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Hazards and Risks Identification in Shipbuilding Industry- A Case Study.

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Abstract

Shipbuilding industry is one of the oldest and the heaviest production industries all over the world. There are several production processes here which result in hazardous waste and pollutants to the environmental safety and health. With over many shipyards, Khulna Shipyard is one of the ship construction and repair yard in Bangladesh renowned as a heavy industrial zone. Production processes are variable and complicated. Different hazards that occur in shipbuilding industries are identified here and risk evaluation is done in structured and systematic way in order to prioritize decisions to reduce risks to a tolerable level. During this study, all processes are investigated in detail and all wastes and residues are described with effects to workers health and safety. This paper includes the identification of potential hazards in the shipbuilding industry (Khulna Shipyard Limited) using the hazard evaluation checklist, determining the risks, preparing hazard evaluation worksheet and deciding corrective actions.

Keywords: hazard evaluation checklist, hazard evaluation worksheet, risk calculator, workers, safety issue..

1. Introduction

Bangladesh has been since 2005 building and exporting ships to owners from Denmark, Mozambique, Germany, The Netherlands and Finland. In September 2008 Bangladesh has been declared as a shipbuilding nation of international standards. Bangladesh is presently contributing to the shipbuilding industries globally through its exported workforce. There are almost 17 shipyards in BANGLADESH. There is a major manpower requirement to process production in shipyard industry under hard working conditions with hazardous material. Most of the processes such as welding, painting, blasting, fiberglass production has direct effect on workers health, i.e. exposure to volatile organic compounds (VOCs), fumes resulting from burning through base metal and from burning the interior and exterior coatings, as well as a significant generation of NOx gases during welding and cutting processes that are often left in place can cause acute and chronic health problems**.**
Production processes of shipyards may be discussed in two main categories: New shipbuilding and ship repair industry. Production methods of these two divisions are similar. Most of them are risky and potentially hazardous..
Shipyard workers tend to be those working in some of the most risky working environments. This not only adds to the problems of their job but actually makes it a work profile full of need for constant caution. Working as a ship yard worker is not as simple or easy as it may seem. Here are with the help of hazard identification checklist, the different types of hazards are identified. Then preparing hazard evaluation worksheet these hazards with respective risk levels and required measures are shown. The risk calculator for each risk was prepared also.

2. Research methodology

A descriptive type investigation was accomplished in a systematic manner on the workers of KHULNA shipyard, Khulna, Bangladesh. In this study, different variables such as age, skill, job type, injury in different body parts, agent of accidents and types of hazards were taken into consideration. Some focus group discussions also arranged to cross-check the information collected through prescribed questionnaires. The details steps of the methodology to accomplish the objectives of the study are stated in the followings:

2.1 Selection of Sample

For the study, it is tried to cover all the active yards of Khulna shipyard. However, due to variation of active yard number and the availability of the different types of employee in the yard, 5 were covered. From each yard 10 categories of employees (generally Ship In In-charge, Yard Supervisor, Forman, Cutter, Fitter, Cutter Helper,

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Fitter Helper, Wire group personnel, Loader and Cleaner are the common categories of work force pattern in each yards) interviewed.

2.2 Sampling Technique

Sample selected in such a way that collected data fulfill the objectives of the study. As the total number of sample were not so big, but considering the limitations and scope of the study, efforts, availability of concurrence for providing information, purposive sampling technique were used in this study.

2.3 Period of Research

Ship building in Bangladesh is not a continuous business & depends on the availability of ship in the yard. The research work was conducted in the field from October-December, 2012 for data collection.

2.4 Research Instruments

In order to collect information, a preliminary questionnaire was prepared keeping the objectives of the study in mind. After a primary visit and informal discussion with some management staffs and workers in order to develop a format with variables of interest, the preliminary questionnaire was modified and finalized.

2.5Procedure of Data Collection:

Data for this study were collected from the respondents through interviews and were made individually in the ship breaking yard during their work and leisure time with the permission of the yard management as well as contractor management.

2.6Techniques of Data Analysis:

Based on the prepared questionnaire, data on the variables were collected and the information were summarized and finally analyzed in accordance with the objectives of the study to identify various hazards, their sources and relative consequences and risk levels.

2.7Interpretation of the Results:

On the basis of the results, interpretations and necessary recommendations were made for the betterment of this sector in terms of both safety and policy issues at the field level.

