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HAZARD IDENTIFICATION AND RISK ASSESSMENT OF HOT WORK AREA AT SWARGATE UNDERGROUND METRO STATION SITE, PUNE.

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ABSTRACT:

Construction industry, often termed as 'high-risk', has a significant impact on the health and safety of the workers. Common causes of fires in different industries originate from a heat source and feeds of combustible materials i.e. hot work operations. The presented work was done in view of hazard identification and risk assessment of hot work operations like Arc Welding and Gas Cutting and examines some occupational health hazard and safety practices in construction industry. Hazard Identification and Risk Assessment is carried for identification of undesirable events that can leads to a hazard. The work reveals that Hazard Identification and Risk Assessment is the most effective tool to eliminate or minimize the Hazard. Additionally, individual experience of those working on construction sites, their educational background and knowledge of health and safety matters also influence health and safety risk management.

KEYWORDS: Hot Work, Arc Welding, Gas Cutting, Hazard Identification, Risk Assessment.

1. INTRODUCTION

1.1 Arc Welding and Gas Cutting:

Welding and cutting operations are frequently used in construction, demolition, repair and maintenance works. The equipment may be permanently installed or portable. Hazards of permanent installation can be minimized by safe design and therefore a fixed welding shop is more desirable than portable moving welding work. Where the work pieces are very heavy or not movable or at height or depth etc. portable equipment is the only convenient device.

Welding is a process to unite pieces of metal at joint faces by heat or pressure or both and sometimes use a filler material. Cutting is a process to remove the metal by the chemical reaction of the metal at high temperature. In both these operations, the common factor is high heat energy and high temperature for melting or fusing of metals.

The three common sources of heat are:

1. Flame produced by combustion of flue gas with air or oxygen (Gas Welding)
2. Electric arc, struck between an electrode and a work piece or between two electrodes (Electric or Arc Welding)
3. Electrical resistance offered to passage of current between two or more work pieces (Resistance welding including spot, steam, projection and butt welding).

Other processes are atomic hydrogen welding, electron beam welding, electro slag welding, flash welding, friction welding, laser welding and drilling, metal spraying, plasma arc welding, plasma arc spraying, tungsten arc cutting, spark erosion machining, stud welding and thermit welding.

1.2 Welding and Fire Safety:

Nearly six percent of all industrial fires are started because of unsupervised welding repair jobs without a permit-to-work system. Common Causes of Fires in Welding and Cutting Fire originates from a heat source and feeds of combustible materials. Welding operations produce sparks which can travel long distances, particularly if the welding torch is not adjusted properly. The hot slag of burning metals may drop down as globules which retain their heat for a very long period and can start a fire long after the welding job is completed. Similarly, application of heat during welding to a closed vessel, pipe or tank can result in an explosion if the vessel contains flammable liquids or gases. An empty vessel that had contained a flammable material is more dangerous than one fully filled with flammable material, because it may be full of invisible vapors.

It involves passage of very large quantities of current, often running into hundreds of amperes. The passage of electric current itself creates heat and therefore cables, junctions, switches and other electrical appliances must be of adequate current carrying/breaking capacity.

Precautions for Preventing Welding Fires:

(A) Before Welding and Cutting:

Work Permit: Make a thorough inspection of the workplace. Ensure that it is safe for welding operations. Issue a written permit as shown below for commencement of welding work, especially when contract workers are involved.

Permit for Cutting and Welding with Portable Gas or ARC Equipment

Date _____
Building _____
Department _____ Date _____
Place or Location _____
Work to be done _____
_____
Special Precautions _____
Is fire watch required?
The location where this work is to be done has been examined, necessary precautions taken, and permission is granted for this work.
Permit expire _____
Signed_____
(Individual responsible for authorizing welding and cutting)
Time started _____Completed _____

1. Check if the area contains flammable liquid/ gases. Ensure that there are no floor openings, open windows nearby or any such ready access through which sparks can pass and fall on combustible materials. (In one such case, flammable vapors on the ground floor 7 mt below, were ignited due to a welding spark fallen from that height and the welder died due to burn injury).
2. Examine whether the job can be welded outside the premises and brought back.
3. If not, remove all combustible materials to a safe distance of at least 20 feet.
4. Sweep the floor and the area nearby and remove all waste materials.
5. If any of the combustible materials cannot be removed, cover it with non-combustible coverings like metal sheets or asbestos curtains.
6. If the floor itself is combustible, cover it likewise and wet it before starting welding work.
7. In case welding or cutting has to be done on a vessel, pipe or other container which contains or had earlier contained flammable liquids, ensure that a detailed 'permit-to-work' procedure involving isolation, blanking, purging, inserting methods is followed. Consult the Indian Standard 3016 for additional details.

(B) During Welding and Cutting:

1. Use portable screens, booths or partitions to minimize the spread of sparks.
2. Keep an observer ready with a portable extinguisher (dry powder), water buckets etc.
3. Ensure that gas cylinders, hose pipes, torches and other appliances are properly selected, installed and used.
4. In case of electric welding, check the connections, cables and earthing in particular.
5. Ensure that the welder uses appropriate personal protective equipment like goggles, gloves, boots, spats and if necessary, an approved respirator.
6. Do not leave electric circuits on, or blow-torches burning when the welder has to take a tea break or has to be away for any reason.

