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A HIRARC MODEL FOR SAFETY AND RISK EVALUATION AT A HYDROELECTRIC POWER GENERATION PLANT

Priyanka Pradhan
Department of Electronics and Communication Engineering

ABSTRACT

Thither are many conventional techniques for the systematic analysis of occupational safety and health in general, and hazard analysis in particular, for power generation plants at hydroelectric power stations.This work was started in order to create a HIRARC model for the evaluation of environmental safety and health at a hydroelectric power generation plant at Cameron Highlands in Pahang, Malaysia.The HIRARC model was applied to distinguish the main and secondary hazards which may be inherent in the organization which were regulated as a serious threat for plant performance and sustenance.The main tools of the model consisted of, generic checklist, work place inspection schemes which included task observation and interview, safety analysis as well as accident and incident investigation.For risk assessment, the Liker scale was complemented by the severity matrix analysis in order to decide the probability and extent of safety and health at the study power generation works.These were used to identify and recommend control measures which included engineering and administrative aspects as well as the usage of personal protective equipment (PPE).A total of forty-one important hazard items were identified in the scheme at the target power generation works.These risks were mainly distinguished by means of checklists which were sourced from literature and subsequently customized for the current function.A hazard assessment was conducted by initially classifying the hazards into three levels such as Low, Medium and High.Generally 66% of the risks identified were at low risk, 32% at medium and 2% at high danger.This showed that in that location was sufficient awareness and dedication to safety and health at the study power station.Meanwhile the Power Station was also certified by MS 1722:2005, OHSAS 18001, MS, ISO 14001:2004, MS, ISO 9001:2000 and scheduled waste regulation 2005 which give credibility to the current field in making a working example which may see widespread application in the future.

KEYWORD:- *HYDROELECTRIC, RISK EVALUATION, SAFETY ETC.*

INTRODUCTION

Background

Hydroelectric power generation plants are getting more and more popular in many regions of the globe.This may be ascribed primarily to the rapidly decreasing conventional energy resources which have been used extensively through time.In that respect is besides a need to look for green, clean and renewable energy sources with regard to the demands of environmental topics. Although risks from dams are seldom encountered perhaps due preventive measures, but the implications are of a high consequence. Dam breaks destroy buildings, wreak economic havoc and affect the environment. The context of dam safety depends on a bit of varied safety decisions and the dedication of dam owners (Bowles, 2001).

In club to preserve the safety and wellness of employees working in hydroelectric power stations it is absolutely indispensable to sustain a safety management system (SMS) in space.With respect to this a policy calling for the recognition and rating of major hazards is necessary in order to implement steps for identifying the risk elements during usual and special operations and to predict the likelihood and severity.The safety management system involves choosing risk analysis methods and their effect in terms of frequency of occurrence and extent of consequences (domicile et al., 2004). O'er the past ten years, intensified interest in applying dam safety risk assessment has been in tandem with a search for criteria underlying risk for making decisions (Bowles, 2001).

Granting to the Department of Occupational Safety and Health of Malaysia (DOSH) an occupational safety and health policy involve a written document expressing an organization's dedication to employee wellness, welfare and safety. It is a basis for efforts made to ensure a proper workplace environment. This policy must encompass all the organization's activities related to staff, equipment and materials selection, work procedures and design as well as provision of goods and services (Department of Occupational Safety and Health Malaysia, 2011).

Research purpose

The HIRARC model consists of a comprehensive series of stages for the identification of risks, assessment of risk and the determination of control measures for the implementation of safety and health in the operations (Insert Fig. 1 here). An important component of jeopardy assessment is the recognition of existing hazards,

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evaluating the probability or chance of occurrence and recommending relevant controls.The hazards in hydroelectric power generation plants are rather varied and have a substantial effect on employees, facilities and the environment.Hence the current survey was undertaken to identify the hazards, estimate the risks and determine control measures based on the data gathered in order to derive a comprehensive HIRARC model for the study power generation plant in Cameron Highlands in Pahang, Malaysia.

Related literature

Kim Froats and Tanaka (2004) found that public safety in the vicinity of hydroelectric power generating stations has become a major concern among the facility managers and operators. Waterways associated with hydroelectric power plants are frequently put aside for recreation.The recreational uses should be considered against the perils and perils of strong flows, rising water levels and rugged topography.Although hydroelectric generating stations account for merely a minority of these accidental deaths, it is imperative for operators to assure that public safety publications are directed.

