Hazards Identification and Risk Assessment in Foundry
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Abstract:
Risk assessment tool which will assist users in identifying hazard and estimating risk involved in each identified hazard. This risk assessment tool will identify possible hazard involved in each task in departments. Once the hazard has been identified, risks involved will be estimated and categorized. If the estimated risk falls in a category, which is higher than the low risk category, then possible control measures will be recommended. At the same time, the user can add new work plan, task, and control measures into the system to update existing information system.

I. INTRODUCTION
This project aims to find out the various challenges for maintaining safety in foundries. It also aims to find out various hazards (including hidden hazards) in the foundries. Any successful industry should have a very healthy safety culture along with very sound HSE policies. The company’s reputation will also increase with an increase in safety standards in the company. HIRA should be conducted periodically in order for a company to achieve a good safety culture. Foundry operation has been considered as a high risk activity for the last 15 years. Any unsafe act or unsafe condition in the foundry operation can result into major accidents and can result to the damage and loss to the humans, property, environment, production time etc. In this project Hazard Identification and Risk Assessment (HIRA) is used to find out hazards and the risk associated with each hazards. Hazards are analysed by assuming the probable and possible damages that it can produce. Risk is then calculated by considering the probability, severity and the number of persons affected by the possible accidents or incidents. Risk assessment is very important for the safe operation in foundries as well as in any industry. HIRA on a periodic interval can eliminate or mitigate the major hazards which have a very high potential to cause accidents or incidents thereby eliminating or mitigating the high risk factor present in the foundries.

1.1 GENERAL PROVISIONS
Foundry work is the process of producing metal castings by melting the metal into a liquid state then pouring the metal into a mould which contains a hollow cavity of desired shape. A pattern is used to make the mould of the required arti-

1.2 CODE OF PRACTICE
1) Establishing a coherent national policy and principles on the occupational safety and health and welfare of workers in iron- and steel- making facilities and on the protection of the general working environment;
2) Establishing the respective duties and responsibilities of the authorities, employers, workers and others involved and making arrangements for a structured cooperation between them;
3) Improving knowledge and competence;
4) Promoting the implementation and integration of consistent OSH management systems with a view to improving working conditions.

1.3 COMPETENT AUTHORITIES ROLE
1) The setting up of legal, administrative and effective frameworks for the prevention and reduction of hazards and risks;
2) The aims of any mechanisms for identifying, eliminating, minimizing and controlling hazards;
3) The assessment of risks and hazards to the safety and health of workers and the measures that need to be taken;
4) The surveillance of the working environment and workers’ health;
5) Emergency procedures and first aid;
6) The provision of information and training to workers.

1.4 OBJECTIVE
The main objectives of this project are the following
• Identify the process in foundry.
• Identify the Hazard associated with each process.

Analysing the Hazards and the persons affected by each hazards.
• Taking account of Risks associated with each hazard by considering its probability and severity Implying control measures.
• Recuperate the safety culture in foundry by using HIRA as a tool.

2. HAZARD IDENTIFICATION
Hazard identification (HAZID) is “the process of identifying hazards, which forms the essential first step of a risk assessment. There are two possible purposes in identifying hazards:

To obtain a list of hazards for subsequent evaluation using other risk assessment techniques. This is sometimes known as “failure case selection”.

IJESC, June 2021
28298
http://ijesc.org/
To perform a qualitative evaluation of the significance of the hazards and the measures for reducing the risks from them. This is sometimes known as “hazard assessment”.

During the hazard identification stage, the criteria used for the screening of the hazards will be established and possible hazards and accidents will be reviewed. For this purpose, the facility will be divided into several sections. Furthermore, the identified hazards will be classified into critical and non-critical hazards. It is of great importance that the hazards considered non-critical are clearly documented in order to demonstrate that the events in question could be safely disregarded. This failure case selection will be executed by generating check lists, accident and failure statistics, hazard and operability Studies (HAZOPs) or by comparison with detailed studies and experience from previous projects. The outcomes of the hazard identification process are to:

- Identify all major incidents which could occur at the facility (irrespective of existing control measures)
- Provide the employer and workers with sufficient knowledge, awareness and understanding of the causes of major incidents to be able to prevent and deal with them.
- Provide a basis for identifying, evaluating, defining and justifying the selection (or rejection) of control measures for eliminating or reducing risk
- Show clear links between hazards, causes and potential major incidents
- Provide a systematic record of all identified hazards and major incidents, together with any assumptions.

