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Standard Practice for Safety Requirements in Metal Casting Operations: Sand Preparation, Molding, and Core Making; Melting and Pouring; and Cleaning and Finishing[1]

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INTRODUCTION

This practice is part of a project started in 1972 under the sponsorship of the American Foundry Society, Inc. Standard for Safety Requirements in Metal Casting Operations—Sand Preparation, Molding, and Core Making; Melting and Pouring; and Cleaning and Finishing.

The metal casting industry shares safety considerations with many other industries requiring the movement of heavy objects, the use of large ovens and melt furnaces, and processing of hot materials. In addition, there are safety considerations common to all industries. The present trend is towards the development of industry-wide standards wherever the need for safety considerations exists. This practice, therefore, is limited to safety considerations of special importance in the metal casting industry operations in which general standards do not exist or are not considered adequate. This practice is not intended to supersede or replace any applicable federal, state, or local governmental safety regulations or requirements, but rather, it is intended to augment and support any such requirements. Operating rules are not included in this practice unless they are vital to safety.

Compliance with this practice should provide a relatively safe environment, which is a fundamental requirement in preventing occupational injuries.

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1. Scope

1.1 This practice covers the requirements of applying the design, construction, and operation of the machinery and equipment used in metal casting operations—sand preparation, molding and core making, melting and pouring, and cleaning and finishing. This practice does not apply to die casting operations.

1.2 *Purpose*—The requirements of this practice, including the training of supervisors and employees, are intended to minimize the possibility of injury to operating and maintenance personnel while working on, or in the vicinity of, the specified equipment. Compliance with this practice, in conjunction with OSHA regulations, provides a relatively safe environment, which is a fundamental requisite in helping to prevent occupational injuries.

1.3 *Application*

1.3.1 *New Installations*—After the date of publication, all new installations within the scope of this specification shall be in conformance with its requirements. Any existing machine installation moved to a new plant or another location in the same plant is deemed a new installation when it is installed in the new location. However, an existing installed machine (former installation) that is moved for a short distance, for example, to provide additional aisle space, is not deemed to be a new installation.

1.3.2 *Existing Installations*—After the approval date of this practice, installations existing on, or before, this date, shall be modified as necessary to be in conformance with all requirements of this practice. Where it is not practical to modify an existing facility in conformance with this practice, deficiencies shall be noted and plans for compliance shall be included in any future facility or equipment changes. Those facilities and equipment on order or in the process of construction on the date of publication of this practice shall be considered as an existing installation. This practice applies to existing equipment if it lacks the necessary employee protection (personal protective equipment or administrative controls).

1.4 The values stated in inch/pound units are to be regarded as the standard. The values in brackets are for information only.

1.5 The text of this practice references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1002 Performance Specification for Protective Clothing and Materials for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards

F1449 Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing

2.2 *ANSI Standards:*[3]

ANSI A12.64.1 Safety Requirements for Workplace, Floor and Wall Openings, Stairs and Railing Systems

ANSI A58.1 Minimum Design Load in Buildings and Other Structures

ANSI B5.35 Machine Mounting for Abrasive Discs and Plate Mounted Wheels

ANSI B 11.6 Safety Requirements for Manual Turning Machines with or without Automatic Control

ANSI B7.1 Safety Requirements for the Use, Care and Protection of Abrasive Wheels.

ANSI B11.9 Grinding Machines, Safety Requirements for the Construction, Care and Use of

ANSI B11 TR3 Risk Assessment and Risk Reduction—A Guide to Estimate, Evaluate and Reduce Risks Associated with Machine Tools

ANSI B15.1 Mechanical Power Transmission Apparatus

ANSI B20.1 Safety Standard for Conveyors and Related Equipment (ASME B20.1)

ANSI/ASME B30.2 Overhead and Gantry Cranes (Top Running, Bridge, Single or Multiple Girder Top Running Trolley Hoist)

ANSI/ASME B30.9 Slings

ANSI/ASME B30.10 Hooks

ANSI/ASME B30.11 Monorails and Underhung Cranes

ANSI/ASME B30.20 Below-the-hook Lifting Devices

ANSI B107.4 Driving & Spindle Ends for Portable Hand, Air and Electric Tools (Percussion Tools Excluded)

ANSI B186.1 Portable Air tools

ANSI Z9.2 Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems

ANSI Z9.4 Ventilation and Safe Practices of Abrasive Blasting Operations

ANSI Z33.1 Standard for the Installation of Blower and Exhaust Systems (NFPA 91)

ANSI Z43.1 Ventilation Control of Grinding, Polishing/Buffing

ANSI Z244.1 Personnel Protection—Lockout/Tagout of Energy Sources—Minimum Safety Requirements

ANSI Z490.1 Accepted Practices in Safety, Health and Environmental Training

ANSI Z535.1 Safety Color Code

ANSI Z535.2 Environmental and Facility Safety Signs

ANSI Z535.3 Criteria for Safety Symbols

ANSI Z535.4 Product Safety Signs and Labels

[1] This practice is under the jurisdiction of ASTM Committee E34 on Occupational Health and Safety and is the direct responsibility of Subcommittee E34.10 on Industrial Safety.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

ANSI Z535.5 Accident Prevention Tags

2.3 *NFPA Standards:*[4]

NFPA 49 Fire Protection Guide to Hazardous Materials

NFPA 68 Guide for Venting of Deflagrations

NFPA 70 National Electrical Code

NFPA 86 Standard for Ovens and Furnaces

NFPA 480 Standard for Storage and Handling of Magnesium

NFPA 484 Standard for Combustible Metals

2.4 *Occupational Safety and Health Administration:*[5]

29 CFR 1910 Code of Federal Regulations, Part 1910 General Industry

29 CFR 1910.23 Guarding Floor and Wall Openings and Holes

29 CFR 1910.94(a) Ventilation—Abrasive Blasting

29 CFR 1910.145 Specification for Accident Prevention Signs and Tags

29 CFR 1910.146 Permit required Confined Spaces

29 CFR 1910.147 Control of Hazardous Energy (LOCKOUT/TAGOUT)

29 CFR 1910.184 Slings

29 CFR 1910.215 Abrasive Wheel Machinery

29 CFR 1910.217 Mechanical Power Presses

NOTE 1—State plan states may have their own regulations.

2.5 *American Foundry Society (AFS)*[6]

Guide for Selection and Use of Personal Protective Equipment and Special Clothing for Foundry Operations Managing the Foundry Indoor Air Environment

3. Terminology

3.1 *abrasive blasting, n*—operation in which an abrasive is forcibly applied to a surface by pneumatic or hydraulic pressure or centrifugal force.

3.2 *adjustable barrier guard, n*—physical barrier with adjustable sections that prevents entry of any part of the body into the hazard zone by reaching through, over, under, or around the barrier. The adjustable sections allow different jobs to be run on the equipment.

3.2.1 *Discussion*—This type of guard requires close supervision of use and adjustment or inadequate protection could result. It shall be the responsibility of the employer to establish and follow a program of periodic and regular inspection of power press and auxiliary equipment. Refer to 29 CFR 1910.217(e).

3.3 *arc furnace, n*—see *direct arc furnace and indirect arc furnace*

3.4 *automatic, adv*—each function in the machine cycle is initiated by the previous cycle and is automatically performed and sequenced, including load, unload, and repeat cycle.

3.5 *bail/spreader, n*—hoop or arched connection between the crane hook and ladle or between crane hook and ladle trunnions.

3.6 *barrier guard*—see *adjustable barrier guard, fixed barrier guard, and interlocked barrier guard*

3.7 *blast, n*—air or oxygen-enriched air that is blown, under pressure into a cupola for supporting combustion.

3.8 *blast compartment, n*—that portion of the blasting enclosure that contains the blasting media propulsion device.

3.9 *blow plate, n*—plate affixed to the magazine or blow head of a core- or mold-blowing machine having holes or slots through which sand or other media in the magazine or blow head passes into the core or mold cavity or around the pattern when air or other gas pressure is applied to the machine.

3.10 *bottom discharge (pour, tap) ladle, n*—ladle that has its molten metal contents discharged through an opening in the bottom.

3.11 *channel furnace, n*—electric induction furnace in which heat is electrically induced in the metal in a refractory channel.

3.12 *charge, n*—material introduced into a melting furnace for the production of molten metal.

3.13 *charging, v*—process of adding a charge to a furnace.

3.14 *control circuit (electrical), n*—circuit of a control apparatus or system that carries the electric signals directing the performance of the controller, but does not carry the main power current.

3.15 *controller, n*—device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

3.16 *core, n*—preformed aggregate or collapsible insert placed in a mold to shape the interior or that part of a casting that cannot be shaped by the pattern.

3.17 *core- or mold-blowing or shooting machine, n*—machine for injecting sand or other media into the core or mold cavity by means of compressed air or other gas.

3.18 *core binder(s), n*—any material, liquid or solid, which is used to bond core aggregates.

3.19 *corebox, n*—a (wood, metal, or plastic) structure, the cavity of which has the shape of the desired core that is to be made therein.

3.20 *coreless furnace, n*—electric induction furnace consisting of an induction coil surrounding a crucible or refractory lining in which metal is melted or molten metal is retained.

3.21 *counterweight, n*—weight that corrects a state of unbalance and establishes static equilibrium.

3.22 *crane ladle, n*—ladle handled by an overhead crane.

3.23 *crucible, n*—container used for the melting, holding, and pouring of metal.

3.24 *cupola, n*—vertical shaft-type furnace for melting and/or producing molten metal by combusting coke or other fuels using a blast, and possibly additional pure oxygen, that is introduced through the cupola tuyeres.

3.25 *cupola drop, n*—materials dropped from the cupola at the end of a heat.

[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[5] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[6] Available from the American Foundry Society, 1695 N. Penny Lane, Schaumburg, IL 60173.

3.26 *direct arc furnace, n*—furnace in which heat is produced by an electric arc between electrodes and the charge.

3.27 *disconnecting means (electrical), n*—device, or group of devices, or other means by which it is possible to disconnect the conductors of the circuit from their source of supply.

3.28 *disconnect switch (electrical), n*—switching device used primarily for isolating a circuit or equipment from a source of power.

3.29 *drop area, n*—the area directly under the cupola that receives the hot bed coke or other hot materials from the inside of the furnace when the bottom doors or side access door are opened.

