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# Safety Measures to Eliminate Human Hazards in Steel Foundry

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**Abstract:**
The aim of the current work is to explicitly link the inherent safety principles of minimization, substitution, moderation and simplification with strategies for dust explosion prevention and mitigation. A brief review of inherent safety and its basic principles is first given. This is followed by a discussion of various ways in which the dust explosion hazard can be minimized, substituted, moderated and simplified. Particular attention is paid to the relationship between each inherent safety principle and (I)various dust expressible parameters,(ii)alternate methods of processing,(iii)selection of process equipment, and(iv)development and complement of safe-work procedures. Original research results are presented, along with industrial case studies and previously published results that have been reinterpreted in terms of inherent safety and its basic principles. It is anticipated that this research will be of value to industry as a complement to the relatively well-established suite of engineered and procedural dust explosion risk reduction measures.

## 1. INTRODUCTION

The production of metal castings is a complex process that has long been associated with worker injuries and illnesses that are related to exposure to chemical and physical agents generated or used in the casting process. Foundry workers may be exposed to numerous health hazards, including fumes, dust, gases, heat, noise, vibration and nonionizing radiation. The continuous exposure to some of these hazards may result in irreversible respiratory diseases such as silicosis and it increases the risk of lung cancer and other diseases. The foundry workers may also be exposed to safety hazards that can result in injuries including strain, burns, eye damage, loss of limb, and death. The major categories of adverse health effects include: Respiratory diseases; ergonomic injuries due to falling or moving objects, lifting and carrying, etc; heat induced illnesses and injuries; vibration induced disorders; noise induced hearing loss; and eye injuries. The occurrence of these problems in a foundry should be considered as **s**afety **h**ealth **e**vents. The means for eliminating or significantly reducing each hazard are well known and readily available. The occupational injuries and illnesses in foundry workers, their working conditions, engineering controls and their work practice used in sand casting foundries are recognized. Based on the recommendations have been developed for reducing the safety and health risk related to working in sand casting foundries. The foundry operations that have been studied include handling of raw material such as scrap metal and sand; preparing sand ; making mold and cores; reclaiming sand and other material used in core and mold production rough cleaning of castings; melting and alloying metals; pouring; removing cores and shaking out castings; maintaining and cleaning all the equipment's regularly and periodically. Founding, or casting, as it is commonly involves in pouring of molten metal into a mold that made in to an external shape of the article to be cast. The mold may contain a core which determines the dimensions of any internal cavity or hollow. Molten metal is introduced into the mold. After cooling occurs, the mold is subjected to a 'shakeout' procedure which releases the casting and removes the core. The casting is then cleaned and any extraneous metal is removed from it.

### 1.1 RISKS IN FOUNDRY

- explosion and burns from molten metal and other hot materials
- respiratory effects from exposre to gases, vapors, fumes and dusts
- skin effects from contct with corrosive or sensitive chemicals
- eye damage from light radiation, metal fragments, dusts and chemical splashes
- heat stress, heat stroke and fatigue from hot working conditions
- slips, trips and falls
- joint, muscle sprains and strains
- physical injuries from machinery and equipment e.g. by entanglement or crushing
- Health effects from machinery and equipment e.g. caused by vibration and noise.

### 1.2 TO MANAGE RISK, A PERSON CONDUCTING A BUSINESS OR UNDERTAKING MUST

- identify reasonably foreseeable hazards that could give rise to risks to health and safety
- eliminate risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety—minimize those risks so far as is reasonably practicable by implementing risk control measures according to the hierarchy of control in regulation 36
- ensure the control measure is, and is maintained so that it remains, effective, and
- review and as necessary revise control measures implemented to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety

### 1.3 MINIMISING THE RISK

#### 1.3.1 Substitution

Minimise the risk by substituting or replacing a hazardous chemical or hazardous work practice with a safer one. For example, use shot blasting of castings instead of sand blasting

### 1.3.2 Isolation

Minimize the risk by isolating or separating the hazard or hazardous work practice from people. For example by carrying out a process from a filtered air control room.

### 1.3.3 Separation

Minimise the risk by separating chemicals from the workplace, for example by using dust filtering or settling devices from which contaminants may escape and positioning them outside or in an enclosure vented to the open air.