(C) After Welding and Cutting:

1. Inspect the area for sparks or smoldering materials. If you find any, remove and extinguish them.
2. If any portable extinguisher has been used, replenish it.
3. Gas cylinders, blow-torches etc. should be returned to the stores or kept at the authorized place.

1.3 Precautions in Gas Cutting and Arc Welding Operations:

- **Gas Cutting:**

In Gas Cutting, oxygen or air and a fuel gas (acetylene, hydrogen, LPG or propane, butane, coal gas, natural gas or their combination) are fed to a blow pipe (torch), usually hand held in which they are mixed prior to combustion at the nozzle. The heat melts the metal faces of the parts to be joined causing them to flow together. A filler metal or alloy is frequently added at a lower melting point than the parts to be joined and in that case (below fusion temperature of the parts to be joined) the process is also known as brazing or soldering. Chemical fluxes may be used to prevent oxidation and facilitate joining.

In gas cutting, the metal is heated by a flame and a jet of pure oxygen is directed on the point of cutting and moved along the line to be cut.

In gas pressure (high or low) welding, the parts are heated by gas jets under pressure, and become forged together.

Safety in handling Cylinders:

1. Do not tamper with the numbers or marks stamped on the cylinders.
2. Do not drop cylinders or let them strike violently.
3. Do not lift cylinders with an electro-magnet. In case cylinders are to be lifted by lifting device, they are to be slung in suitable cradles or platforms.
4. Do not use slings.
5. Do not tamper with the safety device in the valves or cylinders.

6. Do not use oil or grease as lubricants on valves or attachments.
7. In case the regulator or cylinder valves have frozen, wash with hot water, never by a flame.
8. Never transport cylinders with regulator and hose attached unless a proper trolley or carrier is used. While transporting, the cylinder valves should be shut.
9. Do not drag cylinders. They may be rolled on the bottom edge.
10. When the cylinder is not in use, keep the metal cap in place to protect the valve.
11. Before returning empty cylinders, mark them EMPTY
12. Always consider cylinders full, if not definitely known.
13. When in doubt about the proper handling, consult supplier.

Safety in Storage of Cylinders:

1. Ensure that the cylinders are stored properly. Store rooms should be dry, well ventilated and away from oil, or other flammable substances.
2. Store empty and full cylinders separately.
3. Store room should be fire proof and the lighting or electrical switches should of flame- proof type.
4. Oxygen cylinders should be stored away from the cylinders containing combustible gases, preferably in separate rooms. If stored in the same room, they should be kept far apart (6m) or have a non-combustible barrier in between of at last 2 mt height.
5. Acetylene cylinders should always be stored upright.
6. Cylinders are not designed for temperatures in excess of 55 ° C (130 ° F). Accordingly, they should not be stored near the sources of heat, such as radiators, furnaces, etc.
7. Cylinders stored in the open should be protected from the effects of sun and rain to prevent corrosion.
8. Cylinders should be stored away from elevators, stairs, or other such places where they can be knocked down or damaged by passing or falling object.

The Gas Cylinder Rules and following IS should be followed.

IS:818 Code of practice for safety and health requirement in electric and gas welding and cutting operations.
IS: 1179- Equipment for eye and face protection during welding.
IS: 3016- Fire precautions in welding.
UK HMSO - Booklet Welding and Flame-cutting using compressed gases.

Safety in Regulators and Hose connections:

Regulators or reducing valves are used on both oxygen and fuel gas cylinders to maintain gas supply to the torches at correct pressure. Care has to be taken to see that the regulator chosen is the correct one for the gas contained in the cylinder. In order to prevent attachment of oxygen regulators to the fuel gas cylinders or vice-versa, the connection for oxygen cylinders are made with right hand threads and those for acetylene cylinder with left hand threads. A regulator is a delicate instrument and has to be handled carefully and not dropped. Leaky regulators should be withdrawn from service immediately.

Oxygen and fuel gas hoses should be of different color or otherwise identified and distinguished from each other for proper connection on the torches. Red is generally recognized for fuel gas and green or black. hose is used for oxygen. One type of gas regulator should not be used for another type of gas.

Safety in using torches:

1. Set the regulators to the recommended working pressure.
2. Keep the blow pipe nozzle away from any source of ignition until the fuel gas is flowing 'freely from the nozzles.
3. A spark lighter is recommended for lighting purposes.
4. Clean the torch at regular intervals.
5. Sometimes a protective system is provided in the fuel gas piping to prevent -
6. Back flow of oxygen into the fuel gas supply system
7. Passage of a flash back into the fuel gas supply system
8. Excessive back pressure of oxygen in the fuel gas supply system. Such system (back pressure valve, non-return valve) must be checked for its effective working.