3.30 *drop zone, n*—the zone adjacent to the drop area that is exposed to drop hazards during the dropping process.

3.31 *dross, n*—metal oxides or foreign matter or both that accumulates on the surface of nonferrous molten metal.

3.32 *dust collector, n*—air-cleaning device to remove particulate matter from exhaust systems before discharge to the atmosphere.

3.33 *exhaust system, n*—system of air-moving equipment and ducts used to remove airborne contaminants from affected areas.

3.34 *explosion vent, n*—a device that is engineered as part of an enclosure, container, or vessel that is designed to release pressure rapidly.

3.35 *finishing, v*—attainment of a desired surface finish or finish characteristics by such means as abrasive impingement, grinding, or polishing.

3.36 *fixed barrier guard, n*—securely attached physical barrier, not readily removable, that prevents entry of any part of the body into the hazard zone by reaching through, over, under, or around the barrier.

3.37 *flame detector, n*—device, which senses the absence or presence of flame, for the purpose of controlling fuel line valves.

3.38 *flask, n*—container, without top or bottom, used to contain the sand or other media while it is being formed. It is made in two or more parts, the lower part called the drag and the upper part called the cope. Intermediate sections, if any, are called cheeks.

3.39 *flask lifting device, n*—chains, rods, bails, cables, slings and other materials used to support a load such as a flask for turning, inverting, or transporting.

3.40 *fuel-fired equipment (enclosed), n*—specially heated chamber such as core oven, drying oven, thermal sand reclamation, sand heater, or annealing oven.

3.41 *gas handling system, n*—the collective group of equipment that draws cupola gas from the furnace.

3.42 *guarded, adj*—shielded, fenced, enclosed, or otherwise protected by means of suitable enclosure, covers, casing, shield guards, trough guards, barrier guard, railing guards, or guarded by location, or other protective devices, so as to reduce the possible risk of personnel injury from accidental contact or approach, or in the case of spill guards, so as to reduce possibility of personnel injury from material being spilled into the area protected. Where it is not feasible to guard against the hazard, or where the guard itself creates a hazard, the potential hazard shall be marked prominently to warn of its existence.

3.43 *guarded by location, adv*—to be guarded by location or position in accordance with the height above a walkway, platform, or workspace, any moving part shall be at least 8 ft (2.46 m) above same. However, pinch points of all descriptions and moving projections shall not be guarded by location unless they are a minimum of 9 ft (2.74 m) above the pertinent floor. When moving parts are remote from floors, platforms, walkways, other working levels, or by their location with reference to frames, foundations, or structures that minimize the probability of accidental contact by personnel, they shall be considered to be guarded by position or location. Remoteness from regular or frequent presence of public or employed personnel, in reasonable circumstances, constitutes guarding by location.

3.44 *hazard, n*—a condition or series of conditions, either continuous, intermittent or instantaneous in nature that exists, or could exist, such that bodily injury could result. Hazards include, but are not limited to, falling, pinching, crushing, cutting, impaction, burning, concussion, suffocation, occupational disease, asphyxiation and/or electrocution.

3.45 *hazard point, n*—closest point within the hazard zone at which physical contact occurs between machine elements or materials or both.

3.46 *hazard zone, n*—that area where a hazard exists and bodily injury could result upon direct exposure or contact with that hazard.

3.47 *heat, n*—stated weight of metal obtained from a period of melting in a cupola or furnace or the time required to melt and process this material.

3.48 *hopper, n*—bulk container in which materials are stored.

3.49 *hostage control, n*—type of control in which the physical act of operating the initiator prevents operator exposure to the motion or response produced by the initiator.

3.49.1 *Discussion*—An initiator located a sufficient distance from the hazard zone that the operator cannot reach the point of operation during the hazardous portion of the cycle, after operating the initiator, is an example.

3.50 *hostage protection, n*—means of minimizing personnel exposure to hazards by making it easier to perform an operation in a prescribed manner through work piece or machine design or both.

3.51 *inch control, n*—hostage control, which causes machine motion in single or repeated small increments only when controlled by manual pressure.

3.51.1 *Discussion*—It is intended for use in setup or maintenance, but not in normal operation.

3.52 *indirect arc furnace, n*—furnace in which heat is produced by an electric arc between electrodes.

3.53 *induction furnace*—see *channel furnace and coreless furnace*

3.54 *initiator, n*—device that causes an action of control(s) or power.

3.54.1 *Discussion*—Typical operator initiators are pushbuttons, foot switches, manual starters, hand valves, and other valves with manual overrides. Typical non-operator initiators are limit switches, pressure switches, temperature-actuated switches, flow switches, and cam-actuated valves.

3.55 *inspections, frequency of, n*—frequent—daily to monthly intervals and periodic—from one- to twelve-month intervals.

3.56 *interlock, n*—device in a system which, when actuated, permits or prevents the operation of one or more components in the system.

3.57 *interlocked barrier guard, n*—barrier interlocked with the machine power or control so that the machine cycle will stop and cannot be initiated with the operating controls unless the guard, or the hinged or movable sections, effectively encloses the hazard zone.

3.58 *isolation switch*—see *disconnect switch*

3.59 *jamming (hooking), v*—jamming (hooking) occurs when the work rest becomes improperly adjusted to such an extent that the work piece is pulled between the abrasive wheel and the leading edge of the work rest by the grinding action of the wheel resulting in possible injury to personnel.

3.59.1 *Discussion*—Jamming (hooking) should not be confused with the use of work rest mounted tooling, pins, or pressure bars.

3.60 *ladle handler, n*—mechanism used to suspend, transport, raise and/or lower a ladle.

3.61 *ladle pouring stand, n*—structural device for supporting or tilting a ladle or both.

3.62 *lance, oxygen, n*—device consisting of steel pipe, tubing, oxygen source, and controls.

3.62.1 *Discussion*—Frequently used to open frozen tap or slag holes; also occasionally to oxidize impurities in molten metal bath.

3.63 *lip, n*—formed "U" or "V" depression in a molten metal outlet to confine the stream.

3.64 *main burner, n*—primary combustion device commonly ignited by a secondary source.

3.65 *mandatory safety standards, n*—those safety standards that are legally enforceable by agencies of federal, state, or local government.

3.66 *manual, adj*—each machine function in the machine cycle and load cycle is manually initiated and controlled in the sequence or out of the sequence of the normal machine cycle.

3.67 *manual mode, n*—method of operation that requires manual initiation of each function in the equipment cycle.

3.68 *manually powered machines, n*—machine in which the operator provides the motive power to operate the machine.

3.69 *mold, n*—form that contains the cavity into which molten metal is poured to produce a casting of definite shape and outline.

3.70 *molding machine, n*—machine for compacting molding media (usually sand) about the pattern(s), thus forming the mold.

3.71 *moving frame, n*—that part of a molding machine that supports the flask and imparts the motions necessary to the mold making process.

3.72 *muller, n*—machine that blends, coats, kneads, or mechanically combines various sand(s) or other media used for foundry purposes with binders and other additive agents. Typically, it consists of a circular container in which rotating plows or mill wheels (mullers) or both are mounted.

3.73 *nip point, n*—point or zone in which a part of the body could be caught and squeezed between two surfaces, edges, or points.

3.74 *operator's work zone(s), n*—operator's work zone(s) of equipment is that area in which the operator's presence is required while operating in the intended manner.

3.74.1 *Discussion*—An employee's presence applies to the entrance into the operator's work zone of the employee's body or any part thereof.

3.75 *pattern, n*—form of wood, metal, or other material against which molding material is compacted to make a mold for casting metals.

3.76 *pilot (flame or spark), n*—auxiliary source that ignites the main burner.

3.77 *pinch point, n*—zone in which a portion of the body could be caught and injured between surfaces, edges, or points.

3.78 *point of operation, n*—that point or zone in which the principal operation is being performed.

3.79 *pouring, n*—final transfer of molten metal before its solidification into its intended form.

3.80 *pouring area, n*—location in a foundry where molten metal is poured into molds or transferred from a ladle to a furnace.

3.81 *power off or out, n*—state in which power cannot flow to the equipment from the source (see 4.4).

3.82 *power locked off, n*—state in which the device that turns power off is locked in the off position with the padlock of every individual who is working on the machine. Locks are affixed directly to the power disconnect, to a group lockout device, group lockbox, or comparable mechanism.

3.83 *presence-sensing device, n*—device designed, constructed, and arranged to create a sensing field or area that will detect either the presence or absence of personnel.

3.84 *protection from unexpected machine movement, n*—see *protection, primary and protection, secondary.*

3.84.1 *Discussion*—There are hazards other than unexpected movement, and the OSHA machine lockout/tagout standard 29 CFR 1910.147 includes protection against such other hazards.

3.85 *protection, primary, n*—state in which the primary source(s) of power has been isolated by being locked out (off) and in which stored energy in the machine has been dissipated,

constrained, or controlled. The state in which OSHA lockout/tagout has been established.

3.85.1 *Discussion*—Locking out the power to an electric drive motor by means of the main disconnect switch is an example of primary protection against hazards related to the running of the motor.

3.86 *protection, secondary, n*—limited protection by control devices.

3.86.1 *Discussion*—It is possible for control devices, like limit switches, to malfunction mechanically or electrically, and interlocks intended for safety purposes are sometimes bypassed or wedged or tied in actuated states. Secondary protection is only justifiable when there is no practical alternative, that is, when primary protection is not practical and when regular disciplined maintenance is present. The operator, whose constant attitude should be one of caution, should understand the fact that operator protection devices such as interlocked guards are secondary protection. Frequent inspections of such protective devices should be made. Locking a STOP push button in the actuated position instead of using OSHA lockout/tagout is an example of a dangerous attempt to use secondary protection against machine movement.

3.87 *protective device, n*—means whereby personnel access to a hazard zone or area is denied by other than a physical guard.

3.87.1 *Discussion*—Protective devices include, but are not limited to, two-hand controls, two-hand trips, and hostage controls.

3.88 *puncture point, n*—zone in which a part of the body could be punctured or perforated.

3.89 *qualified engineer, n*—qualified engineer is one who possesses an engineering degree from an accredited institution of higher learning or a certificate of professional standing and has engineering experience with the kind of work and equipment involved.

3.90 *qualified person, n*—person determined by the employer to have the training or experience or both to operate or maintain or both the equipment involved.

3.91 *reactive metal, n*—any metal that is readily oxidized with the release of large quantities of heat.

