble and disassemble the belt, chain, and compressor system; (3) Produce maintenance procedure from a coupling and pump system; (4) Perform gear drive maintenance; and (5) Assemble and disassemble a condenser. While the course assessment is 100% of Continuous Assessment that includes (i) Practical Task (P) (7) 60%, (ii) Practical Task (A) (2) 10%, and (iii) Report (4) 30%. Concerning the teaching methods, they must use interactive lectures, demonstrations, lab work, presentations with guided learning, and independent learning modes.

RESEARCH METHODOLOGY

Research Flow Process

During this investigation, the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis is used to identify the direct and indirect hazards that may be inherent in engineering laboratory work of static and rotating equipment at PTSN, Pagoh. The Likert scale was supplemented by the severity matrix analysis for risk assessment in establishing the likelihood and degree of safety and health that could be ascertained as a dangerous concern during the engineering laboratory work for static and rotating in PTSN. These were being used to discover and suggest control measures, such as incorporating engineering and administrative considerations, but also the implementation of personal protective equipment. The technique used in this research procedure was an examination of a variety of risks using the HIRARC approach, which was done by examining selected lab works conducted at PTSN, Pagoh. The flowchart for the research development and data collection procedure is shown in Figure 2.

Hazards Identification

Team members performed observations with the support of Assistant Laboratory Officers who are familiar with the equipment, materials, and possible hazards to determine the sorts of threats that exist in the laboratories. The hazards were identified as a result of the tasks that students virtually accomplished in this laboratory. The core of risk management is risk identification [7, 14].

Risk Assessment

One of the most prominent risk assessment methodologies for evaluating risk is risk matrix rating, which incorporates risk consequence, likelihood, and severity (see Table 1: a, b, c, and d). Risk assessment relates to the capability to quantify the damage or loss generated by a certain phenomenon associated with the operations. The dangers that have been discovered will be graded in two ways: probability and severity. The probability of an event occurring at a certain moment is represented by the likelihood. It is evaluated through experience, analysis, and measurement (Ibrahim et al., 2019). The likelihood (L) scale ranges from "most likely" to "inconceivable." Table 1(a-d) shows the rating for likelihood rating, severity rating, risk matrix, and risk priority. Risk is calculated as follows: L x S = Relative Risk, where L stands for Likelihood and S stands for Severity.