Welding/Cutting Operation with the use of LPG/ Acetylene/Argon:

Safety measures prescribed as below:

1. Gas cylinders, filled or empty, shall not be stored in a room where welding or cutting work is to be carried out.
2. Cylinder in use shall be kept in vertical position and tied to prevent its fall.
3. Source of ignition including smoking is prohibited near flammable gas cylinder except which is in use.
4. Cylinders shall be stored at more than 10 m from source of ignition or excessive heat.
5. Standard pressure regular and second non-return valve to prevent back flow shall be used.
6. Standard torch with non-return valve shall be used.
7. Suitable fire extinguishers shall be kept ready near welding/cutting place and gas cylinder storage.
8. Pipe lines shall be color painted for identification of each gas.
9. Welding/cutting is prohibited in explosive atmosphere.
10. Welding/cutting zone shall be cordoned by screens of 7 ft (2.15 m) height where persons other than welders and their helpers are working or passing.
11. All welding/cutting equipment shall be examined by a competent person in a period of 15 days.
12. Welding/cutting work shall be carried out by specially trained workers.
13. A log book of examination of equipment and a register of trained workers shall be maintained in the forms directed by the Inspectors.

- **Arc Welding (Electric Welding):**

In this process, an arc is struck between an electrode and the work pieces, which are connected to an AC or DC supply. In this usual process, the welder 'strikes an arc' by touching his electrode to the work piece and causes a "short-circuit" stripping electrons from gases in the surrounding air, ionizing it and producing the arc. A temperature of about 4000°C is obtained and the work pieces fuse together. In this type of welding, new metal is fused, either by melting the electrode or by melting a filler rod which does not carry any current. Sometimes some inert gas or a solid flux is also used to shield the weld from oxidation. The operations also include chipping of slag, etc. from the weld.

The current used for electric arc welding may be direct or alternating but the voltage has to be low and consistent. The voltage of 100 between electrode and work should not exceed for hand welding. The supply of current for electric welding would require a generator or transformer of suitable voltage. The commercial 'main supply' (230V) is not suitable on account of the voltage and also it may not be permissible to earth the circuit at points other than approved by the supply authority. Any transformer used for giving supply of current for welding should be double wound to ensure complete isolation of welding circuit from the main supply. The current used, with small diameter electrode on thin sheets for manual arc welding varies I between 10-50 Amps. With larger diameter electrodes, the current used is more. For manual welding, the welder should be able to withstand the heat and as such the current value should not exceed 500-600 Amps.

Hazards of Arc Welding:

The operations of welding and cutting are carried out at high temperatures which are source of "Fire" or Explosion. The liberation of the heat and energy into the work place can cause chemical and physical reactions which do not normally take place at room temperature. The reactions include the various types of radiation and release of various toxic gases, vapors, fumes, etc., which may affect the health of the workers engaged in the process and nearby. Some hazards are:

- Flying metallic sparks and molten metal. Some of these sparks consist of tiny shreds of extremely hot metal, sometimes molten, which may be hotter than 1000° F and may cause painful burns on exposed skin. These sparks are also source of fire or explosion hazard, in case flammable materials are nearby.
- Hot surfaces of the work pieces after welding or cutting may cause harms to unsuspecting persons.
- Flying materials while chipping the weld.
- Enrichment of Oxygen (due to leakage from Oxygen cylinder) radically changes flammability.
- Glare which comes when the arc is struck or the torch is lit. It affects the optic nerve at the back of the eye. Special eye glass (screen) is required.
- Thermal heat radiation from welding can cause headache, fatigue and eye damage.
- Infra-red radiation. Some of the IR is stopped by the upper layer of the skin but part of the radiation penetrates the exposed skin and may cause serious skin burns or pigmentation. Since eye has no absorbing layer, it can be severely damaged by this and may cause "heat cataract".
- Ultra-violet radiation may cause skin burns and prolonged exposure may lead to skin tumors. Inert gas shielding is a strong source of UV radiation.
- Workers on the shop floors may be exposed to noise due to welding, cutting or chipping operations.
- Fall of materials and equipment's during operation.

Electrodes and Holders:

Electrode holders are used to connect the electrode to the welding cable supplying secondary current. In order to prevent accidental striking of an arc they should be fully insulated. Holders should be capable of handling the maximum current required by the electrode. Electrode holders are liable to become hot during welding operations if they are not designed for the purpose, i.e., holders for light jobs are used for heavy work or if there is a loose connection. In case the correct size of holder is not available an additional holder should be provided so that one can cool while the other is in use. Dipping of hot electrode holders in water should be prohibited as it may expose the worker to electric shock.

Electric Shock:

The work set up is such that the work is grounded and if the worker is not careful, he can receive electric shock. A welder may be exposed to the open circuit voltage while changing electrodes, setting up work, or changing working position. Danger is more in humid environment or if the welder is "sweaty". The risk of shock can be reduced by providing an insulating barrier between the worker and the ground of nearby metal objects, while changing electrodes. Dry leather gloves act as good insulator. It is also advisable to use shoes with rubber soles. The electrode holder should be sufficiently insulated between the handle and the bare part that grips the electrode. The welding cables should be of good quality to resist hard ware and inspected for insulation defects. Joints between cables should be by insulated connectors of equivalent capacity. The welding equipment must be safely earthed. There should be two distinct and different earthing circuits so that, in case if one fails, the other will afford protection.

Indoor Exhaust Ventilation:

Local exhaust or positive ventilation is not required in the spaces of 1400 m^3 or over, provided: (a) Welding bays have unrestricted cross ventilation (b) Work is not carried out inside restricted spaces such as tanks and boilers (c) Every welder has about 280m^3 space. (d) Ceiling heights are more than 5m. (e) Process does not require the use of inert gas.

