PLAINTIFF'S
EXHIBIT
AL-1394

OSHA - NEP Consultation Committee
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MATERIALS HANDLING DEPARTMENT
(Transportation, Storage and Shipping)

I.

Transportation

Bulk materials shipped into a foundry usually consist of sand, coal, coke, pig iron, iron and steel scrap, limestone, and additives.

In very large foundries some chemicals may be utilized in bulk or tank car quantities. Bulk materials may be shipped into a foundry via barge, truck, or rail car. Unloading may be accomplished via conveyors, power operated trucks, cranes equipped with electromagnets and clam shells, hand trucks, or manual means.

Bucket elevators, conveyor belts and pnuematic conveying equipment can be employed to transport materials from the unloading area to storage or utilization areas.

Hazards associated with transportation of bulk materials may result in any or all of the personal injuries involving hernia, back strain, crushed toes, cuts, crushing and burns resulting from poor handling practices. It may involve oxygen deficiencies for someone buried in sand, coal, or coke due to a cave-in, or falling into a car while unloading.

Storage of Materials

Storage includes raw materials, processing materials such as patterns and molds and finished products. Raw materials may be stored in silos, bins, racks and shelves. Separate buildings may be utilized for storage of patterns, molds,

suitable for its intended use. Dockboards should be designed with a four : one factor to be used in trailer and rail car loading and unloading. Dockboards must be secured in position and when not in use should be stored in a safe place provided for the purpose. Positive protection should be provided to prevent movement of trucks, trailers or rail cars which are being loaded or unloaded. Precautions should be taken when opening rail car doors to insure that neither the door or material in the car will fall on the employee.

Heavy machinery and materials shipped on skids, pallets or boxes should be well braced inside the car to prevent shifting of the load.

Uneven floors and ramps may lead to sprains and broken limbs, or may cause a load being carried by a fork lift truck to topple, resulting in injuries that may range from broken bones to fatalities. Blind intersections can lead to collisions between personnel and industrial powered trucks and between trucks themselves. The extent of injuries resulting will depend on the load carried and the speed of impact.

Lack of proper dockboards, non-skid surfaces and wheel chocks for trailers and railway cars may lead to serious injury and possibly fatalities.

Steel strapping and tools used for tightening and cutting may contribute to injuries ranging from minor to severe injuries. Proper equipment and instruction in its use is essential.

The use of hot pitch or other heated materials may cause severe burns where these materials are used to protect materials being packed for export. Proper training and personal protective equipment are again essential.

Injury Statistics

Foundry Materials Handling Departments have an injury frequency rate of 16.4 disabling injuries per million man hours worked, and a severity rate of 1.988 days charged per millon man hours worked. The injury statistics closely parallel those for Maintenance Departments having a 17.4 frequency rate and a 1,926 severity rate. However, the average number of days charged per disabling injury for Materials Handling operations is 121 compared to 110 for Maintenance. Maintenance Departments' frequency and severity rates are 17.4 and 1,926 respectively.

II. Principal Hazards

Overexertion -- from heavy manual lifting

Falling objects -- from material handling equipment and improper material storage

Dropped objects -- from manual handling of materials

Dust -- from sand, coal, coke, etc.

Fire and explosion -- from storage and handling of combustible liquids and materials

Burns -- from handling chemicals hot pitch, etc.

Eye Injuries -- from airborne material such as: sand, and metal particles

Cut and laceration -- from handling sharp and abrasive materials

Caught:

In -- machines, conveyors, etc.
Under -- machines, flasks, etc.
Between -- industrial trucks, etc.

MATERIALS HANDLING
(Transportation - Storage & Shipping)

Safety Hazards In Order of Frequency	Type of Injuries That May Result	Relevant Standards	Title	Abatement
Overexertion	Sprains & Strains	No standard		Change in methods Engineering study Proper training in lifting techniques
Falling/Dropped Objects	Contusions Bruises Lacerations Fractures	1910.22 1910.23 1910.25 1910.26 1910.28	Walking & Working Surfaces Guarding Floor & Wall Openings Portable Wood Ladders Portable Metal Ladders Safety Requirements for Scaffolds	Housekeeping - Clearances for mechanical material handling equipment Adequate Guarding for all floor openings & holes Proper care, use and storage of all ladders and scaffolds
Caught:	Contusions	1910.132	Personal Protective Equipment - General	Provide necessary foot protection
In - Machines, Conveyors, etc.	Bruises Lacerations	1910.145 1910.176	Accident Prevention Equipment - General Materials Handling & Storage - General	Adequate lockout procedures Inspection, maintenance and proper use of materials handling equipment - training
Under - Machines, Conveyors, etc.	Fractures Amputations	1910.178 1910.179	Powered Industrial Trucks Overhead & Gantry Cranes	Adequate training - manual lift
Between - Industrial trucks, etc.		1910.180 1910.184 1910.212 1910.219	Crawler, Locomotive, & Truck Crane Industrial Slings General Requirements for all Machines Mechanical Power Transmission	Adequate guarding of all machine and power transmission units
Burns	Hands, Face, Body	1910.132 1910.106 1910.101 1910.104	Personal Protective Equipment - General Flammable & Combustible Liquids Compressed Gases - General Oxygen	Provide the necessary personal protective equipment per hazard Handle, store and dispense flammable & combustible liquids in accordance with safe practices. Also compressed gases.
Slips/Falls	Fractures Sprains	1910.22 1910.23 1910.25 1910.26 1910.28	Walking & Working Surfaces - General Guarding Floor & Wall Openings Portable Wood Ladders Portable Metal Ladders Safety Requirements for Scaffolds	Good housekeeping requirements Proper guarding of all floor openings & holes Proper care, use and storage of ladders and scaffolds
Electrical Shocks	Respiratory and/or Cardiac Arrest	1910.309	National Electrical Code	Maintain all electrical tools/systems in accordance with the required articles of the N. E. C. -NFPA-70-1971
Airborne Material	Abrasions Eye	1910.132 1910.133	Personal Protective Equipment Eye and Face Protection	Provide suitable protective equipment

HEALTH HAZARDS IN MATERIALS HANDLING

In materials handling the health hazards are due to the noise and CO from materials handling equipment and the release of toxic materials from broken containers.

Raw materials are often moved within a plant by powered industrial trucks. Where petroleum based fuels are used, carbon monoxide can build up to hazardous levels when general ventilation is inadequate.

Noise levels at loading and unloading stations can be excessive and if the duration of exposure and noise intensity are great enough, hearing loss may result.

A number of raw materials used in foundries are toxic upon inhalation and/or skin contact and can present a health hazard in materials handling if released from broken containers. Inhalation of silica or fears of silica can cause silicosis. Exposure to vapors of cleaning agents -- e.g. chlorinated hydrocarbons, ketones, and alcohols -- can cause a toxic reaction. Acids and bases, also used as cleaning agents in foundries, can cause chemical burns upon skin contact. The organic resins used in binding molding material can cause skin irritation, dermatitis and sensitization upon skin contact. The peroxide catalysts which cure the resins can also cause skin irritation. Emergency procedures for cleaning up spills and for escape should be posted.

Compressed gas cylinders of chlorine are a raw material unique to the aluminum foundry, where chlorine is used to degas the molten metal. Exposure to chlorine gas from the handling of a damaged cylinder can cause respiratory tract irritation. Compressed gases which may be stored should be handled in accordance with the OSHA Standards and the manufacturer's recommendations.

Materials Handling

Process Hazards

Health Hazards In Order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
Carbon monoxide	cardiac strain	1910.1000 - air contaminants 1910.134 - respiratory protection	use of battery powered truck
noise	hearing loss	1910.95 -- occupational noise exposure	engineering controls administrative controls hearing protection

Contamination Due to Spills

Health Hazards In Order of Severity	Type of Illness that may develop	Relevant Standards	Emergency Procedures
silica and flours of silica	silicosis	1910.1000 - air contaminants 1910.134 - respiratory protection 1910.22(a) - housekeeping	clean up spills use respiratory protection

Contamination Due to Spills

Health Hazards in Order of Severity	Type of Illness that may develop	Relevant Standards	Emergency Procedures
chlorinated hydrocarbons	systemic poisoning narcosis	1910.1000 - air contaminants 1910.132 - personal protective equipment, general requirements	clean up spills use respiratory protection and protective clothing
ketones	systemic poisoning	1910.133 - eye and face protection 1910.134 -- respiratory protection	clean up spills use respiratory protection and protective clothing
alcohols	"	"	"
acids and bases	Chemical burns	1910.151 - medical services and first aid 1910.133 - eye and face protection 1910.134 - respiratory protection	clean up spills use protective clothing and equipment wash substance from eyes and body using emergency wash systems

Contamination Due to Spills

Health Hazards In Order Of Severity	Type of Illness that may develop	Relevant Standards	Emergency Procedures
organic resins:			
epoxy resin phenolic resin urea formaldehyde urethane (diisocyanate based) resin furan resin	skin irritation dermatitis sensitization	1910.1000 - air contaminants 1910.132 - personal protective equipment, general 1910.133 - eye and face protection 1910.151 - medical services and first aid	clean up spills use respiratory protection and protective clothing wash substance from eyes and body using emergency wash systems
peroxide catalysts	skin irritation	"	"
aluminum foundry -			
compresses gas: Chlorine	respiratory irritation	1910.1000 - air contaminants 1910.134 - respiratory protection 1910.166 - inspection of compressed gas cylinders	use respiratory protection

COREMAKING

I. Cores are simply patterns which reproduce the openings or hollow spaces that are desired in the finished casting. When a mold of the solid pattern has been made the cores are set in place within the opening and the molten metal is poured around them. Cores must possess three essential characteristics. They must be sufficiently cohesive to retain their shapes while being placed and while the metal is being poured; they must be highly refractory to stand up under the intense heat of the molten metal; and they must be capable of being easily broken up so that they can be removed from inside the finished casting. Various materials are used in making cores, but the dry-sand core is the most common type. In general the process of core-making consists of mixing sand with a binder material, such as flour, powdered resin, linseed oil, and of tamping or blowing this mixture into molds which give it the desired shape. The molded cores are then baked or dried to make them hard. Cores may be shaped by hand-ramming or blowing the sand into a core box; by the use of a conveyor-screw core-making machine, which is similar in appearance to a meat grinder and which is used to compact the sand into bar-like cores of uniform cross section; or by the use of a core-turnover-draw machine, which compacts the sand into the core boxes by jarring and jolting.

A variety of hand tools, such as mallets, trowels, shovels, pliers, core boxes, clamps, core plates, and compressed-air blowers for cleaning, are used in core rooms. Various machines, and other mechanical equipment, such

as sand-mixers, conveyors, baking ovens, and core machines, are also commonly used in this department. The hand tools used are not particularly hazardous, but the machines which may be used frequently present serious possibilities of injury to hands and arms from contact with moving parts. Burns from contact with hot ovens, oven trays, gas burners, and shell core machines are common.

Generally, core making is not considered very heavy work. The metal core boxes and core plates, however, are sometimes fairly heavy and present lifting hazards and the possibility of pinched or crushed fingers or toes, if they are mishandled or dropped.

The frequency of injuries reported for the core rooms was somewhat greater than that for the pattern shops, but was less than that for any of the other major departments. In the ferrous job foundries the core rooms had the highest number of disabling injuries while the nonferrous and other job type foundries injuries were considerable less than ferrous.

Injuries to hands, fingers, feet, toes, and backs were outstanding among the reported injuries to core-room workers. Injuries in these categories are all closely related to the use of hazardous machines or to the handling of heavy, bulky, or awkward materials, and indicate a need for better machine guarding and for careful planning and training of the workers in the operations they must perform. The volume of foot and toe injuries also indicates that the use of foot protection might well be emphasized in the core rooms.

Injury Statistics

Coremaking injuries accounted for 6% of the total number of foundry injuries and 10% of the lost time days. The operation results in a frequency rate of 13.5 disabling injuries per million man hours worked and a relatively low severity rate of 797 days charged per million man hours worked.

II. Principal Hazards

Overexertion -- from heavy manual lifting

Exposure to heat and radiation -- from ovens and heated cores and core boxes

High noise and vibration levels -- from operation of production machines, equipment and systems

Falling objects -- from material handling equipment and improper storage

Fire and explosion -- from ovens, chemical bindery, flammable and combustible materials used in process

Unguarded belts, pulleys (and gears) -- from mechanical power transmissions and other equipment

Electrical Shock -- from ungrounded machines, tools and materials handling equipment

Slips and falls -- from poor housekeeping, uneven floors, etc.

Dropped objects -- from manual material and equipment handling

Fumes -- from ovens and chemical binders

Dust -- from sand

Moving machines and parts of machines -- points of operation hazards from cutting machines and tools

Eye injuries -- from airborne materials such as sand, and metal particles

COREMAKING

Safety Hazards In Order of Frequency	Type of Injuries That May Result	Relevant Standards	Titles	Abatement
Overexertion	Sprains & Strains	No standards		Change in methods Engineering study Proper training in lifting techniques
Falling/Dropped Objects	Contusions - Bruises Lacerations Fractures	1910.132 1910.145 1910.176 1910.178	Personal Protective Equipment - General Accident Prevention Signs & Tags Handling Materials - General Powered Industrial Trucks	Provide necessary protective equipment Adequate lockout procedures Proper use of material handling equipment - training
Caught: In - Machines, Conveyors, etc.	Contusions - Bruises Lacerations Fractures Amputations	1910.212 1910.219 1910.242 1910.243 1910.244	General Requirements for All Machines Mechanical Power Transmissions Hand & Portable Powered Tools & Equipment Guarding Portable Powered Tools & Equip. Other Portable Tools	Install all guards as required Guard all power transmission units Maintain all portable powered tools & equipment in good condition ANSI Z241.1-1975 Mold and Coremaking
Slips/Falls	Fractures Sprains	1910.22 1910.23	Walking & Working Surfaces - General Guarding - Floor & Wall Openings	Housekeeping Provide guardrails where required
Electrical Shocks	Respiratory and/or Cardiac Arrest	1910.309	National Electrical Code	Maintain all electrical tools/systems in accordance with the required articles of the NEC-NFPA 70-1971
Fire & Explosions	Cuts & Burns	1910.106 1910.93	Flammable & Combustible Liquids Air Contaminants	Dispense and handle all flammable and combustible liquids in a safe manner

Health Hazards in Mold and Core Making, Shakeout and Core Knockout

The major health hazards associated with mold and core making are due to the components of the mold and core material which can become airborne during sand mulling, sand slinging and mold packing. Mold and core material can contain silica, asbestos, organic resin binders and catalysts. These same materials can again become airborne during the shakeout and core knockout processes.