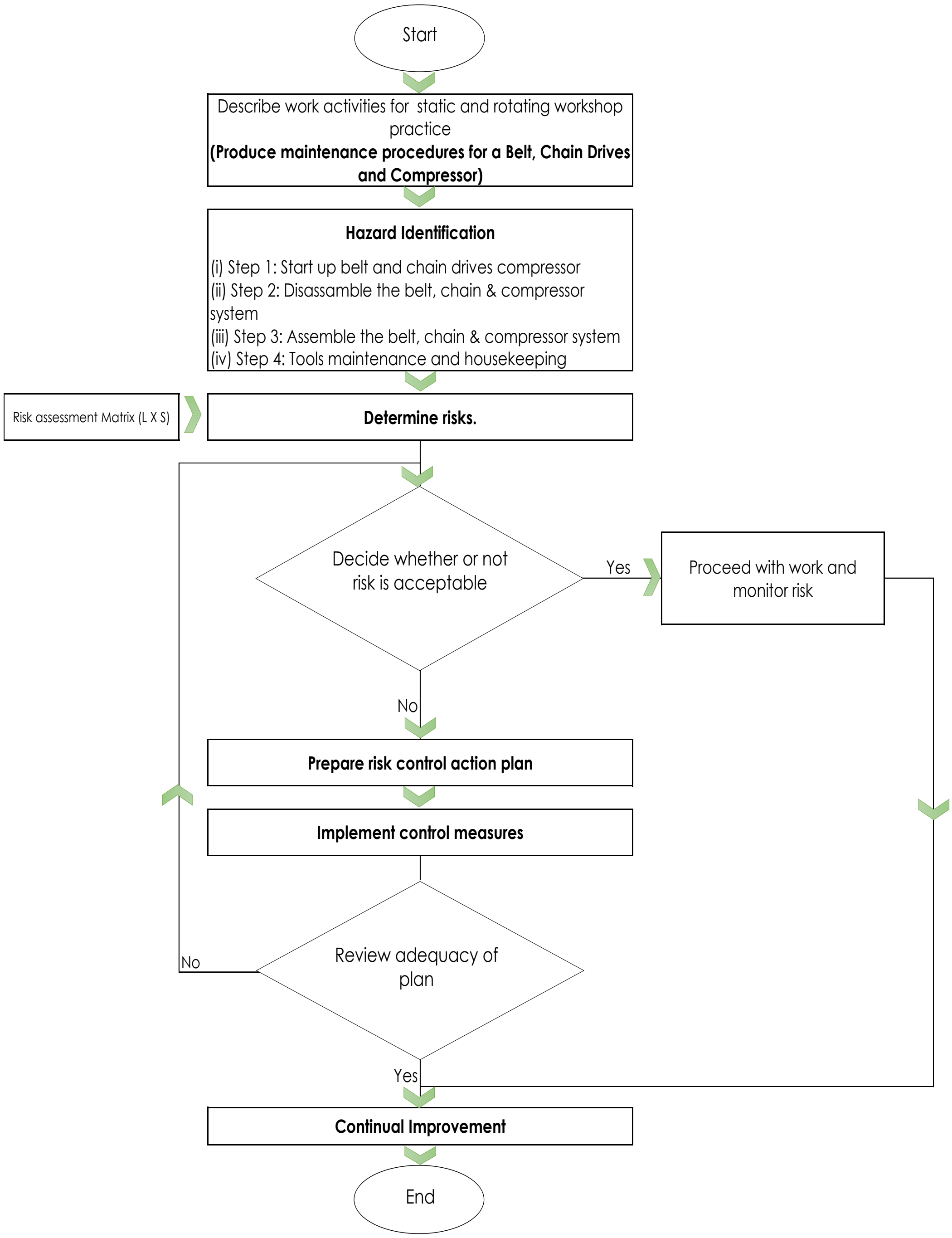


Figure 2. Flowchart for the research procedure.

Likelihood Rating

Table 1 (a) Likelihood Values in Hazard Identification

Likelihood (L)	Example	Rating
Most likely	The most likely result of the hazard/event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur at some time in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

Source: Department of Occupational Safety and Health Malaysia [1-2]

Severity Rating

Table 1 (b) Severity Values in Hazard Identification

Severity (S)	Example	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately on single fatality major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Neglible	Minor abrasions, bruises, cuts, first aid type injury	1

Source: Department of Occupational Safety and Health Malaysia [1-2]

Risk Matrix

Table 1 (c) Example of Risk Matrix to Identify the Risk Value

	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**	
		Low		**Medium**		**High**

Source: Department of Occupational Safety and Health Malaysia [1-2]

Risk Priority

Table 1 (d) Risk Priority Table

Risk Priority	Definitions of Priority	Suggested Time Frame
High	Stop working immediately or consider stopping the work process if the situation is urgent. Must be fixed now; consider short-term and/or long-term activities.	Now
Medium	Is critical, must be solved this week, and consider short-term and/or long-term solutions.	This Week
Low	Is still vital, although it may be managed with by planned maintenance or comparable programming. However, if the remedy is quick and simple, implement it immediately. Routine processes are used to review and/or manage the situation.	1 - 3 Months

Risk Control

The following are the most commonly used methods of hazard control: Elimination (also known as substitution): removing the hazard from the workplace or replacing it with less hazardous materials or machines. Engineering controls are modifications made to factories, equipment, ventilation systems, and processes to reduce the source of exposure [1-2].

Administrative controls are controls that alter how work is performed, such as work schedules, rules, and other laws; and work practices such as standards and operating procedures (including training, housekeeping, equipment maintenance, and personal hygiene practices). Personal Protective Equipment (PPE) is equipment that people wear to restrict their exposure to hazards such as chemical contact or noise exposure [1-2]. These methods are known as the "hierarchy of control." However, regardless of the number of levels offered, the hierarchy should be examined in the order presented. The hierarchy of control as shown in Figure 3 must be followed while implementing risk control for each danger. Controls are often set at the source (where the danger "comes from"), along the path (where the hazard "travels"), and at the worker [1-2].