In case the above conditions are not met, mechanical ventilation at the minimum rate of 56 m^3/ min of air per welder is to be provided with a velocity in the direction of hood of 30 m/min at the point of welding. The duct diameter and air flow volumes that would produce the control velocity using a 7 cm wide flanged section is given in the following table:

Table no 01: Showing Distance from Arc, Minimum air flow and Duct Diameter.

Distance from arc or torch, cm	Minimum air flow, m^3/ min	Duct Diameter cm.
10 to 15	4.5	7
15 to 20	8.0	9
20 to 25	12.0	11
25 to 30	17.0	13

For hoods without flanges, minimum air flow shall be increased by 60 m"/min. I cm duct dia is based on relatively 1200 mt/min velocity in pipe.

Personal Protection:

For the safety and health of the workers, precautions have to be taken to safeguard against the various physical and chemical hazards. Maintenance of the equipment and proper care in the use, adequate ventilation etc. may reduce some of the hazards, but it may not be possible to eliminate all the hazards and hence the workers have to be supplied with suitable personal protective equipment. Since a helper is always posted near the place of work, he too has to be provided adequate protection.

Ordinary clothing may be sufficient to protect against UV and IR radiation, but some exposed areas such as face, wrist, neck, hands etc. would be affected. Asbestos/leather gloves may be useful to protect hands from electric shocks, heat and sparks.

Eye protection is the most critical problem. Hence the measures have to be taken to stop flying particles, glare and the radiation. Since the welding temperature for various materials may be different, different types of shades may be needed for different jobs, and at the same time clear glass may be needed while chipping the weld.

If possible, the welding operation in a shop floor be isolated and screened so that other workers engaged nearby are not affected. However, measures should be taken to protect the crane drivers and others from the hazardous fumes, rays etc., of welding operation.

To protect the workers from the toxic fumes, suitable respiratory protection should be provided.

Cotton apron if used by the workers may be treated with fire retarding chemicals. When there is a risk of materials falling on the workers, suitable hard hats may be provided. While doing electric arc welding, instead of holding the shield in one hand, it is advisable to wear a welder's helmet which protects the workers in many ways.

2. STUDY AREA

The study was carried out at the Hot Work Area located at Latitude $18^0$29’56.22”N and Longitude $73^0$51’24.94”E in the SWARGATE UNDERGROUND METRO STATION PUNE. The hot work area where the presented study was carried out is shown below in Google earth image.

(Photo 01: Hot work Location in layout of swargate underground metro station pune)

3. METHODOLOGY:

3.1 HAZARD IDENTIFICATION AND RISK ASSESSMENT (HIRA):

There are many definitions for hazard but the most common definition when talking about workplace health and safety is “A hazard is any source of potential damage, harm or adverse health effects on something or someone.”

The CSA Z1002 Standard "Occupational health and safety - Hazard identification and elimination and risk assessment and control" uses the following terms:

- Harm – physical injury or damage to health.
- Hazard – a potential source of harm to a worker.

Basically, a hazard is the potential for harm or an adverse effect (for example, to people as health effects, to organizations as property or equipment losses, or to the environment).

Hazard Identification:

Hazard identification is part of the process used to evaluate if any particular situation, item, thing, etc. may have the potential to cause harm. The term often used to describe the full process is risk assessment:

- Identify hazards and risk factors that have the potential to cause harm (hazard identification).
- Analyze and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).
- Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control).

Overall, the goal of hazard identification is to find and record possible hazards that may be present in your workplace. It may help to work as a team and include both people familiar with the work area, as well as people who are not – this way you have both the experienced and fresh eye to conduct the inspection

Hazard identification can be done:

- During design and implementation
  - Designing a new process or procedure
  - Purchasing and installing new machinery
- Before tasks are done
  - Checking equipment or following processes
  - Reviewing surroundings before each shift
- While tasks are being done
  - Be aware of changes, abnormal conditions, or sudden emissions
- During inspections
  - Formal, informal, supervisor, health and safety committee
- After incidents
  - Near misses or minor events
  - Injuries

To be sure that all hazards are found:

- Look at all aspects of the work and include non-routine activities such as maintenance, repair, or cleaning.
- Look at the physical work environment, equipment, materials, products, etc. that are used.
- Include how the tasks are done.
- Look at injury and incident records.
- Talk to the workers: they know their job and its hazards best.
- Include all shifts, and people who work off site either at home, on other job sites, drivers, teleworkers, with clients, etc.
- Look at the way the work is organized or done (include experience of people doing the work, systems being used, etc).
- Look at foreseeable unusual conditions (for example: possible impact on hazard control procedures that may be unavailable in an emergency situation, power outage, etc.).
- Determine whether a product, machine or equipment can be intentionally or unintentionally changed (e.g., a safety guard that could be removed).
- Review all of the phases of the lifecycle.
- Examine risks to visitors or the public.
- Consider the groups of people that may have a different level of risk such as young or inexperienced workers, persons with disabilities, or new or expectant mothers.

Types of hazards

A common way to classify hazards is by category:

- Biological – bacteria, viruses, insects, plants, birds, animals, and humans, etc.,
- Chemical – depends on the physical, chemical and toxic properties of the chemical,
- Ergonomic – repetitive movements, improper set up of workstation, etc.,
- Physical – radiation, magnetic fields, temperature extremes, pressure extremes (high pressure or vacuum), noise, etc.,
- Psychosocial – stress, violence, etc.,
- Safety – slipping/tripping hazards, inappropriate machine guarding, equipment malfunctions or breakdowns.