Crystalline silica (SiO_2) is a major constituent of foundry sand and may be present in high concentrations in silica flour and in sand mold and core materials. The inhalation of crystalline silica may cause silicosis. The degree of hazard depends on the crystalline silica content, concentration and size of airborne dust, as well as the length of exposure. Return sand is a greater hazard due to its smaller size from the abrasion of former processes. Heavy exposures have produced symptoms in less than one year after initial exposure; many years, however, are generally required to produce symptoms. Settled silica containing dust is an important source of exposure in foundries where good housekeeping is lacking. Settled dust is easily reentrained by slight vibrations of air currents.

Asbestos is occasionally used as an insulating material in riser sleeves and may lead to exposure to airborne asbestos fibers. The fibers become airborne when the asbestos is cut for fitting, when the asbestos breaks up during shakeout and knockout operations, and when the broken-up asbestos

becomes entrained in return mold material (usually primarily sand).

The remaining components of mold and core material which can present a health hazard are the organic resin and their catalysts used for binding the mold material. Vapors can evolve while the resin ingredients are being mixed, added to the mold material, and while the resins are curing.

The resins used to bind the mold or core material can include phenolic resin, urethane (isocyanate based) resin, urea formaldehyde resin and furan resin. Skin contact with chemicals involved in resin systems can cause skin irritation, dermatitis or sensitization. (Follow-up information is contained in American Foundry Society (AFS) guide sheets.)

Noise is a hazard in core and mold making due to the sand slinging machine and pneumatic tools used to pack molds. It is a constant hazard in shakeout and knockout due to metal banging against metal and vibrating and jolting of machines. Excessive noise exposure can produce temporary and/or permanent loss of hearing. Total loss of hearing may result after extended exposure to very high levels.

Health Hazards - Mold and Core Making, Shakeout and Core Knockout

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
silica	silicosis	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, administrative controls, respiratory protection
asbestos	asbestosis	1910.1001--asbestos 1910.134--respiratory protection	local exhaust ventilation, work practices, respiratory protection
noise	hearing loss	1910.95--occupational noise exposure	engineering and administrative controls, hearing protection
Resins:			
epoxy resin	skin irritation, dermatitis, sensitization	1910.132--personal protective equipment, general requirements	personal protective clothing, gloves
phenolic resin	"	"	"

Health Hazards - Mold and Core Making, Shakeout and Core Knockout

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
urethane (isocyanate based resin)	skin irritation, dermatitis, sensitization	1910.132--personal protective equipment, general	personal protective clothing, gloves
urea formaldehyde resin	"	"	"
furan resin	skin irritation, dermatitis; sensitization	1910.132--personal equipment, general requirements	personal protective clothing, gloves
Catalysts and Evolved Vapors:			
Phenol	systemic poisoning	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
isocyanates	asthma-like attacks	"	"
hexamethylene-tetramine	sensitization	1910.132--personal protective equipment	protective clothing

Health Hazards - Mold and Core Making, Shakeout and Core Knockout

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
ammonia	eye and respiratory tract irritation	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
formaldehyde	"	"	"
furfuryl alcohol	respiratory tract irritation and sensitization	"	"
triethylamine	irritation of cornea and lung	"	"
mineral acids (sulfonic, phosphoric, sulfuric)	skin and respiratory tract irritation	"	"
carbon monoxide	cardiac strain	"	"
vibrations	Raynaud's Syndrome	none	Engineering, Heavy gloves

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MOLDING

I. Permanent metal molds are sometimes used when many identical or precision castings are to be made, the common practice is to prepare sand molds for casting. Briefly, the process of making a sand mold consists of compacting prepared sand around a pattern and then withdrawing the pattern so as to leave an opening in the sand which reproduces the outside contours of the pattern. Cores, which are solid reproductions of the hollow spaces desired within the finished casting, are then set in their proper places inside the opening in the mold and the mold is poured off.

The first step in making a mold is to prepare the sand by mixing it with binder materials such as clay and tempering it with water. Sand-mixing is done with sand-mixing machines or mullers. The chief danger in mixing the molding sand is that of coming into contact with the moving parts of the mixing machines especially when sampling.

When the sand and binder has been mixed properly and the pattern is placed inside a flask, the sand is then compacted around the pattern by ramming, jolting, squeezing or the use of high pressure means. To facilitate the subsequent withdrawal of the pattern,

both the pattern and the flask are generally divided into two sections. The bottom, or drag, section of the flask is usually rammed first in an inverted position. Then the drag is turned over, the upper or cope section placed on top and the packing of the sand is completed. The cope section is then removed from the drag, the pattern sections are withdrawn from the sand, and any necessary cores are set in position within the opening left by the pattern. Then the cope is placed on the drag and the two sections are clamped together. The metal is poured into the mold cavity through a sprue cut into the sand. In jobbing foundries these operations are often performed by hand. In production foundries, however, machines are commonly used to compact the sand, withdraw the patterns, and sometimes to turn over the flask sections.

Substantial portions of the industry product and the majority in terms of tonnage results from flask-less molding operations, however, the hazards associated with sand molding are not generally prevalent.

The principal hazards connected with hand molding are those arising from lifting and moving the flasks, which are heavy. The same hazards prevail in machine molding, with the added danger of

contact with the moving parts of the machines. Sand mixing or mulling machines can present a serious hazard if not properly guarded.

Particular attention should be paid to hazards associated with centrifugal casting operations such as; metal splashes at high speed turning operations.

Die casting operations pose hazards such as; squirting metal under high pressure, accidental combination of flammable hydraulic fluid with molten metal and pinch and nip points.

The injuries to the lower extremities reported for the molding departments points to a need for greater emphasis upon the use of adequate personal protective equipment for legs and feet. Hand and finger injuries indicates a need for use of gloves and for adequate training in handling procedures. Back injuries in this department point to a need for more instruction in the proper methods of lifting and closer supervision to see that the proper methods are used. Eye injuries indicate that more extensive use of eye protection would be desirable.

Injury Statistics

Approximately one-third of all injuries and days lost due to injuries occur in Molding Departments. The injury frequency rate of 32.4

disabling injuries per million man hours worked is combined with the highest severity rate of all operations in foundries -- 2,070 days charged per million man hours worked.

II. Principal Hazards

Overexertion — from manual lifting

Falling objects — from material handling equipment and improper storage

High noise and vibration levels — from production machine and equipment

Eye injuries — from airborne materials and splashes from molten metal

Slips and falls — from poor housekeeping, uneven floors, unguarded open floors and pits, etc.

Caught --

In - machines, conveyors
Under - machine flasks, etc.
Between - machines, industrial trucks, etc.

Dropped objects — from manual material handling

Exposure to heat and radiation -- from molten metal, sand and hot castings

Cuts and lacerations -- from sharp and abrasive materials

MOLDING DEPARTMENTS

Safety Hazards In Order of Frequency	Type of Injuries That May Result	Relevant Standards	Titles	Abatement
Overexertion	Sprains & Strains	No standards		Change in methods Engineering study Proper training in lifting techniques
Molten Metal Flying Particles	Burns & Scalds Eye Injury	1910.132	Personal Protective Equipment - General	Provide adequate personal protective equipment
		1910.133	Eye protection	
		1910.176	Handling Materials - General	Inspection, maintenance, and proper use of materials handling equipment
		1910.178	Powered Industrial Trucks	Adequate Training: Power industrial truck operators Manual lifting Slings
		1910.179	Overhead & Gantry Cranes	
		1910.184	Industrial Slings	
Falling/Dropped Objects	Contusions-Bruises Lacerations Fractures	1910.22	Walking & Working Surfaces	Housekeeping - Clearances for mechanical material handling equipment
		1910.23	Guarding Floor & Wall Openings	Adequate Guarding for all floor openings & holes
		1910.25	Portable Wood Ladders	Proper care, use, & storage of all ladders and scaffolds
		1910.26	Portable Metal Ladders	
Caught:		1910.28	Safety Requirements for Scaffolds	Provide necessary foot protection
In - Machines, Conveyors, etc.	Contusions-Bruises Lacerations	1910.132	Personal Protective Equipment - General	Adequate lockout procedures
		1910.145	Accident Prevention Signs & Tags	Inspection, maintenance & proper use of materials handling equipment - training
Under - Machines, Conveyors, etc.	Fractures Amputations	1910.176	Materials Handling & Storage - General	Adequate training - manual lift
Between - Machines Conveyors, etc.		1910.178	Powered Industrial Trucks	Adequate guarding of all machine & power transmission units
		1910.179	Overhead & Gantry Cranes	ANSI-B152.1-1973 Die Cast Machines
		1910.184	Industrial Slings	ANSI 2241.1-1975 Mold & Coremaking
		1910.212	General Requirements for all Machines	
		1910.219	Mechanical Power Transmission	
Slips & Falls	Fractures Sprains	1910.22	Walking & Working Surfaces - General	Good housekeeping requirements
		1910.23	Guarding Floor & Wall Openings	Proper guarding of all floor openings & holes
		1910.25	Portable Wood Ladders	Proper care, use, & storage of ladders and scaffolds
		1910.26	Portable Metal Ladders	
		1910.28	Safety Requirements for Scaffolds	
Electrical Shocks	Respiratory and/or Cardiac Arrest	1910.309	National Electrical Code	Maintain all electrical tools/systems in accordance with the required articles of the N.E.C.-NFPA-70-1971

MELTING AND POURING

I. The various types of melting equipment used in foundries are the cupola, crucible, the reverberatory, the electric arc, induction, channel, air, duplexing, forehearth, and the open-hearth furnaces. The cupola is used for melting iron and is commonly found in iron foundries. The above furnaces may be used in either ferrous or nonferrous foundries; these types of furnaces permit a greater degree of control over the quality of the metal and are used in foundries whenever particular characteristics are essential in the finished castings. Open-hearth furnaces are essentially steel-making furnaces rather than melting furnaces and are generally used only in foundries connected with steel works or engaged in making very large quantities of steel castings.

A cupola is essentially a steel cylinder lined with firebrick, open at the top and closed at the bottom with dual doors. The entire unit is supported upon a framework, which leaves an open space beneath the bottom doors. The top of the cupola may or may not extend through the roof. Alternate layers of coke and metal are changed into a door from a charging platfrom at a point near the middle of the cupola. Near the bottom of the cupola are blast openings (tuyeres) through which air is blown to accelerate combustion. Combustion air, its ducting and wind box shall be protected with proper valving to prevent back flow of air or gases. The central opening in the bottom or bedplate of the cupola is closed by hinged doors which are dropped at the completion of the run to permit the unconsumed

fuel and the residue of molten metal in the cupola to fall out. Molten iron flows out through a taphole near the bottom, and slag is removed through a hole in the opposite side at a slightly higher level.

The procedure of "dropping bottom" may present a hazard in cupola operations. Cupola workers, are exposed to other hazards, such as burns from spattering metal while tapping or from slag thrown from the slag hole; injury from falls while cleaning or repairing the cupola, or from falling off the charging floor into the cupola or onto the ground; and eye injuries from airborne material or radiation from the hot metal. Charging operations generally involve the use of a crane or skip hoist. Considerable manual labor is involved, however, even in the highly mechanized plants; and the workers are exposed to the hazards of crushed hands or feet while moving heavy pieces of scrap or pig iron, and of cuts from the sharp edges of scrap. The cranes or skip hoists may be hazardous in operations resulting in injuries from falling objects, and there is also a danger of burns from sparks thrown through the open charging door. Protective clothing, gloves, eye and face protection, head and foot protection can help to reduce the injuries to cupola workers. Good housekeeping practices around the cupola, particularly on the charging floor, and the provision of safety devices, such as shields for the slag hole and shields suspended over the workers while they are cleaning or repairing the inside of the cupola, can also do much

to reduce the volume of accidents arising from cupola operations. On water cooled cupolas proper maintenance should be applied to the water circuitry to assure against leaks which can result in super-heated steam and splashing metal.

Crucible furnaces are used primarily for melting relatively small quantities of metal. This type of furnace consists of a cylindrical metal shell lined on the bottom and sides with firebrick and is usually placed in a pit so that the top is level with the floor. In some instances coke is used as fuel, but generally the heat is provided by burning oil or gas. Unlike the cupola process, the crucible method does not permit the metal to come into direct contact with the flame. The crucible, a cup-shaped container which holds the metal, is placed in the furnace and the flames play around its outside surface. Crucible-furnace operators do not have the great volume of heavy materials to handle that is common in cupola operations. They are, however, exposed to intense heat radiation when removing the crucible or whenever the cover is off while the furnace is lighted, and they are faced with the danger of burns from the molten metal and of eye injuries from light intensity or from spattering metal. Personal protective clothing and equipment are essential.