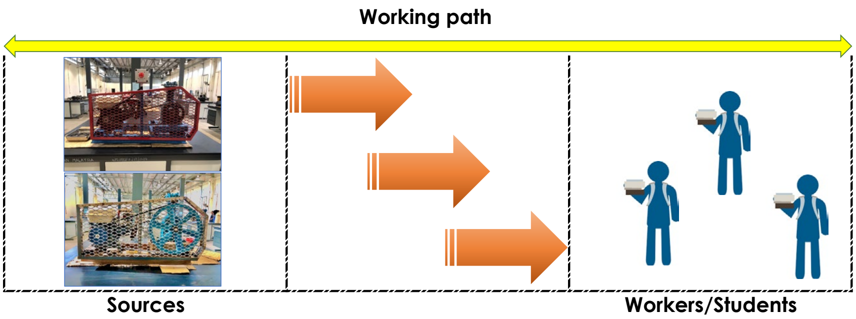


Figure 3. Risk controls used in static and rotating lab works.

Case Study

Table 2 describes the full case study for HIRARC conducted in the maintenance of belt, chain, and compressor lab work. There are eight procedures involved in the lab work as depicted in the description. Static and rotating equipment course exposes students to the understanding of static and rotating equipment which frequently used in petrochemical plant. This course provides basic knowledge on the classification, types and specific functions of the components of several systems. During this course, the student will also be exposed into practical skills regarding belt, chain drive, and compressor maintenance through practical works (refer Table 3 for activities conducted).

Table 2 HIRARC form of Static and Rotating Equipment Workshop Practice 1: Maintenance of Belt, Chain Drives and Compressor

Hazard Identification				Risk Analysis				Risk Control	
No.	**Work Activity**	**Hazard**	**Which can cause/ Effect**	**Existing Risk Control (if any)**	**Like-lihood**	**Seve-rity**	**Risk**	**Recommended Control Measures**	**PIC**
1	Select tools, prepare materials, set up equipment & machineries ignition combustion engines (ICE)	Physical hazard arises from work environment hazard- unguarded machine Ergonomic hazard Physical hazards - Hoses, cord, equipment- tripping hazards, Electrical-voltage high, exposed conductors	Working at height to start up the ICE -fall hazards; and Muscle cramp due to pull the start-up puller on ICE Serious bodily injuries, eye injuries by flying fragments of drive shafts that break during set up ICE of static and rotating equipment Set up ICE of static and rotating equipment	Safe work practice, training, safety helmet, safety goggles, fire extinguishers	3 1 1 1	1 2 1 3	3 (L) 2 (L) 1 (L) 3 (L)	Use full specs safety attire completed with face shield; Provide adjustable workbench	
2	Running mechanically static machineries, appliances (rotating belts and rotating drive shafts)	Mechanical hazards (Plant and equipment) include electrical or fuel powered equipment for rotating compressor, tools and appliances or non- powered Fumes emitted by exhaust Electrical-voltage high, exposed conductors	Bodily injury getting caught in rotating parts if machine is accidentally started Running the combustion engine of static and rotating equipment Running the combustion engine of static and rotating equipment	Safe work Practice, fire extinguisher	2 1 2	4 1 4	8 (M) 1(L) 8 (M)	Administrative control with giving training to workers (safe work practice), Flow of work properly organized, PPE with offering clothing, and equipment	
3	To remove guarding and the metal cladding of static and rotating equipment in off supply conditions	Ergonomic hazards- torque wrenches over tightening forces If extreme tightening force is applied, or if a lubricant is used, bursting pressures will be created in the hub of the mating part	Bodily injuries- hand lesion if extreme tightening force is applied, muscle cramp	Safe work practice	1	2	2 (L)	Used powered hand tools for iterative movements	
4	Installing belt, belting inspection, and tensioning belting	Ergonomic hazards-standing for long time to do the	Discomfort, fatigue, Work Related Musculoskeletal	Safe work practice, training,	2	4	8 (M)	Provide PPE, use testing meter, use fully insulated	