3.92 *runout pit, n*—pit placed below or in front of a furnace or both to receive molten material in an emergency.

3.93 *safety, n*—state of being reasonably free or reasonably protected from injury or risk. Never to be construed as absolute or perfect protection from harm, injury, or risk.

3.94 *sand mixer, n*—machine for conditioning mold and core sand by controlled mixing with additives.

3.95 *sand muller, n*—machine for conditioning mold and core sand by controlled mixing with additives.

3.96 *sand system, n*—that part of a foundry installation that processes and transports sand or other media in bulk form.

3.97 *screen (sand), n*—sieve or riddle with openings of definite size used to separate one grain size from another or to remove lumps and foreign objects from sand.

3.98 *semiutomatic, adj*—at least one machine function in the cycle is automatically performed and sequenced, but which requires the operator to initiate at least one function manually.

3.99 *semiautomatic mode, n*—method of operation in which at least one function in an equipment cycle requires manual initiation and at least one function is automatically sequenced.

3.100 *shear pin, n*—pin built into a mechanism designed to fail under specified loading and act as an overload disconnect.

3.101 *shear point, n*—point or zone in which body parts could be caught by one machine member moving past another.

3.102 *shutdown, n*—planned steps required to take machine or process out of operation.

3.103 *skimming, n*—removing slag or dross from the surface of the molten metal.

3.104 *skip hoist, n*—basket, bucket, or other container that is drawn or elevated on rails by a pulling or pushing action.

3.105 *slag, n*—nonmetallic byproducts and contaminants generated during the melting, transferring, and holding of molten metal.

3.106 *slag hole or door, n*—opening in the furnace through which slag is removed.

3.107 *slagging, v*—see *skimming*.

3.108 *slinger, n*—machine that throws sand or other media into a flask, corebox, or other container.

3.109 *start up, n*—planned steps required to place a machine or process into operation.

3.110 *stop block, n*—rigid restraining device that will prevent hazardous movement of a machine or equipment member(s). A stop block shall be designed and constructed to withstand the forces to which it will be subjected.

3.111 *tapping, v*—removing molten material from the furnace by opening a tap hole.

3.112 *transfer car, n*—vehicle used for transporting vessels or material(s), usually in a fixed path.

3.113 *trunnions, n*—shafts used to support, turn, or tilt a vessel.

3.114 *tumbling barrel, n*—power-driven rotating drum or barrel in which castings are cleaned or polished or both. The castings act as abrasives for each other or are tumbled in an abrasive media.

3.115 *tuyere, n*—nozzle opening through which the blast enters a cupola.

3.116 *two-hand control, n*—type of control in which the operator causes a motion by manually operating an initiator concurrently with each hand, the motion stopping or reversing upon deactuation of either or both initiators.

3.117 *two-hand trip device, n*—type of control in which the operator causes a motion by manually operating an initiator concurrently with each hand, the motion continuing to completion whether the initiators continue to be held actuated or not.

3.118 *work zone and work station, n*—see *operator's work zone(s)*

4. Materials and Manufacture

4.1 *Responsibility*—It shall be the responsibility of any person purchasing, constructing, reconstructing, or modifying any equipment covered by this practice to:

4.1.1 Design, construct, and modify equipment in accordance with the provisions of this practice. (Consider other applicable safety standards.)

4.1.2 Select and include in construction only components that have a working rating equal to or greater than required to meet the maximum recommended operating condition(s).

4.1.3 Furnish printed instructions with each unit of equipment. (To minimize hazards, it is essential that this material be readily available to maintenance, operations, and engineering personnel.) The instructions shall include:

4.1.3.1 Engineering drawings and other materials required to install and place such equipment into operation properly.

4.1.3.2 Operating and maintenance instructions as specified in Section 5.

4.1.3.3 Spare parts lists.

4.1.3.4 Procedures in accordance with 29 CFR 1910.147 OSHA lockout/tagout standard shall be followed.

4.1.4 Hazard alert signs when used shall comply with the following standards: ANSI Z535.1 Safety Color Code, ANSI Z535.2 Environmental and Facility Safety Signs, ANSI Z535.3 Criteria for Safety Symbols, ANSI Z535.4 Product Safety Signs and Labels, ANSI Z535.5 Accident Prevention Tags.

4.1.5 Apply a legible identification plate to each piece of equipment. This plate shall include as a minimum the manufacturer's name, equipment type or model identification or both, serial number, and rated capacity(s).

4.1.6 Insure that any modification(s) or alteration(s) to a piece of equipment or machinery covered by this practice that result in a change from the manufacturer's original design or intended method of operation or both shall be done under the supervision of a qualified engineer and shall comply with mandatory safety standards for that given category of equipment. An additional legible identification plate shall be attached to the machine or equipment adjacent to the manufacturer's original identification plate (see 4.1 (5)). The new identification plate shall state the date the modification(s) was made and the person or organization responsible. (Restrictions on modifications or alterations are not intended to bar repair or maintenance including the substitution of substantially equivalent components.)

4.2 *Inherent Hazards*

4.2.1 *Hazards to Personnel Associated with Moving Parts*—Hazards to personnel associated with moving parts (other than point of operation hazards) shall be guarded in accordance with ANSI B15.1 or ANSI B20.1, as appropriate.

4.2.1.1 *Discussion*—Some examples of hazards to personnel associated with moving parts are:

(1) Rotating components, such as flywheels, gears, sheaves, and shafts in proximity to personnel;

(2) Run-in pinch points, such as meshing gears, belts, and chains; and

(3) Pinch points between the moving and stationary components of the machine.

4.2.1.2 *Responsibility—Manufacturer*—The manufacturer shall endeavor to eliminate the hazards by design or provide protection against them. When hazards cannot be eliminated by design or protection, the manufacturer shall warn against them by using signs in accordance with ANSI Z535.1, 2, 3, 4, 5, as appropriate.

4.2.1.3 *Discussion*—Together, these five ANSI standards contain information needed to specify formats, colors, and symbols for safety signs used in environmental and facility applications, product applications, and accident prevention signs.

4.2.1.4 *Responsibility—Employer*—Equipment with moving parts that could cause injuries to personnel shall be guarded.

4.2.2 *Hazards to Personnel Associated with the Point of Operation*—Refer to Section 6.

4.2.3 *Hazards to Personnel Associated with Broken, Falling, or Flying Equipment Components*—The manufacturer shall design, secure, or cover machine components to minimize hazards caused by falling or flying components resulting from loosening or breakage.

4.3 *Installation*

4.3.1 *Employer Responsibility*—The employer shall be responsible for safe conditions for installing the equipment covered by this practice.

4.3.2 *Safeguarding During Construction, Reconstruction, or Modification*—Use of barriers, shields, and covers over excavations, pits, or tanks shall be required and used. Means shall be provided to prevent unauthorized persons from entering an area or zone in which construction or repair is in progress.

4.3.2.1 *Discussion*—ANSI A12.64.1 contains the appropriate requirements and recommendations.

4.3.3 *Workstation*—Each workstation shall have space to permit work without physical interference from equipment or another employee(s) within that workstation. Services, including electric power, air hydraulic, water, steam, or process liquids, shall be delivered in identified conductors with shutoff valves or disconnecting means legibly marked, and shall be visible and accessible.

4.4 *Power Requirements*

4.4.1 *Disconnect Means*—All motors, motor circuits, and controllers shall have disconnecting means as required by Article 430 of the National Electric Code (ANSI/NFPA 70). The disconnecting means shall be capable of being locked in the (OFF) position.

4.4.1.1 *Disconnect Means Identification*—Each disconnect means shall be marked with a legible durable label that identifies the voltage and equipment controlled. Identification shall be verified at time of installation.

4.4.1.2 *Disconnection*

(1) Control circuits shall be so arranged that they will be disconnected from all sources of power when disconnecting means is in the open (OFF) position.

(2) There shall be an interlock, on separate power source feeds, that opens when the main disconnect is opened.

(3) The disconnecting means consists of two or more separate devices, one of which disconnects the motor and the controller from the source(s) of power supply for the motor,

and the other disconnects the control circuit(s) from its power source. Where separate devices are used, they shall be located immediately adjacent, one to the other.

4.4.1.3 *Disconnection Hazards*—Where the operation of a disconnecting means could create a hazard, a suitable hazard alerting nameplate shall be provided and located adjacent to the label required in 4.4.1.1

4.4.1.4 *Motor-Starting Equipment*—Motor-starting equipment with the potential to restart a motor automatically after an unplanned power interruption or power outage shall not be used when automatic restarting would potentially result in injury to personnel. It shall be necessary to restart the motor manually.

4.4.2 *Electrical Power Off—Electrical Panels or Electrical Furnaces*

4.4.2.1 *Disconnect Means*—All control and power circuits shall be equipped with disconnecting means that have the capability to be locked in the open (OFF) position for the protection of the operating or maintenance personnel.

4.4.2.2 *Isolation (Disconnect) Switches*—Isolation switches not capable of interrupting load current shall not be opened under load and shall be provided with signage warning against opening under load.

4.4.2.3 *Discussion*—Where possible, these isolation switches shall be key interlocked with the circuit-interrupting device so that the isolation switch cannot be opened under load. Individual consideration shall be given to keep these switches in a locked closed (ON) condition during normal operation.

4.4.2.4 *Door Interlock*—All doors providing access to electrical circuits that operate at over 50 V shall be interlocked to disconnect electrical power when the door is opened. If voltages in excess of 50 V remain after electrical power has been disconnected, hazard alert signs shall be provided.

4.4.2.5 *Discussion*—While power has been disconnected when the door is opened, electrical power remains at the primary terminals. In addition, in some instances capacitors will remain charged and must be discharged to remove all voltage from the circuits inside the cabinet.

4.4.3 *Fluid Power Off*—Means shall be provided for isolating fluid (air, oil, or other) energy sources from a machine, or group of machines, controlled as a system. These means shall have provisions for being locked in the isolating mode. Pressure buildup on the machine side port of the isolating means shall be eliminated by positive means such as venting to atmosphere or drainage to tank.

4.5 *Electrical Ground Faults*

4.5.1 *Grounded Control Circuit*—When one side of the control circuit is grounded, the control circuit shall be designed so that an accidental ground will not start a motor, energize any component, or cause a machine movement.