## 1.4 HAZARDS IN FOUNDRY

- ❖ The layout of the workplace allows, and the workplace is maintained so as to allow,for persons to enter and exit and to move about without risk to health and safety, both under normal working conditions and in an emergency
- ❖ Work areas have space for work to be carried out without risk to health and safety
- ❖ Floors and other surfaces are designed, installed and maintained to allow work to be carried out without risk to health and safety.

## 1.5 PHYSICAL HAZARDS

### 1.5.1 Noise

- ❖ Noise levels have been measured by a calibrated sound level meter at 114 dB(A) nearby the workers locations at knocking out and cleaning operations. The average level was computed.
- ❖ Evaluation by occupational health and safety personnel of noise should be undertaken to identify areas where noise levels may be excessive. Surveys of foundries have shown that dressing, fettling and shakeout operations give rise to considerable noise levels, with potentially harmful effects on the hearing of exposed workers. In addition to the workers immediately involved in these processes, people working in the vicinity may be exposed to noise levels well in excess of 85dB(A).
- ❖ Some fettling workers have been shown to be exposed to levels of noise over 100 dB(A); shakeout and knockout processes are typically associated with readings of 90-110 dB(A). Mechanical sand mixing processes and forced draught furnaces may produce noise levels of 90-100 dB(A),averaged over an eight hour shift.
- ❖ Extraction fans, die casting machines, core-making and shell-making equipment may also be sources of excessive noise.

### 1.5.2 Vibration

- ❖ Pneumatic grinding and chipping tools used in dressing the cooled castings may cause vibration-induced health effects in operators. Potentially hazardous vibration equipment may also be utilized in shakeout and core removal operations. Advice should besought in these matters from a specialist in this field.

### 1.5.3 Heat and heat stress

- ❖ Radiant heat is the major contributor to the heat load imposed on the worker by the environment. Convective heat transfer adds to this radiant heat. Protective clothing is worn for protection against the heat radiating from the heat sources and against contact with molten metal. Such clothing greatly restricts the potential for body heat loss via evaporation.
- ❖ The foundry worker experiences a total heat load which is determined by the time spent at each workstation, the intensity of work, the clothing worn and the immediate workstation environment, including air circulation. If the heat load is sufficiently severe, effects on health and performance will occur. These range from decreased concentration to painful cramps, fainting, heat exhaustion and heatstroke. These signs and symptoms require immediate medical attention.
- ❖ Heat stress can also aggravate the effects of exposure to other agents such as noise and carbon-mono oxide.

## 1.6 PHYSICAL INJURIES

- ❖ Serious burns may result from splashes of molten metal in the melting and pouring areas of foundries.Frequent, unprotected viewing of white-hot metals in furnaces and pouring areas may cause eye cataracts. Eye injuries from molten metal or fragments of metal may occur in pouring and dressing areas.During continuous casting processes, non-ferrous molten metals, such as copper and aluminum,may explode violently if they contact water. Such explosions can occur in water-cooled furnaces; whenever spillages of molten metal occur; during the charging of furnaces with wet ingots or scrap metal; and whenever moist tools, molds or other material come into contact with molten metal.Injuries related to the manual handling of materials, and injuries due to falls, may occur. Grinding wheels used for dressing small articles may result in hand injuries.

## 1.7 MONITORING

- ❖ Monitoring may be used for the evaluation of a hazard and for assessing the effectiveness of control measures. The design and implementation of a monitoring program should be carried out by, or in consultation with, a properly qualified person.
- ❖ Monitoring of the work environment involves the measurement of atmospheric contaminants at selected locations in the workplace (static, positional monitoring). Personal monitoring involves the measurement of atmospheric contaminants in the breathing zone of the individual worker. Biological monitoring involves measurement of the concentration of a contaminant, its metabolites or other indicators in the tissues or body fluids of the worker. In some cases, biological monitoring may be required to supplement static or personal monitoring.
- ❖ When developing a monitoring program in foundries, due consideration should be given to heat stress, exposure to noise, gases, for example, carbon monoxide, vapour s, fumes, for example, zinc and copper fumes, and dusts, for example, silica and olivine sand dusts.
- ❖ Where there is a likelihood of worker exposure to foundry hazards, steps should be taken to minimize that exposure as far as workable. A thorough examination of work practices is essential. Procedures should be adopted to ensure that workers are not unnecessarily exposed to the hazard. Control measures include, but are not limited to, the following, which are ranked in priority of their effectiveness:
  - ❖ elimination/substitution and process modification;
  - ❖ engineering controls;
  - ❖ administrative controls; and
  - ❖ use of personal protective equipment.