What materials or situations do come into contact with workers? Possibilities could include:

- Electricity
- Chemicals (liquids, gases, solids, mists, vapors, etc.)
- Temperature extremes of heat or cold (e.g., bakeries, foundries, meat processing)
- Ionizing/non-ionizing radiation (e.g., x-rays, ultraviolet (sun) rays)
- Oxygen deficiency
- Water

What materials or equipment could worker be struck by?

- Moving objects (e.g., forklifts, overhead cranes, vehicles)
- Flying objects (e.g., sparks or shards from grinding)
- Falling material (e.g., equipment from above)

What objects or equipment could strike or hit workers body upon, or that part of body might be caught in, on, or between?

- Stationary or moving objects
- Protruding objects
- Sharp or jagged edges
- Pinch points on machines (places where parts are very close together)
- Objects that stick out (protrude)
- Moving objects (conveyors, chains, belts, ropes, etc.)

What could worker fall from? (e.g., falls to lower levels)

- Objects, structures, tanks, silos, lofts
- Ladders, overhead walkways
- Roofs
- Trees, cliffs

What could worker slip or trip on? (e.g., falls on same level)

- Obstructions on floor, stairs
- Surface issues (wet, oily, icy)
- Footwear that is in poor condition

How could worker overexert himself?

- Lifting
- Pulling
- Pushing
- Carrying
- Repetitive motions

What other situations could worker come across?

- Unknown/unauthorized people in area
- A potentially violent situation
- working alone
- confined space
- Missing/damaged materials
- New equipment/procedure at work site
- Fire/explosion
- Chemical spill or release

3.2 Methodologies of risk analysis-

A qualitative analysis uses words to describe the magnitude of potential severity and the probability that those severity will occur. These scales can be adapted or adjusted to suit the circumstances and different descriptions may be used for different risks. This method uses expert knowledge and experience to determine likelihood and severity category.

In semi-quantitative analysis, qualitative scales such as those described above are given values. The objective is to produce a more expanded ranking scale than is usually achieve in qualitative analysis, not to suggest realistic values for risk such as is attempted in quantitative analysis.

Quantitative analysis uses numerical values (rather than the descriptive scales used in qualitative and semi-quantitative analysis) for both severity and probability using data from a variety of sources such as past accident experience and from scientific research. Severity may be determined by modeling the outcomes of an event or set of events, or by extrapolation from experimental studies or past data. Severity may be expressed in terms of monetary, technical or human impact criteria, or any of the other criteria. The way in which severity and probability are expressed and the ways in which they are combined to provide a level of risk will vary according to the type of risk and the purpose for which the risk assessment output is to be used.

Probability of an occurrence:

This value is based on the probability of an event occurring. You may ask the question “How many times has this event happened in the past?” Assessing probability is based worker experience, analysis or measurement. Probability levels range from “most likely” to “inconceivable.” For example, a small spill of bleach from a container when filling a spray bottle is most likely to occur during every shift. Alternatively, a leak of diesel fuel from a secure holding tank may be less probable.

Severity of hazard:

Severity can be divided into five categories (Negligible, Slight, Moderate, High, Very High). Severity is based upon an increasing level of severity to an individual's health, the environment, or to property.

3.3 RISK ASSESSMENT:

Risk can be presented in variety of ways to communicate the results of analysis to make decision on risk control. For risk analysis that uses likelihood and severity in qualitative method, presenting result in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace.

Risk can be calculated using the following formula:

P x S = Relative Risk (R)

P = Probability

S = Severity

Risk Matrix

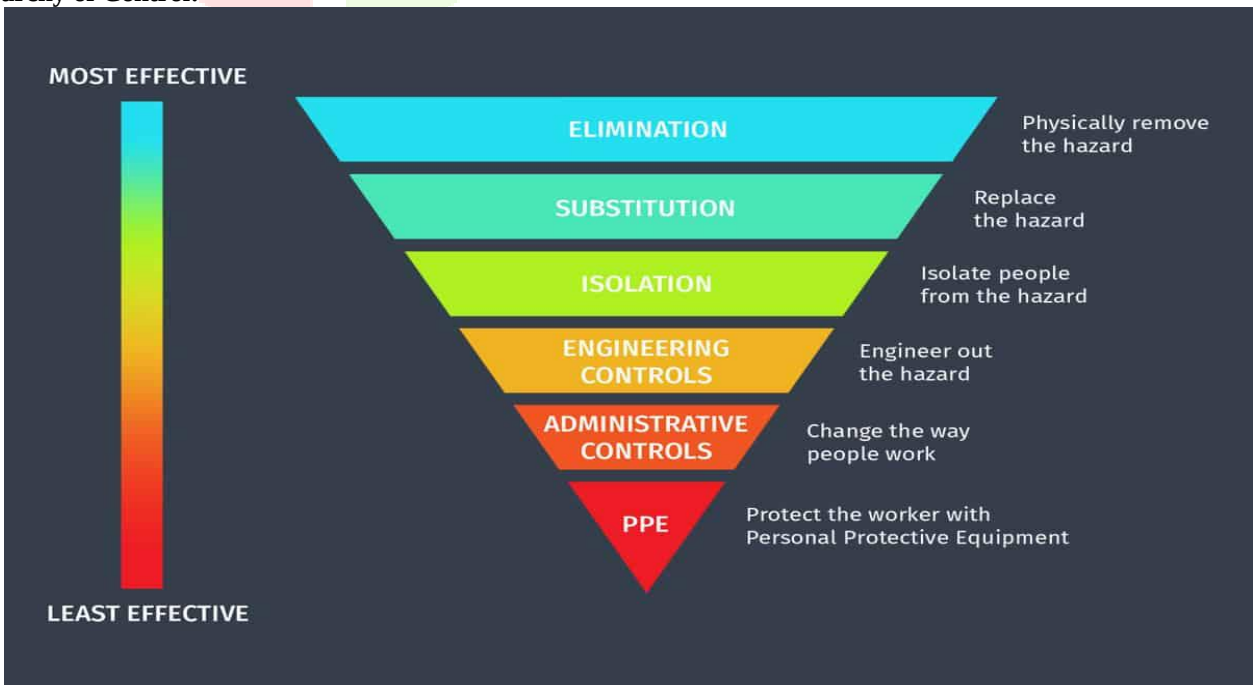
To use this matrix, first find the severity column that best describes the outcome of risk. Then follow the probability row to find the description that best suits the probability that the severity will occur. The risk level is given in the box where the row and column meet. The relative risk value can be used to prioritize necessary actions to effectively manage work place hazards.