4.5.1.1 *Discussion*—Circuits that have all coils or solenoid(s) common to the grounded side of the control circuit, without intervening contacts, will almost always meet these requirements on a circuit that is grounded. It is possible that circuits that do not have this characteristic are hazardous in that an accidental ground might cause unwarranted energization or machine movement or both.

4.5.2 *Ungrounded Control Circuit*—Ungrounded control circuits shall have operative ground-indicating lights. An indicated ground shall be reported at once by the employee and investigated immediately. If a personnel hazard exists, corrections shall be made before resuming operation of the equipment.

4.5.2.1 *Discussion*—Without grounds, each light has only one half voltage and both lights are therefore equally dim—the normal condition. A ground causes one light to glow brightly, the other to dim or go out. Depending upon the location of the accidental ground this indication is usually either constant or intermittent during operations. In an ungrounded system, it is not clear whether the first accidental ground will indicate a personnel hazard possible with the second accidental ground—or with simultaneous double accidental grounding.

(*1*) For instance, a ground on the common coil side of the control circuit will in effect merely convert the ungrounded circuit into a grounded circuit. The remarks in 4.5.1 and the Discussion in 4.5.1 are then applicable.

(*2*) However, where the first accidental ground is on the contact side, it could possibly create a personnel hazard. This potential hazard must be resolved by authorized personnel.

4.6 *Fluid Power Off*—Means shall be provided for isolating fluid (air, oil, or other) energy sources from a machine, or group of machines, controlled as a system. These means shall have provisions for being locked in the isolating mode. Pressure buildup on the machine side port of the isolating means shall be eliminated by positive means such as venting to atmosphere or drainage to tank.

4.7 *Electrical Equipment Grounding*—All electrical equipment shall be grounded in accordance with the National Electrical Code.

4.8 *Fluid Exhaust (Gas or Liquid)*—The employer shall be responsible for arranging conductors to direct the exhaust of fluids to a location(s) that will not create a hazardous condition.

5. Care of Equipment—General Provisions

5.1 *Instructions*

5.1.1 *Manufacturer*—The manufacturer shall furnish operating and maintenance instructions with equipment covered by

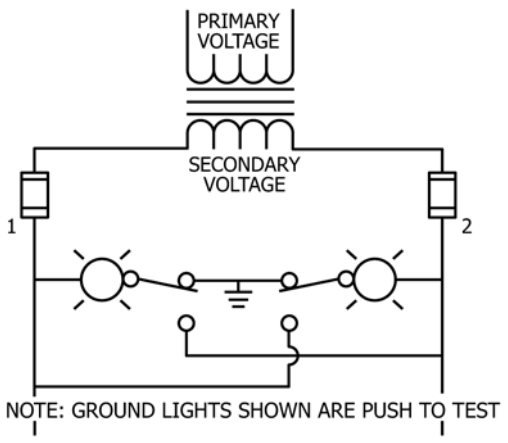


FIG. 1 Ungrounded Control Circuit

this practice. These shall be in conformance with 29 CFR 1910.147 OSHA lockout/tagout.

5.1.1.1 *Discussion*—Most operating and maintenance manuals provide specific instructions to aid in the proper operation and maintenance of the equipment. Optional means to provide adequate instructions include written, illustrated, audio, and visual recorded material. However, the employer is responsible for making sure all equipment is adequately guarded and safe for operation.

5.1.2 *Modification/Reconstruction*—Any person modifying or reconstructing any piece of equipment covered by this practice shall furnish operating and maintenance instructions, including updated functional engineering drawings of controls covering the modified portion of the equipment. Refer to Section 4.

5.1.2.1 *Discussion*—Many modification and rebuilding efforts are so extensive that the original instructions from the manufacturer are incorrect or meaningless.

5.1.3 *Employer*—The employer shall specify corrective maintenance procedures for the equipment covered by this practice that minimize hazards to operating and maintenance personnel.

5.2 *Installation*—The employer shall provide work areas around the equipment covered by this practice to minimize hazards to operating and maintenance personnel.

5.3 *Inspection and Preventive Maintenance*—The employer shall establish and supervise a program of documented inspections and preventive maintenance of the equipment covered by this practice. Designated personnel shall perform the required inspections and maintenance.

5.3.1 The frequency of inspecting the equipment is based on the manufacturer's recommendations, the number of hours used per month, and the maintenance history. The employer shall schedule frequent or periodic inspections or both that would reveal hazards caused by age, overloading, corrosion, fatigue, improper use, or improper installation.

5.4 *Maintenance Personnel Training and Experience*—The employer shall provide trained and competent personnel for maintaining the equipment covered by this practice.

5.4.1 Competent maintenance personnel shall have the technical background necessary to understand the information contained in the maintenance manuals for the machine they are inspecting or maintaining.

5.5 *Startup Procedures*

5.5.1 *Manufacturer*—The manufacturer shall recommend a startup procedure that minimizes hazards.

5.5.2 *Employer*—The employer shall establish and follow a startup procedure considering the manufacturers' recommendations before any equipment covered by this practice is placed in regular operation.

5.5.3 *Employee*—The employee shall follow the startup procedure established by the employer.

5.6 *Shutdown Procedure*

5.6.1 *Manufacturer*—The manufacturer shall recommend a shutdown procedure that minimizes hazards.

5.6.2 *Employer*—The employer shall establish and follow a shutdown procedure considering the manufacturer's recommendations for necessary lockouts before allowing any inspection, adjustments, or maintenance of the equipment covered by this practice.

5.6.3 *Employee*—The employee shall follow shutdown, lockout, and safeguarding procedures established by the employer.

5.7 *Troubleshooting, Maintenance, and Repair*

5.7.1 *Employer*—The employer shall provide training for employees engaged in troubleshooting, maintenance, or repair in isolated or hidden areas. For work in confined spaces entry procedures shall be in conformance with 29 CFR 1910.146.

5.7.2 *Employee*—The employee shall use the monitoring means established by the employer to inform others of his or her presence when performing maintenance or setup work in hidden or isolated areas.

5.7.3 *Physical Entry into Machine or Equipment*—The employee shall follow established lockout/tagout and confined space procedures for the machine or equipment before physical entry.

5.7.3.1 *Discussion*—It is possible that the rules for confined space or permit required confined space or both will also apply.

5.7.4 *Troubleshooting, Maintenance, and Repair with Power On*—Exception for qualified persons only: When necessary to locate and define problems and make adjustments with power on, qualified persons are allowed to perform work on machines or equipment with guards removed or within areas protected by barriers, if protective measures have been taken to train and supervise the employees to not place any part of the body in the path of any movable machine or equipment member or in contact with any hazardous energized electrical equipment. Employees shall follow OSHA regulations 29CFR1910.331, 29CFR1910.332, 29CFR1910.333, 29CFR1910.334, and 29CFR1910.335.

5.7.5 *Defeating Protective Devices*—No employee other than authorized and qualified personnel performing special maintenance shall remove, bypass, or alter any device that was provided to reduce hazardous conditions.

5.7.5.1 This practice does not condone defeating any protective device at any time. This practice does, however, recognize that maintenance conditions exist when authorized maintenance personnel would be permitted to bypass the protective device. Under such conditions, 5.7.4 shall be strictly followed.

5.7.6 *Returning Equipment to Production*—The employee shall verify that the machine or equipment has all guards secured in place and operators have been informed before releasing it for production use.

6. Safeguards—General Requirements

6.1 *Discussion*—Refer to the definitions "protection-primary" and "protection-secondary."

6.2 *Responsibility for Safeguarding*

6.2.1 *Discussion*—It must be understood that in the application of this practice, there are responsibilities incumbent upon the employer, the manufacturer, the installer, and the operator of foundry equipment. (See ANSI B11.6, ANSI B11.9 and ANSI B11 TR3 on hazard analysis and risk assessment.) Some safety features are incorporated in the design of the

equipment. Some protection depends on installation after assembly of all of the associated components in the field. Some safety features are a part of a building or structure and are not an integral part of the components themselves. Some protection depends on the operation and maintenance by the employer and operators. Some protection depends on training and supervision.

6.2.2 *Manufacturer*—The manufacturer of equipment shall furnish equipment that complies with mandatory safety standards for that given category of equipment.

6.2.3 *Employer*—The employer shall be responsible for the installation and maintenance of guards, shields, or barriers and for maintaining the condition and position of such devices to protect against recognized hazardous conditions. The employer shall be responsible for providing, installing, and maintaining any additional guards required to provide protection against recognized hazardous conditions created by the use or installation or both of the equipment.

6.3 *Guarding*—Potential hazards including, but not limited to, nip, pinch, shear, puncture, or catching points, or a combination thereof shall be guarded.

6.3.1 *Exception*—The requirement does not apply when:

6.3.1.1 The exposed pinch point openings in conformance with Table 1 and Fig. 2. Figure 2 shows the accepted safe openings at the bottom edge of a guard at various distances from the hazard point.

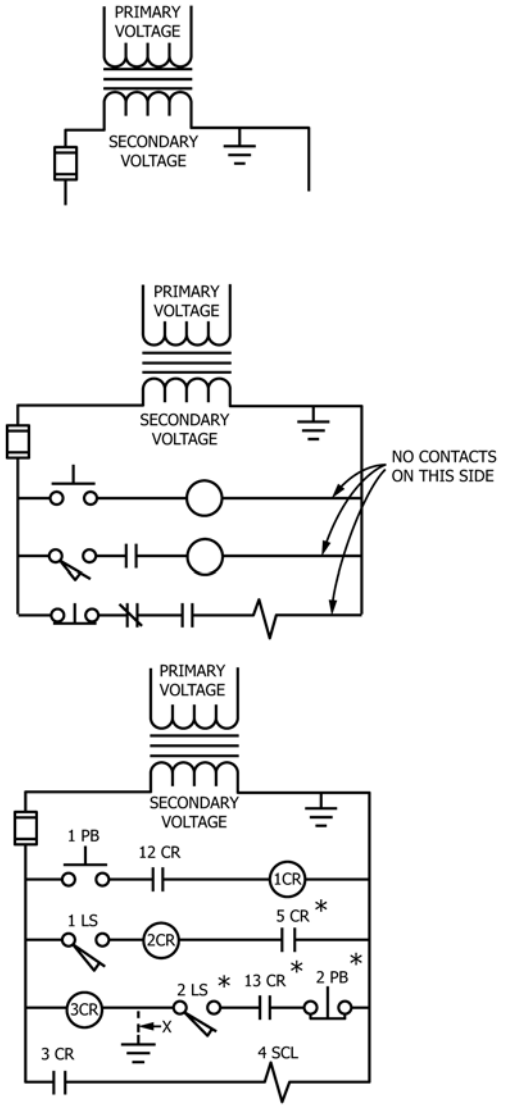
6.3.1.2 Manual operation, such as placing copes on drags, manually closing molds, with or without mechanical assists, shall be excluded from mandatory guarding where variable conditions preclude the use of barriers or devices. For these operations, special emphasis shall be given to operator training.