## 1.8 PREVENTING PHYSICAL INJURIES

- ❖ An understanding, appreciation and application of prevention and control measures can contribute greatly to the minimization of the risk of physical injury in foundry work. Some general principles are outlined below:
- ❖ • Mechanically propelled vehicles or machinery should be inspected regularly, kept inefficient working order, and operated only by trained personnel.

- • Maximum loads for winches, hoists, lifts and cranes should be clearly marked on the equipment. These maximum capacities must never be exceeded.
- • Contact between molten metal and water must be avoided. All ladles and other equipment used for handling metal should be completely dry before contacting molten metal.
- • Work areas should be checked regularly to ensure that good housekeeping practices are being followed.
- • Any defective equipment should be repaired immediately or removed from service.
- • Floors around furnaces should be of slip-resistant, non-combustible material, kept free of obstructions and cleaned regularly.
- • Operating instructions for each furnace should be clearly displayed in the furnace area and issued to the person responsible for the furnace.
- • Suitable protective clothing and equipment, including eye protection such as goggles, should be worn by furnace operators. This clothing and equipment should comply with the relevant Australian Standards.
- • Eye protection should be required in all metal cleaning/dressing areas and should comply with the relevant Australian Standard.
- • Barriers or other suitable shields against molten metal splashes should be installed where necessary.
- • Persons should be prohibited from entering furnace areas when the temperature exceeds50°C, except in cases of emergency.
- • Foundries should be equipped with safety blankets, automatic emergency showers or hoses to extinguish burning clothing.

| **d**B(A) levels of common foundry equipment | |
|---|---|
| Mold vibrators | Mold vibrators |
| Inverter | Inverter |
| Arc/air gauging | Arc/air gauging |
| 9-inch angle grinder | 9-inch angle grinder |
| Shot blasting | Shot blasting |
| Shake out | Shake out |

## 1.9 DUST

### 1.9.1 Minimizing exposure to dusts

- Concentrations of silica dust, coal dust, metal fragments and other airborne contaminants should be controlled and utilizing the basic principles.
- It may be necessary to substitute less hazardous sands, such as olivine sand, for quartz sand to reduce free silica concentrations. Local exhaust ventilation should be provided at the mixing or mulling stage as the sand is dry. This also applies to the shakeout operation. Sand, metal and coal dust at this point represent a major hazard. Carbon monoxide gas, from the combustion of coal dust, may be released at shakeout. It is desirable, therefore, to contain the shakeout process and exhaust the enclosure. If the mechanical ventilation in the foundry is not adequate in removing the dust at all points of contamination, the wearing of personal respiratory protective equipment, such as a face mask/respirator, is a complementary preventive measure. Such equipment should only be necessary when the provision of adequate exhaust ventilation is highly impractical, the materials or process cannot be replaced by less hazardous operations or during maintenance procedures.

**CORE SHOP WASTE**

**THE FRESH SAND IS COMING OUT DUE TO LEAK IN THE CONVEYOR BELT**

**CONVEYOR BELT LEAKAGE**

### 1.9.2Chimney dust:

The dust is coming out of the chimney due to the improper maintaince and over usage of the filter bags without proper shakeout is done. The shakeout is the process that must have to be done every two cycle of the shot blasting process.