		tasks(accessories-belting)	Disorders (WMSDS),					handle tool, training	
5	To check alignment drive shafts	Ergonomic hazards- standing for long time to check the alignment drive shafts Physical hazards - steel ruler	Fatigue due to pro long standing. Muscle cramp to hold the steel ruler to perform alignment task Steel ruler also has fall hazard	Safe work practice	2 1	2 1	4 (L) 1 (L)	Take short break within the lab works	
6	Installing chain, chain inspection, and tensioning chain	Ergonomic hazards-standing for long time to do the tasks(accessories-chain)	Discomfort, fatigue, Work Related Musculoskeletal Disorders (WMSDS),	Safe work practice, training,	2	4	8 (M)	Provide PPE, use testing meter, use fully insulated handle tool, training	
7	To install guarding to the place of work	Ergonomic hazard by extra forces with their hand and body	Discomfort, fatigue, Work Related Musculoskeletal Disorders (WMSDS),	Safe work practice, training	1	2	2 (L)	Take short break within the lab works	
8	Maintaining tools & equipment /Housekeeping	Physical hazards- Sharps tools, objects or material Ergonomic hazard by extra forces with their hand and body	Discomfort, fatigue, Work Related Musculoskeletal Disorders (WMSDS), Hand sprained and body cramp, hand injury, skin lesion and twisting	Safe work practice Housekeeping	3 1	1 1	3 (L) 1 (L)	Use leather glove	

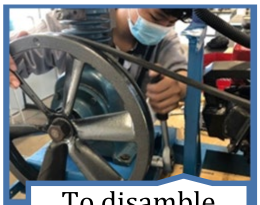
Table 3 Activities Conducted in Maintenance of Belt, Chain Drives and Compressor During Static and Rotating Labworks

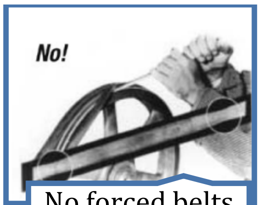
Static and rotating (belt, chain and drive)

Unguarding for start up ignition combustion engine

To Remove guarding and the metal cladding of static and rotating equipment (Chain and Belt)

Shorten the centre distance between the driver and driven sheaves to reduce drive stress. Belts should be removed. Cap screws should be loosen and removed. Loosen any keyway setcrews on the bushings. Insert cap screws into tapped removal holes and gradually tighten each one until mating part is loose on bushing, as illustrated below


To disamble belt from drive



No forced belts into the sheave

The correct way to install V-belts

To Assemble/ Dissemble Belts
Belts and cables are commonly torn when a screwdriver or other object is forced into the sheave. It is well worth the time to move the driver unit forward so that V-belts may be put easily into the sheave groove without harming them. Never "roll" or "pry" the belts into the sheave grooves. This can harm the belt chord, causing belt turnover, short life, or outright breakage. Furthermore, belt installation in this method is both difficult and hazardous.

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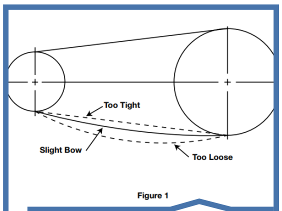
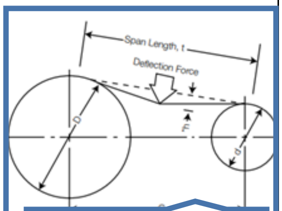
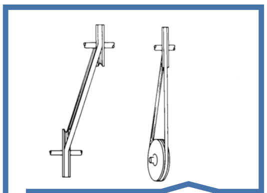


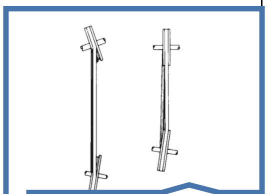
Tensioning V-Belt Drives

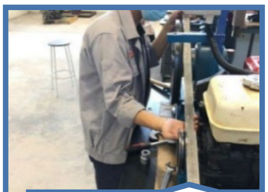


Belt tensioning testing

Tensioning V-Belt Drives and **Belt tensioning testing using Force Deflection Method**