Numerous generic risk evaluation methods are usable for defining the extent of danger.However, drowning is the obvious major public hazard given the quantity of bass water in man-made lakes.Falling, presents another major risk.A hazard assessment is the initial step in devising a waterway safety management program.According to Au Yong and Hui Nee (2009) as far as hydroelectric power stations are concerned, each facility can let in the following structures which may bear a direct relation to hazards in the plant: a) head pond b) water conveyance structure to include dam construction, power intake canal, overflow spill walls, stop log sluices and sluice gates c) spillway d) powerhouse tail-race and e) downstream.

Among the variety of hazards associated with hydroelectric power generation plants, some are common to all employees while others are limited only to those working with or maintaining electrical or mechanical

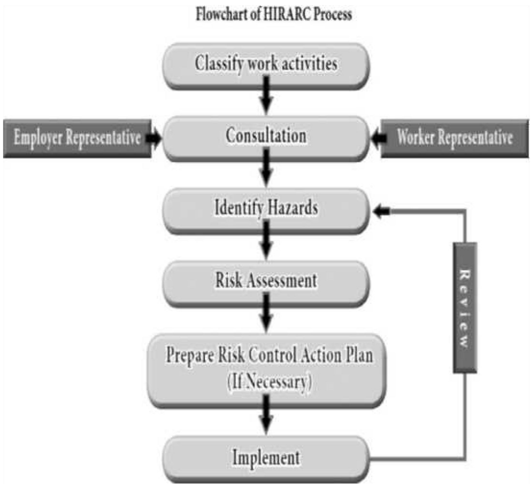

Fig. 1. *Hazard identification,* ***risk assessment and risk control model.*** **Source:** ***Department of Occupational Safety and Health Malaysia (2008)***

equipment (McManus, 2011). According to Lamark et al. (1998) the following types of failure, not ranked in order, which can cause costly damage and power outages are responsible for the most frequent losses in hydroelectric power plants:

- Failure in the stator winding of the generator.
- Failure in switch control room and set of electrical tracks and cable fire.
- Failure in control equipment.
- Disappearance of auxiliary and power supply.
- Failure in transformers.

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- Cracks and breakage in shovels and other turbine failures.
- Failure in bearings with lubrication and cooling systems
- Flooding of machine hall and other room for machinery equipment, and
- Fire in the machine hall or other engine rooms.

Therefore, in parliamentary procedure to insure the safety of hydroelectric power plant operations, maintenance and supervision programs should be included in the safety and health management programs.These should let in a schedule for essential upgrading as well as renewal of plant equipment.This is critical for cost efficiency, safety and to avoid material damage and equipment failure.In unmanned stations which are common today, evaluations are generally taken out according to schedule, hence putting a higher requirement on the reliability of control and safety bars.Early automatic detection of some incidents such as flooding is really difficult in unmanned facilities.Table 1, indicates a risk exposure matrix for a hydroelectric power plant (Lamarck et al., 1998). Smith (2000) explained that ongoing risk monitoring and efficient control measures are indispensable for insuring a continuous improvement process in occupational safety and wellness.

Although, data on safety and health in hydroelectric power stations are highly specialized and focused, information from diverse disciplines with actual and potential applications to causal modeling for the HIRARC model was reviewed. In this study the HIRARC model proposed by the National Institute of Occupational Safety and Health (NIOSH) of Malaysia was used to look into the safety and health in the study hydroelectric power generation plant, in Cameron Highlands, Malaysia.

WORK OPERATIONS

The power station

According to McManus (2011) a hydroelectric generating station has a dam that traps a great quantity of water, a spillway for controlled discharge of surplus water and a ball of fire. The powerhouse contains channels guiding water through turbines that convert the linear water flow into a rotating flow. Since the turbine and generator are connected together, the rotating turbine causes the generator rotor to revolve.The electric power voltage of urine current is connected to water mass, the fall height and gravitational acceleration.The mass depends on the quantity of water available and its pace of stream.The power station design determines the height of the water. The majority of designs takes in water from the upper side of the dam to release it at the base into an existing downstream river bed. This optimizes height while ensuring controlled water flow.