The operator must base the hazard identification process on a comprehensive and accurate description of the facility, including all necessary diagrams, process information, existing conditions, modifications and material safety data sheets (MSDS). Prior to conducting the hazard identification, the operator should collect all relevant information, compile it and then check it for accuracy. The hazard identification may be supported by past risk assessments and historical incident data. The operator should refer to previous hazard studies, if they are relevant to identifying major incidents, and consider all the issues discussed in this guidance note. However, the operator must ensure that any existing studies:

- Are fully understood by the hazard identification participants
- Are still relevant for the current operating conditions and condition of the facility
- Were conducted to an acceptable standard
- Addresses identified gaps.

The operator should review its own plant operating history and conditions (eg corrosion, breakdowns and maintenance) for potential scenarios. However, major incidents are rare and historical incidents are unlikely to represent the full range of potential incidents. Incident data should be used to supplement more systematic hazard identification techniques. Another useful source of information on the hazards associated with storage and handling of hazardous materials are MSDS. It is also worth referring to the technical literature provided by material suppliers on their products. Workplace safety requires effective identification, assessment and control of significant workplace hazards.

2.1 HAZARD MANAGEMENT STEPS ARE:
- Identification of hazards.
- Determination of their significance
- Control of significant hazards by Elimination, Isolation or Minimization.
- Training and advising staff of the control measures in place.

2.2 A HAZARD MANAGEMENT SYSTEM CONTAINS:
- A systematic process for identifying existing hazards in the workplace.
- A systematic process for identifying new hazards in the workplace.
- A process to review hazards to determine their significance and adequacy of control A systematic process to ensure that the selected controls in place are not only adequate but the controls are in keeping with industry standards.
- Changes or proposed changes in the organization, its activities or material.
- Modifications, including temporary changes and its impact on operation, processes and activities.
- Legal requirements related to activities performed and related controls.
- Design of work areas, processes, installation, machineries / equipment, operating procedures and activities performed including their adaption to human capabilities.
- Investigation results of previous incident, accidents.
- Feedback, suggestion, observation from workmen or any person.

2.3 TYPE/CONDITIONS OF THE JOB:
- During the risk assessment following type of jobs/situations/conditions was considered.
- Routine: Done by usual / regular method of procedure.
- Normal Condition: Risks converted to tolerable condition by way of engineering control or by using PPE.
- Abnormal Condition: Deviation from normal condition, which requires immediate attention.
- Emergency Condition: Hazards and Risks, which are contained or mitigated by invoking emergency procedures.

3. FOUNDRY HAZARDS, EFFECTS AND CONTROL MEASURES
Major hazards in the foundry industry are: Working in heat; hazardous chemicals (incorporating hazardous substances and dangerous goods); airborne contaminants; manual tasks; noise; vibration; molten metal; plant and machinery and electricity

3.1 HEAT EXPOSURE
High temperatures and direct infrared (IR) radiation are common hazards in foundries. Where the body is unable to lose heat fast enough through the evaporative cooling process to maintain a steady core body temperature, it begins to experience physiological heat strain with different illnesses depending on the degree of heat stress.
Potential health effects for persons under increasing levels of heat stress include: discomfort; heat fainting; heat stroke; prickly heat; irritability, dehydration; reduced concentration or attention; heat rash; reduced tolerance to chemicals and noise exposure; heat cramps; heat exhaustion. Heat cramps, heat exhaustion and heat stroke are the most serious forms of heat illnesses. Heat stroke is a life threatening condition and may result in permanent damage to the heart, kidneys and brain. The effects of heat stress are most likely to increase during the hot season. Exposure of the skin to strong IR may lead to local thermal effects and even serious burns, especially if the exposure covers the whole body. Eliminating situations that could lead to heat related illnesses is the best form of control strategy. This can be done by: eliminating unnecessary sources of radiant heat; eliminating sources of water vapour in the workplace (i.e. leaks from steam valves, evaporation of water from wet floors, etc.). Where exposure to heat cannot be prevented or reduced by any other form of control, all exposed persons must be provided with PPE. PPE may be used in addition to other control measures. The PPE are: eye wear, such as ultra- violet glasses and radiant energy reflective face shields; non-flammable and heat reflective clothing and equipment; water cooled bodysuits/vests and other equipment; protective gloves and footwear - Metatarsal safety shoe with Heat resistant soles.