3. DATA ANALYSIS

In total 100 workers (25 High-skilled, 11 skilled, 38 semi-skilled and 26 un-skilled) were interviewed. After completion of these data, these are feed into tabular format/figures and then analysis is done in the following subsections.

3.1 Identifying hazards with hazard identification checklist

In this paper hazards are identified from gathered data and summarized in a checklist with their respective sources and exposure. The main hazards of Khulna Shipyard is identified and shown below in the checklist.

Hazard Identification Check-list:

Types of Hazards	Source	Task involved (Who is exposed and when?)
1. Working Conditions	1.1.Cramped spaces for working 1.2.Lack of comfortable environment 1.3.Excessive source of falls 1.4.Dull and dirty work area	Most of the workers working on the shipyard
2.Mechanical Hazard 2.1 Crushing 2.2 Knock with metal parts 2.3 being caught in machine 2.4 Injury due to Automatic machine startup 2.5 Fire	2.1 Crushing in metal cutting machine 2.2 unprotected prolonged machine part / tool 2.3 Unprotected and automatic start of machine 2.4 Automatic start of machine 2.5 Unauthorized use of lubricants	1. concerned worker 2. anyone going through the work area or in work 3. worker and anyone going through the work area 4. worker and anyone going through the work area 5. Concerned worker and surrounding area.
3.Physical Hazards: 1.1 Physical injury to limbs 1.2 suffocation, asphyxiation, pressure 1.3 Hearing problem	1.1.Cramped spaces 1.2.Cramped spaces 1.3 -Working near abrasive blasting or jack hammering operations -Heavy equipment or machinery	People working in the shipyard and all concerned near the source of hazard.

(eardrum rupture etc.) 1.4 Extreme temperatures 1.5 Vibration 1.6 Radiation	-Fuel-powered hand tools and power actuated tools -Compressed air 1.4 -Slag, weld splatter, or sparks -Combustible material closer than thirty-five feet (10.7 m) to the hot work 1.5 -Heavy equipment or machinery -power actuated tools 1.6 -x-ray machines and radioactive sources (radiography) used to test pipe welds, bore-holes	
4.Chemical Hazards: 4.1Asbestos fibers, dusts 4.2 Heavy and toxic metals (lead, mercury, cadmium, copper, zinc, etc.) 4.3Welding fumes 4.4Inhalation in confined and d spaces	4.1 & 4.2 - Materials of broken ships. -Fuel oil and Lubricants -Heavy metals like Tin, Lead and chemical constituents of paints and coatings. -Remnants of toxic chemicals in cargo compartment of chemical carriers. Bilge and ballast water 4.3Oil sludge in oil tankers and oil/bulk ore carrier 4.4Solid waste viz. hydrated/solidified cement	The people at working with chemicals, broken ships, and other relevant sources as well as other people not in direct contact with these sources.
5.Biological hazards: 5.1Toxic marine organism 5.2Risk of infectious diseases 5.3Risk of diseases transmitted by pests, rodents, insects and other animals	-Animal guts: fatal contamination -Soil and water contaminated by non-treated manure -Human contamination due to poor personal hygiene -Bacteria, Virus, Parasites	Almost all people of shipyard and surrounding area.
6.Timing Problem (causing fatigue & mental disruption)	6.1.No fixed timing with extreme nature of job 6.2.Erratic time schedule 6.3. Prolonged working hours without rest.	Workers are the actual sufferers.
7. Slips, falls and trips 7.1 fall from several feet 7.2Slipping 7.3.just fall 7.4. Multiple fractures 7.5.head injuries 7.6 traumatic experiences 7.7.amputations 7.8. drowning	7.1 –unconsciousness -misalignment of lifting equipments and tools - lack of PPE 7.2 -lubricants , oils, and other slippery substances -unconsciousness -work area kept unclean 7.3 - Improper orientation of work area. 7.4 All above 7.5 mainly lack of personal protective equipment. 7.6-7.8 Almost all of above points.	Workers on operation as well as people needs to pass through the work area.
8.Fires and explosions 8.1.Fire explosion 8.2.Electrical Explosion 8.3.Short circuits 8.4.Electric shocks	8.1 - Generating excessive heat near lubricant or flammable materials. -naked flames -lack of sufficient fire extinguisher.	Workers working close to fire and electricity.