Types of misalignment

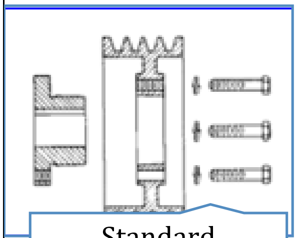
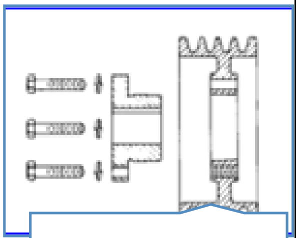
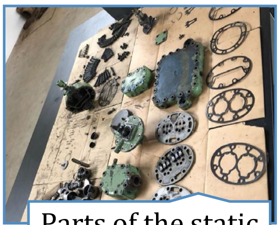

Types of misalignment


Alignment step for drive shaft

To Check Alignment Drive Shafts
Check that the driving shafts are parallel. Non-parallel shafts and poorly positioned sheaves are the most typical causes of misalignment. Belts on one side are pulled tighter and pull more than their share of the weight when shafts are not parallel. As a result, these belts wear down faster, necessitating the replacement of the complete set before it has served its purpose. Belts will enter and exit the grooves at an angle if the sheave is misaligned, producing extra belt cover and sheave wear.
Muscle cramp to hold the steel ruler to perform alignment task for pro long duration, steel ruler also has fall hazard.


Standard chain

To Install chain, Tensioning V-chain Drives and Chain tensioning testing using Force Deflection Method
When a screwdriver or other instrument is forced into a sheave, chains are usually broken and wires are torn. It is well worth the time to move the driver unit forward so that the V-chain may be placed easily into the sheave grooves without breaking them.

*  Standard mounting  Reverse mounting	**To install Sheaves and Brushing** (i) Standard mounting (ii) Reverse mounting WARNING: The wedging effect of the tapered surface multiplies the tightening force on the screws many times. Burst pressures will be formed in the hub of the mating component if severe tightening force is exerted or a lubricant is utilized.
 Hand Tools  Fragments of parts after maintenance  Parts of the static and rotating	**Tools maintenance and housekeeping** Keeping tools, machines and workplace in good working condition.

*Pictures taken from [13].

RESULTS AND DISCUSSION

Total Hazards

During the engineering workshop, a total of five significant group danger items were discovered in the system (Table 4). Risk assessment was carried out by first categorizing the dangers into three categories: low, medium, and high. Based on the findings in Table 4, ergonomic or manual handling hazards are the first highest hazard for the study practices in engineering static and rotating laboratories. These issues arise when most of the activities in the lab require static postures, repetitive movement, or awkward postures such as bending and overstretching. Students and lab supervisors need to stand for a period time to complete the task given. This is one of the main reasons why the percentage of ergonomic hazards is quite high in the study findings [3].

Table 4 Total Hazard of Static and Rotating Practice in Mechanical Engineering Workshops at PTSN

No.	Classify Hazard	Frequency/ Percentage	Low Risk/ Percentage	Medium Risk/ Percentage	High Risk/ Percentage
1.	Physical hazard (Work environment)	4	4	0	0
2.	Electrical Energy	2	1	1	0
3.	Ergonomic/Manual Handling	7	5	2	0
4.	Mechanical Energy (Plant and Equipment)	1	0	1	0
5.	Chemical/Hazardous (Fumes emission from ICE)	1	1	0	0
Total Hazards		**15 (100%)**	11 (73.3%)	4 (26.7%)	0 (0%)

We can define the second-highest hazard as a work environment hazard observed in the study engineering workshop on several factors such as air quality, poor lighting, noise, and thermal discomfort. Likewise, electrical energy is the third preceding hazard since most laboratory equipment and machinery are driven by electricity, and some of the operational procedures are dangerous. As a result, electrical dangers are regularly detected and rated as high in such laboratories. However, electrical hazards are tolerable even they have a risk rating of 8.0, since wiring and power supply concerns are uncommon or do not frequently occur, while environmental threats have already been addressed by laboratory management [10]. The results also show that risk assessment execution at PTSN study workshops is still inadequate and not entirely suited to daily work practice, particularly in technological processes and associated routines, but that there is potential for improvements in the future. The greatest risk level value was 8, which was contributed by hazards associated with the electrical, rotating parts, and ergonomics due to an unsuitable workstation set up during start-up ignition combustion engine lab work activities. There are another five applicable hazards relating to machinery and equipment that are being utilized in the workshop operations. These included employing powered rotating equipment; non-powered equipment such as compressors; vibration; moving parts; and noise or fumes (hazardous emission from ICE combustion) [15], produced by static and rotating exhaust machinery.