3.2 HAZARDOUS CHEMICAL
Hazardous chemicals (which incorporate hazardous substances, dangerous goods and combustible liquids) are widely used in the foundry industry. The Regulation also requires manufacturers or importers of a hazardous chemical to prepare a Safety Data Sheet (SDS) for each hazardous chemical dealt with and for suppliers to provide a current SDS to any person that is likely to use or be affected by the hazardous chemical. Hazardous chemicals common to the foundry industry include: amines; benzene; hexachloroethane; ammonia; epoxy resins; formaldehyde; furfuryl alcohol; isocyanates; mould release compounds; the treatment and inoculation of molten metal before pouring; and mould and core making processes during sand reclamation, sand preparation and sand mixing; mould and core forming processes including core baking and mould drying from additives, binders and catalysts; cooling of casts causing decomposition of organic binders; casting knockout and shake-out; and fettling.

Health Effects of Airborne contaminants: Other gases may indicate their presence by various irritating effects such as respiratory irritation, coughing, asthma, acidic taste and eye irritation. The inhalation of wood dusts causes a slowing of dust clearance and alteration to the structure of the mucous membrane lining of the nasal cavity. This may be accompanied by the risk of cancer of the nasal cavity and sinuses. Some wood dusts also act as sensitizers that may manifest itself as a skin rash, inflammation or as an asthmatic condition. The inhalation of heavy metal dusts may produce diverse health effects depending on the specific metal dust involved. For example: iron dust may accumulate in the lungs and cause siderosis; aluminium dust irritates the respiratory system and may result in chronic non-specific lung disease; beryllium dust irritates the lungs and may result in tracheobronchitis, pneumonitis and berylliosis, and may also be a possible carcinogen; lead dust results in systemic poison effects; manganese dust irritates the lungs and may have a chronic effect on the nervous system; nickel dust irritates the respiratory tract and some nickel exposures may result in lung or nasal cancer. Respirable crystalline silica (RCS) dust presents one of the greatest risks to the health of foundry workers. Fine silica dust is produced in foundries by the rubbing, abrading or mechanical action on quartz and which is primarily composed of crystalline silica. The major foundry operations which produce RCS dust are mould and core
making, shakeout, cleaning of castings, furnace and ladle repair, sand reclamation and sand preparation. The principal health effect associated with silica dust is silicosis, which is stiffening and scarring of the lungs. Silicosis is a chronic disease, and usually takes a number of years for the symptoms to appear. It results in increasing shortness of breath, coughing and chest pain. The effects are irreversible, and lead to degeneration in the person’s health, invariably resulting in the premature death of the worker. Silica is also now classed by the International Agency for Research on Cancer as an occupational carcinogen, where excessive exposures can lead to irreversible lung cancer.

There are a number of control options that can be used alone, or in combination, to prevent or minimise exposure to the risk. The risks from airborne contaminants may be controlled by substituting a hazardous process or material for a safer one. For example: using wet (with caution for recycled sands) or vacuum methods or brushes to remove loose dust or sand in the mould making process rather than compressed air to minimise dust creation and using chromite sand instead of silica sand. Engineering controls may involve the use of plant or processes which: minimise the generation of a contaminant; suppress or contain a contaminant; limit the area of contamination. Administrative controls largely involve the development and training of workers in safe work practices and procedures that should be used in combination with other control measures for airborne contaminants. For example: use of continuous monitoring devices to monitor the levels of carbon monoxide in the work area; systematic monitoring to ensure airborne contaminants do not exceed the exposure standard; training in safe work practices and use and maintenance of personal protective equipment. Personal protective equipment that can be used in the control of airborne contaminants includes: face and eye protection; respiratory protection appropriate to the contaminant; respirators with organic vapour filters for organic vapours.