The reverberatory furnace is a horizontal furnace in which metal is melted in a basin (hearth) by heat from flames and from radiating furnace walls. The furnace is constructed of firebrick supported on a metal framework. Flames and hot gases from oil, gas, are generated in the firebox at one end of the furnace, conducted

over a firebrick wall (fire bridge), deflected down over the hearth chamber, and conducted out through a stack at the other end. Their passage heats the interior walls of the hearth chamber, and the heat radiated and deflected (reverberated) from these walls and from the flames melts the metal placed on the hearth. The molten metal collects in the basin of the hearth and is drawn off through a taphole. The top of the furnace is constructed in removable bungs which can be lifted off to provide access for charging or repairing the furnace. The metal to be charged may be placed upon the hearth manually, but is commonly handled mechanically, frequently in large charging buckets handled by a crane. Slagging is performed by hand and involves opening the slag door, stirring the molten metal with a puddling bar to make the slag rise to the surface, and then skimming the slag from the surface with a skimming bar. Samples of the molten metal for test purposes are also taken from the furnace through the slag door by means of a small hand ladle.

Reverberatory furnace workers are exposed to intense heat during slagging, sampling, and tapping operations, and they may experience burns and eye injuries from spattering metal. They are also exposed to all the hazards of crane operations while charging their furnaces. Suitable protective clothing and equipment are generally considered essential for the protection of these workers.

MELTING AND POURING

Safety Hazards In Order of Frequency	Type of Injuries That May Result	Relevant Standards	Titles	Abatement
Molten Metals	Burns and Scalds	1910.22	Walking & Working Surfaces - General	Housekeeping - Clearances for materials handling equipment
		1910.23	Guarding - Floor and Wall Openings	Adequate guarding for all floors openings & holes
		1910.132	Personal Protective Equipment - General	Provide proper personal protective equipment
		1910.133	Eye and Face Protection	Inspection maintenance & use of materials handling equipment
		1910.176	Handling Materials - General	Training:
		1910.178	Powered Industrial Trucks	Power Industrial Trucks
		1910.179	Overhead & Gantry Cranes	Manual Lifting
		1910.184	Industrial Slings	Slings
Overexertion	Sprains & Strains	No standards		Change in methods
				Engineering study
				Proper training in lifting techniques
Falling/Dropped Objects	Lacerations	1910.22	Walking & Working Surfaces	Housekeeping - Clearances for mechanical material handling equipment
	Contusions-Bruises	1910.23	Guarding Floor & Wall Openings	Adequate Guarding for all floor openings & holes
	Fractures	1910.25	Portable Wood Ladders	Proper care, use and storage of all ladders and scaffolds
		1910.26	Portable Metal Ladders	Provide necessary foot protection
Caught:	Contusions-Bruises	1910.28	Safety Requirements for Scaffolds	Adequate lockout procedures
In - Machines, Conveyors, etc.	Lacerations	1910.132	Personal Protective Equipment - General	Inspection, maintenance & proper use of materials handling equipment - training
Under - Machines, Flasks	Fractures	1910.145	Accident Prevention Signs & Tags	Adequate training - manual lift
Between - Machines, materials handling equip. (conveyors, ind. trucks, cranes)	Amputations	1910.176	Materials Handling & Storage - General	Adequate guarding of all machine & power transmission units
		1910.178	Powered Industrial Trucks	
		1910.179	Overhead & Gantry Cranes	
		1910.184	Industrial Slings	
		1910.212	General Requirements for all Machines	
		1910.219	Mechanical Power Transmission	
Slips and Falls	Fractures	1910.22	Walking & Working Surfaces - General	Good housekeeping requirements
	Sprains	1910.23	Guarding Floor & Wall Openings	Proper guarding of all floor openings & holes
		1910.24	Fixed Industrial Stairs	Maintain all industrial stairs in good order
		1910.25	Portable Wood Ladders	Proper care, use and storage of ladders and scaffolds
		1910.26	Portable Metal Ladders	
		1910.28	Safety Requirements for Scaffolds	
Electrical Shocks	Respiratory and/or Cardiac Arrest	1910.309	National Electrical Code	Maintain all electrical tools/systems in accordance with the required articles of the NEC-NFPA-70-1971

The electric furnaces used in foundries may be either the electric arc type or the induction type. In the arc-type furnace, heat is generated by intense arcs formed between electrodes so placed that the arcs pass through the charge. In the induction furnace the heat is generated by the resistance of the charge to electric currents induced within its mass by passing heavy currents through a ring encircling the furnace.

Arc furnaces vary widely in design. One type consists of a bowl-shaped metal shell lined with firebrick and fire sand, mounted on trunnions, supported by a heavy frame, and provided with a cover or roof. The arched roof is constructed of a refractory material and contains openings through which three triangularly arranged electrodes pass. These electrodes can be raised and lowered by small electric motors so as to place them close to the surface of the charge in order that the arcs will either lick the surface of the charge or pass through it. The intensity and length of the arc is adjusted by manipulating switches or turning wheels while observing meters in the arc circuits. These are all conveniently grouped upon a control board. In opposite sides of the furnace are two doors, one for charging and pouring, the other for slagging. Spouts for conducting the molten metal or slag from the furnace are attached to the respective door frames. The doors, electrode clamps, and roof openings are water-jacketed and water-cooled. In some furnaces the roof is arranged so that it may be swung aside to permit access to the interior. The molten metal is removed by tilting the entire furnace upon its

trunnions. Slagging is done by hand with a skimming bar, and the charge occasionally may be rearranged during the melting process by pushing and poking with a heavy metal bar. In some instances the charge is partially melted in other furnaces before being introduced into the electric furnace.

Electric-furnace operators are exposed to the hazards of noise, handling heavy rough, and sharp materials in charging; are faced with intense heat in slagging; rearranging or adding to the charge; and when taking samples of the melt in hand ladles; and are subject to injuries and burns from spilled or spattered metal in pouring. There is also some danger of shock or burns from contact with electric circuits. Personal protective clothing and equipment are essential equipment. In aluminum operations there is danger of explosion from the failure to pre-heating materials if not stored indoors.

In the pouring operations the molten metal is drawn from the furnace and transported to the mold by ladle. The refractory lining in the ladle must be properly cured. For small castings a ladle or crucibles can be used. For large castings and extensive pouring operations larger ladles are used. Ladles of this size are frequently supported by a hoist during pouring and are often moved by means of a monorail crane or on a wheeled carriage. Either of the latter methods relieves the workers of the necessity of lifting and holding the heavy

ladle, but it still must be pushed into position. Large ladles, with a capacity up to about 50 tons, are transported by overhead cranes, and a geared mechanism is used to tilt them for pouring. There are other types of ladles to be considered. (Bottom poured, etc.)

The greatest hazard connected with pouring operations is that of severe burns from contact with the molten metal which may splash or spill as it is being carried, when additives are introduced, or from overflow if the mold is poured too full. Molten metal may even run out of the mold if the mold is not properly vented to permit the escape of gases formed by the contact of the molten metal with the sand. It is recognized as essential, therefore, that workers engaged in pouring operations should wear proper protective clothing or equipment. It is also important to maintain good housekeeping in the pouring area to avoid the possibility of bumping the ladle against improperly placed materials and to eliminate tripping hazards which might cause the ladle carriers to spill the metal. Only workers who are participating in the pouring should be permitted to be within the range of possible spill, and all steps in the pouring should be under close supervision. Pouring platforms should be free of objects that could pose an obstruction in case of emergency exit.

Injuries to feet and toes, hands and fingers, eyes, and backs were common among the melting department injuries reported in the survey. Protection from hot and heavy materials is recognized as essential in this department, but the injury distribution indicates that the proper protective equipment frequently is not used. It is evident that greater attention should be given to the use of protective equipment for the lower extremities, and that the use of gloves and eye and face protection should be stressed.

Injury Statistics

Melting and Pouring operations sustain approximately 25% of all foundry injuries and 20% of the total days lost due to injuries. The frequency rate of 43.8 disabling injuries per million man hours is higher than any other foundry operation. The severity rate of 1,926 days per million man hours worked is second only to that of Molding by a very slight margin (2,070)

II. Principle Hazards

Burns -- from molten metals and improper clothing (flammable synthetic materials)

from obstructed work areas.

Falling objects -- from material handling equipment and improper storage

Eye injuries -- from airborne materials, intensive glare, and molten metal

Exposure to heat and radiation -- from furnaces and pouring operations

Overexertion -- from heavy manual lifting

Dropped objects -- from manual material handling

Caught --

In - machines, conveyors, elevators, etc.
Under - machines, flasks
Between - machines, material handling equipment (conveyors, industrial trucks, cranes)

Slips and falls -- poor housekeeping, uneven floors, guarding platforms

Explosions -- from moisture in pouring areas, ladles, and charging materials

Electrical malfunctions -- furnace operations and power supply systems

HEALTH HAZARDS - MELTING AND POURING

A. All Foundries

In oil fired furnaces, incomplete combustion due to faulty burners may result in the products of incomplete combustion being released into the air (e.g. CO). Where fuels with a high sulfur content are used, there is the danger of high atmospheric concentrations of sulfur dioxide developing, and consequently low-sulfur fuel should be used. During furnace and flue cleaning there is the hazard of exposure to vanadium pentoxide concentrated in furnace soot. Equipment, such as bag houses, used to collect particulate matter may pose exposure to toxic dust during the equipment cleaning process.

B. Iron Foundries

The iron foundry uses primarily the cupola furnace, charged with coke, pig iron, and/or iron and steel, scrap and limestone. The cupola, because of the use of coke as a fuel in order to melt pig iron and scrap, may produce immense quantities of carbon monoxide. This may leak from the charging doors or be blown back by high winds. This exposure to carbon monoxide may be highly acute on the charging platform surrounding catwalks and around the base of the furnace.

Cupola cleaning can result in intense short term exposure to silica. Repair of refractory material can result in exposure to high concentrations of crystalline silica and to high levels of noise.

Smoke, gases, and vapors from the destructive distillation of sea coal mixed into the molding sand and small amounts of iron oxide fume, arise from the pouring operation, and for a considerable period after pouring. The gases, including carbon monoxide, escape from the mold and usually ignite spontaneously or are fired by a torch. If hood type local exhaust ventilation is not provided for the cooling flasks there may be a problem with irritant aldehydes and other volatilized components of the mold. In addition exposure to metal fumes, principally iron oxide from the pouring operation, as well as furnace fumes will frequently be contaminated with soot from the pouring operation and silica from adjacent sand handling operations.

Heat and noise are potential problems found in the iron foundry.

In the ductile iron foundry magnesium oxide fume is a potential health hazard.

C. Steel Foundries

The primary furnaces encountered in the steel foundry are the open hearth and the electric furnace.

Since the metal temperatures involved are much higher in steel production than in iron production, eye protection with colored lenses is essential.

Electric furnaces in the steel industry, in contrast to the iron foundry cupola, do not present a carbon monoxide and sulphur dioxide hazard, however, nitrogen oxides, ozone, and noise all are substantial hazards with the electric furnace.

Electric furnaces may give rise to large amounts of iron oxide and various other fumes in specialty alloy shops (e.g., manganese, chromium and nickel oxides).

If selenium, or other elements are added to the molten metal, exposure levels should be investigated.

D. Aluminum Foundries

Any health problems associated with the production and fabrication of aluminum are primarily due to the processes and allied materials used in the processes rather than to aluminum itself.

Aluminum alloys often contain small amounts of metals which under certain circumstances may give off toxic fumes (example: beryllium). Where alloys are used which contain such components the fume should be analyzed to determine their airborne levels.

In aluminum foundries melting is commonly done in open pot furnaces. These are often fired by gas or oil, although electric furnaces are occasionally encountered. It is advisable to have exhaust vents around the top of the pot for remaining fumes.

Fluorspar is commonly used as a flux in aluminum melting and significant quantities of flouride dust may be released to the environment. In certain cases, barium chloride, a significantly toxic substance, has been used as a flux for magnesium alloys. Light alloys may occasionally be degassed by passing sulfur dioxide or chlorine (or proprietary compounds that decompose to produce chlorine)

Where phosphor bronze is made by adding white phosphorus to the molten metal, strict safety precautions and good ventilation are necessary. Phosphorous alloys are sometimes used in lieu of phosphorous.

F. Die Casting

In addition, the worker may be exposed to the mist of oils used as die lubricants; the worker must be protected from the inhalation of these mists and from the danger of oil saturated clothing. The fire-resistant hydraulic fluids used in the presses may contain toxic organophosphorate compounds and particular care should be taken during maintenance work on hydraulic systems.

Zinc is a common die-casting metal and exposure to its fumes must be controlled to avoid the occurrance of metal fume fever.

G. Precision Founding

An important process in precision founding is the investment of lost-wax casting process in which patterns are made by injecting moulding wax into a die; these patterns are coated with a fine refractory powder which serves as a mould facing material, and the wax is then melted out prior to casting or by the introduction of the casting metal itself.

through the molten metal; exhaust ventilation and respiratory protective equipment are required for this operation. In order to reduce the cooling rate of the hot metal in the mould, a mixture of substances (usually aluminum and iron oxide) which react highly exothermically is placed on the mould riser. This "thermit" mixture gives off dense fume which has been found innocuous in practice. When the fume is brown in color, alarm may be caused due to suspicion of the presence of nitrogen oxides; however, the suspicion is unfounded.

E. Copper Alloy Foundries

In the founding of brass and bronze, attention should be paid to the possibility of emissions of toxic fumes from metals used in the alloys. Some high-duty alloys contain cadmium, beryllium, lead, or other toxic metals which may lead to the emission of dangerous quantities of metal fume. The lead hazard in furnace cleaning and dross disposal is particularly acute.

During the melting and pouring operations in brass and bronze foundries which mechanical ventilation is not used to control metal fumes, the primary alloy metals which may be airborne as fume, such as lead, berryllium, zinc, copper, and tin, should be measured.

The removal of wax presents a definite fire hazard and wax removal stoves must be adequately ventilated. Chlorinated solvent has been used to remove the last traces of wax; there is the danger that this solvent may collect in pockets in the mould or be absorbed by the refractory materials and be vaporized or decomposed during pouring. There has been a trend towards the inclusion of asbestos in investment casting refractory materials. The introduction of effective safeguards for this material is so difficult in foundries that its inclusion in the mixtures should be abandoned.