## 1.10 Mold making

In the casting process a pattern is made in the shape of the desired part. Simple designs can be made in a single piece or solid pattern. More complex designs are made in two parts, called split patterns. A split pattern has a top or upper section, called a cope, and a bottom or lower section called a drag. Both solid and split patterns can have cores inserted to complete the final part shape. Cores are used to create hollow areas in the mold that would otherwise be impossible to achieve. Where the cope and drag separates is called the parting line. When making a pattern it is best to taper the edges so that the pattern can be removed without breaking the mold. This is called draft. The opposite of draft is an undercut where there is part of the pattern under the mold material, making it impossible to remove the pattern without damaging the mold. The pattern is made out of wax, wood, plastic or metal. The molds are constructed by several different processes dependent upon the type of foundry, metal to be poured, quantity of parts to be produced, size of the casting and complexity of the casting. These mold processes include: Sand molds are commonly used for ferrous founding. To produce the depression in the sand into which the metal is poured, a pattern of the object to be cast is formed. Hardwoods, metals or resins are used by pattern makers in this forming process. The majority of ferrous castings are produced by 'green'sand molds. The molding mix usually contains silica sand, coal dust, and organic binders such as dextrine and carbon oil. The molding sand may also contain metal fragments from previous pourings as the sand is recycled. Water and binder are normally added to the sand before it is re-used. Synthetic resins are sometimes used in mold making. The casting of non- ferrous metals often utilizes graphite or metal dies in the molding operation. The use of such dies requires specific procedures and safety precautions.

**1.11 Core making:** Cores are traditionally formed of sand, with an organic binding agent added. The processing of these traditional cores involves oven curing, which releases acrolein, if oils are used, and produces a disagreeable, choking odour. Several new binding systems contain various synthetic resins such as phenol formaldehyde, urea formaldehyde, furfural alcohol (furan), polyurethanes and various amines. The curing of these resins is achieved by chemical reaction or heating. Gases may be used as catalysts for reactions. The mixing of sodium silicate with sand, and the passing of carbon dioxide through the mixed core,is also utilized. Silica gel and sodium carbonate are formed through this process which forms arigid core. The completed, cured cores are sprayed with a coating material prior to pouring. This may involve a combination of alcohol and graphite.

**1.12 Furnace**

Several specialized furnaces are used to heat the metal. Furnaces are refractory lined vessels that contain the material to be melted and provide the energy to melt it. Modern furnace types include electric arc furnaces (EAF), **induction furnaces**, cupolas, reverberatory, and crucible furnaces. Furnace choice is dependent on the alloy system quantities produced. For ferrous materials EAFs, cupolas, and induction furnaces are commonly used. Reverberatory and crucible furnaces are common for producing aluminium, bronze, and brass castings. Furnace design is a complex process, and the design can be optimized based on multiple factors. Furnaces in foundries can be any size, ranging from small ones used to melt precious metals to furnaces weighing several tons, designed to melt hundreds of pounds of scrap at one time. They are designed according to the type of metals that are to be melted. Furnaces must also be designed based on the fuel being used to produce the desired temperature. For low temperature melting point alloys, such as zinc or tin, melting furnaces may reach around 500° C. Electricity, propane, or natural gas are usually used to achieve these temperatures. For high melting point alloys such as steel or nickel based alloys, the furnace must be designed for temperatures over 1600° C. The fuel used to reach these high temperatures can be electricity (as employed in electric arc furnaces) or coke.

**THE FURNACE FEEDING SECTION IS DUMPED WITH THE REJECTION SCRAP**

**1.13.1 Melting**

Melting metal in a crucible for casting. Melting is performed in a furnace. Virgin material, external scrap, internal scrap, and alloying elements are used to charge the furnace. Virgin material refers to commercially pure forms of the primary metal used to form a particular alloy. Alloying elements are either pure forms of an alloying element, like electrolytic nickel, or alloys of limited composition, such as ferroalloys or master alloys. External scrap is material from other forming processes such as punching, forging, or machining. Internal scrap consists of gates, risers, defective castings, and other extraneous metal oddments produced within the facility. The process includes melting, refining the melt, adjusting the melt chemistry and tapping into a transport vessel. Refining is done to remove gases and elements from the molten metal to avoid casting defects. Material is added during the melting process to bring the final chemistry within a specific range specified by industry and/or internal standards. Certain fluxes may be used to separate the metal from slag and/or dross and degassers are used to remove dissolved gas from metals that readily dissolve certain gasses. During the tap, final chemistry adjustments are made.

**1.13.2 Pouring:** In a foundry, molten metal is poured into molds. Pouring can be accomplished with gravity, or it may be assisted with a vacuum or pressurized gas. Many modern foundries use robots or automatic pouring machines for pouring molten metal. Traditionally, molds were poured by hand using ladles.