Table 1 ***The risk exposures for a hydroelectric power plant.*** **Source:** ***Lamark et al. (1998).***

Item/peril	Fire	Frequency, machinery, breakdown	Natural perils	Consequence
Dams	-	Low	Low	Large
Water ways	-	Low, low, medium	Low	Medium
Valves	-	Low, low, medium	Low	Medium
Turbine	Low	Medium,	Low	Large
Generator	Low	High	Low	Large
Transformer	Low	High	Low	Medium
Switchgear	Low	Medium	Low	Small
Lines	Low	Medium	Low	Medium

The power generation hall and switchyard

Most generating stations now have vertically aligned turbo generators. These structures rise above the main level of the power stations.The mass of the structure, such as the generator pit, the turbine pit, breathing in and discharge tubes is found below the visible main floor. In older stations, turbo generators are horizontally aligned (McManus, 2011). The turbine shaft protrudes into the powerhouse from a wall, where it connects to the generator or huge electric motor. The rotor motion and the magnetic field present in the rotor windings induce an electromagnetic field in the stator windings. The magnetic field maintained in the generator rotor windings is powered by lead acid or nickel cadmium batteries.

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The electromagnetic field induced provides the electrical energy supply for the power grid. Electric voltage is the electrical pressure arising from the flowing water. The electricity flow can lead to electrical arcing in the exciter assembly of the rotor. This can produce ozone which may damage rubber in fire hoses and other sensitive materials. Very high flows and high potentials are created by hydroelectric power generators. Conductors from the generators join a unit transformer and subsequently connect to a power transformer for boosting the voltage and reducing the current for long distance delivery; low current minimizes heat related energy loss during transmission. Some systems use sulphur hexafluoride gas instead of conventional oils as insulators. Breakdown products of electrical arcing can be more dangerous than sulphur hexafluo-ride (McManus, 2011).

HIRARC MODEL

Hazards Identification

Presently it is apparent that operational safety receives more care in contrast to design safety.In the light of this, a number of potential hazards have been placed in power generation plants of hydroelectric power stations.The unexpected release of hazardous energy, flammable and explosive atmosphere, oil-filled transformers, insufficient oxygen, air pollution (toxic chemical material, toxic gas) and chemical reaction leading to oxygen deficiency, electrical cables and switchgear, cooling system and large quantities of combustible hydraulic oil are part of the risks identified.There are also numerous areas related to risk such as heat injury, poor visualization, noise pollution, physical barriers or movement limitations (ergonomics) as comfortably as other unsafe conditions like electrical hazards, spills and mechanical hazards related to the equipment.

In this study hazard identification is concerned to the identifying of undesired events leading to hazard materialization and the mechanism of their happening.Various techniques were employed to conduct hazard identified in the subject region. These were dependant on the size of the power plant. The following methods were used to ascertain the hazards at any particular area:

- Hazard identification checklist.
- Workplace inspection (observation and interview).
- Task safety analysis or job hazard analysis.
- Accident and incident investigations.

This clause is based on site visits to the power generation plant in Cameron Highlands, with a view to map the process flow of the dam and particularly the power generation plant, interview data from employees, safety officers and senior managers and checking the plant previous accident/incident documents.It is significant to have opinion and feedback from different points in the organization regarding to hazards and hazards in the workplace environment.A standard checklist was modified according to study area with experts and used to key out the hazards, the purpose of using hazard identification checklist in this study was to list all anticipated and unexpected hazards to navigate and better realize the peril.The hazard identification checklist was mainly directed at assessing every parameter involved in the hazard identification process in the taxonomic recognition of hazards, to critique the effectiveness of safety measures selected and, where required, to carry out the safety standards to reach a tolerable residual risk.This study concentrated on some main aspects such as chemical, physical, electrical, ergonomical and biological hazards, while the hazards were identified in study plant by (standard checklist, interview, job safety analysis and plant accident/incident documents).