8.5.Burns	-Lack of maintenance. 8.2 - Improper maintenance of electrical machinery. - Excessive heat generation 8.3 - Improper circuit design & maintenance. 8.4 - unconsciousness - placing conducting materials near the electricity driven machines & circuits - lack of PPE 8.5- exposure to fire/ flame/ electric shocks.	
9.Asbestosis and Mesothelioma 9.1.Asbestosis 9.2.Mesothelioma 9.3.Cancer	-construction material, exposure to asbestos, Mesothelioma causing cancer	Almost all persons of shipyard especially workers.(long term effect)
10. Improper knowledge 10.1. Unawareness of law 10.2. Safety measures 10.3. PPE	10.1. Unawareness of working procedure & safety law 10.2. Safety measures 10.3. Not using PPE	Workers of shipyard.

3.2 Hazard Evaluation Worksheet preparation

After the hazards and relative sources being identified, their consequences (both existing and potential), frequencies and risk levels were identified based on the consequence analysis technique. In this technique, hazard category is grouped as insignificant, minor, major, severe, fatality and multi-fatalities depending on consequences. Risk is also grouped as risk level A (Multi-fatalities, fatality, severe), B (Severe, major, minor) and C(Insignificant, minor consequences). The necessary tables & hazard evaluation worksheet is shown below.

Table 2: Category of consequences

Category	Description	Examples
I	Insignificant	Bruising, Light abrasion etc
II	Minor	'First aid' (normally reversible)
III	Major	Loss of consciousness, burns etc.(3 days off work)
IV	Severe	Serious injury/damage to health(normally reversible)
V	Fatality	Permanent disability ,Loss of sight, amputation, respiratory damage etc (not reversible)
VI	Multi-fatality	To include delayed effects, catastrophic

Table 3: Risk level

Risk Level	
A	Unacceptable risk and cannot be justified on any ground
B	Risk level reduced to ALARP
C	Risk level is broadly acceptable & no further precautions necessary

Table 4: Hazard analysis study reference/ worksheet

HAZARD ANALYSIS STUDY REFERENCE/ WORKSHEET						
Activity no	**Hazardous events**	**Possible causes**	**Consequences**	**Risk level**	**Frequency**	**Control Measures**
1	Poor working conditions.	1.Cramped spaces for working 2. Lack of comfortable environment 3. Fumes from residual materials in tanks	1. damage to physical and mental health 2. discomfort leads to injury 3. can create both health and fire hazards.(major) 4.Falls and slips	**A** **A** B	1 in 10	1.Ventilation in confined spaces must be supplied mechanically 2. supplied-air respirators must be used

		4.Excessive source of falls 5. Dull and dirty work area 6. extreme concentrations of fibers	5. Long term diseases.	B B		
2	Crushing in metal cutting machine	1.Poor Machine tool condition 2. unsafe clamping of machine parts 3. Problem in electric circuit.	1.Serious crash 2.serious injury 3.damage to health	B B B	1 in 10	1.Routine check up of machines 2.Attention to circuits
3	Knock with metal parts	1.Unprotected machine part 2.Extra prolonged portion of machine 3. Lack of efficient storage of metal parts 4.inattention	1. first aid needed, light abrasion 2.lack of consciousness 3. first aid needed, light abrasion 4. first aid needed, light abrasion	B/C B B/C B/C	In 10	1. Be attentive 2. use safety sign 3. cover machine parts
4	Being caught in machine	1.Automatic start of machine 2.Inattention 3.using inappropriate cloth	1.catastrophic 2.serious injury 3.serious injury	A A/B A/B	1 in 1000	1.Be attentive 2. use safety sign 3. use proper clothing
5	Fire	1.sparks at metal contact 2.sparks in machine tool 3. faulty storage & Unauthorized use of lubricants	1.burns 2.burns 3.permanentdisability /catastrophic	B B A	1 in 100	1.be conscious in lubricating 2. lubricant storage should be far from workplace
6	Injury due to Automatic machine startup	1.Automatic start of machines 2.Lack of safety sign	1.Catastrophic 2.Catastrophic	A A	1 in 100	1.use safety sign 2.protect machine switches
7	Physical injury to limbs	1.Cramped spaces 2. Dangerous working environment	1.Permanent disability	A	1 in 10	1.Ventilation in confined spaces must be supplied mechanically 2. supplied-air respirators must be used
8	suffocation, asphyxiation, pressure	1.Cramped spaces 2.extreme concentrations of fibers 3.Welding in confined spaces can yield high concentrations of toxic airborne contaminants 4. Painting	1. permanent disability 2. Delayed effects	A A	1 in 10	1.potentially dangerous spaces must be tested, inspected, and determined as safe for entry by a marine chemist, industrial hygienist, or other qualified person