Melting and Pouring

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards		Methods of Abatement
carbon monixide	asphyxiation, cardiac stress	1910.1000--air contaminants 1910.134--respiratory protection		local exhaust ventilation, respiratory protection
Metal fumes:				
iron oxide	siderosis	"	"	"
lead	lead poisoning	"	"	"
manganese	manganism	"	"	"
zinc	metal fume fever	"	"	"
copper	"	"	"	"
magnesium oxide	"	"	"	"
chromium	pulmonary disease	"	"	"
nickel	dermatitis, sensitization	"	"	"
beryllium	berylliosis	"	"	"
thorium	bone and kidney damage	"	"	"
selenium	systemic effects	"	"	"

Melting and Pouring

Health Hazard in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
Metal Fumes:			
vanadium	respiratory tract irritation	1910.1000--air contaminants 1910.134--Respiratory protection	local exhaust ventilation, respiratory protection
cadmium	cadmium poisoning	" "	"
Ultraviolet and infrared radiation	eye irritation	1910.133--eye and face protection	eye protection
Noise	hearing loss	1910.95--Occupational Noise exposure	hearing protection
Silica	silicosis	1910.1000--air contaminants 1910.134--Respiratory protection	local exhaust ventilation, respiratory protection

Melting and Pouring

Health Hazard in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
aldehydes	respiratory tract irritation	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
ozone	"	"	"
nitrogen oxides	"	"	"
chlorine	"	"	"
organophosphates	nervous system effects	"	"
barium chloride	system effects	"	"
flourides	bone disease	"	"
trichloro-ethylene	CNS effects	"	"
SO2	respiratory tract irritation	"	"
oil mist	lung irritation	"	"
heat stress	cardiac strain	1910.132--personal protective equipment	barriers

Shakeout and Core Knockout

The removal of the casting from the mold after the metal has solidified and cooled sufficiently to be further processed is generally termed shakeout and is commonly a function of either the molding or melting and pouring departments. It is not unusual for the work to be assigned to a general labor department or even to be constituted as a separate department in large foundries. For this report injury statistics are combined with those of melting and pouring. Applicable safety standards and abatement procedures can also be found under that heading.

The shakeout operation consists of opening the flask and removing the casting, shaking off any adhering sand, breaking out the cores, transporting the castings to the finishing department, and returning the flasks and sand. Shakeout machines are normally used to loosen the sand, but in jobbing shops other equipment such as; sledges, mallets, bars, shovels, wedges and hand trucks are used and hoists and cranes when the castings are large. The principal hazards are those involved in handling hot, heavy, rough, and sharp-edged materials. Foot and hand protection are generally considered to be essential equipment in this operation.

Injury Statistics

The shakeout and core knockout operation has an injury frequency rate of 45.7 disabling injuries per million man hours worked and a severity rate of 2.316 days per million man hours worked.

CLEANING, CHIPPING, AND FINISHING

I. When castings are first removed from the mold they are generally rough and have arm-like spurs resulting from the molten metal which fills the gates, risers and sprues. These superfluous projections are removed with a sledge, a metal bandsaw, or a power-operated shear. The castings are then either tumbled or blasted to smooth the rough surfaces and to impart a dull finish to the metal. Tumbling consists simply of placing a group of castings inside a steel drum and allowing them to rub and bump together as the drum revolves. In blasting, metallic shot or grit is directed against the surface to be cleaned. Small castings may be blasted inside a closed machine, but large castings must be cleaned in the open or in a large enclosed blasting room. Great quantities of flying particles and dust accompany all blasting and present serious hazards to all workers in the vicinity unless proper precautions are taken. Gloves, eye and face protection are essential equipment for the operator of a blasting machine, and blasting-room workers should wear fresh-air-supplied airline helmets or masks, gloves, and protective clothing. The blasting room should have an efficient exhaust system discharging into a dust collector system.

After the castings have been tumbled or blasted, any remaining undesirable projections are removed either by chipping or burning (oxyacetylene or electric arc). Chipping is generally

performed with a powered chisel, although a hand hammer and chisel are used at times. The chisels shave off small pieces of metal which frequently fly considerable distances and strike with great force. Gloves, protective garments, eye and sometimes face protection are used for the protection of the chippers. Consideration must be given to the protection of adjacent workers and passers by.

In the burning process personal protective equipment suitable for the process being performed must be used.

The final, or finishing, process in cleaning castings is to grind off the remaining rough spots and chisel marks. Equipment used may be stand grinders, swing grinders, portable and/or hand held grinders, and belt grinders. Grinding produces large quantities of airborne dust and metal particles, which constitute a eye and respirable hazard not only for the operator but also for everyone else in the vicinity of the operation. Eye and/or face protection is essential equipment in this operation, even when there is an exhaust attached to the grinding wheel. It is important that grinding wheels be stored, handled, inspected and mounted properly, and used in accordance with the manufacturer's instructions, and that each wheel be covered with a guard of guarded by the work itself which will effectively contain any flying pieces if the wheel should break. Consideration must be given to the protection of adjacent workers and passers by.

In cleaning, chipping, and finishing operations the workers are exposed to the possibility of injury arising from the handling of the castings. This presents possibilities of strained backs, and of bruised or mashed fingers and toes. Rough spots and sharp edges on the castings also present the possibility of severe cuts and scratches to the workers who handle them. The use of gloves and foot protection by all workers in this department is generally recognized as desirable.

Eye injuries are predominate in the cleaning, chipping, and finishing departments. The high prevalence of finger, hand, foot, toe and back injuries reveals the need for greater attention to the methods of handling such materials and call for the wider use of gloves and foot protection. Consideration for fire and explosions should be given to painting, dipping, and/or spraying operations carried on in close proximity of chipping and grinding areas.

Chemical cleaning processes pose additional hazards. Chemicals used should be treated with the same respect as hot molten metal as far as contact with the skin and eyes. Eye wash stations and deluge shower must be located in close proximity to this process especially when molten salts are used.

Injury Statistics

Approximately 24% of all foundry injuries and 19% of all days charged due to injuries are the result of Casting Cleaning operations. The

injury frequency rate of 35.0 disabling injuries per million man hours ranks the operation second to that of Melting and Pouring. The injury severity rate of 1,716 days per million man hours worked is also relatively high.

II. Principal Hazards:

Eye Injuries -- from airborne dust, chemicals, metal particles and burning operations

Respirable dust -- from grinding, cleaning, and machining operations

Falling objects -- from material storage and handling

Dropped objects -- from manual handling of materials

Fumes -- from cleaning chemical operations, gas torches-- painting and heat treatment

Caught:

In - machines, conveyors
Under - machines, conveyors
Between - machines, conveyors
Unguarded belts, pulleys, gears from machines and equipment

Point of contact hazards -- from cut-off machines

Body damages -- from misuse of portable pneumatic grinders and exploding grinding wheels

Cuts and lacerations -- from handling sharp, abrasive materials, flying chips and lugs

High noise and vibration levels -- from machines and equipment

CLEANING - CHIPPING & FINISHING

Safety Hazards In Order Of Frequency	Type of Injuries That May Result	Relevant Standards	Titles	Abatement
Falling/Dropped Objects	Contusions-Bruises Lacerations Fractures	1910.132	Personal Protective Equipment - General	Provide necessary protective equipment
		1910.176	Handling Materials - General	Inspection, maintenance, and proper use of materials handling equipment
		1910.177	Indoor General Storage	
		1910.178	Powered Industrial Trucks	Adequate training: Power Industrial Truck Operator Manual Lifting Slings
		1910.179	Overhead & Gantry Cranes	
		1910.184	Industrial Slings	
Caught: In - Machines, Conveyors, etc. Under - Machines, Conveyors, etc. Between - Machines, Conveyors, etc.	Fractures Lacerations Bruises	1910.132	Personal Protective Equipment - General	Provide necessary protective equipment
		1910.145	Accident Prevention Signs & Tags	Adequate lockout procedures
		1910.176	Handling Materials - General	Inspection, maintenance and proper use of materials handling equipment
		1910.178	Powered Industrial Trucks	Adequate training: Power Industrial Truck Operator Manual Lifting Slings
		1910.179	Overhead & Gantry Cranes	
		1910.184	Industrial Slings	
		1910.212	General Requirements for all Machines	Provide required guarding devices
		1910.219	Mechanical Power Transmissions	
Overexertion	Sprains & Strains	No standards		Change in methods Engineering study Proper training in lifting techniques
Flying Particles: Sand, Emory & Metal Parts	Eye Injuries Punctures Lacerations Burns	1910.132	Personal Protective Equipment - General	Adequate personal protective equipment
		1910.133	Eye Protection	Proper use and maintenance of tools and equipment
		1910.215	Abrasive Wheel Machinery	Training in use of equipment
		1910.242	Hand and Portable Powered Tools	Adequate guarding of welding and cutting operations
		1910.243	Guarding Portable Powered Tools	
		1910.252	Welding and Cutting	
Slips and Falls	Fractures Strains	1910.22	Walking & Working Surfaces - General	Good housekeeping requirements
		1910.25	Portable Wood Ladders	Proper care and use of ladders and scaffolds
		1910.26	Portable Metal Ladders	
		1910.28	Safety Requirements for Scaffolds	
Electrical Shocks	Respirator and/or Cardiac Arrest	1910.309	National Electrical Code	Maintain all electric tools/systems in accordance with required articles of NEC-NFPA 70-1971

HEALTH HAZARDS - CLEANING, CHIPPING & FINISHING

Silicosis is the predominant health hazard in the cleaning room due to the silica dust generated by the operations of abrasive blasting and grinding. Crystalline silica (SiO_2) is a major constituent of foundry sand and may be present in high concentrations in silica flour and in sand mold and core materials. Two crystalline forms of silica -- tridymite and cristobalite -- are generated at the mold metal interface as a result of the high temperature transformation of quartz. They are a special hazard where the molten metal is heated to very high temperatures. The degree of hazard depends on the silica content, concentration and size of the airborne dust, as well as the length of exposure, Recycled sand is a greater hazard due to its smaller size from the abrasion of former processes. Heavy exposures have produced symptoms in less than one year after initial exposure; many years, however, are generally required to produce symptoms.

Noise is a hazard associated with most of the processes in the cleaning room -- sawing, chipping, grinding, tumbling machines, shotblasting and welding -- and is a greater hazard in mechanized than in manual foundries. Excessive noise exposure can produce temporary and/or permanent loss of hearing. Total loss of hearing may result after extended exposure to very high levels.

Noise control is complicated by the size of the casting, the type of metal and the work area available, the use of portable tools and a number of other related factors.

Metal dust in a foundry can contribute to a nuisance dust problem or depending on the metal used cause pneumoconioses or systemic poisoning. Metal dust is encountered in the cleaning room where gates and risers are removed by sawing and where surfaces are smoothed by grinding.

Hand or powered chisels used to remove burnt-in sand produce much finely divided dust and should be used as little as possible. Brushing-off excess materials with revolving wire brushes or hand brushes also produces dust and exhaust ventilation is required.

Cleaning castings by the use of the gas lance or air assisted electric arc plus welding and cutting expose workers to metal fume with the consequent hazard of poisoning and metal fever, depending on the composition of the metals involved. The plasma torch in particular produces a considerable amount of fume and noise.

The hazards of burns, ultraviolet and infrared rays are also associated with welding and cutting and the use of the gas lance and air assisted electric arc. Exposure to ultraviolet rays can lead to the development of cataracts.

Heat stress may also be encountered where an air assisted electric arc is used and possibly around the heat treating furnaces. Cardiac strain can develop from heat stress and barriers and/or ventilation should be used where possible to reduce this hazard.

Chemical cleaning of iron castings is sometimes done in open surface tanks using heated sodium hydroxide solution. Exposure to sodium hydroxide mist may result. Chemical burns will result if the solution comes into contact with the eyes or skin.

Portable vibrating tools, e.g., power pneumatic chisel may cause the appearance of Raynaud's phenomenon: this is more prevalent in steel cleaning than in iron cleaning and more frequent in those using rotating tools. The critical vibratory rate for the onset of this phenomenon is between 2000-3000 revolutions per minute and in the range of 40-125 Hz.

Where acid pickling is done prior to nitriding in the steel foundries, acid mist may be present in concentrations sufficient to cause skin lesions and tracheobronchitis. Chemical burns will result if the solution comes into contact with the eyes or skin.