3.5 MANUAL TASKS
This is a task that requires a person to lift, lower, push, pull, carry or otherwise move, hold or restrains any person. Manual working is a major source of hazards and problems for industrial workers worldwide. Tasks which are performed manually constitute a considerable proportion of work done in industries around the globe, especially in developing areas. Manual carrying is defined as the unaided moving of objects, often combined with twisted and awkward postures, contributing to musculo-skeletal disorders (MSDs).

These tasks are part of nearly all work done by workers. They include any activity where workers grasp, manipulate, carry, move (lift, lower, push, pull), hold or restrain a load. Workers in most areas within a foundry would perform manual tasks. The areas that involve frequent performance of manual tasks are part of nearly all work done by workers. They include: Sign posting noisy areas; providing quiet rest areas for food and rest breaks; limiting the time workers spend in noisy areas by moving them to quiet work areas before their daily tasks at comfortable working height. Administrative controls involve task specific training; work organisation; preventive maintenance programme and personal protective equipment (PPE). To prevent a decrease in work efficiency or an increase in injury potential, consider the following: Clothing which restricts the ability to move freely should not be worn; when gloves have to be worn provide different sizes so the right size can be selected and cover only the area of the hand necessary to protect the worker; provide knee protectors for work involving kneeling to reduce stress on the knee.

3.6 NOISE
Hazardous noise is unwanted sound that may damage a person’s hearing. The amount of damage caused by noise depends on the total amount of energy received over time. This means as noise becomes louder, it causes damage in less time. In the foundry industry, hazardous noise levels are produced in many operations. The noise created by foundry machinery is complex due to the wide variety of noise sources and whether it is constant or intermittent. These noise sources include: machinery used in pattern making; moulding machinery; core-making machinery; furnaces; shake-out and knockout of castings; machinery used in tumbling, grinding and cleaning of castings; fettling and dressing of castings.

Health Effects of Noise include: temporary threshold shift which occurs immediately after exposure to high noise levels, condition may last for minutes to hours; noise induced hearing loss that occurs from long term exposure to high noise levels, irreversible; tinnitus which is ringing in the ears that sometimes accompanies noise induced hearing loss; acoustic trauma resulting from explosions or extremely loud impulsive noise which may destroy the cilia hair cells and ear structure. In addition high noise levels may cause difficulties in verbal communication and in hearing warning signals or emergency commands. The following control measures are listed in order of the most effective way of managing risks from noise: elimination by: replacing the machine or its operation with a quieter alternative with equal or better efficiency, replacing noisy machinery with newer equipment designed to operate at lower noise levels; correcting the specific noise source by design changes (e.g. replacing metal components with plastic). The engineering noise control measures for managing noise levels are treatment of: the source; the noise transmission path and treatment at the receiver. Administrative control measures include: Sign posting noisy areas; providing quiet rest areas for food and rest breaks; limiting the time workers spend in noisy areas by moving them to quiet work areas before their daily noise exposure levels are exceeded etc. Workers should be supplied with personal hearing protectors as ear plugs; ear muffs and ear caps.

3.6 VIBRATION
Exposure to noise in industry is often accompanied by exposure to vibration which is classified as: whole body vibration (1 to 80 Hz), or hand-arm or segmental vibration (8 Hz to 1 kHz). Foundry workers may be subject to whole-body vibration during shake out processes, sand- sifting and from forklift truck, conveyor, overhead crane, pneumatic ramming operations and jolt-squeeze machines. Hand-arm vibrations occur when using hand-held power grinders, chippers and other pneumatic tools.
Health effects of vibration: Vibration disease may develop after several years of exposure and result from either whole body vibration or segmental (hand arm)vibration. The main effects of whole-body vibration include: blood pressure and heart problems; nervous disorders; stomach problems; joint and spine damage, influence on speech, shortness of breath, chest pain. The factors that influence the effect of vibration on the hand and wrist include: vibration frequency; level of insulation; duration of exposure etc. The symptoms include: blanching and numbness in the fingers (white finger disease); decreased sensitivity to touch, temperature and pain; loss of muscular control and discomfort and/or pain in the joints, such as the wrists, elbows and shoulders.