**1.14 SHAKEOUT (KNOCKOUT):** The hardened metal component is then removed from the mold. Where the mold is sand based, this can be done by shaking or tumbling. This frees the casting from the sand, which is still attached to the metal runners and gates - which are the channels through which the molten metal traveled to reach the component itself. The removal of the cooled casting from the mold is termed 'shakeout'. The molding sand is dry and friable at this stage, and particles of metal, sand and core material can become airborne during this process. While new foundries may have automated shakeout facilities, many smaller foundries do not, and the shakeout is performed manually. When the technique of 'jobbing' molding is utilized, the molds are knocked out by hand, usually with a hammer. If coal dust is incorporated into a sand mold, carbon monoxide will be generated during cooling and shakeout. When considering the hazards associated with any workplace, it is essential to understand the relationship between 'hazard', 'exposure' and 'risk'. 'Hazard' is the potential for an agent or process to do harm. 'Risk' is the likelihood that an agent will produce injury or disease under specified conditions. Health effects can only occur if a worker is actually exposed to the hazard. The risk of injury or disease usually increases with the duration and frequency of exposure to the agent, and the intensity/concentration and toxicity of the agent. Toxicity refers to the capacity of an agent to produce disease or injury. The evaluation of toxicity takes into account the route of exposure and the actual concentration of an agent in the body. The various processes outlined in the preceding section give rise to heat, molten metal splashes, dusts, noise, gases and vapor s in the foundry environment. If these hazards are not controlled or contained, serious health effects in exposed workers can result. Foundry work also involves various manual operations which carry a risk of physical injury.

**THE DUST COMING DURING CLEANING THE FILTER BAGS**

## 4.1 AMBIENT AIR MONITORING SYSTEM:

Ambient air quality monitoring is required to determine the existing quality of air, evaluation of the effectiveness of control programmer and to identify areas in need of restoration and their prioritization.

**The following precautions must be followed in sampling of air pollutants**

1. The dust sampler (DS) must be properly calibrated to get the correct flow rate.
2. maintenance must be done properly.
3. The filter used sampling should be of good quality
4. Filter should be mounted properly on the support screen with the rough side of the filter facing upwards.
5. The wing nuts should be tightened properly to avoid any leakage
6. Distilled water must be used in manometer tube and water must be changed every fortnightly and zero level must be checked every time.
7. Manometer must have to be filled every time before the monitoring is started.
8. The equipment must have to be monitored for 24 hours.
9. The succession part must have to be removed and cleaned.

## 4.2 STACK MONITORING SYSTEM:

Online Continuous Stack Emission Monitoring System (CSEMS) are used for the measurement of pollutants within the stack emission. Monitoring within the stack presents a number of problems due to extremes of temperature, velocity of sample and pressure.A stack testing program can last a few days or even weeks, depending on the needs.A stack testing program can last a few days or even weeks, depending on the needs.Stack testing is typically conducted at considerable height, including on roof tops, scaffolding, elevated walkways and gratings, and on stack testing platforms. It is also frequently performed during inclement weather, including cold, rain, wind, ice and snow.

## 5. PROPOSED METHODOLOGY IMPLEMENTED

### 5.1Shot Blasting:

The dust collectors 2 NOS are replaced with new latest state of art equipements with cost of Rs.18.93 Lakhs. Copy of Invoice and challan given below.

**Sand Plant:**

1. Replaced with new dust bags for the existing shot blasting machines.
2. Wetting of the solid waste generated from the shot blasting machine to avoid the dust flying.
3. Improved dust handling by collecting the dust in bags
4. Two 1 Ton capacity shot blasting machines shall be replaced with new 2 Ton capacity machine with latest design dust collector before May month end .(Purchase order copy given below )
5. The sand cooler blower outlet is connected to the tank filled with water to ensure that the dust is settled at the bottom. Slurry is removed at regular intervals
6. The sand plant lowers are replaced with vertical cladding so that the dust from the sand plant does not fly.and for the succession of the dust inside the sand plant we have provided the succession blower and it will be releasing through the chimney.
7. **5.2** We added 15 NOS of sprinklers at the sand preparation plant for dust suppressions.it will be continuously running.
8. We arrested sand leakages from the conveyor belts carrying sand by changing the conveyor drum with proper alignment.
9. The damaged duct is replaced for the dust collector for the sand plant.
10. Generator with acoustic encloser for the heat treatment plant.
11. Fume Extraction System the fume from the furnace is directly connected and the blockages were removed and new duct was erected for the system.
12. **5.3** Swivel Hoods for the furnace not provided properly we have implemented hoods separately for each furnace.
13. The Bentonite powder hopper is covered from all sides to avoid flying of powderdue to vibration the welded part was again starting to leak so the mixture drum was fully erected.
14. Management has released purchase order for A VALUE OF 1.27 Cr for the upgradation of dust extraction