Level of Risks

Figure 4 shows that 73.3 % of the risk is relevant to a low level of danger, which is the highest proportion of total risk in the research region. Furthermore, 0% of the overall risk is deemed high risk, while 27% is rated medium risk. Overall, the danger level is rated as low (73.3%). The low-risk level resulting from the risk ranking discovery indicates that it is still significant, but it may be addressed with planned maintenance or a similar type of programming. Alternatively, if the solution is quick and simple, then modify it as needed [1-2]. Low-risk ranking must be reviewed and/or managed by routine procedures such as correct Safety Operating Procedures (SOPs), safe work practices, and wearing appropriate Personal Protective Equipment (PPE). Regarding the medium risk rating, its risk assessments are very important, it must be fixed as soon as possible, and it was considered a short-term and/or long-term action to be taken. It is suggested to install an adequate machine barrier or safety guard and an emergency push button to switch off the electrical instruments and types of machinery [1-2].

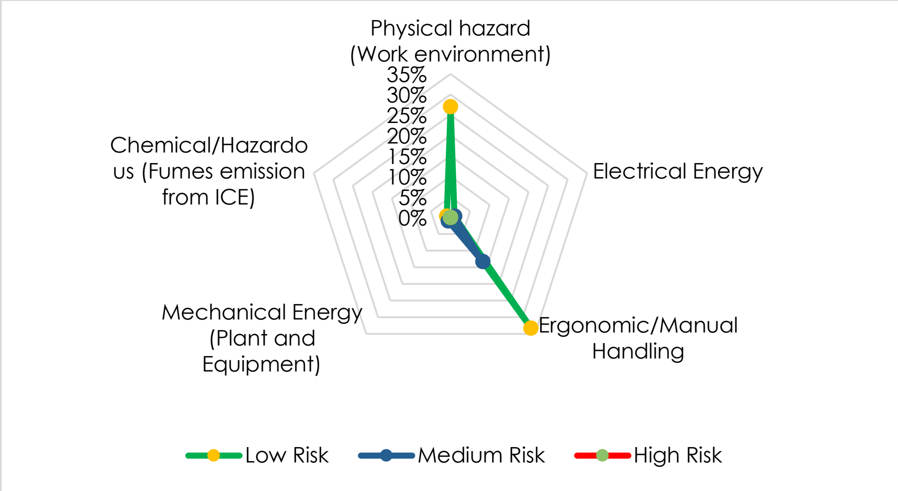


Figure 4. The result shows the total level of risk relevant to the study area.

Future Activities and Research Direction

The simple, rapid, low-cost, and efficient risk assessment will be required in future work to assist educational laboratories in further enhancing laboratory risk management. Furthermore, a mix of qualitative and quantitative risk assessment methodologies may be necessary to improve the risk assessment process by leveraging the benefits of both approaches. Moreover, a digital risk assessment may indeed be required to properly convey the risk to laboratory personnel to eliminate or decrease accidents in academic laboratories.

CONCLUSION

For hazard identification, fifteen hazards were identified in the observation; 27% related to physical hazards, while 47% related to ergonomic hazards. The majority of the hazards addressed were ergonomic hazards and physical hazards presented in the assessments due to the scope of work and hazardous nature of static and rotating types of machinery; the use of electrical energy in the laboratory to conduct experiments; and the type of laboratory assessed, which is primarily a mechanical engineering laboratory. To mitigate risk, the majority of activities utilized at least one control mechanism. A most frequent control measure is a mix of engineering and administrative controls, along with personal protective equipment (PPE). The authors wish to acknowledge the Politeknik Tun Syed Nasir, Pagoh for their technical support in this research.

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