The control measures of vibrations are: tools with vibration dampers should be used. They should weigh as little as possible to reduce muscular effort and have handgrips that do not involve twisting the hand away from a normal position while using the tool; Machinery must be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to the lowest level. Administrative controls involve the development of safe work practices and procedures like labeling equipment to warn workers of potential hazards; avoiding prolonged use of vibrating equipment etc. Where exposure to vibration cannot be prevented or reduced by any other form of control, PPE should be provided like: protective gloves and provision of vibration absorbing materials.

3.7 MOLten Metal
Molten metal is a major hazard in foundry melting and pouring areas. Workers, who perform tasks with or near molten metal, may come into contact with metal splashes and be exposed to electromagnetic radiation. Extreme caution must be taken to prevent metal and metal slag from coming into contact with water or moisture, as this may result in an explosive reaction or ejection of molten metal with catastrophic consequences. Electromagnetic radiation is emitted from molten metal in the furnaces and pouring areas. Foundry workers are mainly exposed to infrared and ultraviolet (UV) radiation

Health effects of molten metal: Serious burns may result from splashes of molten metal and radiant heat at any time in the melting and pouring areas. Sparks from molten metal may also damage the eyes. Exposure to infrared and UV radiation may result in eye damage including cataracts.

To control molten metal exposure, barriers and other suitable protection, including mobile shields should be used or installed to protect workers against molten metal splashes and electromagnetic radiation; restricting visitors and workers from wearing synthetic clothing, including undergarments when entering the furnace and pouring areas; keeping melting and pouring areas free of combustible materials and volatile liquids using: heat resistant protective clothing as footwear, headgear, face shields, fire retardant spats, aprons, coats and gaiters; eye protection with side shields; special UV and infra-red glasses

4. PLANT AND MACHINERY
Special care should be taken with plant and machinery used in foundry environments. For example, the elevated temperature in a foundry creates greater stress on crane components and may dramatically reduce a crane’s working life. Continuous vibration of some equipment results in increased mechanical stress on nuts, bolts, chains and cables, which may eventually lead to equipment failure. This in turn may result in major explosions, fires, spills and burns. Atmospheric particulate matter also increases wear through contamination of lubricants and ingress to bearings.

Health effects of plant and machinery: Improper maintenance, repair, guarding and use of plant and machinery in foundries may result in significant increases in the risk of injury to operators and nearby workers. The injuries are: cuts and lacerations; amputations; foreign bodies in eyes; crush injuries; fractures; burns and manual handling injuries To avoid plant and machinery injuries: Redesign can be carried out which involves changing the design of the workplace, equipment or work process. It involves thinking about ways the work could be done differently to make the plant safer such as modifying equipment, combining tasks, changing procedures, changing the sequence of tasks. Administrative measures involve; ensuring that purchasing specifications for new equipment incorporate all required safety features, for example, safety devices and guards and “fail safe” design; carrying out routine and preventive maintenance programs at regular intervals; PPE should be used as: eye protection; hearing protection; safety helmets, and skin protection - gloves, barrier creams.

5. ENVIRONMENTAL ISSUES
Today pollution has become big challenge around the globe. The major terms of pollution are air pollution, water pollution, soil contamination, plastic pollution. Air pollution comes from both natural and man-made sources. However, globally human made pollutants from production, combustion, construction, mining, agriculture and welfare are increasingly significant in the air pollution equation. Adverse air quality can kill many organisms including humans. Pollution prevention and waste minimization are most desirable than pollution control. The pollution control devices used commonly are dust collection systems, scrubbers, and sewage treatment, industrial wastewater treatment, vapour recovery systems and phytoremediation. The environmental issues associated with foundries primarily include air emissions, solid waste, wastewater and noise.
Dust and particulate matters are generated in each of the process steps with varying levels of mineral oxides, metals (mainly manganese and lead), and metal oxides. Dust emissions arise from thermal (e.g. melting furnaces) and chemical / physical processes (e.g. moulding and core production), and mechanical actions (e.g. handling of raw materials, mainly sand, and shaking out and finishing processes). Metal emissions should be controlled during the melting and casting processes. Metal emissions may be emitted through volatilization and condensation of metals during molten metal pouring into moulds. Particulates in ferrous foundries may contain heavy metals, such as zinc (mainly if galvanized steel scrap is used), cadmium, lead (e.g. from painted scrap), nickel, and chromium (these last two in alloy steel casting production) depending on the steel grade being produced and scrap used. Particulates associated with nonferrous metal production may contain copper, aluminium, lead, tin, and zinc.