Casting Cleaning

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
silica	silicosis	1910.1000--air contaminants 1910.94--ventilation 1910.134--respiratory protection 1910..33--eye and face protection	enclosure, local exhaust ventilation, respiratory protection, face and eye protection
noise	hearing loss	1910.95--occupational noise exposure	engineering and administrative controls, hearing protection
Metal fumes and dusts:			
Iron Foundry-			
iron oxide	siderosis	1910.1000--air contaminants 1910.134--Respiratory protection	local exhaust ventilation, respiratory protection
magnesium oxide fume (in ductile iron foundry	metal fume fever	" "	"
manganese	manganism	" "	"

Casting Cleaning

Health Hazard in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
nickel	dermatitis, sensitization	1910.1000--air contaminants 1910.134--respiratoy protection	local exhaust ventilation, respiratory protection
vanadium	respiratory tract irritation	" "	"
zirconium	granulomas of the skin	" "	"
molybdenum	none	" "	"
titanuim dioxide	none	" "	"
metal fumes and dust:			
Steel Foundry-			
iron oxide	siderosis	1910.1000--air contaminants 1910.134--respiratopry protection	local exhaust ventilation, respiratory protection
manganese (if high alloy)	manganism	" "	"
nickel (if high alloy)	dermatitis,	" "	"

Casting Cleaning

Health Hazard in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
chromium (if high alloy)	pulmonary disease	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
magnesium oxide fume	metal fume fever	"	"
nickel	dermatitis; sensitization	"	"
vanadium	respiratory tract irritation	"	"
metal fumes and dust:			
Aluminum foundry-			
beryllium	berylliosis	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
thorium	bone and kidney damage	none	
Metal fumes and dust:			
Copper alloy foundry-			
copper fume	metal fume fever	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection

Casting Cleaning

Health Hazards in order of Severity	Type of Illness that may develop	Relevant Standards	Methods of Abatement
zinc fume	metal fume fever	1910.1000--air contaminants 1910.134--respiratory protection	local exhaust ventilation, respiratory protection
lead oxide fume and dust	lead poisoning	" "	"
beryllium	berylliosis	" "	"
tin	tin oxide pneumonitis	" "	"
ultraviolet and infrared rays	cataracts	1910.133--eye and face protection	eye protection
heat stress	cardiac strain	1910.132--personal protective equipment, general requirements	barriers
vibrations	Raynauds's Syndrome	none	heavy gloves

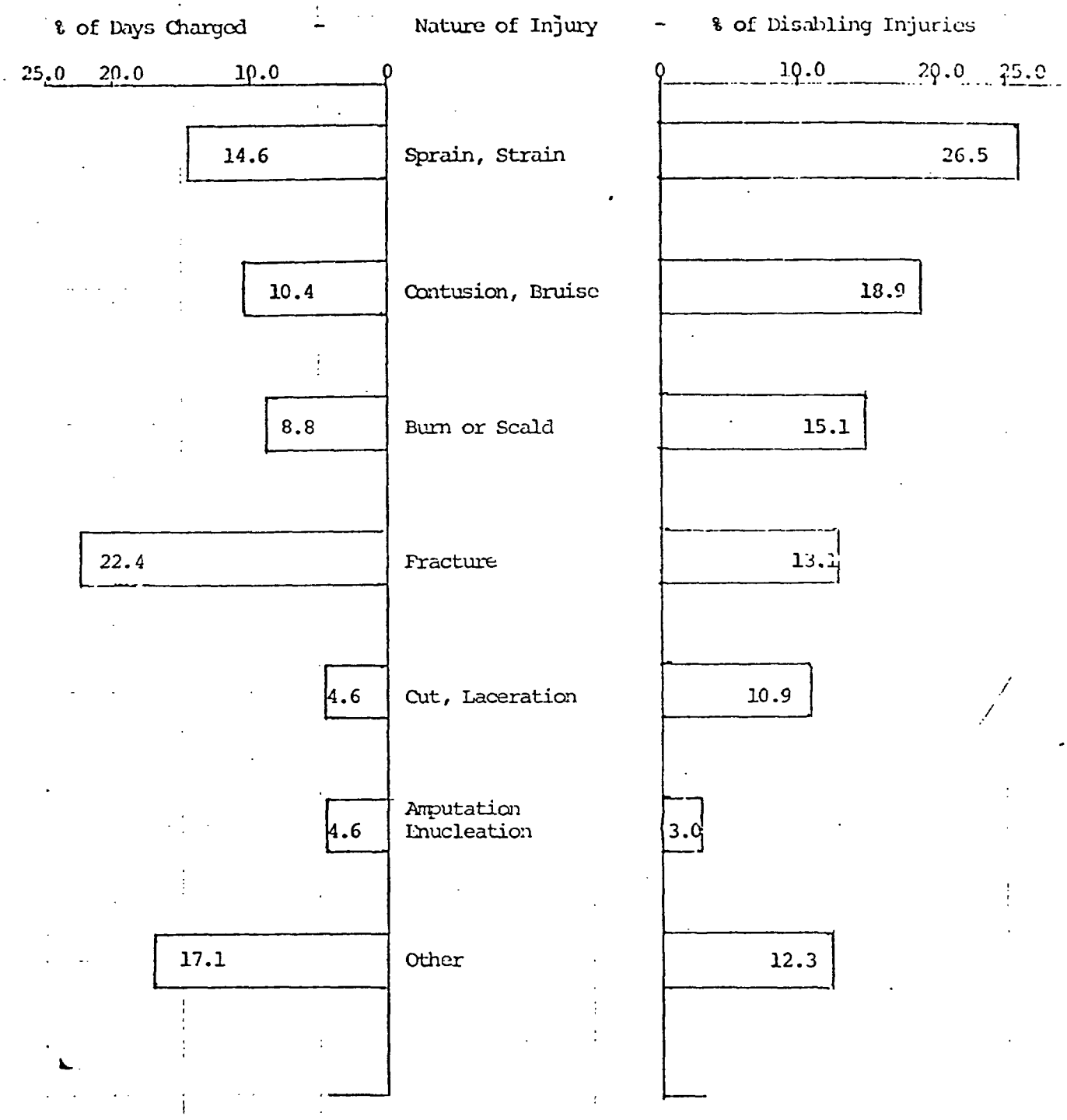
Steel Foundry: acid mist	skin lesions, tracheobronchitis	1910.1000--air contaminants 1910. 94--ventilation 1910.134--respiratory protection 1910.132--personal protective equipment 1910.133--eye and face protection 1910.151--medical services and first aid	slot ventilation, respiratory protection, skin and eye protection, eye wash facilities
NaOH mist	"	"	"

Foundry Dept. & Occupation	No. of Employees	No. of Injuries	No. of Days Charged	Injury Frequency Rate	Injury Severity Rate	Severity Frequency Ratio
All Foundry Depts.	375,112	*18,039	1,137,059	23.1	1,445	63
Cleaning Dept. Total	55,740	4,074	199,629	35.0	1,716	49
Burners	1,314	106	5,039	39.1	(3)	(3)
Casting-Repair Welders	3,254	191	17,751	28.2	(3)	(3)
Chippers	12,077	723	39,320	28.8	1,564	54
Grinders	18,366	1,666	54,056	43.9	1,423	32
Sandblasters	2,521	173	19,007	33.4	(3)	(3)
Tumbler Operators	2,316	149	7,544	30.8	(3)	(3)
** Laborers	12,391	857	49,393	32.9	1,894	58
Others	3,532	209	7,520	27.5	991	36
Maintenance Dept Total	24,157	935	102,265	17.4	1,926	110
Carpenters	876	33	563	17.7	(3)	(3)
Electricians	3,378	78	5,738	10.4	(3)	(3)
Mechanics (incl. Repairmen & Millwrights)	14,394	617	65,563	19.3	2,049	106
Helpers	1,951	46	9,758	11.0	(3)	(3)
** Laborers	1,722	101	18,283	27.9	(3)	(3)
Others	1,835	50	2,360	12.8	(3)	(3)
Patternmaking Dept. Total	10,552	176	8,460	7.9	(3)	(3)
Pattern Room Attendants	1,222	24	874	9.3	(3)	(3)
Metal Pattern Makers	2,965	33	963	5.1	(3)	(3)
Wood Pattern Makers	3,899	69	1,617	8.4	(3)	(3)
** Laborers	1,151	39	2,782	16.2	(3)	(3)
Others	1,316	12	2,224	4.3	(3)	(3)
Materials Handling Dept. Total	21,484	734	88,943	16.4	1,988	121
Crane Operators	5,602	76	11,701	6.5	(3)	(3)
Shippers	3,026	107	3,499	17.0	(3)	(3)
StockRoom Attendants	1,285	18	736	6.6	(3)	(3)
Truck Drivers	5,143	202	52,891	18.6	4,872	262
** Laborers	5,309	238	17,225	26.7	1,594	60
Others	1,119	43	2,890	18.4	(3)	(3)

NOTE: Injury-Frequency Rate = Number of disabling injuries per million man hours worked.
Injury-Severity Rate = Number of days charged for all injuries per million man hours worked.
Severity, Frequency Ratio = Average number of days charged per disabling injury.
*Total includes 983 unclassified injuries.
**See Laborers-All Departments.

Foundry Dept. & Occupation	No. of Employees	No. of Injuries	No. of Days Charged	Injury Frequency Rate	Injury Severity Rate	Severity Frequency Ratio
All Foundry Depts.	375,112	18,039	1,137,059	23.1	1,455	63
Molding Dept. Total	82,778	5,492	350,358	32.4	2,070	64
Bench Molders	5,249	343	14,562	30.9	1,312	42
Floor Molders	12,456	818	36,746	32.1	1,443	45
Machine Molders	21,590	1,498	61,681	34.8	1,432	41
Molder's Helpers	6,982	426	36,383	30.0	2,563	85
Mulling Mach. Operators	3,965	215	41,377	27.3	(3)	(3)
Die Cast. Mach. Operators	10,321	696	74,397	31.9	3,408	107
Mach. Pipe & Fitting Occup.	1,104	27	6,413	18.6	(3)	(3)
**Laborers	17,774	1,346	63,810	36.5	1,732	47
Others	3,338	114	14,998	15.8	(3)	(3)
Coremaking Dept. Total	33,293	950	55,927	13.5	797	59
Bench Coremakers	5,839	180	14,704	15.1	(3)	(3)
Core Assemblers	5,426	83	2,464	7.2	(3)	(3)
Core Oven Tenders	1,397	30	4,168	10.0	(3)	(3)
Core Sand Mixers	1,467	50	1,518	16.4	(3)	(3)
Floor Core Makers	2,378	117	3,776	23.8	(3)	(3)
Machine Core Makers	7,449	193	6,854	12.4	(3)	(3)
**Laborers	7,194	272	20,656	17.5	1,331	76
Others	2,143	25	1,787	5.3	(3)	(3)
Melting & Pouring Dept. Total	35,443	3,205	140,842	43.8	1,926	44
Brick Mason	651	16	365	12.0	(3)	(3)
Crucible Melters	1,427	70	10,310	23.0	(3)	(3)
Cupola Tenders	2,431	278	20,174	54.2	3,938	72
Electric Furnace Tenders	1,792	175	7,161	45.8	(3)	(3)
Furnance Chargers	3,288	241	6,328	34.8	912	26
Laddle Men-Pourers	10,523	857	26,775	35.3	1,362	32
Shake Out Men	9,438	880	44,561	45.7	2,316	51
**Laborers	4,702	620	23,817	64.2	2,467	38
Others	1,191	68	1,351	28.5	(3)	(3)
Machining Dept. Total	21,538	822	68,677	18.5	1,544	84
Machine Operators	17,613	700	52,538	19.6	1,467	75
Tool & Die Makers	2,120	30	497	6.3	(3)	(3)
Machine Operators (Die Cast)	1,742	92	15,642	24.2	(3)	(3)
Laborers-All Depts.	58,085	3,616	198,592	32.7	1,794	155

Foundry Work Injuries by Nature of Injury



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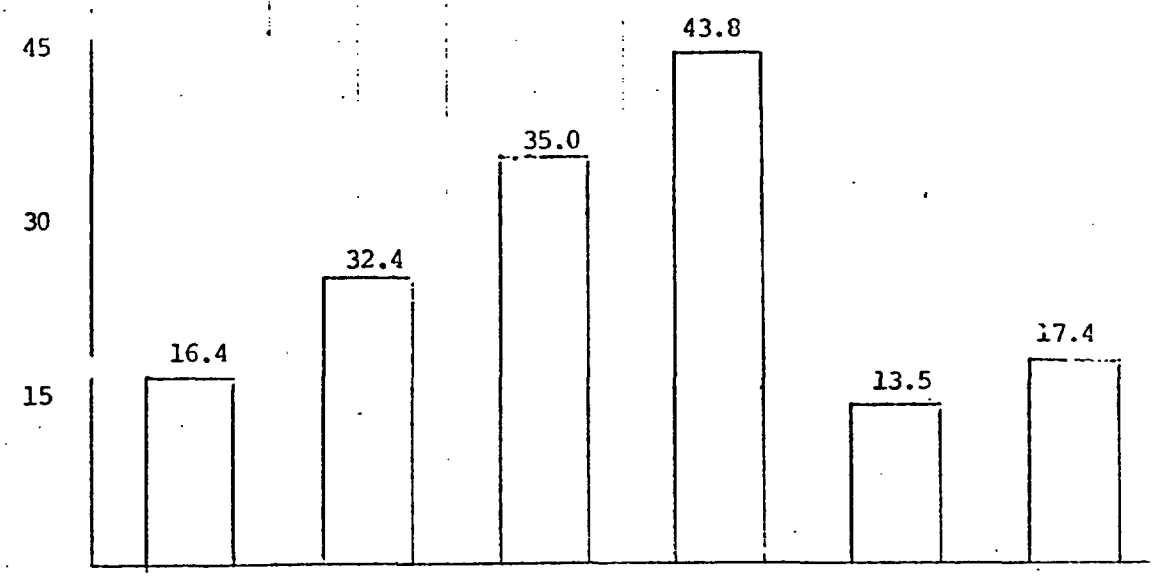
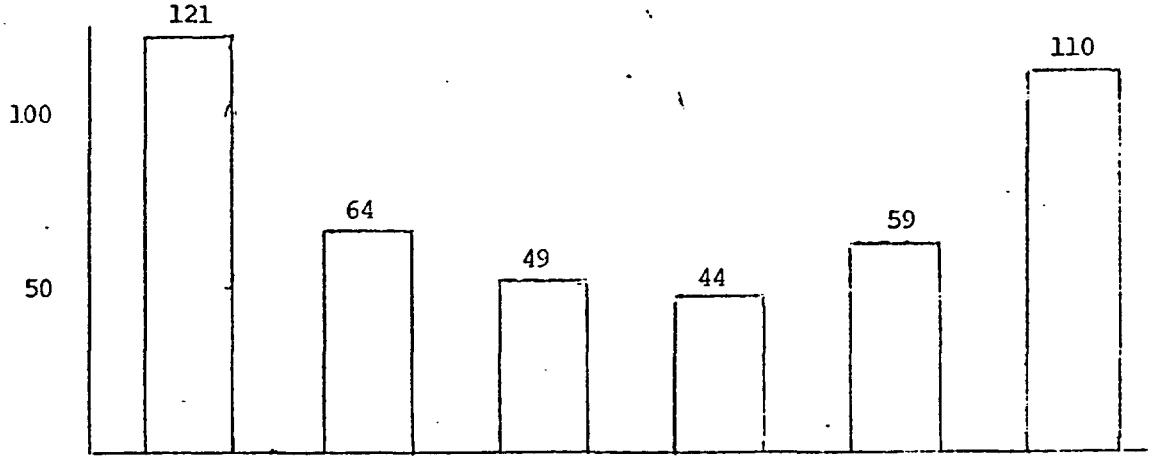
FOUNDRY INJURY RATES-BY MAJOR OPERATION