		operation generating toxic fumes				
9	Hearing problem (eardrum rupture etc.)	1.Working near abrasive blasting or jack hammering operations 2.Heavy equipment or machinery 3.Fuel-powered hand tools and power actuated tools 4.Compressed air	1.Permanent disability 2.Damage to health	A A	1 in 10	1.Proper protection in ear should be taken
10	Extreme temperatures	1. Slag, weld splatter, or sparks 2.Combustible material closer than thirty-five feet to the hot work 3. insufficient ventilation	1.Burns	B	1 in 10	1.Proper coolant , ventilation system should be used 2.Workplace should be organized in such a way that it should keep combustive material apart from heat generating sources
11	Vibration	1.Heavy equipment or machinery 2.power actuated tools	1.Loss of concentration	C	1 in 1000	1.Machinery should provided with proper maintenance 2.Hydraulic powered tools can be used
12	Radiation	1.x-ray machines and radioactive sources (radiography) used to test pipe welds, bore-holes 2.Toxic rays emitted during various operation	1. Permanent disability/ Irreversible disease 2.Include delayed effects	A A	1 in 100	1. Radiation affected areas should be kept apart from work areas. 2. Safety sign should be used. 3. PPE should be properly designed in case of those areas.
13	Asbestos fibers, dusts	1. Materials of broken ships. 2.Fuel oil and Lubricants 3. Heavy metals like Tin, Lead and chemical constituents of paints and coatings. 4. Remnants of toxic chemicals in cargo	1.All have catastrophic long term effects	A	1 in 100	1.potentially dangerous spaces must be tested, inspected, and determined as safe for entry by a marine chemist, industrial hygienist, or other qualified person 2.PPE must be worn

		compartment of chemical carriers. Bilge and ballast water				
14	Heavy and toxic metals (lead, mercury, cadmium, copper, zinc, etc.)	1. Materials of broken ships. 2.Fuel oil and Lubricants 3. Heavy metals like Tin, Lead and chemical constituents of paints and coatings. 4. Remnants of toxic chemicals in cargo compartment of chemical carriers. Bilge and ballast water	All have catastrophic long term effects	A	1 in 100	1.PPE must be worn 2.Proper ventilation should be provided
15	Welding fumes	1. Confined space 2.Oil sludge in oil tankers and oil/bulk ore carrier 3.toxic fume in welding where surfaces are coated with lead- and chromium-based finishes etc 4.fatal levels of nitrogen dioxide	All have catastrophic long term effects as well as permanent disability	A	1 in 1000	1.Ventilation in confined spaces must be supplied mechanically 2. supplied-air respirators must be used
16	Inhalation in confined and enclosed spaces	1.Solid waste viz. hydrated/solidified cement 2. welding & painting fumes 3. Asbestos	Loss of consciousness	B	1 in 10	1.Ventilation in confined spaces must be supplied mechanically 2. supplied-air respirators must be used
17	Toxic marine organism	1.Materials released during ship breaking 2. Asbestos & other marine particle	All have catastrophic long term effects as well as permanent disability	A	1 in 100	1. Affected areas should be kept apart from work areas. 2. Safety sign should be used. 3. PPE should be worn.
18	Risk of infectious diseases	-Animal guts: fatal contamination -Soil and water contaminated by non-treated manure -Human	Insignificant damage	C	1 in 1000	1. Proper measures should be taken to avoid contamination. 2. Workplace should be kept clean.