RISK MATRIX						
PROBABILITY →	Very Likely - 5	5	10	15	20	25
	Likely - 4	4	8	12	16	20
	Possible - 3	3	6	9	12	15
	Unlikely - 2	2	4	6	8	10
	Very Unlikely - 1	1	2	3	4	5
		1	*2*	*3*	*4*	*5*
		Negligible	*Slight*	*Moderate*	*High*	*Very High*
		SEVERITY →				

Risk	Risk Level	Action
1 to 6	Low Risk	May be acceptable but review task to see if risk can be reduced further
8 to 12	Medium Risk	Task should only be undertaken with appropriate management authorization after consultation with specialist personnel and
15 to 25	High Risk	Task must not proceed. It should be redefined or further control measures put in place to reduce risk. The controls should be

(Photo 02: Risk Matrix)

3.4 Hierarchy of Control:



(Photo 03: Hierarchy of Controls)

Definition: Control is the elimination or inactivation of a hazard in a manner such that the hazard does not pose a risk to workers who have to enter into an area or work on equipment in the course of scheduled work.

Hazards should be controlled at their source (where the problem is created). The closer a control to the source of the hazard is the better. This method is often referred to as applying engineering controls. If this does not work, hazards can often be controlled along the path to the worker, between the source and the worker. This method can be referred to as applying administrative controls. If this is not possible, hazards must be controlled at the level of the worker through the use of personal protective equipment (PPE), although this is the least desirable control.

Selecting a suitable control:

Evaluating and selecting short- and long-term controls; Implementing short-term measures to protect workers until permanent controls can be put in place; and Implementing long term controls when reasonably practicable.

For example, suppose a noise hazard is identified. Short-term controls might require workers to use hearing protection. Long term, permanent controls might remove or isolate the noise source.

Types of Control:

Elimination:

Getting rid of a hazardous job, tool, process, machine or substance is perhaps the best way of protecting workers. For example, a salvage firm might decide to stop buying and cutting up scrapped bulk fuel tanks due to explosion hazards.

Substitution:

Sometimes doing the same work in a less hazardous way is possible. For example, a hazardous chemical can be replaced with a less hazardous one. Controls must protect workers from any new hazards that are created.

Engineering control:

Redesign - Jobs and processes can be reworked to make them safer. For example, containers can be made easier to hold and lift.

Isolation - If a hazard cannot be eliminated or replaced, it can sometimes be isolated, contained or otherwise kept away from workers. For example, an insulated and air-conditioned control room can protect operators from a toxic chemical.

Automation - Dangerous processes can be automated or mechanized. For example, computer- controlled robots can handle spot welding operations in car plants. Care must be taken to protect workers from robotic hazards.

Barriers - A hazard can be blocked before it reaches workers. For example, special curtains can prevent eye injuries from welding arc radiation. Proper equipment guarding will protect workers from con tacking moving parts.

Absorption - Baffles can block or absorb noise. Lockout systems can isolate energy sources during repair and maintenance. Usually, the further a control keeps a hazard away from workers, the more effective it is.

Dilution - Some hazards can be diluted or dissipated. For example, ventilation systems can dilute toxic gasses before they reach operators.

Administrative controls:

Safe work procedures - Workers can be required to use standardized safety practices. The employer is expected to ensure that workers follow these practices. Work procedures must be periodically reviewed with workers and updated.

Supervision and training – Initial training on safe work procedures and refresher training should be offered. Appropriate supervision to assist workers in identifying possible hazards and evaluating work procedures.

Job rotations and other procedures can reduce the time that workers are exposed to a hazard. For example, workers can be rotated through jobs requiring repetitive tendon and muscle movements to prevent cumulative trauma injuries. Noisy processes can be scheduled when no one is in the workplace.