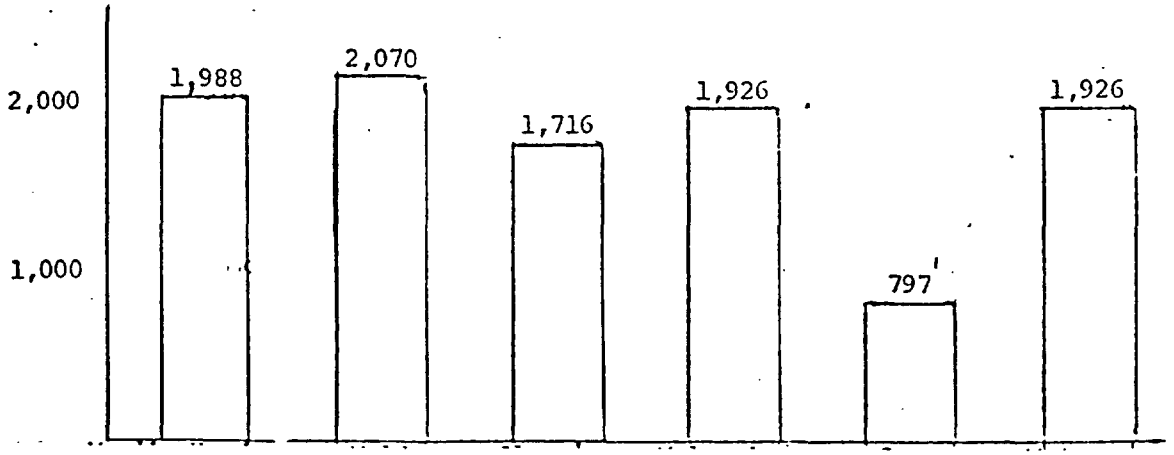
INJURY-FREQUENCY RATE: Number of disabling injuries per million man hours worked.



SEVERITY-FREQUENCY RATIO: Average days charged per disabling injury



INJURY-SEVERITY RATE: Number of days charged per million man hours worked.



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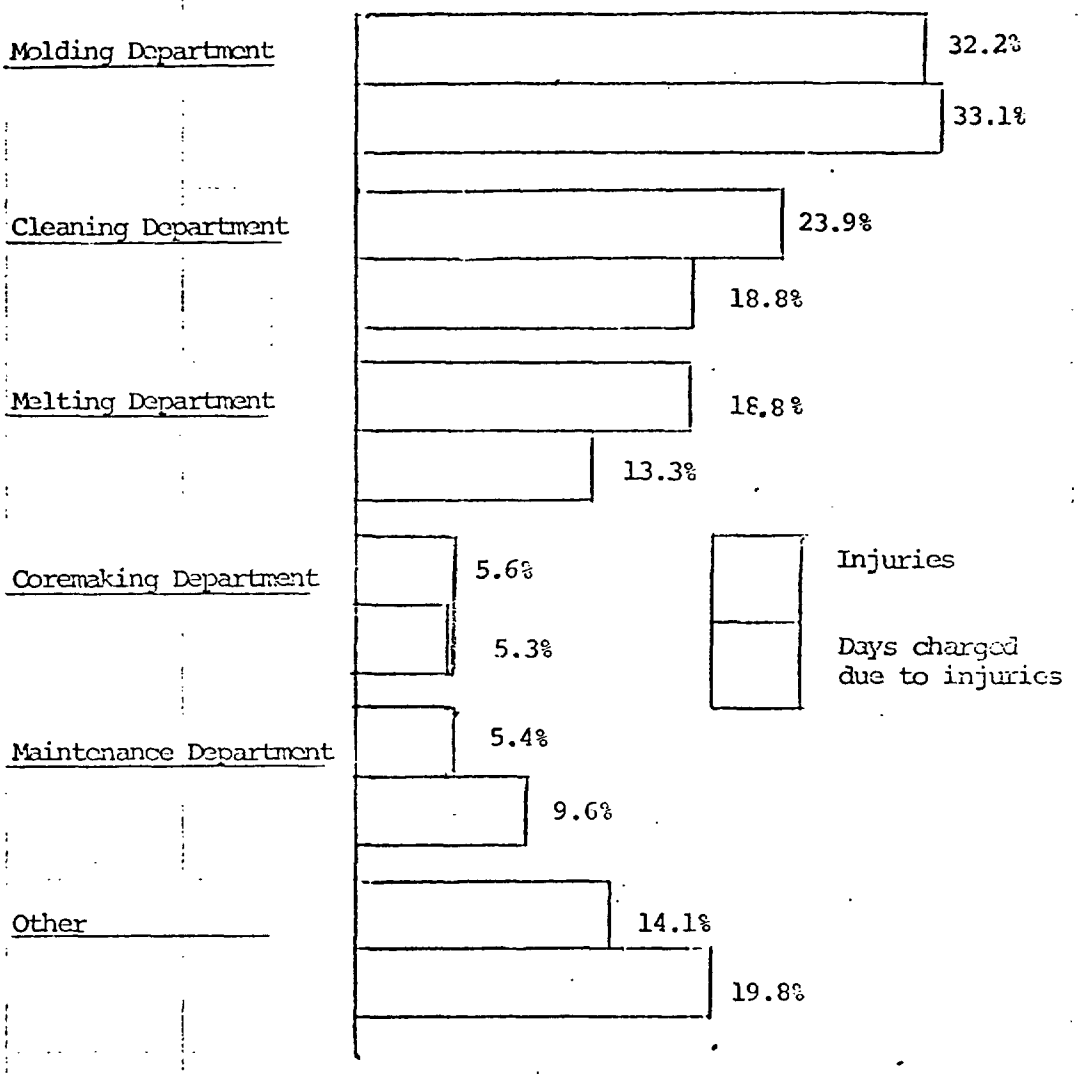
Work Injuries in Foundry Operations by Foundry Departments



NOTE:

(1) 5 Departments = 86% of Injuries and 80% of Lost Days

(2) 4 Departments - Molding, Cleaning, Melting and Maintenance sustained 86% of the injuries and 75% of the lost days.

(3) Approximately one-third of all injuries occurred in the Molding Department.

DESCRIPTION OF ACCIDENTS
BY DEPARTMENT/EQUIPMENT

Cleaning, Chipping and Finishing Accidents

1. Worker was greasing the tumbling mill but had not shut off the machinery. His clothing caught on the jackshaft coupling, pulling him between the revolving jackshaft and the tumbling mill. Fatal.

2. Laborer was moving castings away from a sprue-cutting machine. He stepped on a piece of sprue, turning his ankle, and dropped a heavy casting on his foot. Fractured three toes.

3. A chipper was working without goggles. A chip struck his eye. Lost sight of eye.

4. As a chipper turned a casting it struck a chisel, which whirled up and smashed his safety glasses, destroying his eye.

5. A new grinding wheel (20 by 3 inches) fragmented, shearing five half-inch bolts which held the guard, and caused the guard to swing back and strike the operator's head. Fatal.

6. Operator was grinding a piece of gray iron, cylindrical in shape, 6 inches in diameter, and 14 inches long. He forced the piece into the 3-inch face of the grinding wheel and jammed the wheel, which broke and kicked the piece back into his abdomen. Guards

prevented broken pieces of the wheel from flying around. Fatal.

7. Worker was grinding a casting when the grinding wheel broke. No reason for the break is known. Fatal.

Conveyor Accidents

8. Employee was handling baked aviation cylinder head cores on a gravity conveyor. One fell off onto his foot. Broken toe; lost 29 days.

9. A finisher was caught between squeeze head and flask on the flask-return conveyor. Fatal.

10. Worker was removing sand from conveyor belt at the pulley while it was in motion. His arm was caught between the belt and the pulley. Lost 2 weeks.

11. Employee climbed on guard rail to release material caught in belt conveyor. He overreached, lost his balance, and thrust his arm between the moving conveyor and the housing. Torn muscles resulted in the loss of use of his hand.

Core-Room Accidents

12. A core maker stepped upon a core wire which punctured his shoe and entered his foot. Lost 3 days.

13. Employee was lighting gas core oven. Evidently the oven was filled with gas and exploded when he went to light it. Fatal.

Crane, Elevator, and Hoist Accidents

14. Repairman working on crane rail repair was crushed against building column when crane was moved. Repairman depended on men stationed on floor to signal crane operator instead of using rail stops. Crane operator obeyed signal from an unauthorized man on floor. Fatal.

15. While repairing a crane, a maintenance man caught his hand between trolley wheel and bumper. Middle finger amputated.

16. Maintenance man was standing on a beam which supports the elevator track, while oiling a sheave bearing on a skip hoist. Another employee started the elevator and the maintenance man's

hand was caught between the pulley and cable. The result was permanent impairment of all fingers on his left hand.

17. Craneman was oiling the trolley. He slipped and fell 20 feet to the floor. Fatal.

18. A molder's finger was crushed between the ladle and rack when the craneman misunderstood the molder's signal and set the ladle down on his hand. Lost half of middle finger.

19. A workman was standing on a grab bucket holding the cable with his left hand while he placed the crane hook in the lifting hook of the bucket. The craneman lifted on a signal from another employee and the first worker's finger was crushed between the crane cable and the sheave wheel. Lost one finger.

20. Laborer was electrocuted when he attempted to replace a blown fuse on the overhead crane.

21. Chain on crane broke and dropped heavy mold on right hand. Right hand amputated.

22. Injured was turning a magnet holding seven scrap freight-car wheels. Two wheels dropped, one striking his foot. Entire loss of great toe.

23. While a molder was bending and working over his mold, another mold was being raised by the crane. His fellow-workers called to him not to raise his head. Not understanding them, he raised his head, bumping it on the flask which was being carried by the crane. Died of blood clot under the skull.

24. Crane operator blocked main hoist, breaking cable and dropping casting tray which struck employee. Fatal.

25. Man was attempting to pick up a casting. He used an "S" hook incorrectly, and this made it necessary for him to hold the hook as the crane block was raised. When the weight of the casting was put on the hook, it was pulled against the casting and caught man's finger, smashing it badly. Traumatic amputation of right little finger.

26. Molder had hooked onto a mold which was to be moved across the floor for inspection. As he was underneath, one of the four hooks came loose and the flask fell over. One leg badly crushed and later amputated.

27. Yardman had one foot on clamshell and the other on the ground when boom of rubber-tired crane touched high-tension wires. Fatal.

28. A molder, who was using an electric hoist to lift a ladle, pulled the wrong control. The ladle tilted and spilled molten metal on a nearby worker. Fatal.

29. Cupola man was attempting to replace the control cable of the charging elevator on the lower pulley. In doing so he pulled the cable into the down position and was crushed when the elevator descended upon him. Fatal.

30. Cupola man was taking iron up to charge into cupola when the elevator cable broke and the elevator fell. Fractured hip, lost 6 months.

31. Cupola charger was hauling pig iron up to charging deck. Drum on the elevator broke causing the elevator to fall. Fractured foot; lost 8 weeks.

32. Worker was removing core from a large casting which was suspended by a chain hooked around a riser. The riser broke off, dropping the casting, and the worker's finger was crushed between the casting and the cleaning bar. Lost 3 days.

33. A heavy plate was being carried by a crane over the head of a core maker. One of the chains broke and let the plate swing down to strike the core maker. Permanent partial loss of use of one leg.

34. Employee lifted the safety gate of the elevator shaft at the first floor. The elevator at the time was at the second floor. He stepped into the open shaft and fell about 8 feet. Lacerations, fractured ribs, and fractured wrist; lost 6 weeks.

Furnace Accidents

35. A cupola liner was working from a scaffold. The scaffold collapsed, throwing him to the floor. Broken shoulder; lost 6 weeks.

36. Cupola worker was caught in flames when the cupola bottom was dropped. Fatal.

37. Worker was cleaning out furnace pit when burning slag from the furnace broke out. Fatal.

38. Worker was preparing a charge for the cupola when he dropped a piece of pig iron onto his foot. Fractured toe; lost 2 weeks.

39. The operator of a furnace-car turntable attempted to put a dog in place while the turntable was in motion. Amputated finger.

Pouring Accidents

40. A pourer, who was using a hand ladle, struck another worker, who was shifting molds, with the shank of the ladle. Molten iron splashed from the ladle and fell into the pourer's shoe. Lost 20 days.

41. Ladle broke in pouring and spilled molten metal on the molder's feet and legs. The molder was not wearing leggings or molder's shoes, despite a shop rule requiring their use in all

pouring operation. Severe burns caused the loss of 45 days.

42. A helper was pouring aluminum from a pot into a mold. The mold overflowed and the molten metal ran down onto the worker's foot. Lost 2 weeks.

43. A molder was standing beside a flask skimming the iron when an explosion in the mold caused molten iron to spurt out of the joint of the flask. The iron fell on the molder's foot and ran inside his shoe, which had no tongue and was unlaced. Lost 28 days.

Sand-Mixing Accidents

44. Two workers were cleaning a sandmuller. One placed his hand upon the gears just as the other started the mill to turn over the rollers. Right index finger amputated by gears.