system for sand plant, shakeout and cooler this will be completed within two months.

15. After implementing above corrective actions the emissions levels from the plant are found to be within the permissible limits.

16. Third party agency monitoring reports for the AAM performed on 1st April is given below and it must have to be done regularly for three months.

17. The daily monitoring report of ONLINE AAM is given below.

**Road Sweeper**

This is a new road sweeper it will be running for each and every one hour continuously.

## 6. RESULTS AND DISCUSSION

The CAPA is implemented for reducing the dust which is the major issue that occurs in our company and it created a lot of problems among the public and the samples were tested by using the required dust sample equipment’s for PM 10 & PM 2.5 by the APPCB and it is the periodic inspection by the pollution control board according to the complaints raised by the public. The readings what PCB people were given is not in the limit so we again monitored the AAM system by using our own equipment’s in various places both inside and outside the factory and we have collected the readings in that inside the factory is less and standard but outside near the public area is high and the samples were crossing the limit. As the result of my project the dust sample monitoring and stack monitoring have done successfully and the reports are submitted .After this we are gioing to change the new type of vacuum scrubber for all the dust bags in shot blasting and the sand plant dust collectors. We have also conducted third party inspection from the public side and is was also under the limits. We have analyzed the other dust that arises from the neighbor companies so we are having the photos that the dust coming other than our company.

| **S. No** | **Point Of Sampling** | **RSPM Value** | **Boards standard** | **REMARKS** |
|---|---|---|---|---|
| 1 | On the roof top of Sri ram rao's house | 62.7 | 100 | With in the limits |
| 2 | On the roof top of Sri ram rao's house | 44.8 | 100 | With in the limits |
| 3 | On the roof top of Sri P.Narayana reddy's house | 92.6 | 100 | With in the limits |
| 4 | On the roof top of Sri P.Narayana reddy's house | 132.4 | 100 | We can see from the google map that house is road facing and lot of traffic,vehicular movement exist throughout the night |
| 5 | On the roof top of gram panchayat Office, Divipalem Gudur | 223.6 | 100 | In this season the wind direction is towards the east and the location exists in west to the plant.<br>It is a katcha road.<br>Lot of auto's movement on the road.<br>Near by hotels/residences still used fire wood for cooking. |
| 6 | Near online AAQM station of the industry | 426.7 | 100 | Remarks are given below |

## 7. THIRD PARTY MONITORING DATA

| LOCATION | PM 2.5 Concentration | PM 10 Concentration |
|---|---|---|
| NEAR MAIN GATE | 38 | 82 |
| NEAR POWER HOUSE | 31 | 77 |
| NEAR INDUCTION FURNACE | 26 | 85 |
| SO2 CONCENTRATION | 15,13,16 is less than 80 | |
| NOX CONCENTRATION | 21,19,18 is also less than 80 | |

## 8. CONCLUSION

The project assessment carried out in **Nelcast ltd** they have identified and rectified the major problems and they have taken various measures and implemented all over the plant the problem raised due to huge exposure of dust and it was travelling towards the public living area so the past two months the problem was huge so we have raised for new type of filter bags and we have planned to implement vacuum type of dust collectors for all the shot blasting machines and the shakeout process must have to be done after every cycle by conducting the meeting and the other major thing is sand plant because75% of the dust is escaping out from the sand plant so we have done all required measures according to our needs as the documents were shown above and sprinklers is the main thing we have fixed around the sand plant to avoid the dust flying from the sand plant after taking the measures we have submitted the documents to the APPCB and they reviewed the measures and analyze the problems we have rectified.

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