Hazard identification checklist has been consisted of seven main items to insure every aspect of hazards that mentioned above: Hazard chemical exposure, Electrical, Mechanical, Ergonomic, Biology and Method of control. Follow hazard identification checklist, general workplace inspection checklist has been applied with fourteen main factors as follows: Worksite general, Training, Work processes, Record keeping, Fire emergency procedures, Means of exit, Lighting, Machine guards, Tools and machinery, Confine spaces, Housekeeping, Sound level/ Noise, Employee facilities, Personal protective equipment.

Interview questionnaire has been applied to get some complimentary date about safety and better understanding of the hazard in the plant. Interview conducted to plant internal management, safety officer and shift supervisors. This interview questions adapted from (Cox, S. & Cox. T. 1996) with some modification according to the plant and study objectives, it has been included 6 items: Attitudes toward safety, Safety program, Attitudes toward the program, Incentives, Safety awareness/Training and Miscellaneous.

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Analyses of above factors were helped to identify hazards by separating the negative answers from the positive point of the checklists. Those negative points that observed considered as active hazards items in the selected plant, 27 different factors that mentioned above, including 258 questions were applied via checklists and interview, 41 negative answers were detected as active hazards items in plant. These items were applied for risk assessment.

Risk assessment

Risk assessment consists of a serial publication of procedures referred to risk analyses, assessment of the magnitude of risk, judgment on whether the risk is acceptable or unacceptable, and producing and assessing risk control options, to attain this end.So, later on the hazards in the system are identified, the probability of occurrence and magnitude of impairment is determined, the hazard is estimated, and hazard control options are judged based on the answers.Risk assessment takes on an significant part in the decisions made by an arrangement in order carry out safety and health policies in a rational manner (Nippon Kaiji Kyokai, 2009).Fig. 2, illustrates the risk assessment procedure for a facility.

Risk measures the likelihood and severity of the accident/event sequences in order to gauge the magnitude and to prioritize identified hazards. Risk assessment can be done by quantitative, qualitative, or semi quantitative approaches. This study consisted of a mixture of the three methods in order to ensure completeness. Lik-ert (1932) proposed a summated scale for the assessment of survey respondent's attitudes. Individual items in Likert's sample scale had five response alternatives: Strongly approve, Approve, Undecided, Disapprove, and Strongly disapprove. Likert noted that descriptors could be anything. It is not necessary to have negative and positive responses. He implies that the number of alternatives is too subject to manipulation. Indeed, in contemporary work many classifications are used besides the traditional five point classifications (Clason and Dormody, 1994).

In this study the assessment of likelihood in the plant was based on supervisor and worker experience, analysis or measurement. Likelihood levels ranged from "most likely" to "inconceivable". Table 2, elaborates different ranges of likelihood with their rating.

Severity is generally divided into five categories. It is based on an increasing level of injury to an individual's health, the environment, or to property. Table 3, shows the rating of severities. The likelihood and severity of forty-one hazard items evaluated by Tables 2 and 3 respectively. In this step qualitative data were converted toquantitative data. The rates were given to hazards followed the guideline of DOSH Malaysia 2008. One of the most common risk assessment instruments to measure risk is a risk matrix ranking, which includes consequence, likelihood and severity axis, then the combination of these parameters gives us an estimate of risk or risk ranking (see Table 4).
Risk is calculated as follows:

$L \times S$ = Relative risk
L = Likelihood
S = Severity

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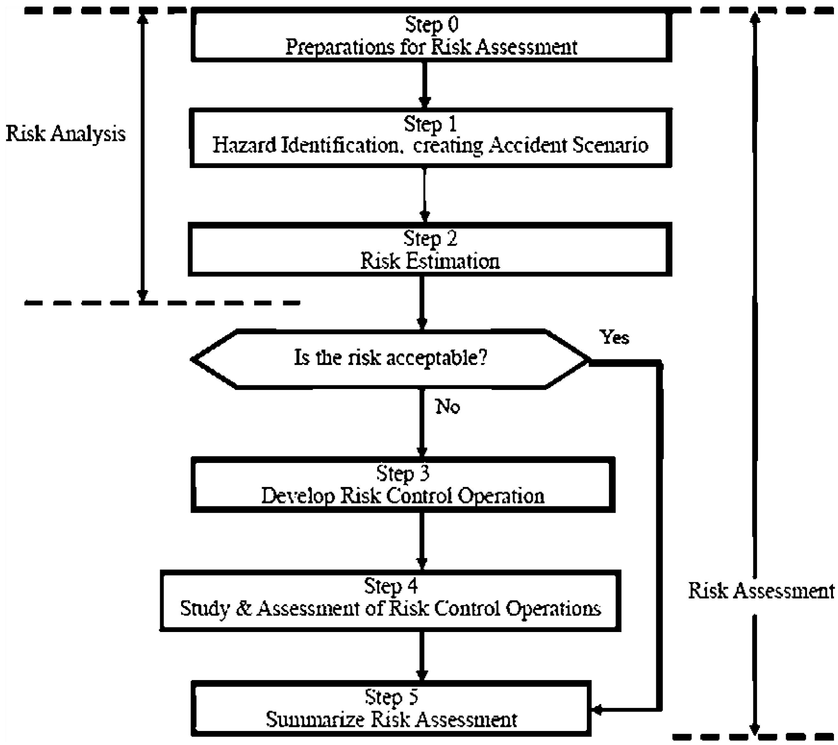

Fig. 2. ***General flow of risk assessment.*** **Source:** ***Nippon KaijiKyokai (2009).***

Controls

In this study control measures were seen with regard to the source of the peril and the application of engineering controls, administrative controls, and personal protective equipment.The restraints which were employed to verify and regulate hazards were taken out by conducting a parallel experiment or by comparing with standards in order to lose weight or prevent risks.

RESULTS

The information gathered from the study power generation plant was based on walk through surveys, interview, hazard checklist, accident and job hazard analysis.A Total of forty-one important hazards were identified with the operations which were evaluated by a checklist analysis technique.Table 5 shows, framework of HIRARC in the study hydroelectric power station.

The consequences of forty-one important hazards with the degree of risks were presented in Table 6 as below.

Based on identifying parameters, the answers were classified into three stages with three degrees of risks followed by the methodology of risk assessment. Risk assessment is presented in percentage of number of items as shown in Fig. 3.

Table 2 Likelihood values in hazard identification. Source: Department of Occupational Safety and Health Malaysia (2008).

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 sometime in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

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Table 3 Indicates severity in hazard identification. Source: Department of Occupational Safety and Health

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

Malaysia (2008).

Table 4 ***Example of risk matrix to identify the risk value.*** **Source:** ***Department of Occupational Safety and Health Malaysia (2008)***.

	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

High Medium Low

Table 5 Framework of (HIRARC) in the study hydroelectric power station.

Activities	Hazard identification			Risk assessment		
	Hazard	Consequences	Risk control	*L*	*S*	*R*
Measuring and changing chemical component in transformer and cooling system	Chemical oil exposure	Inhalation and skin irritation	PPE with providing respiratory system, clothes and gloves	2	3	6(*M*)
Running of cooling system and oil supply tank	Leaking of lubrication and oil supply in cooling system	Environmental pollution, water contamination	Engineering control with high maintenance	4	4	16(H)
Crane operating with carrying loads over employees and system	Failing the heavy items	Body injury and damaging the equipment	PPE with wearing the safety boots and hat, AD control with giving the proper instruction to crane operator and workers, and checking the crane frequently. Engineering control with designing safety guard for equipment	1	4	4(*L*)
Using hand tools or hand parts or objects with employees, (gripping, pulling...)	Ergonomic hazard by extra forces with their hand and body	Hand sprained and body cramp, hand injury and twisting	AD control with giving announcement to workers and applying machine to settle work, PPE with offering gloves	3	3	9(*M*)
Influence of sediment in operating system specially cooling system and turbine	Blocking and damaging the cooling system and its filter, damage turbine propeller, stuck sediment in pipe and draft tube	Increasing maintenance cost, flashback of water and sinking the equipment	Administrative control by controlling the amount of sediment, Engineering control with keeping the system in high maintenance	3	3	6(*M*)

L = Likelihood, *S* = Severity, *R* = Risk.

The main hazards at the marked hydroelectric power station were identified as chemical, physical, electrical, biological and ergonomic. The outcomes are sorted based on five items and presented in percentage of the number of items (Fig.4) The bar chart indicates that physical hazards at 36.58% are the primary reason of

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hazards, followed by biological hazards at 21.96% as well as chemical and ergonomic hazards constituting 17.07% and 14.63% respectively.Electrical hazards at 9.76% constituted the lower limit.