45. An overload had stayled the sand mixer. The operator shoveled some sand from the machine and then pushed the starter button. In starting this machine under full load, however, there is a delay of about 8 seconds after power is turned on because of the action of the relays. Apparently the delay caused the operator to think that the machine was still stalled and that the automatic cut-off head again operated. He jumped inside the

machine with his shovel, evidently to remove more sand, just as it started. The mixer was examined immediately after the accident and was found to be mechanically and electrically perfect. Fatal.

46. Operator of sand mixer reached up to turn on the power and absent-mindedly placed his other hand on the edge of the mixer drum. The revolving blade amputated his index finger.

47. The operator, who was cleaning the sand-mixing machine, put his finger into a small hole in the guard of the machine. Lost first phalange of index finger.

48. Worker was shoveling sand from under muller, which was operating. His glove caught in the gears and he lost 3 fingers.

49. Core maker reached into the back of the sand-mixing machine while it was operating, to feel the texture of the mix. A blade caught and amputated his finger.

Woodworking Accidents

50. A patternmaker was operating a jointer when the wood kicked back and his hand slipped into the blade. Ends of 3 fingers amputated.

51. Worker was cutting a board on a miter saw. The board kicked and his hand went into the saw. Lost parts of 4 fingers.

52. Workman was sawing 7/8-inch square wooden flask bars, pushing the material across the table. One piece jammed, throwing his hand against the saw. Lost 3 fingers.

53. Worker cleared off the table of a band-saw trimming machine with his gloved hand. The saw caught the glove and sawed off a finger.

Maintenance Accidents

54. Maintenance man caught his finger in fan blade while working on hot air blower. Permanent loss of use of one finger.

55. An oiler and maintenance man was attempting to tighten a bearing on the drive shaft of a bucket elevator. His sleeve caught in the gears and his right arm was crushed between the gear and pinion. Arm amputated.

56. An electrician who was installing a new electric line fell over a hot bus. Electrocuted.

57. An extra employee, hired to clean up the shop in preparation for painting, disregarded warning signs and crawled into a

restricted area underneath some transformer housings. He raised up and contacted an 11,500 volt wire. Electrocuted.

58. A maintenance man who was filling a storage tank with fuel oil was burned when the oil overflowed and caught fire from an adjacent ladle. Fatal.

59. (a) Maintenance man neglected to turn off the air while he was repairing an oil torch. Burned to death.

(b) Maintenance man was about to repair the motor of a dryer. He pulled the switch, climbed up onto the dryer, and before the motor stopped turning put his hand on the belt which pulled his hand into the motor. Lost little finger.

60. Worker put gasoline into a blower to clean the fan chamber and started the motor. Sparks from the motor ignited the fumes and the fan blew out a torch-like flame against his arm. Lost 18 days.

Miscellaneous Accidents

61. Worker was drilling a pig for sampling. He attempted to brush off dirt and rust with one hand while holding the running drill with the other. His glove caught in the drill, and his left first finger was so torn that it had to be amputated.

62. Laborer was moving castings on a small truck. The side of the truck broke and spilled the castings out onto his foot. Three toes broken; lost 8 weeks.

63. An overhead exhaust pipe fell, striking a chipper. Fatal.

64. Worker was heating a hollow brass casting in a forge preparatory to remelting. Moisture in the interior of the casting caused it to explode, throwing fragments all about. Fatal.

65. Worker slipped while taking a shower and caught his hand on a projecting nail on the shower platform. Lost 2 days.

ABRASIVE-BLASTING CABINET: A metal cabinet, equipped with windows, in which a blast of sand, steel grit, or steel shot forced through a nozzle by compressed air is sprayed over metal castings to remove extraneous material such as scale and molding sand.

AIR COMPRESSOR: A power-driven pump used to compress air to high pressure. Compressed air is used for cleaning purposes and the operation of pneumatic tools and machinery.

AIR RAMMER: A hand tool consisting of a pneumatic hammer fitted with a blunt-end tamping tool.

AMMETER: An instrument used to measure the intensity of electrical current.

ANNEAL: To treat metal by gradual heating to a suitable temperature and slow cooling so as to relieve internal strains to reduce brittleness and increase toughness.

ANNEALING OVEN: A large oven lined with firebrick, used for heating metal castings.

ANNEALING POT: An open-ended, circular metal container in which castings are packed with sand for annealing.

ARBOR (GRID): A network of rods or wires, embedded in a core or the top section (cope) of a mold to support and reinforce the sand.

AUTOMATIC STOKER: A powered mechanism which automatically feeds coal from a hopper into the firebox of a Boiler.

AWL: A pointed instrument for making small holes.

BAND SAW: A power-driven saw for cutting wood or metal. The blade, an endless steel band toothed on one edge, runs over the rims of two wheels mounted one above the other. The descending side of the blade passes through a slot in a table mounted between the wheels. The design of the saw teeth differ in the metal-cutting and wood-cutting blades.

BINDER: A material, such as clay, flour, molasses, or linseed oil, used to increase the bond (cohesiveness) of core or molding sand.

BLACK WASH: A mixture of powered charcoal and mineral carbon (coke), plumbago, or a patent blacking in a liquid mixture.

BLACKING SOLUTION: A mixture of graphite and water used to paint the surface of a core to make it stronger, smoother, and more refractory.

BLASTING SAND: A coarse, hard sand used as an abrasive in cleaning castings by the sandblasting process.

BLOW SPRAY: A container provided with a removable top through which air is blown to force liquids from the jar through a spray nozzle.

BLOWHOLE: A defect in a casting, caused by the imprisonment of a gas bubble in the metal during its solidification.

BORER AND ROUTER: A machine for boring large holes or cutting grooves in wooden surfaces. The work is placed on an adjustable table and pushed and guided by hand under a power-rotated spindle to which appropriately shaped cutters are affixed.

BOTT STICK: A long metal or wooden bar with a disk at one end to which are affixed plugs of clay (botts), used in stopping furnace tap holes.

BOTTOM PLATE: A plate used to hold the bottom of a flask while making a mold.

BRACKET: A stiffening rib placed at intersecting surfaces on a casting to reinforce it against shrinkage stresses as it cools. The bracket is usually cut away before the casting is machined.

BRICKLAYER'S HAMMER: A hammer with a chisel-like edge at one end of the head.

BUCKET (CRANE): A rectangular or circular, open-topped, steel container that is suspended from a hoist or crane cable and used to transport materials.

BUGGY: A vehicle used to transport materials in the foundry.

BURNING EQUIPMENT: Two regulators, which measure and control the pressure and flow of gases from tanks: a hand torch, which mixes the gases (oxygen and acetylene) before ignition at the torch tip; two hoses to convey gas from the regulators to the torch; a number of torch tips with a variety of orifice sizes.

BUTT-RAM: To compact sand with the flattened end of a ramming tool.

CASTING: An article made by pouring molten metal into a mold and allowing it to solidify.

CHAIN HOIST: A system of chains and pulleys, operated by hand and used for lifting heavy objects.

CHAPLET: A sheet-metal support for cores, used to hold them in position in a mold.

CHILL: A piece of metal which is placed adjacent to the cavity in a mold to hasten the cooling of the metal it contacts when the mold is filled.

CIRCULAR SAW: A power-driven, toothed disk of thin steel designed to cut material. The work is supprted by a table through which the disk or saw projects.

CLAMP: A C-shaped metal implement used to hold together objects such as the sections of a foundry flask.

CLAMSHELL BUCKETT: A heavy steel bucket, consisting of two parts that are hinged together at the top and open and close at the bottom line like a clamshell.

CONVEYOR-SCREW COREMAKING MACHINE: A machine for making cores of circular, oval, triangular, or irregular cross section. Sand is forced through a tube of the desired shape by the rotation of conveyor screw and emerges as a compacted body of sand.

COPE: The top section of a flask, mold, or pattern.

CORE: An appropriately shaped body of sand, which is placed within a mold to prevent molten metal from completely filling the mold cavity, thus forming a hole or hollow of the desired shape in the solidified casting.

CORE BOX: A wooden or metal mold, of one or more sections, in which sand is compacted to form a core.

CORE-BOX DRAWING MACHINE: A machine for lifting core boxes from compacted cores.

CORE CARRIAGE OR RACK: A rectangular metal framework mounted on wheels and bearing a series of shelves for core trays.

CORE CUTTING MACHINE: A circular, motor-driven, revolving metal blade, mounted on an arm above a table. The blade is lowered to the core, which is laid on the table, to cut it.

CORE OVEN: A brick-or asbestos- lined oven in which sand cores are baked to harden them.

CORE PLATE: A metal plate on which cores are laid after their removal from the core boxes. The upper surface of the plate may be either flat or shaped to fit the cores.

CORE SAND: A mixture of sand, clay, and a binder such as linseed oil, molasses water, ground rosin, flour or special core oils and compounds. The types and proportions of sand, clay, and binder used depend upon the size of the core and the metal with which it is to be used.

CORE TRAY: (See Core Plate.)

CORE-TURN-OVER DRAW MACHINE: A small, powered machine for making sand cores. A jolting mechanism compacts the sand within a core box and another mechanism inverts the box and withdraws the core.

CRANE LADLE: A large, refractory-lined bucket-shaped vessel, used to transport molten metal from furnaces to molds into which it is poured to form castings.

CRUCIBLE FURNACE: A refractory-lined oven, heated by coal, coke, gas or oil, for melting small amounts of metal in large pots (crucibles).

CUPOLA: A vertical, refractory-lined furnace for melting iron and other metals in contact with burning coke. Metal, coke, and flux, are charged into the furnace in alternate layers, and combustion is forced by a continuous blast of compressed air. Molten metal and slag are withdrawn from their respective tap holes as they accumulate at the bottom.

CUT-OFF CIRCULAR SAW: A circular saw mounted on a sliding or swinging support. The saw is moved across the grain of wood to cut it to length.

CUTTING TOOL: A sharpened, hardened piece of tool steel used in powered machines to cut metal.

DOWEL; A round, wooden or metal pin which fits into corresponding holes of abutting pieces to hold them in their correct relative positions.

DRAG: The bottom section of a flask, mold, or pattern.

DRAWKNIFE: A sharp, steel-bladed tool with a handle at each end; it is pulled toward the worker to shave wood.

DRESSING TOOL: An implement used to even the surfaces of abrasive wheels. It consists of a number of toothed disks which turn freely on an axle, and a handle by which it is held and pressed against the surface of a rotating wheel to trim it.

DRILL: A pointed, spirally fluted tool which is clamped in a drilling machine or hand tool and rotated to drill holes in materials such as metal, wood, and bakelite.

DRILL PRESS: An upright, powered machine for drilling holes in wood or metal. The drilling tool is forced into the work by hand or automatic feed.

DRYING CRADLE: A metal frame or rack in which ladles are placed while their linings are dried and heated.

ELECTRIC-ARC FURNACE: A refractory-lined furnace in which metals are melted from the heat generated by an arc passed between electrodes and the metal. This furnace permits the production of high temperatures and makes available a furnace atmosphere which will not contaminate the melting metal.

ELECTROMAGNET: A crane attachment for lifting heavy loads of iron and steel by magnetic attraction.

ENGINE LATHE: A power-driven, metal-working machine for turning stock to circular cross section. The stock is supported and rotated on a horizontal axis and formed to size and shape by the shaving action of a cutting tool, clamped in a holder, being fed against the surface.

FACING MATERIAL: A substance such as molasses, powdered coal, or graphite, with which the surface of mold cavities are coated to smooth and strengthen them.

FILLET: A grooved strip of leather, wax, solder, or wood fastened into the angle between two joining planes to form a rounded interior junction.

FIN: (I) A thin rim of metal projecting from the surface of a casting, at the parting line between upper and lower halves of the mold. (II) A small ridge of hardened sand on the surface of a core caused by the parting line of two sections of a core box.

FIRE CLAY: A mixture of a heat-resisting clay and water.

FLASK: An open-ended wooden or metal framework in which sand is packed and shaped to make a mold. A snap flask is one equipped with hinges and a lock so that the flask may be removed from the mold after it is finished.

FLUX: A substance which is added to a furnace charge to fuse or combine with metallic and nonmetallic impurities to remove and carry them off in the slag.

FOLLOW BOARD: A wooden or metal plate on which the pattern and flask lie while sand is rammed into the flask.

FORGE: A small, forced-draft furnace for heating metal that is to be worked by hammering. A forge consists of a hearth, usually covered by a smoke-catching hood, and hand or powered forced-draft mechanism to intensify the fire.

FORM: A metal or wooden pattern that is placed inside a ladle. The clay lining is packed between the form and the ladle. Hence, the form will shape the inside.

GAGGER: A rod or piece of wire, usually L-shaped, which is embedded in the sand of a mold or of a core to reinforce it.

GATE: (I) The passageway in a mold through which molten metal is poured to form the casting. (II) The metal that has solidified within pouring and connecting channels in the mold. (III) A wooden or metal strip which serves as a pattern to form the pouring or connecting channels in the mold.

GATE CUTTER: A stake or tube, used to cut the pouring passage (gate) in the copes of molds.

GATE STICK: A rod that is embedded in the sand of a mold as it is compacted, and then withdrawn, leaving a passage through which molten metal can be poured to fill the mold.

GRATE: A perforated iron plate or framework of brass which supports the bed of fire above the floor in a furnace.

GUIDE PINS: Short wooden or metal rods that are fastened to the drag section of a flask. The rods fit in corresponding lugs or holes in the cope flask, thus serving to aline the two sections and keep them from twisting out of position.

HAND CAR-MOVER: A long-handled lever that is used as a pry between the track and the car wheel to move cars.

HAND PLANE: A hand tool for smoothing surfaces of wood.

HAND RAMMER: A hand tool with a blunt-edged wedge at one end of a short handle and a flat surface at the other, used to compact sand in molds by tamping.