6.4 *Hazard Zone Guarding*

6.4.1 *Discussion*—Guarding within that area of the operator's work zone where the work process is being performed.

6.4.2 *Hazard Zone Guard(s)*—Every hazard zone guard shall meet the following design, construction, application, and adjustment requirements:

6.4.2.1 It shall prevent entry of any part of the body into the hazard zone by reaching through, over, under, or around the guard.



NOTE 1—Location marked with "*" purposely shown incorrect for illustration. For instance, if an accidental ground occurred at "X", 3CR coil would always be energized with power on.

FIG. 2 Control Circuits

TABLE 1 Accepted Safe Opening Between Guard and Hazard Zone

NOTE 1—Source: 29 CFR 1910.217 Table 0-10.

Distance of Opening from Hazard Zone (in.)	(mm)[A]	Maximum Width of Opening (in.)	(mm)[A]
½ - 1½	13-38	¼	6
1-½ – 2 ½	38-64	⅜	10
2-½ – 3-½	64-89	½	13
3-½ – 5-½	89-138	⅝	16
5-½ – 6-½	138-165	¾	19
6-½ – 7-½	165-191	⅞	22
7-½ – 12½	191-318	1-¼	32
12-½ – 15½	318-394	1-½	38
15-½ – 17-½	394-445	1-⅞	48
17-½ – 31-½	445-800	2-⅛	54

[A]Approximate.

6.4.2.2 It shall be in conformance with the maximum permissible openings shown in Table 1 above.

6.4.2.3 It shall not create pinch points.

6.4.2.4 It shall not be readily removable.

6.4.2.5 It shall offer maximum visibility of the equipment operation consistent with the other requirements.

6.4.2.6 It shall be inspected at intervals as outlined in ANSI B11.6 and ANSI B11.9 standards.

6.4.3 *Barrier Guard(s)*—Barrier guards shall meet the following criteria:

6.4.3.1 Prevent bodily entry into the process pinch or shear point by reaching through, over, under, or around the guard during the production cycle;

6.4.3.2 Conformance with the maximum permissible openings shown in Table 1 above;

6.4.3.3 In itself create no pinch point between the guard and moving machine parts;

6.4.3.4 Use fasteners not readily removable by the operator so as to minimize the possibility of misuse or removal of essential parts;

6.4.3.5 Be readily inspected for its effectiveness; and

6.4.3.6 Offer maximum visibility of the hazard zone consistent with the other requirements.

6.4.3.7 *Discussion*—Take care to ensure that the guard itself has no sharp edges, burrs, and so forth, which could be a hazard.

6.4.4 *Fixed Barrier Guards*—A fixed barrier guard, when used, shall meet the criteria of 6.4.2.1 – 6.4.2.6 and shall be attached securely.

6.4.4.1 *Discussion*—Addition of an interlock to a fixed barrier guard does not necessarily make this an interlocked barrier guard.

6.4.5 *Interlocked Barrier Guards*—An interlocked barrier guard, when used, shall meet the requirements of 6.4.2.1 – 6.4.2.6 and shall be interlocked with the machine power or controls so that the machine will not operate unless the hinged or movable section of the guard is in the closed position(s).

6.4.5.1 If the interlock device is used as an alternative measure for lockout/tagout as permitted by 29 CFR 1910.147 an authorized employee shall inspect the interlock device at the beginning of each shift of operation and immediately report any damage or malfunction of the device to the supervisor. If an interlocking device is found to be defective, the machine shall not be put into operation until repaired and re-checked.

6.4.5.2 *Discussion*—The hinged or removable section(s) of this guard are intended for use when frequent access is required.

6.4.6 *Adjustable Barrier Guards*—An adjustable barrier guard shall be securely attached and shall meet the criteria of 6.4.2.1 – 6.4.2.6.

6.5 *Hazard Zone Protective Devices*—A hazard zone device shall be provided to protect the operator and other personnel in the area by:

6.5.1 preventing or stopping the equipment motion or condition that would create a hazard or pinch point if any portion of the body is in the hazard zone,

6.5.2 preventing personnel from inadvertently reaching into the hazardous motion that has started or been initiated,

6.5.3 requiring personnel to position all parts of the body away from possible hazardous conditions and position both hands on initiators during the period of time when the possibility of pinching motions or hazardous conditions is present,

6.5.4 requiring personnel to move away from the area of possible hazardous conditions and activate an initiator at a remote location (hostage control), or

6.5.5 the employer shall be responsible for enforcing a rule that actuation of equipment controls be made only by the operator. An operator shall not be assisted by another employee operating the equipment controls.

6.5.5.1 *Discussion*—Hazard zone protective devices do not offer the degree of protection provided by a guard. These devices are secondary protection and it is permissible to use them alone or in multiples to create the greater degrees of protection. In regard to 6.5.4, hostage controls must be located so that inadvertent entry into pinch pints by parts of the body is prevented. The possibility of stumbling, slipping, or fatigue must be considered in control placement. It is acceptable to class hostage controls as a guard device if their location provides unimpeded access and visibility for the operator to the hazard zone and they are located so that possible pinch points or hazardous conditions cannot be reached.

6.5.6 *Presence-Sensing Hazard Zone Device*—A presence-sensing hazard zone device, when used, shall protect the operator by deactivating the machine or equipment motion when the presence of personnel is detected in the hazard zone.

6.5.6.1 *Discussion*—These devices are necessarily secondary protection. Their value is dependent upon their correct adjustment and maintenance.

6.5.6.2 This device shall not be installed, connected, or used in a manner that could create any hazard to the operator.

6.5.6.3 This device shall not be used as an initiator of any motion or function being protected by the device. Where or when the device is used to prevent the closing of a machine on an operator's body part, withdrawal of the operator's hands shall not automatically restart the cycle.

6.5.6.4 To the extent permitted by current recognized design techniques, this device shall be designed and applied so that any malfunction or failure of the device would prevent or stop the function or motion in the area being protected by the device.

6.5.6.5 *Discussion*—Although there is much talk about "fail-safe," there cannot be such an absolute condition. Single failures of device components result in stopping or prevent initiation.

6.5.6.6 This device shall be installed, adjusted, and maintained only by authorized competent personnel.

6.5.6.7 *Discussion*—These devices are necessarily secondary protection. Their value is dependent upon their correct adjustment and maintenance.

6.5.7 *Hostage Controls*—Hostage controls shall be one or more of the following types of initiators:

6.5.7.1 *Two-Hand-Maintained Initiators*—A two-hand-maintained initiator shall be designed, installed, and connected to protect the operator by requiring application of both of the operator's hands to the machine operating initiators until the hazardous portion of the cycle is completed and shall be equipped with anti-tiedown features. Each hand control shall be protected against unintended activation and arranged by design, construction, or separation, or a combination of the three, so that the concurrent use of both hands is required to initiate the equipment.

6.5.7.2 *Two-Hand Momentary Initiators*—A two-hand momentary initiator shall protect the operator by requiring that the single-cycle initiators be operated at a position so that the operator cannot reach into the hazard zone during the hazardous portion of the cycle. Two-hand momentary initiators shall be equipped with anti-tiedown feature. Each hand control shall be protected against unintended activation and arranged by design, construction, or separation, or a combination of the three, so that the concurrent use of both hands is required to initiate the equipment.

6.5.7.3 *Single-Maintained or Momentary Initiator*—A single-maintained or momentary initiator shall protect the operator by permanently locating the single-cycle operating initiator remote from the hazard zone so that the machine completes its hazardous portion of the cycle before the operator has a chance to place any part of his or her body into the hazard zone. All single-maintained or momentary initiators shall be protected against unintended activation.

6.5.7.4 *Discussion*—Examples of this type of initiator include pushbutton, foot switch, knee switch, and so forth. Foot switches on mechanical connectors do not meet this requirement.

6.5.7.5 *Additional Initiators*—In an operation requiring more than one operator, separate hostage controls shall be provided for each operator.

6.5.8 *Hand-Positioning Tools*—Hand-positioning tools shall not be used in place of guards or protective devices.

6.5.8.1 *Discussion*—Hand-positioning tools, such as pliers, tongs, forceps, and specially designed devices are commonly used for placing, positioning, or moving materials into or away from hazardous locations.

6.5.9 *Stop Block—Manual*—A manual stop block shall be used to eliminate potential pinch points where setup or maintenance work necessitates exposure of personnel in the hazard zone.

6.5.10 *Stop Block—Mechanical*—The use of mechanical stop block devices in place of hazard zone protective devices is acceptable. When used, it shall stop a motion that might cause injury or create a hazardous condition and be able to withstand the forces to which it is subjected.

6.5.10.1 A mechanical stop block device shall, in itself, create no pinch points between the device and equipment parts.

6.5.10.2 It shall use fasteners not readily removable by the operator.

6.5.10.3 An authorized person shall inspect the device daily and immediately report any damage or malfunction of the device to their supervisor.

7. Operation of Equipment–General Requirements

7.1 *Employer's Responsibility*

7.1.1 *Training Operators*—The employer shall train all operators to perform their assigned functions in a manner that will minimize hazards. The training shall include familiarization of the operators with the provisions of this practice that relate to their assigned functions. Operator(s) shall demonstrate to the employer competence to perform the assigned function before starting work on any operation. (See ANSI Z490.1)

7.1.1.1 Give special attention to non-English-speaking operators. In some cases the use of translations is required. Machine instruction manuals need to be explained and made available to operators and maintenance employees.

7.1.2 *Supervision*—The employer shall enforce established operating procedures.

7.1.2.1 *Discussion*—For those employees who disregard safety rules and correct operating procedures, disciplinary measures shall be used and documented.

7.1.2.2 *Actuation of equipment controls*—The employer shall be responsible for enforcing a rule that actuation of equipment controls be made only by authorized and qualified personnel.