Fig. 3 shows 66% of total risk rel3 shows 66% of total risk relevant to low level of risk in addition, 32% of that total risk is considered as medium risk as well as 2% of high tier of risk which is a minimal percentage of total risk in the work region.as been collected from the study hydroelectric power station and risk matrix ranking, the result of classified risk levels for each specific hazard of risk assessment are as below.

	Hazards	Risk
1.	Chemical oil exposure due to measuring and changing chemical component in transformer and cooling system	6(M)
2.	Failing of the ventilation system at underground power station	4(L)
3.	Mishandling of auxiliary equipment by employees	2(L)
4.	Exposure to asbestos and chemical component	4(L)
5.	Leaking of lubrication and oil supply in cooling system	16*(H)*
6.	Contact directly or indirectly with parts which have become live under faulty condition	10*(M)*
7.	Thermal radiation (heat) or the projection of molten particles	4*(L)*
8.	Failing of bushing due to partial discharge degradation in insulation under high voltage stress	6*(M)*
9.	Create hazard due to not cutting off the power supply in the event of overloading and short circuit	6*(M)*
10.	High voltage electricity and it radiation at switchyard and surrounding area	4*(L)*
11.	Crane operating and failing the heavy items	4*(L)*
12.	Drowning, falling due to fixing and maintenance of draft tube	4*(L)*
13.	Collapsing and blocking cause by swelling clay, ageing, land slide or water pressure	5*(M)*
14.	Breaking or cavitation on turbine shaft, shovels or propellers	2*(L)*
15.	Failing of rotor caused by short circuit, increasing the temperature by failing of cooling system and overloading	6*(M)*
16.	Ergonomic hazard by extra forces with hand and body (gripping, pulling...)	9*(M)*
17.	Lifting and carrying of semi or heavy items, goods weight and Ergonomic hazard by musculoskeletal	12*(M)*
18.	Oxygen deficiency by working in confined space	4*(L)*
19.	Discharging heat air into the power house and make biological heat hazard	2*(L)*
20.	Noise pollution and vibration by running the whole system	2*(L)*
21.	Physiological and psychological stresses due to Employee activities such as working position and working schedule	6*(M)*
22.	Biological hazard by entering birds and animals, accumulation of conductive dust at underground power house access tunnel and power house hall	8*(M)*
23.	Influence of sediment in operating system, blocking and damaging the cooling system and its filter, damage turbine propeller, stuck sediment in pipe and draft tube	6*(M)*
24.	Workers falling down due to climbing up from crane stairs in power station	6*(M)*
25.	Body injury due to slippery and wet floor cause by lubrication, grease and water	6*(M)*
26.	Fall in grease tank by greasing over crane	3*(L)*
27.	Slippery and fall down due to greasing the crane sling wire	2*(L)*
28.	Grease and oil splashing due to fixing the cranes, turbines and cooling systems	2*(L)*
29.	Trapped during the drum rotating while greasing the crane sling wire	3*(L)*
30.	Mixing the sludge, water with chemical component due to flushing cooling system	4*(L)*
31.	Physical hazard with liberated water compressed caused by flushing cooling system	4*(L)*
32.	Physical hazard by using ladder and falling due to opening and closing valve	4*(L)*
33.	Ergonomic hazard with working in high place without good condition and fall	4*(L)*

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34.	Biological hazard due to using chemical cleaner to mopping the floor at underground hall	4*(L)*
35.	Ergonomic hazard associated with standing in the work area for a long time for measuring and mixing chemical material in transformer and cooling System	2*(L)*
36.	Physical hazard with mixture splashing and spilling chemical material that cause slippery floor	2*(L)*
37.	Mixture spilling and contact online life due to shifting chemical material into the injection container	2*(L)*
38.	Ergonomic hazard by downloading and lifting the stack	4*(L)*
39.	Physical hazard by falling goods on leg and hand injury	3*(L)*
40.	Ergonomic hazard with getting involved of Installing and cleaning air hoses at underground power station	4*(L)*
41.	Chemical hazard due to storage of hazardous waste (lubricating, wire and etc.)	2*(L)*