HAND MATCH: A false cope, molded in sand and baked. The match supports the pattern in position in the flask while the drag section of the mold is compacted.

HEAT-TREAT: To alter the physical properties of metals by the controlled application of heat.

HYDRAULIC PRESS: A heavy steel table equipped with a hydraulic ram, used for straightening bent or warped castings. The casting is supported between two adjustable supports and straightened by the pressure of the ram at the apex of the bend or warp.

JAR-TYPE MOLDING MACHINE: A pneumatic-powered machine for compacting sand evenly within a Flask in the process of making a mold. The Flask, assembled with the pattern on the jarring table, is filled with loose sand. By means of a piston the table is raised a short distance and allowed to fall, the repeated jolts being transmitted to and packing the sand about the pattern.

JOINTER OR PLANER: A woodworking machine for planing the surface and reducing the width or thickness of lumber. Cutting blades, attached to a power-rotated cutter head, project slightly above the surface of a table. Work is cut by being pushed along the table over the rapidly rotating blades.

LADLE: A vessel for transporting and pouring molten metal.

LATHE: (I) A woodworking machine for turning (cutting) stock to shapes of circular cross section. The stock is supported and rotated on a horizontal axis and is cut by a hand tool, supported on a tool rest, being fed against the surface.

LIFTER: A thin, knife-like tool, bent at right angles to its handle and used to lift loose sand from deep pockets in a mold.

LINE SHAFT: A cylindrical metal bar upon which are mounted pulleys for the transmission of power from engines or motors to machines. The shaft is usually supported overhead in bearings that are fastened to the building structure.

MALLET: A short-handled hammer, the head of which is usually wooded, used especially for striking a tool such as a chisel.

MATCH PLATE: A wooden or metal plate with half a pattern attached to each of its sides.

MILLING MACHINE: A metalworking machine in which the surface of work is shaped and dressed by the shaving action of rapidly rotating cutting tools against which it is fed.

MITER BOX: A wooden or metal frame used to hold and guide a saw at a predetermined angle to the length of a board when cutting across it. The saw is moved back and forth in the frame in vertical slots, which guide it at the desired cutting angle.

MIXING BOX: A shallow, rectangular pan in which sand, clay, and water are mixed.

MOLD: A form, composed of one or more sections, into which molten metal is poured to cast it into a predetermined shape. The form is usually made by compacting sand around a pattern and withdrawing the pattern from the sand.

MOLDING SAND: A mixture of sand, binding material, and water used to make molds. It possesses the qualities of holding together when rammed into a compact mass, resisting melting from contact with molten metals, and allowing the escape of gases generated by the molten metals when they are poured into the mold.

MOLDER'S SPOON: A spoon-shaped smoothing tool, used to repair interior surfaces of molds that have been damaged in withdrawing the pattern.

MONORAIL CRANE: A system of chains or cables and pulleys suspended from wheels that run on a single track overhead and used to lift and transport heavy loads. The lifting device is operated by hand manipulation of the chains or may be motor-powered.

MONORAIL HOIST: (See Monorail Crane.)

NAILS: Special metal nails with large, flat heads that are thrust into the compacted sand of molds to reinforce and sustain it.

OVERHEAD TRAVELING CRANE: A machine for raising and lowering a heavy load, and transporting it over a limited distance while it is suspended. The Crane is mounted on overhead tracks and spans the width of the floor.

PARTING LINE: The plane along which the cope and drag sections of a mold are separated to withdraw the pattern.

PARTING COMPOUND: A moisture-absorbing powder such as silica dust or vegetable pollen, used to prevent the adherence of molding sand where it is undesirable, as on the surface of a pattern and along the plane of parting between the sections of the mold.

PATTERN: An object from which a metal casting of the same size and shape is to be reproduced. The pattern is embedded in sand and withdrawn, leaving a mold which, when filled with molten metal, produces the required casting.

PATTERN PLATE: A flat plate to which halves of a pattern are attached so that the patterns can be placed in, and withdrawn from, the sand of molds easily and quickly.

PEEN: To tamp sand with the wedge-shaped end of a ramming tool.

PIG IRON: Crude iron which is the product of a blast furnace. It is usually delivered to the foundry molded into pigs, which are oblong in shape and of a weight that can be handled by one man.

PLUMB BOB: A weight hung on a cord; when the weight is suspended by the cord it serves to establish a vertical line.

PNEUMATIC HAMMER: Is essentially a cylinder containing a compressed-air driven piston. The reciprocating motion of the piston imparts blows to a chisel inserted in one end of the cylinder. To the other end of the cylinder is attached a revolver-grip handle equipped with a trigger valve for admitting compressed air into the cylinder.

PNEUMATIC RAMMER: A pneumatic hammer, equipped with sand-ramming bits.

PORTABLE GRINDER: A grinding wheel, mounted on the shaft of a small air or electric motor.

POT HANGER: Tongs used to handle large pots in which castings are heat treated.

POURING LADLE: A vessle, used to transport molten metal and pour it into molds to make castings.

POWER HACKSAW: A metal-working machine in which stock, clamped in position, is cut to length by a reciprocating saw blade.

POWER HAMMER: Consists of a vertical ram, supported in a steel frame, and powered by steam, compressed air, or an electric motor. Centered directly below the ram is an anvil. The surfaces of the ram and the anvil may be fitted with dies (swages) to shape the metal.

PUDDLING BAR: A long, metal, clay-tipped rod that is used to stir and move plastic or molten metal in furnaces.

PYROMETER: An instrument for measuring high temperatures, as for furnaces and molten metals.

RAMMING: To compact molding sand, usually by hand tamping.

RAMMING TOOL: A hand tool with a blunt-edged wedge at one end and a flat surface at the other, used to compact sand in molds.

REFRACTORY CEMENT: Industrial cement that withstands high temperature without melting, cracking, or crumbling.

REVERBERATORY OR AIR FURNACE: A horizontal furnace in which metal is melted in a basin (hearth) by heat from flames of an oil, or gas fire being deflected (reverberated) downward from the furnace roof.

RIDDLE: A sieve used to sift sand.

RISER: (I) A reservoir of molten metal, usually above a high point of a casting, which feeds into the casting to compensate for the contraction of the metal during cooling. (II) The metal that has solidified within the reservoir that is provided for feeding molten metal into a casting as it cools. (III) The rod which serves as a pattern within a mold for a reservoir which supplies molten metal to the casting to compensate for the contraction of the metal during cooling.

RISER STICKS: A rod that is embedded in the sand of a mold as it is compacted, and then withdrawn, leaving a passage in which molten metal rises when the mold is poured. The riser passage insures the presence of a supply of molden metal to fill the mold as shrickage occurs during solidification.

ROLL-OVER MACHINE: A machine which facilitates the making of a large sand mold by turning the mold over, after the sand is compacted, so that the pattern may be removed. The mold is made on one table equipped with a mechanism to lift, invert, and deposit it on another table, thus eliminating turning it by hand or with the aid of a crane. The machine may be provided with a jolting mechanism to compact the sand.

ROSIN: A vegetable substance mixed with foundry sand to increase its cohesiveness; used in powered form.

ROTARY-TABLE BLASTING MACHINE: A machine for cleaning adhering scale from the surfaces of castings by the action of an abrasive-laden stream of compressed air. Castings are placed on a rotating table that carries them through a chamber in which one or more nozzles direct streams of abrasive-laden air against them.

RUNNER: A passage cut in the sand of a mold to conduct molten metal from the gate passage to the mold cavity during pouring.

SAND CUTTER: A power-driven, sand mixing machine, which, by the action of whirling spiral blades, stirs and aerates foundry sand for reuse in making molds and cores.

SAND-MIXING MACHINE: Any one of several types of machines designed to thoroughly mix sand, binder, and water in preparing sands suitable for use in making cores or molds.

SAND RIDDLE: A sieve which is held in a frame and shaken by an electric motor.

SAND SLINGER: A mobile or stationary electrically powered machine that throws sand forcibly into flasks to produce evenly compacted molds. Sand flows from a hopper into an impeller head where a revolving arm picks it up and throws it downward into the flasks where it is compacted by the force of the impact.

SANDBLAST HELMET: A hood, equipped with a window and an air line, which is worn over the head and shoulders to protect the face and supply fresh air while sandblasting castings.

SANDBLAST TUMBLER: A machine in which castings are cleaned by tumbling them against one another as they are subjected to a blast of sand, steel grit, or steel shot hurled from a rapidly rotating wheel or by a compressed-air blast.

SANDER: A powered machine for smoothing the surfaces of wood by the abrasive action of sand paper attached to a rapidly rotating spindle or disk.

SHANK (LADLE CARRIER): A handle by which one or more men lift, carry, and pour a ladle of molten metal. Usually the ladle is set in a circle forged from the metal of the shank.

SHAPER (METAL): A power-driven machine for shaping the surface of metal. A reciprocating ram carries a cutting tool across the surface of the work, which is clamped in a vise on the adjustable table of the machine

SHAPER (WOOD): A power-driven machine for cutting and shaping the edges of wood stock to a curved outline or profile. The stock is held firmly on the machine table and pushed against the rapidly rotating cutter blades, which are mounted on a vertical spindle projecting through the center of the table.

SHAPING TOOL OR SWAGE: A metal block, grooved or shaped on one end (face). It is used to shape heated metal by placing the metal on the swage (or the swage on the metal) and striking with a hammer or sledge. The heated metal is forced into the shape of the swage.

SHEAR, OR SPRUE CUTTER: A machine for cutting metal by the shearing action of blades rather than the cutting action of a saw. The work is placed on the bottom blade and the top blade driven downward, thus shearing the metal between them.

SKIMMER: A strip of heat-resisting material such as fire clay which spans the spout of a pouring ladle to hold back the floating slag when molten metal is poured from the ladle.

SKIMMING BAR: A long, metal rod with a hooked or hoe-like end, used to skim floating slag from molten metal.

SKULL CRACKER: A heavy, cast-iron ball which is lifted by a crane and dropped upon masses of solidified metal or slag to break them into pieces of suitable size for use or disposal.

SLAG: The dross of flux and impurities which rises to the surface of molten metal.

SLIP BAND: A metal reinforcing band placed around the pattern within a flask to reinforce the sand in the flask as it is compacted.

SLIP JACKET: A metal or wooden frame that is placed around a mold to support it, after the flask has been removed. The slip-jacket is shaped like a flask, but is made in one piece.

SOLDIER: A straight rod embedded in the sand of a mold to reinforce it.

SPOON (SLICK): A double end, bladed metal smoothing tool used to repair damaged cores. Slicks are made in many styles, having various sizes and shapes of blades for use in different kinds of repairing.

SPRUE: The vertical passageway in a mold down which molten metal is poured to form the casting, or the metal that solidified within the passage.

SQUEEZE MOLDING MACHINE: A machine used to compact the sand in a mold by compression. The flask containing the pattern, covered with sand, is placed on the machine table, which is raised against a pressure head to effect the compression. The machine may be equipped with a jolting mechanism to partially compact the sand before it is squeezed, see Jar-type Molding Machine.

STARS: Small star-shaped pieces of iron, steel, or brass, used as an abrading material to clean castings by tumbling.

STATIONARY OR BENCH GRINDER: A motor carrying a large abrasive (grinding) wheel at each end of the shaft. It is used to smooth and dress the surface of metal.

STEEL GRIT: An abrasive composed of small sharp, irregular pieces of steel.

STEEL SHOT: Hard iron or steel pellets.

STORAGE LADLE: A large ladle in which molten metal, tapped from furnaces, is stored so that a sufficient supply is on hand to complete the pouring of the molds without interruption.

STRIKING TOOL: A straight-edged bar used to scrape excess sand from the top of a flask after molds have been rammed.

STRIPPING-PLATE MOLDING MACHINE: A machine for mechanically withdrawing complicated or intricate patterns from the compacted sand of molds without damage to the pattern impression. The stripping plate fits closely around the periphery of the pattern and holds the compacted sand in place as the pattern is withdrawn through the plate opening by a draw frame to which it is attached.

SWING OR BALANCE GRINDER: A large, powered, grinding wheel, mounted on a counterbalanced, swivel-supported beam. By means of two handle bars, the worker can swing and guide the wheel.

TAMPING BAR: An iron bar with a disk or butt mounted on one end and a blunt wedge, or peen, on the other, used to compact sand.

TAPPING BAR: A long, metal bar with a pointed end which is used to pick away the clay plug (bott) in tapping a furnace.

TEST-BAR MOLDS: Sand or cast-iron molds in which samples of molten are cast to make test pieces.

TEST LADLE: A long-handled dipper with which test samples of molten metal can be dipped from the bath of molten metal in a furnace.

TILTING FURNACE: A furnace for melting metal, so supported between two pivots that it can be tilted to pour the molten contents. Tilting is accomplished by means of a hand-wheel or powered mechanism.

TOOL GRINDER: A machine for sharpening metalworking tools and cutters. Generally it consists of a rotating abrasive disk against which the tool is pressed.

TORCH: A gasoline, kerosene, or oil burner equipped with a nozzle for projecting flame. Valves are provided for regulating the relative amounts of fueld and air supplied for combustion.

TOTE BOX: A box for carrying castings or other materials from place to place in the foundry.

TUMBLER OR RATTLER: A power-rotating metal drum in which castings are cleaned by tumbling them with an abrading material to free them of scale and adhering sand.

VENT WIRE: A straight piece of wire used to pierce cores or molds to produce openings through which gas can escape.

VIBRATOR: A compressed-air operated hammer.

WAX CORD: A wax-coated, fiber thread embedded in a core, during construction, to produce an irregularly shaped vent. When the core is heated the wax melts into the sand and the thread can be pulled from the hole so made.

WEIGHT LORRY: A dump car equipped with a scale that indicates the weight contained in its hopper.

WIND BOX: Plenum chamber surrounding the cupola to contain and distribute combustion air.