7.1.3 *Work Area*—Space shall be maintained in each work area so that movement of one operator will not interfere with the work of others. The floor area of the operator's work area shall be maintained and free of obstructions. Housekeeping procedures shall be established to minimize the accumulation of grease, oil, water, and abrasive blasting material.

7.1.3.1 *Discussion*—For additional information regarding walking and working surfaces, refer to ANSI A12.64.1 and ANSI A58.1.

7.1.4 *Overloading*—The employer shall require that machines and equipment be operated within the posted capacity ratings.

7.1.5 *Personal Protective Equipment (PPE)*—Based on the hazard assessment the employer shall specify the personal protective equipment required to perform work functions. The employer shall enforce the proper use of this equipment.

7.1.6 *Emergency Equipment*—Suitable facilities for quick drenching or flushing or eyes and body shall be provided within the work area for immediate emergency use in the event of personal contact with injurious corrosive materials.

7.2 *Employee's Responsibility*

7.2.1 It shall be the responsibility of the employee(s) to:

7.2.1.1 Follow all safety practices and procedures specified for the functions for which they are responsible.

7.2.1.2 Notify their supervisor when they observe unsafe practices or conditions. They shall immediately report any damaged, missing, or malfunctioning guards.

7.2.1.3 Use personal protective equipment as specified by the employer in the PPE hazard assessment.

7.2.1.4 Refrain from wearing such clothing or jewelry as will be hazardous to personal safety.

7.2.1.5 *Discussion*—When working around moving parts of machines or equipment, loose clothing, neckties, finger rings, necklaces, watch bands, body ornaments, long hair, and beards constitute potential hazards.

7.2.1.6 Maintain an orderly work area.

7.2.1.7 Not alter, remove, or disable safety equipment.

7.2.1.8 Never initiate a motion that could cause injury or damage.

7.2.1.9 Never blow, throw or move material to create a hazard for other personnel.

7.2.1.10 Never remove a lock placed by other personnel.

7.2.1.11 Never alter, block, deface, or obliterate any sign, notice or advisory plate that relates to equipment.

7.2.1.12 An operator shall not perform adjustments, make equipment changes, or perform maintenance unless trained and authorized by the employer. Authorized maintenance shall be performed in accordance with Section 5.

8. Sand Preparation, Molding, and Coremaking

8.1 *Sand Handling and Preparation*

8.1.1 *Silos, Hoppers, and Bins*—Silos, hoppers, and bins are confined spaces and it is possible that they are also permit

required confined spaces. Entry procedures shall be in conformance with 29 CFR 1910.146, and lockout/tagout procedures shall be in conformance with 29 CFR 1910.147.

8.1.2 *Gates (Closures)*—All nip or pinch points or both of gates (closures) in silos, bins, and hoppers shall be guarded with barrier guards or by location.

8.1.3 *Dislodging Material*—Safe work practices shall be developed to prevent injury when employees must dislodge clinging or bridged material with a mallet or other instrument in one hand while actuating the gate (closure) with the other hand. Guarding against contact between the operator's body (hands primarily) and pinch or nip points or both is the intent of this section.

8.1.4 *Gate (Closure) Actuators*—Guards, shields, chutes, remote actuating devices, or a combination of thereof, for gates (closures) on silos, hoppers, and bins shall be installed to prevent the employee from being directly in the path of material being discharged.

8.1.5 *Conveyors, Bulk Material, Elevators, and Turntables*—Equipment shall be installed that complies with mandatory safety standards for that given category of equipment.

8.1.5.1 *Discussion*—Consider overhead spill pans under conveyors, crossing walkways, or work areas.

8.1.6 *Screw or Flight Conveyors, Screens, Coolers, Agitators, and Blenders*—Guards shall be installed to prevent entry of persons or reaching into vessels or equipment with internal moving members

8.1.7 *Mullers and Mixers*—The blending area of mullers and mixers of sand or other materials shall be fully guarded or guarded by location. All muller or mixer openings shall be guarded to prevent personnel from the foreseeable risk of accidental contact or hazardous approach to machine elements performing the mixing or mulling. Sand or additive entry points or discharge doors shall be guarded by a barrier, screen, cover, or other means. Elements protected by virtue of their remote or inaccessible locations shall be considered to be guarded.

8.1.7.1 *Discussion*—Unprotected opening(s) encourage personnel to reach into the path of moving machine elements to take sand samples rather than using the sand-sampling device. The intent of this section is to prevent any part of the body from coming into the path of, or between, two or more moving elements or between a moving and a fixed machine element during operation. Secondary protection is recommended by electrically interlocking inspection doors.

8.1.8 *Entry into Mullers or Mixers*—Mullers and mixers are confined spaces and it is possible that they are also permit required confined spaces. Entry procedures shall be in conformance with 29 CFR 1910.146, lockout/tagout procedures shall be in conformance with 29 CFR 1910.147.

8.1.9 *Sand Sampling*—When equipment is in operation, sand samples shall be taken externally.

8.1.10 *Sand Contamination*—Means shall be provided to minimize contamination of sand by tramp metal or debris.

8.1.10.1 *Discussion*—It is possible to achieve this by magnetic separation (for ferro-magnetic materials) or screening or both.

8.1.11 *Skip Hoists, Operating Controls*—When material transfer is manually controlled, the operating controls shall be located so that:

8.1.11.1 the operator is isolated from the transfer mechanism,

8.1.11.2 the operator is not in the path of discharged material,

8.1.11.3 the operator has access to operating controls, and

8.1.11.4 the operator has an unobstructed view of the transfer point(s).

8.1.12 *Skip Hoists, Guarding*—Guards, shields, or other devices shall be provided so that the operator or other personnel are isolated from the path of operation of the skip hoist bucket or contact with any of the moving parts. If, by virtue of its location, the drive mechanism is isolated from contact by the operator and others, with the exceptions of authorized maintenance personnel, then it shall be considered to be guarded.

8.1.13 *Skip Hoists, Employer Responsibility*—It shall be the responsibility of the employer to provide equipment that complies with mandatory safety standards for that given category of equipment, in accordance with ANSI B20.1, Section 6.21.

8.1.14 *Hazardous Substances*—The handling and storage of hazardous substances and the issuance of protective clothing, eyeshields, and respirators shall be in conformance with existing standards, regulations, and written PPE hazard assessments.

8.1.14.1 *Discussion*—A variety of substances, with potential flammable, explosive, and toxic properties, are used in the preparation of molding sand and core sand. Detailed and individual safety requirements for these substances are considered not to be within the scope of this practice.

8.1.15 *Permissible Exposure Limits (PELs)*—Equipment, operations, and processes producing concentration of any airborne contaminant in excess of current PELs at the operator's breathing zone shall be provided with feasible engineering controls, administrative controls, or personal protective equipment that will reduce the contaminant below the PEL.

8.1.15.1 *Discussion*—Other exposure limits such as Recommended Exposure Limits from NIOSH, airborne exposure standards from ASTM, manufacturer recommendations, and Threshold Limit Values from the American Conference of Governmental Industrial Hygienists are often informative.

8.1.16 *Exhaust Systems for Shell Sand Mixers*—Ventilation controls for shell sand mixers shall be provided which will maintain the atmosphere within the mixer less than 25 % of the lower explosive limit (LEL).

8.1.16.1 *Discussion*—Shell resins are available in solid form or suspended or dissolved in water or a solvent such as alcohol. The intent of this section is that ventilation not only is required to control any dust generated to a level not exceeding the proper PEL but to assure that additional ventilation is supplied when solvent evaporation might cause an explosion hazard. For additional information, refer to ANSI Z9.2 and AFS Managing the Foundry Indoor Air Environment.

8.2 *Core Making*

8.2.1 *Discussion*—It is not the intent of this section to restrict the materials used in the core-making operation. Because of the large number of binder chemicals available, the Material Safety Data Sheet for the material used shall be consulted for information on possible chemical contaminants in the work environment.

8.2.2 *Coremaking Equipment*—Hazardous areas and zones on core-making equipment shall be guarded by one or more of the methods listed in 6.3 of this practice.

8.2.3 *Blow Plate and Corebox Seal*—The operator shall be protected from sand that escapes from joints or parting lines.

8.2.3.1 *Discussion*—Any one or more of the following means are acceptable ways to protect from sand:

(*1*) Not permitting magazine faces, blow plates, and mating surfaces on coreboxes to become worn to the point at which a good mechanical seal cannot be achieved.

(*2*) Cleaning loose sand from all mating surfaces before the corebox is blown.

(*3*) Use of sealing members between mating surfaces.

(*4*) Protective shields or curtains between the operator and machine.

(*5*) Good maintenance of vents and blow tubes or slots.

8.2.4 *Corebox Handles*—Core blower boxes shall be provided with means for positioning and removal of the box without any portion of the operator's hands exposed to pinch points. When safe gripping points are not naturally provided, they shall be added.

8.2.4.1 *Discussion*—Some coreboxes, by the nature of their height, size, and configuration provide safe gripping points for the operator's hands.

8.2.5 *Corebox Pressure*—Coreboxes shall be capable of withstanding the pressure of forces, both mechanical and pneumatic, imposed.

8.2.5.1 *Discussion*—It is not the intent of this section to place a restriction either on the materials used for, or the method of, constructing a corebox. A well-constructed corebox for use with either a coreblower or coreshooter allows for simultaneous introduction and exhaust of the air, leaving only compacted sand in the corebox cavity.

8.2.6 *Corebox Vents*—Atmospheric vents shall be provided in either the corebox, the blowplate, or a vent plate below the corebox.

8.2.7 *Green Sand Cores*—Molding sand, with bentonite as the binder, is acceptable for the production of green sand cores.

8.2.8 *Chemically Activated Core Processes*

8.2.8.1 *Discussion*—It is not the intent of this section to restrict the materials used in the coremaking operation. Because of the large number of binder chemicals available, the Material Safety Data sheet for the material used shall be consulted for information on possible chemical contaminants in the work environment.

8.2.8.2 *Heat-activated cores*—Personal protective equipment shall be provided for the operator of a core machine using a heat-activated core process that will protect the operator from contact with the binder chemicals and burns as a result of the elevated temperatures of the core box or finished cores when exposure is possible. Ventilation will be provided that will maintain a work atmosphere that is within the established PELs for any contaminants present during the coremaking process. Review the Material Safety Data Sheet for information on the material with which you are working.