According to Fig. 5, the result of classified r5, the result of classified risk levels for each specific hazard in the purpose hydroelectric power generation plant indicates 73.34% lower risk, 26.66% medium risk and no high risk from the total 36.58% of physical risk, chemical hazard with 17.07% of total hazard and 71.42% of this measure of jeopardy is in low risk condition, 14.29% go to medium risk and 14.29% of high risk, is one of the main important hazard in purpose study area.te 9.76% of total hazards presented as a lowest hazard in study hydroelectric power plant including 25% of low risk, 75% of medium risk and 0% of high risk in the system; 21.96% of biological hazard with 66.67% of low risk, 33.33% of medium risk and 0% of high risk was identified and finally ergo-nomic hazard with 66.67% of low risk, 33.33% of medium risk and no high risk from the total 14.63% of hazard. Generally above data present all hazards and their classified levels of dangers in the present field of hydroelectric Power generation Plant.

Table 6 Results of forty-one important hazards with the level of risks.

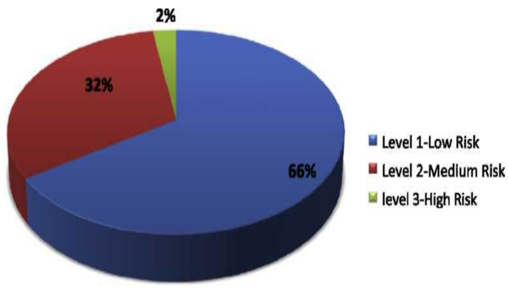

Fig. 3. Percentage of risk levels in the study powe

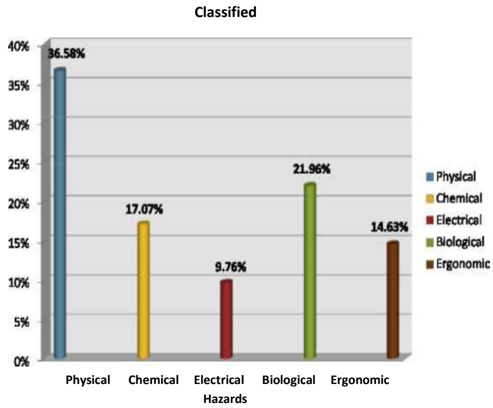

Fig. 4. Percentage of main classified hazards in

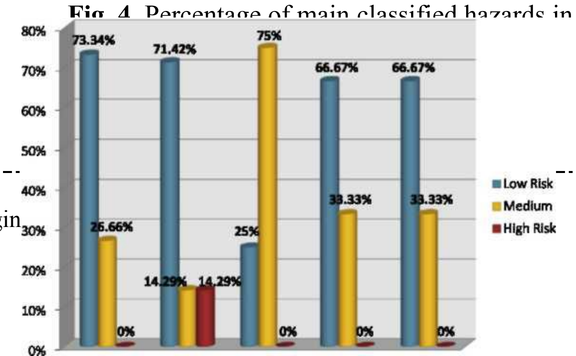

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Fig. 5. Three risk levels for five main hazards in the study hydroelectric power generation plant.

17.07% of total hazard and 71.42% of this measure of jeopardy is in low risk condition, 14.29% go to medium risk and 14.29% of high risk, is one of the main important hazard in purpose study area.The electrical hazard allocates 9.76% of total hazards presented as a low hazard in study hydroelectric power plant, including 25% of low risk, 75% of medium risk and 0% of high risk in the system; 21.96% of biological hazard with 66.67% of low risk, 33.33% of medium risk and 0% of high risk was placed and finally ergonomic hazard with 66.67% of low risk, 33.33% of medium risk and no high risk from the total 14.63% of the risk.Generally above data present all hazards and their classified levels of dangers in the present field of hydroelectric Power generation Plant.

DISCUSSION

Established on the survey, the markers hydroelectric power generation Plant currently has an acceptable safety policy.Staying secure at work means understanding hazards such as mechanical equipment, extreme noise, or hazardous chemicals that are inherent in hydroelectric power generation plants.Still, others may be due to human error, structural failures, equipment or machinery failure and misuse, power system failure or chemical spills.