The presence of metal in particulate emissions can be especially significant during alloying activities and during the introduction of additives. For example, the addition of magnesium to molten metal to produce ductile iron may result in a reaction releasing magnesium oxides and metallic fumes. Dust, fumes and particulate emission can be controlled by using high-efficiency dust abatement techniques. Solid waste streams include sand waste, slag from desulfurization and from melting, dust collected within emissions control systems, refractory waste, and scrubber liquors and sludges. General techniques to manage the waste generated by foundries include the selection, design and construction of storage areas for metals, dust waste from filters, refractory waste, slag, and sand waste, with due consideration of site geological and hydrogeological conditions to prevent potential contamination from potential heavy metal leaching. Disposal by landfill of spent sands is becoming an increasing hazard to the environment and to the environment which eventually affects the wider population. However, a knowledge of the possible solutions could lead to choosing modifications that might be acceptable. Silica sands for foundry products in the different European countries are commercialised at different prices: in Italy the price is about 0.04 €/kg while in Belgium and Netherland the same product is sold at about 0.01 €/kg. These differences and the landfilling costs justify the different solutions adopted in European countries for green moulding sands (recycling or reuse): recycling in Italy, re-use as capping for landfills and concrete production in Sweden, re-use for road construction in Belgium and so on. The most significant use of water in foundries is in the cooling systems of electric furnaces (induction or arc), cupola furnaces, and in wet dedusting systems. In most foundries, water management involves an internal recirculation of water resulting in a minimal effluent volume. Use of wet dedusting techniques may increase water use and consequent disposal management. In core making, where scrubbers are used, the scrubbing solutions from cold-box and hot-box core-making contain biodegradable amines and phenols. In high-pressure die-casting, a wastewater stream is formed, which needs treatment to remove organic (e.g. phenol, oil) compounds before discharge. Wastewater containing metals and suspended solids may be generated if the mould is cooled with water. Wastewater with suspended and dissolved solids and low pH may also be generated if soluble salt cores are used. Wastewater may be generated by certain finishing operations such as quenching and deburring, and may contain high levels of oil and suspended solids. Prevention techniques for effluent streams from foundries include: installation of closed loops for cooling water to reduce water consumption and discharge; recycle tumbling water by sedimentation or centrifuging followed by filtering; store scrap and other materials (e.g. coal and coke) under cover and / or in bunded area to limit contamination of storm water and facilitate drainage collection; process water treatment. Industrial operators must ensure that waste generated at the premises is not discharged into any waters or onto land where it is reasonably likely to enter any waters (e.g. by seepage, runoff or infiltration). The foundry process generates noise from various sources, including scrap handling, furnace charging and electric arc furnace melting, etc. The recommended noise management techniques include: enclosing the process buildings and / or insulate them; enclosing fans, insulate ventilation pipes and use dampers; implement management controls, including limitation of scrap handling and transport during night time.

6. CONCLUSION

A review on effects of hazards in foundries to workers and environment has been conducted where the general overview on foundry industry and the associated hazards was carried out. Major hazards in the foundry industry, the effects and control measures were presented. In the studies, various hazards were identified and elaborated which are heat exposure, hazardous chemicals, airborne contaminants; manual tasks; noise; vibration; molten metal; plant and machinery and electricity. Finally the effects of hazardous materials to environment and their control were looked at. It has been revealed that hazards in foundries are many and very dangerous both to foundry workers’ health and to the environment which eventually spread and affect the wider population.

7. REFERENCES