Housekeeping, repair and maintenance programs - Housekeeping includes cleaning, waste disposal and spill cleanup. Tools, equipment and machinery are less likely to cause injury if they are kept clean and well maintained.

Hygiene - Hygiene practices can reduce the risk of toxic materials being absorbed by workers or carried home to their families. Street clothing should be kept in separate lockers to avoid being contaminated by work clothing. Eating areas must be segregated from toxic hazards. Eating should be forbidden in toxic work areas. Where applicable, workers should be required to shower and change clothes at the end of the shift.

Personal Protective Equipment (PPE):

Personal protective equipments are any equipment which is intended to be worn or held by person's present at work and which protects them against one or more risks to their health or safety and any additional accessory designed to meet that objective;

PPE is usually chosen to provide protection appropriate to each of type of hazard present. There are specifications for the types of PPE used for protecting an individual's head, eyes, footwear, limb and body, fire retardant clothing, respiratory, hearing, and personal flotation devices.

It may also include required apparel for example when traffic hazards are present high visible and distinguishable "vests must be worn"

Personal Protective Equipment (PPE) and clothing is used when other controls measures are not feasible and where additional protection is needed. Workers must be trained to use and maintain equipment properly. The employer and workers must understand the limitations of the personal protective equipment. The employer is expected to require workers to use their equipment whenever it is needed. Care must be taken to ensure that equipment is working properly. Otherwise, PPE may endanger a workers' health by providing an illusion of protection.

4. HAZARD IDENTIFICATION AND RISK ASSESSMENT (HIRA) OF Arc Welding and Gas Cutting –

1. **Arc Welding-**

Table No. 02 - HAZARD IDENTIFICATION RISK ASSESSMENT

Activity: Arc Welding
Location: Swargate Underground Metro station (Pune Metro Rail Project)

S/No.	HAZARD	Consequences	Pre-RISK EVALUATION			RISK	CONTROLS MEASURES	Action Taken	Post-RISK Evaluation			RISK
			S	P	R				S	P	R	
1	Fumes	1.Respiratory problems. 2.Eye itching/irritation	4	4	16	High	1. Provide adequate respiratory PPE. 2. Provide welding goggles.	1. Regular Supervision by supervisor	4	1	4	Low
2	Electric shock	1. Burns and unconsciousness2. Fatal injury	4	2	8	Medium	1. Provide ELCB. 2. Provide proper coated wire	1. Supervisor should check the condition of wires before starting the work regularly. 2. Provide adequate PPE.	4	1	4	Low
3	Fire/ Explosion	1. Burns and unconsciousness2. Fatal Injury 3. Property Damage	4	2	8	Medium	1. Area shall be cleared of flammables and combustible before commencing welding. 2. Provide Fire Blanket 3. Provide Fire Extinguisher	1. Regular Supervision by supervisor 2. Emergency contact numbers board should be provided.	4	1	4	Low

4	Fall /Stumbling	1.Personal Injury. 2. Fatal Injury	4	2	8	Medium	1. Maintain proper Housekeeping. 2. Provide sign board.	1. Provide Barricades 2. Provide first aid kit. 3. Emergency contact numbers board should be provided. 4. Regular Supervision by supervisor	4	1	4	Low
5	Noise	1. Ringing in Ear (Tinnitus) 2. Noise Induced Hearing Loss. 3. Increase Heart Rate. 4. Dizziness	4	4	16	High	1. Provide adequate PPE's like Ear Muffs, Ear plugs.	1.Regular Noise Monitoring 2. Regular observation by Supervisor.	4	1	4	Low
6	UV Radiation	1. Temporary Vision loss 2. Red eyes, Gritty feelings, extreme light sensitivity and excessive tearing.	4	3	12	Medium	1. Provide welding goggles 2. Provide face shield.	1. Regular Supervision by supervisor	4	1	4	Low

GENERAL COMMENTS:

1. Tool Box Talk will be conducted prior to job start.
2. Unauthorized entry of the person not allowed in work premises.
3. Proper PPE's are must for all the crew.
4. Stand by vehicle must be present at the site in case of emergency.
5. S = Severity; P = Probability; R=Risk

2. Gas Cutting-

Table No. 03 - HAZARD IDENTIFICATION RISK ASSESSMENT

Activity: Gas Cutting
Location: Swargate Underground Metro station (Pune Metro Rail Project)

S/No.	HAZARD	Consequences	Pre-RISK EVALUATION			RISK	CONTROLS MEASURES	Action Taken	Post- RISK Evaluation			RISK
			S	P	R				S	P	R	
1	Fumes Created during Flame Cutting.	1.Respiratory problems. 2.Eye itching/irritation	4	3	12	Medium	1. Provide adequate respiratory PPE. 2. Provide welding goggles.	1. Regular Supervision by supervisor	4	1	4	Low
2	Burns and Serious Injury.	1.Personal major injury	4	2	8	Medium	1. Provide proper PPE such as Welding Apron.	1. Supervisor should supervise regularly and check the condition of PPE.	4	1	4	Low
3	Fire/ Explosion	1. Burns and unconsciousness 2. Serious Injury 3. Property Damage	4	2	8	Medium	1. Area shall be cleared of flammables and combustible before commencing welding. 2. Provide Fire Blanket 3. Provide Fire Extinguisher	1. Regular Supervision by supervisor 2. Emergency contact numbers board should be provided. 3. Provide first aid kit.	4	1	4	Low