The primary purpose of the department of safety and health at study hydroelectric Power generation Plant is to insure the safety and health of employees, work in process and equipment. This is in line with the regulatory requirements set out by OSHA and Tenaga Nasional Berhad (TNB). The aim of the risk control in aimed hydroelectric power generation plant is to insure that risk control methods and natural processes are taken according to the safety plan, in a systematic way in order to cut down the risk of residual impact on the environment, equipment and employees.

According to McManus (2011), most of the controls in hydroelectric power plants focus on Personal Protective Equipment, Engineering and administrative commands.For example, oil and lubricants are the chemical factors that can cause chemical hazards with direct and indirect impact on workers. Noise pollution is a common cause of concern in the generator hall. This may be due to steady-state noise from generators and other relevant auxiliary equipment. Therefore, applying noise control technology by controlling the interference floor is imperative in the flora.

Other aspects of plant safety include battery explosion caused by an electrical short circuit. At the study plant this is mitigated by engineering controls by means of making shields to the battery terminals and insulated conductors to make suitable barriers. Administrative controls are instituted in relevant places in the plant. These are implemented mainly to create awareness in workers on safety and to prepare employees for medical surveillance (McManus, 2011).

In line with the HIRARC model stipulated by the Department of Occupational Safety and Health (DOSH) of the Ministry of Human Resource of Malaysia and Act 514 Occupational Safety and Health Act 1994, the marked hydroelectric power generation plant is in compliance with the existing regulatory requirements having an overall risk level of only 2% in the power generation plant which constitutes a minimum level with regards to safety. This may go up to a maximum of 66% which is regarded as manageable in such a situation.

According to Lamarck et al. (1998) most hydroelectric pow(1998) most hydroelectric power generation plants have similar hazards which can lead to more or less costly price.nerator's stator winding which depends on the machine age, type of installation, rated voltage, design, running conditions and maintenance. Yet, according to the data collected at study power station this problem was not evident in all likelihood due to regular care and command of the stator wings which may have brought down the possibility of occurrence and damage.The other

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most common important hazards in most hydroelectric power plants are a loser in the switch control room and control equipment of the power generation plant, where the primary electrical system from the generating unit with the transformer and external grid is extremely vulnerable to short-circuit in large plants.

Electrical arc short circuits may also cause substance damage and the survey conducted at study plant was not exempted from this. This may be attributed to not cutting off the power supply in the case of overloading leading to short circuit which may damage the transformer, bushing and wires leading to electrical shock risks. This was addressed by the safety department, which applied Engineering controls by providing regular maintenance, checking the system, increasing awareness and providing information to employees in order to prevent such hazards.

The American Society of Civil Engineers Hydropower Task Committee (2007) explained that oil contamination and emergency access as other main important hazards that can create risk in every hydroelectric power generation plant. Most hydroelectric plants face oil and lubrication contamination in the system. Nevertheless, at the study plant the problem was linked up with leaking of lubricants and oil in the cooling system which sometimes got through into the transformer section and the stirring of chemicals into the injection container caused environmental pollution, water pollution and chemical risks.Nevertheless, at the study plant, the management, as well as, the safety committee followed the OSHA standards by offering regular maintenance of machinery and monthly inspection in order to thin out the hazard and keep it at an satisfactory degree.

The study indicated that it is significant to take in a well-established maintenance and oversight program in order to assure the safety and health in hydroelectric power stations.Modern power plant control and automation systems give optimized mechanical and electrical support in terms of planning, operations and maintenance for new projects as easily as for renovating substations (Brauner, 1995). Very old stations may experience frequent breakdowns in the system. Therefore it may be necessary to renovate such plants and to furnish replacement components in society to ensure strength and productivity.

CONCLUSION

In conclusion, marked hydroelectric power generation plant is totally committed to safety and health, which is reflected in their certifications, namely MS 1722:2005, OHSAS 18001, MS ISO 14001:2004 and MS ISO 9001:2000. With these accreditations, the management at the power station hopes to preserve a high quality of standard in its operations in order to offer a secure operating environment.

In study plant waste management is carried out following the Scheduled Waste Regulation 2005 under the Environmental Quality Act 1974 for hazardous and non-hazardous wastes.HIRARC is reviewed and updated annually during the document review in order to assure the strength of the OH&S Management system.

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