8.2.8.3 *Cold box cores*—The Personal protective equipment assessment shall consider cold box process operator skin contact with the binder chemicals. If necessary, ventilation will be provided that will maintain a work atmosphere that is within the established PELs for any contaminants present during the coremaking process. Review the Material Safety Data Sheet for information on the material with which you are working.

8.3 *Molding Equipment*—Hazardous areas and zones on molding equipment shall be guarded by one or more than the methods listed in 6.3.

8.3.1 Molding equipment covered by this section includes:

8.3.1.1 mold-making machines,

8.3.1.2 flask-handling machines,

8.3.1.3 rollover machines,

8.3.1.4 mold-closing machines, and

8.3.1.5 conveying devices connected to any of the above machines.

8.3.2 *Piston Retainers*—The squeeze or jolt pistons of molding machines shall have restraining features to retain the pistons within the cylinders.

8.3.3 *Clamp Return*—When gravity chutes used for returning clamps to clamping station(s), the clamps shall be fully contained and the exit opening(s) guarded.

8.3.4 *Slings*—All mandatory standards pertaining to slings are required by this section in accordance with 29 CFR 1910.184 and ANSI/ASME B30.9.

8.3.5 *Flask Lifting Devices*—Flask lifting devices shall be constructed so that adequate clearance is provided or separate handles attached to the legs or cross members or both of a sling or bail to minimize the possibility of pinching body parts.

8.3.5.1 *Discussion*—Many flasks are rotated in the flask lifting device to inspect the mold cavity or cleanliness or both of mating flask and mold surfaces.

8.3.6 *Slingers and Mold-Filling Machines—Limiting Trajectory*—The head of a mold-filling device shall not be rotated to create a trajectory of sand into a nonconfined zone or toward any person.

8.4 *Fuel-Fired Equipment*—Arrangements for fuel fired equipment shall be in conformance with NFPA 86 "Standard for Ovens and Furnaces."

8.5 *Operating Procedures for Sand Preparation, Molding, and Core Making*

8.5.1 *Equipment Adjustments, Changes, and Maintenance Work by Operator*

8.5.1.1 An operator shall not perform adjustments or make equipment changes that require special precautions unless trained and authorized by the employer to perform these tasks.

8.5.1.2 An operator shall not perform maintenance tasks unless trained and authorized by the employer to perform these tasks. Such authorized maintenance tasks shall be performed in accordance with Section 5.

9. Melting and Pouring

9.1 *Cupola*

9.1.1 *Discussion*—Cupolas are confined spaces as defined by 29 CFR 1910.146. Under most conditions, a cupola is considered a "permit-required confined space." Refer to 29 CFR 1910.146 for additional OSHA requirements.

9.1.2 *Discussion*—Cupola gas combustion chambers and gas handling equipment generally are confined spaces as defined by 29 CFR 1910.146. Under most conditions this equipment is considered a "permit-required confined space." Refer to 29 CFR 1910.146 for OSHA requirements.

9.1.3 *Written Procedures*—Written procedures shall be established, maintained and followed for all safety related cupola operating practices. Procedures shall be reviewed and updated as needed or at least annually.

9.1.4 *Hazard Zone Work:*

9.1.4.1 *Designation of Hazard Zone Around Cupola*—The employer shall perform a hazard assessment of the cupola area to determine the extent of the hazard zone and shall designate this hazard zone.

9.1.4.2 *Employer Responsibility*—Employers shall be responsible for the proper training of all workers and personnel that work in, or have authorized access to the cupola hazard zones. Authorized personnel shall use appropriate PPE as determined by the PPE hazard assessment.

9.1.4.3 *Hazard Zone Emergency Egress*—Free and open stairways, aisles and walkways shall exist for rapid egress from all cupola hazard zones and shall be available at all times in the event of an emergency. Employers shall provide a means to notify employees of an emergency that requires the evacuation of areas around the cupola. The cupola operator or other authorized person shall turn the blast OFF and stabilize the cupola operation, to the extent possible, prior to leaving the cupola area in any circumstance.

9.1.4.4 *Hazard Zone Access*—Entry to the melt deck hazard zone shall be restricted to authorized persons. It is recommended that the time spent in any cupola hazard zones be kept to a minimum, especially in those areas with exposure to molten metal, slag and hot equipment.

9.1.5 *Cupola Design, Controls and Operation:*

9.1.5.1 *Blast Control and Furnace Parameter Monitoring*—All essential operator blast controls shall be designed and installed such that the cupola operator(s) have access to them at all times while the cupola is operating. Essential cupola operating parameters (for example, blast flow, blast temperature, backpressure, oxygen flow, etc.) shall be accurately monitored and clearly displayed for the operator(s).

9.1.5.2 *Windbox Back Draft Prevention*—A qualified engineer(s) shall design equipment, instrumentation, controls or practices that will prevent the backdraft of combustible cupola gases into the cupola blast wind box for those periods when the blast is off.

9.1.5.3 *Blast OFF Initiators (Switches)*—While the main blast ON/OFF switch(es) is (are) located in a control room or out of a hazard zone, it is recommended that additional "BLAST OFF" switches be installed in or around the cupola melt deck hazard zones as needed, to ensure the operator is able to quickly access them during an emergency. Multiple switches are needed for clear access in one of more hazard zones in the event a path of access is cut off by an emergency.

9.1.5.4 *Tuyere Sight Glasses*—Tinted tuyere sight glasses are recommended for furnace interior visual monitoring for all cupola. Sight glasses shall be kept clear and in good repair.

9.1.5.5 *Emergency Cupola Cooling*—Means for emergency cooling of localized hot spots on the cupola body, well, bedplate, or bottom doors shall be provided and readily available. Procedures for emergency cooling shall be written.

9.1.5.6 *Structural Integrity*—The cupola body, bed plate, support structures, bottom doors, door hinges, water moats, tuyere holders, tuyeres, and related equipment shall be inspected and monitored for structural integrity and watertightness, on a regular basis, for example, daily. All piping systems, water jackets and water moats shall be kept free of debris and buildup. The findings of inspections shall be recorded and retained. Repairs shall be made as needed to ensure the structural integrity and to prevent water leakage into the furnace.

9.1.5.7 *Refractory Lining and Bottom Integrity*—Thermal imaging, hand held infrared temperature sensors, stick on thermometers or other means shall be used as needed to monitor the temperature of all non-water cooled cupola shells, well and bottom surfaces to detect refractory failures during a heat. In the event of a failure, heat duration shall be adjusted and repairs made as needed to prevent failure.

9.1.5.8 *Well Side-Access Doors*—For cupolas with side-access doors (cupola well entry) whether solid-bottom or open-bottom opening cupolas, the following elements shall be designed, installed and maintained:

(1) Emergency drain pipe leading out of the lower level of the door to the "drop area", to be used in the event of a taphole freezeup.

(2) A safe "drain and drop" area shall be maintained at all times below the access door area. This area shall be kept dry with a ready sand bed or dry lined drop box at all times to accept slag and/or liquid metal.

(3) Proper ventilation, cooling and heat protection shall be provided in and around the side-access door and the drop area to protect personnel during removal of the coke bed or other hot materials from the furnace interior.

(4) Fall protection shall be provided and maintained at all times around the melt deck floor opening area below the side-access door.

9.1.6 *Cupola Gas Combustion and Gas Handling Systems:*

9.1.6.1 *Design, Construction, and Control(s)*—Cupola gas combustion systems, equipment, controls, instrumentation and logical control shall be designed by a qualified engineer(s). Design of cupola gas combustion systems shall consider and follow, to the extent possible, NFPA 86 and NFPA 79. Primary gas combustors shall have provisions for complete system purging and over-temperature protection, at a minimum. The minimum excess oxygen levels, or final combustion flame temperature, or both, in the primary combustor shall be monitored and controlled in a manner that ensures smooth and consistent burning and prevents fugitive emissions of the cupola gas during normal operation.

9.1.6.2 *Uncontrolled Gas Ignition*—Periods of uncontrolled or unstable gas ignition occasionally occur during unpredictable times of cupola melting disruption. Such periods include

unusual furnace gas transitions, power outages, lightning strikes, equipment failure, etc. Gas combustion and gas handling systems shall have engineered provisions, to the extent possible, to minimize uncontrolled or unstable ignition conditions.

9.1.6.3 *Combustion Chamber Overtemp Interlock*—A hard-wired relay electrical circuit with a dedicated temperature sensor shall be used for the over-temperature safety interlock in the primary combustor. This is in addition to any other primary temperature controller(s) that has its own high temperature warnings or fault limits. This interlock shall directly disable the wiring circuit that allows the blast valve to open.

9.1.6.4 *Primary Combustor and Gas Handling System Purge Interlock*—Purging of the primary combustor and the entire gas handling system prior to afterburner ignition is controlled by software or firmware. It must be supervised by a hard-wired electrical circuit with a dedicated safety-rated timer. This interlock shall directly disable the wiring circuits that enable the ignition of the primary combustor afterburner until proof of purge is complete. A differential pressure switch, flow switch or similar input shall initiate the supervisory purge timer and must guarantee a minimum of 3.0 air exchanges has occurred prior to afterburner ignition.

9.1.6.5 *Cupola Gas Fugitive Emissions and Personnel Monitoring*—Any buildings or structures that fully or partially enclose the cupola furnace and gas handling systems shall have adequate ventilation provisions to prevent the accumulation of toxic fumes from the cupola melting process or emission control system. Any areas of the foundry, whether enclosed or open, especially in the vicinity of the cupola charge opening, where personnel are potentially exposed to cupola waste gases shall be designated as "Gas Monitoring Required" zones. Stationary or fixed gas monitors shall be installed to monitor specific areas. Personnel that enter these gas hazard zones shall wear personal gas monitors that monitor, at a minimum CO and O_2 content, in accordance with all OSHA standards. It is highly recommended that these zones be limited access zones and not be entered, unless absolutely necessary while the cupola is melting, and then, only by authorized and qualified persons. It is recommended that these persons notify the control room of their entry and departure from these zones and be in radio contact with the cupola control room during that period.