		contamination due to poor personal hygiene -Bacteria, Virus, Parasites				
19	Timing Problem causing fatigue & mental disruption	1.No fixed timing with extreme nature of job 2.Erratic time schedule 3. Prolonged working hours without rest.	Major & minor fatigue	B	1 in 10	1.A proper scheduling technique should be maintained and followed 2. Work should be properly/ equally delegated among workers.
20	Falls from several feet	1.Inattention 2.slippery passage 3.using improper /extra cloths 4. lack of safety sign 5.misalignment of lifting equipments and tools 6. lack of PPE	1.first aid needed 2. first aid needed, damage to health 3. first aid needed 4.first aid needed, permanent disability	B A/B B B/A	1 in 10	1.Be attentive 2. use safety sign 3. use proper clothing
21	Slipping	1.lubricants , oils, and other slippery substances 2.unconsciousness 3.work area kept unclean	first aid needed, permanent disability	B/A	1 in 10	1.Be attentive 2. use safety sign 3. keep workplace clean
22	just fall	Improper orientation of work area.	first aid needed, serious injury	A/B	1 in 10	1.Be attentive 2. use safety sign 3. use proper clothing
23	multiple fractures	All causes for slips and falls	Loss of limbs/ serious injury	A	1 in 10	1.Using PPE 2. Be attentive during work. 3. Keep extra workers. 4.provide appropriate training
24	head injuries	Mainly lack of personal protective equipment.	serious injury	A	1 in 100	1.Use Helmets 2.Using PPE 3.provide appropriate training
25	traumatic experiences	Almost all of above slips, falls and injury related causes	Delayed effects	A	1 in 100	All like 23
26	amputations	Almost all of above slips, falls and injury related causes	Delayed effects	A	1 in 100	All like 23
27	drowning	Almost all of above slips& falls	Catastrophe	A	1 in 100	1. Workplace should be kept

		related causes				clean. 2. Necessary boundaries and safety signs should be provided.
28	Fire explosion	1. Generating excessive heat near lubricant or flammable materials. 2.naked flames 3. Lack of sufficient fire extinguisher. 4. Lack of maintenance.	1.Burns 2.Death / catastrophe	B A	1 in 10 1 in 100	1. Keeping lubricant or flammable materials apart from excessive heat generating sources. 2.naked flames should be in secured place 3. Providing sufficient fire extinguisher. 4. Maintenance.
29	Electrical Explosion	1. Improper maintenance of electrical machinery. 2. Excessive heat generation	1.Burns/ shocks 2.Death / catastrophe	B A	1 in 100	1. Maintenance of circuits and electrical equipments. 2. Providing sufficient fire extinguisher. 3. using non conducting material in PPE 4.Skilled operator should only be allowed
30	Short circuits	Improper circuit design & maintenance.	1.Catastrophe	A	1 in 100	As 29
31	Electric shocks	1.lack of consciousness 2.placing conducting materials near the electricity driven machines & circuits 3. lack of PPE	1.Burns 2.Major & Minor shocks 3.Death	B B A	1 in 10 1 in 100	As 29
32	Burns	Exposure to fire/ flame/ electric shocks.	burns	B	1 in 10	As 28 & 29
33	Asbestosis, Mesothelioma & Cancer	-construction material, exposure to asbestos, Mesothelioma causing cancer	Permanent disability	A	1 in 100	1.PPE should be worn by all 2. PPE should be perfectly designed using proper material.
34	Unawareness of law	Unawareness of working procedure & safety law	Major , minor & severe losses	A/B	1 in 10	1.Introducing mandatory training courses on safety & respective rules

35	Lack of Safety measures	Lack of Safety measures of management	Major , minor & severe losses	A/B	1 in 10	1.Introducing safety measures in workplace strongly 2.Strenthening the safety management team
36	Not using PPE	Not using PPE	severe losses	A	1 in 10	1.Using sufficient amount of PPE 2.Following & impelling workers to follow safety laws

The risk levels given here were determined using RISK CALCULATOR concept. The risk level for activity 1 and activity 2 with their respective subcomponents are shown in different risk calculators below.