4	Awkward Posture	1.Personal Injuries like compress tendons, nerves and blood vessels.	4	2	8	Medium	1. Provide proper working technique.	1. Conduct regular working Trainings and Tool Box Talk. 2. Regular Supervision by supervisor.	4	1	4	Low
5	Vehicular Accidents Near Gas Cutting Activity.	1. Serious Injury to Workers. 2. Property Damage.	4	3	12	Medium	1. Provide Proper barricading. 2. Provide sign boards.	1. Regular observation by Supervisor.	4	1	4	Low

GENERAL COMMENTS:

1. Tool Box Talk will be conducted prior to job start.
2. Unauthorized entry of the person not allowed in work premises.
3. Proper PPE's are must for all the crew.
4. Stand by vehicle must be present at the site in case of emergency.
5. S = Severity; P = Probability; R=Risk

5. RESULT AND DISCUSSION

Construction is a high hazard industry that comprises a wide range of activities involving construction, alteration or repair. Examples include residential construction, bridge erection, excavations, demolitions and large-scale painting jobs. Hazard identification and risk analysis is carried for identification of undesirable events that can leads to a hazard. The analysis of hazard mechanism by which this undesirable event could occur and usually the estimation of extent, magnitude and likelihood of harmful effects.

As the part of the work, hazard identification and risk analysis were carried out for Hot Work operations like **Arc Welding** and **Gas Cutting**. The hazards were identified and risk analysis was carried out. The risks associated with different hazards were divided into high, medium, and low depending upon their likelihood and consequences. These have been presented in **Table no 02** and **Table no 03**. The high-risk activities have been marked in **Red** color are **HIGH RISK** and must be reduced. The risks which are marked in **Yellow** color are **MEDIUM RISK** but efforts must be made to reduce risk without expenditure that is grossly disproportionate to the benefit gained. The risks which are marked in **Green** color have the **LOW RISK** level so that it is not required for taking actions to reduce its magnitude any further. The risk rating calculations were carried out by a qualitative, semi-qualitative, quantitative method. The study also revealed that systematic methods were used and risk was assessed by brainstorming, checklist and health and safety regulations.

The study also reveals that PPE is used for risk control. However, there was enough PPE on the sites. Based on factors influencing risk management, the study reveals that legal system plays a major role in risk assessment, communication and control. They also require that health and safety risk to be communicated to workers and that PPE be provided for worker. Knowledge of health and safety is a criterion for employment. Meanwhile a safety culture provides resources for site workers, such as PPE and training. Additionally, individual characteristics such as experience of those working on construction sites, their educational background and knowledge of health and safety matters also influence health and safety risk management.

REFERENCES

1. A book by Clifton A. Ericson, II, Hazard Analysis Techniques for System Safety,Hazard Analysis Types and Techniques , a John Wiley & Sons, Inc. Publication.
2. Ahmed, S.M., Kwan, J.C., Ming, F.Y.W., Ho, D.C.P., 2000. Site safety management in Hong Kong. Journal of Management in Engineering, November 2000, 34–42.
3. Ale, B.J.M., Bellamy, L.J., Baksteen, H., Damen, M., Goossens, L.H.J., Hale, A.R., Mud, M., Oh, J., Papazoglou, I.A., Whiston, J.Y., 2008. Accidents in the construction industry in the Netherlands: an analysis of accident reports using Storybuilder. Reliability Engineering and System Safety 93 (2008), 1523–1533.
4. Devdatt P Purohit.et el., (2018). Hazard Identification and Risk Assessment in Construction Industry. *International Journal of Applied Engineering Research*. ISSN 0973-4562 Volume 13, Number 10 (2018) pp. 7639-7667
5. Duijm, N. J., (2001), Hazard analysis of technologies for disposing explosive waste, *Journal of Hazardous Materials*, A90, pp. 123–135.
6. Frank, T., Brooks, S., Creekmore, R., Hasselbalch, B., Murray, K., Obeng, K., Reich, S. and Sanchez, E., (2008), Quality Risk Management Principles and Industry Case Studies, pp. 1-9.,
7. Fundamentals of Industrial Safety & Health- K.U. Mistry.
8. Naikwadi Ghanshyam b., Gurav Vikas v and Kasar S.R (2021). SCAFFOLDING: H.I.R.A. *Journal of emerging technologies and innovative Research*. ISSN 2349-5162. Volume 8, Issue 2. Page no: 1797-1811.
9. Hazardhttp://www.uws.edu.au/__data/assets/pdf_file/0020/12917/Hazard_Identification_Risk_Assessment_and_control_Procedure_2008.pdf
10. Labour Department (2014). A Casebook of Fatal Accidents Related to Work-at-Height Hong Kong: Labour Department
11. Rozenfeld, O., Sacks, R., Rosenfeld, Y., 2009. CHASTE – construction hazard analysis with spatial and temporal exposure. Construction Management & Economics 27 (7), 625–638.
12. Sacks, R., Rozenfeld, O., Rosenfeld, Y., 2009. Spatial and temporal exposure to safety hazards in construction. ASCE Journal of Construction Engineering and Management 135 (8), 726–736.
13. Safety at work - John Ridle
14. The factory act 1948.