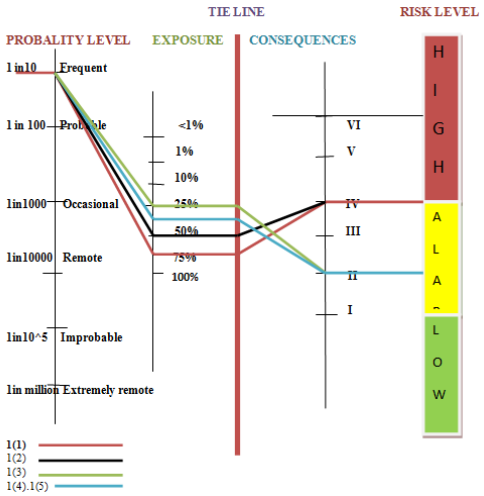

Fig 1: Risk calculator for hazard 1

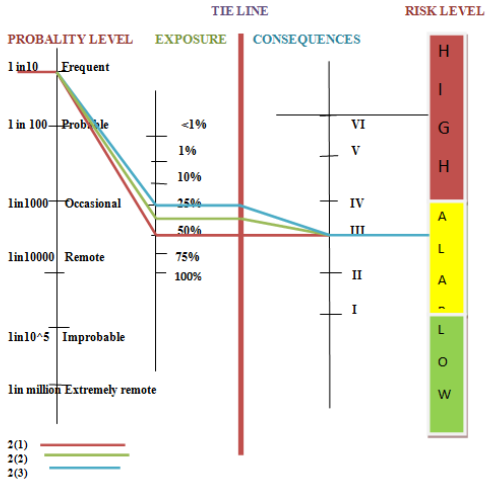

Fig 2: Risk calculator for Hazard 2

Where, respective numbering means-

1(1). Damage to physical and mental health
1(2). Discomfort leads to injury
1(3). Can create both health and fire hazards.(major)
1(4). Falls and slips
1(5). Long term diseases.

2(1).Serious crash
2(2). Serious injury
2(3).damage to health

By preparing such calculators for all hazardous events risk level is determined which is already shown in Table 4 in column no 5.

4.0 Risk reduction measures and Recommendations:

The accidents or hazardous events with their risk levels are shown in the topic above. Certain control measures are shown there also. These are some common measures that can easily be practiced and accident probability decreases. It is shown that almost all hazardous events possess high risk levels with a great frequency which is totally undesirable. By detailed analysis of risk preventive measures and from detailed discussion with qualified workers and management of Khulna shipyard it is found that almost 32% of them believe that the accidents can be minimized by ensuring the use of PPE, 27% mentioned awareness campaign on occupational safety and health issues. Training can play vital role to reduce accident expressed by the 24% respondents. Rest 8% do not have any idea about any measures to prevent or to minimize accident or may be they would not like to mention anything.

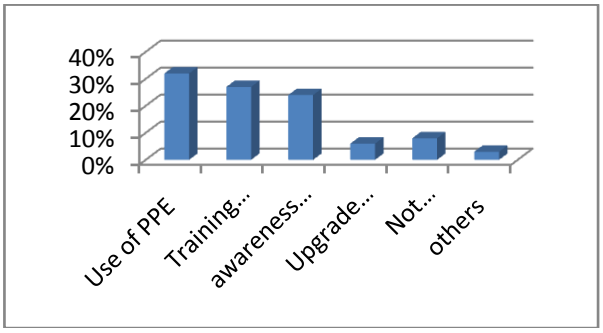

Fig3: Measures of hazard prevention (by interview and questionnaire)

Here the figure shows the percentage of people vote for suggestion along Y axis with respective preventive measure in along X axis.

Khulna Shipyard can follow some recommendations for decreasing their probability of hazardous events as well as risks. Some precautions are mandatory.

1. The first and foremost task is to implementing safety rules and conducting primary trainings to workers as well as all persons of shipyard.
2. Personal protective equipment should be provided and should be 'declared' as mandatory in workplace.
3. Safety sign is must in risky areas.
4. Means of escape should be kept clear at all times.
5. Roadways quays, yards where persons or vehicles move or are stationed should be so constructed and maintained as to be safe for the traffic that they have to carry.
6. A suitable housekeeping program as proper material handling and storage equipment, scrap removal etc. should be designed.
7. Necessary fences and guards should be provided where falls generally happen.
8. Sufficient secure storage areas should be provided for flammable liquids, solids and gases as LPG.
9. "No smoking" notices should be prominently displayed in all places containing readily combustive or flammable material.
10. Suitably protected electrical installations should be used.
11. Color codes and symbols may be used.
12. Unauthorized entry should be prevented.
13. OSHA safety rules should be followed.
14. Arrange the workplace layout to minimize noise exposure to workers.
15. If possible replace noisy parts with quieter alternatives.
16. Radiation exposed area should be detected and adequate protective equipment should be used.
17. Regular medical checkup to workers should be arranged.
18. Light should ensure safe working, prevent glare.

11 Background of the study

This job has been taken into account mainly considering the accidents involved in the Khulna Shipyard. Khulna shipyard is easily reachable for anyone resides in Khulna. As we all authors live in Khulna, it is much more convenient to us about studying it. Convenient related researches also made before by some members of IEM department on related topics which influenced us in proceeding our research work.

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