9.1.6.6 *Discussion—Cupola Flue Gas*: Cupola top gas consists of nitrogen, carbon monoxide, carbon dioxide and small amounts of hydrogen and water vapor. It also contains submicron particulate metallurgical fume and other gaseous contaminants that potentially include sulfur dioxide, oxides of nitrogen and volatile organic compounds. A thorough hazard assessment must therefore be performed and proper safety practices must be applied to prevent bodily harm with respect to gaseous emissions around the cupola operation. Invisible and significant gaseous hazards, like liquid metal and slag hazards must be identified and addressed for all persons working in the vicinity of the cupola furnace and gas handling systems.

9.1.7 *Water Cooling Systems:*

9.1.7.1 *General*—Cupola shell and tuyere cooling systems shall be designed by a qualified engineer(s). All visual gauges shall be located in a manner to allow for safe and ready access.

9.1.7.2 *Cross-Connection Prevention*—The design and operation of cupola water cooling systems shall prevent back flow and cross connections.

9.1.7.3 *Water Cooled Tuyeres*—It is recommended that water-cooled tuyeres be leak tested prior to installation and prior to the beginning of each campaign. Tuyeres shall be inspected and replaced as needed.

9.1.7.4 *Tuyere Water Shutoffs*—Shutoff valves shall be available at the inlet and outlet to each tuyere, at the tuyere location. In the event of a significant tuyere water leak, both valves are to be closed and shall remain closed, thus sacrificing the tuyere while preventing the introduction of any additional water to the cupola. Upon the loss of one or more tuyeres, a qualified person(s) shall ascertain whether or not it is safe to return to melting, then determine the next operating steps to ensure personnel safety.

9.1.7.5 *Safety Tuyere*—All cupolas with water cooled tuyeres or water jacket shells in the melt zone shall utilize and maintain a safety tuyere to ensure that the iron level in the furnace shall never reach the level of the tuyeres. The safety tuyere shall be used during furnace tapping and during the beginning of the cupola heat. It is recommended that the safety tuyere be kept open and ready at all times. The safety tuyere drain area shall be kept clean, dry and with a ready sand bed or lined box to accept slag and/or liquid metal at any time.

9.1.7.6 *Rodding*—To prevent the safety tuyere from plugging, rodding of the tap hole shall be performed every 30 minutes or less, or if the slag stops flowing.

9.1.7.7 *Bottom Doors and Props*—Cupola bottom doors shall be supported by at least two metal post props with sufficient strength to support the doors, bottom, charge impact and cupola burden. Props shall have provisions for height adjustment to allow tightening between the doors and foundation. A safe and secure means of temporarily raising the doors to allow for prop installation and tightening is required. Alternative mechanisms to raise and support bottom doors shall be permitted provided that the practice is structurally equivalent to the post prop method. A qualified engineer(s) shall design bottom doors and props.

9.1.8 *Oxygen Addition Systems:*

9.1.8.1 *Oxygen Addition Controls and Piping*—Oxygen injection and/or oxygen enrichment controls, piping, instrumentation, logical control and safety interlocks shall be designed by a qualified engineer(s).

9.1.8.2 *Oxygen Addition OFF Initiators (Switches)*—While the main Oxygen Addition ON/OFF switch(es) are often located in a control room or out of a hazard zone, additional oxygen "OFF" switches shall be installed in or around the cupola melt deck hazard zones as needed, to ensure that the operator has quick access to them during an emergency. It is possible that multiple switches will be needed for clear access in one of more hazard zones in the event a path of access is cut off by an emergency.

9.1.9 *Skip Hoists and Charging Systems:*

9.1.9.1 *Guarding*—Charging system equipment including skip hoists, feeders, transfer cars, lifts, buckets, trolleys, etc. shall at a minimum be guarded, operated and maintained according to OSHA regulations.

9.1.9.2 *Scrap Handling*—All scrap shall be lifted, transferred or dropped in manner that is safe and prudent to prevent materials from falling or being projected where they could cause bodily injury to any personnel including the crane operator.

9.1.9.3 *Scrap Breaking*—Scrap breaking shall only be performed in clearly designated areas, that are designed and maintained to prevent flying scrap from striking personnel including the crane operator.

9.1.10 *Slag Handling:*

9.1.10.1 *Wet Sluice and Vibratory Quench*—In the event water sluice or wet vibratory tanks are used for slag cooling and granulation, all reasonable means and practices shall be employed to prevent the introduction of liquid iron from entering the water with the slag. Shielding and guarding shall be designed, installed and maintained as needed to prevent injury to operators in the event this does occur.

9.1.10.2 *Slag Tub Ingot Molds*—If large tubs are used to accumulate cupola slag, the tubs shall be set aside sufficiently long enough to allow for complete solidification prior to dumping to prevent liquid slag from unexpectedly breaking out and causing a dangerous condition.

9.1.11 *Tapping:*

9.1.11.1 Written procedures shall be established, maintained and followed for tapping and draining of the cupola furnace.

9.1.11.2 All melt deck work associated with tapping or draining shall be performed only by qualified person(s).

9.1.11.3 Operator tools and lances shall be kept organized, clean, dry and readily accessible.

9.1.11.4 All hoses, valves, connectors and other equipment that is used by personnel for oxygen burning shall be maintained in excellent condition and inspected prior to each use. Damaged equipment shall be immediately removed from service and repaired or discarded.

9.1.12 *Accessory Equipment:*

9.1.12.1 *Compressed Air and Gas Preheating Torches and Tools*—Portable torches shall be kept clean and in good repair. Hoses, hose connectors, valves and torches shall be rated for their use, inspected on a regular basis, and repaired or replaced as needed. Clear labeling of all compressed air and natural gas (or other fuel) in-plant piping, supply sources and hoses shall be maintained. Connections for air and fuel shall be of different connector designs to prevent incorrect connections to the air or fuel All operator tools including lances, hoses, hose connectors, hammers, rammers, rods, probes, sampling cups, etc., shall be kept organized, easily accessible, clean, dry and in good repair.

9.1.13 *Cupola Entry by Personnel:*

9.1.13.1 *Access and Lift Equipment*—All personnel lift mechanisms shall comply, with applicable OSHA standards for personnel lift equipment.

9.1.13.2 Written procedures shall be established and followed for the following:

(1) A procedure for the raising and lowering of personnel and their tools within the cupola for cupolas with top or bottom entry.

(2) A procedure for the removal of an injured or incapacitated person(s) from the cupola.

(3) A procedure to ensure clear communication between personnel inside and outside of the cupola. It is recommended that a reliable means of electronic communication be used and two way radios are highly recommended for most cases.

9.1.13.3 Before entry into and during the time that personnel are inside the cupola the following practices shall be followed:

(1) Any charging system equipment that approaches the cupola charge opening shall be locked out.

(2) Mechanisms that operate the bottom doors shall be locked out. In the case where props are manually removed and installed from below the doors, a reasonable method shall be used to prevent the unintentional closing or opening of the bottom doors.

(3) The cupola charge opening shall be guarded to prevent personnel or materials from falling into the cupola.

(4) Means shall be provided to protect personnel inside the cupola from falling objects.

(5) Means shall be provided to ensure a non-hazardous atmosphere inside the cupola. This includes forced draft ventilation or pressurized fresh air supply into the cupola, if necessary, through the open tuyeres.

(6) Personnel inside the cupola shall wear PPE as determined by the hazard assessment.

(7) The blast gate and/or the cupola blast blower(s) shall be locked out.

(8) In the case of an above-charge takeoff cupola, the cupola cap shall be locked out .

(9) All potential sources of compressed air, water, combustion air or burner fuel in the upper stack shall be closed and locked out.

(10) All oxygen addition supply valve(s) that provide enrichment or injection to the cupola shall be closed and locked out.

9.1.13.4 *Nuclear Level Detectors*—Prior to entry into the cupola or prior to performing authorized duties in the vicinity of a nuclear level detector, the radiation shutter(s) shall be closed and locked out. Personnel training, badge monitoring programs, wipe testing, lock out methods, etc., shall be followed in accordance with NRC, OSHA or other applicable regulations.

9.1.13.5 *Multiple Cupolas*—In the case where multiple cupolas share blast systems or gas handling systems and are operated alternately while repairs are being made to the off-line furnace, provisions shall be made to ensure complete isolation of the off-line cupola from any operating blast, emission controls, charging or oxygen injection systems.

(1) Discussion—This could require ductwork disconnection or piping disconnection. Continuous monitoring for CO shall be provided.

9.1.14 *Cupola Bottom Drop*—Cupola drop methods include bottom-door drop (hot or cold) and hot side-door rake out. Written procedures shall be established, maintained and followed for the appropriate method and practices.

9.1.14.1 Bottom-door drop procedures shall include the following steps:

(1) Drain the cupola into dry sand pigs.

(2) Ensure that the drop area is ready to receive hot coke, iron and slag. The entire drop area and drop zone must be dry.

(3) Ensure that the drop bed or drop wagon is large enough to capture the entire drop. The quantity of drop materials must not completely cover or encapsulate the drop bed or wagon.

(4) Visually verify that the drop zone is clear of all personnel and signs are posted at the perimeter of the area.

(5) Only authorized persons shall be allowed in the areas adjacent to the drop zones.

(6) Precautions, such as posting guards or use of physical barriers, must be taken to keep unauthorized personnel out of the area.

(7) An audible alarm shall be sounded prior to dropping. A visual alarm shall also be activated.

(8) Remove locks and safety devices and activate the bottom opening mechanisms or remove the prop posts.

(9) Prop posts must be removed in a safe manner that does not expose personnel to the drop zone hazards. All prop removal equipment must be kept in good repair and inspected prior to use.

(10) The drop zone shall not be entered until it is determined to be safe by a qualified person.

(11) The drop must be cooled sufficiently to protect equipment operators or other personnel prior to cleaning up the drop area.

(12) Do not use water to quench the drop if the drop contains calcium carbide based on knowledge of charge materials.

(13) A qualified person shall determine that there is no molten metal in the drop materials prior to handling.

(14) If using a cable, personnel shall stand clear in the event of cable breakage.

9.1.14.2 Hot side-door rake out procedures shall include the following steps:

(1) After the cupola is drained it is recommended that the backup drain be tapped and opened to ensure that no molten metal or slag remains in the cupola.

(2) Ensure that the drop area is ready to receive hot coke. The entire drop area and drop zone must be dry.

(3) Ensure that the drop bed is large enough to capture the entire drop. It is possible that the quantity of drop materials does not completely cover or encapsulate the drop bed.

(4) Visually verify that the drop zone is clear of all personnel.

(5) Only authorized persons shall be allowed in the areas adjacent to the drop zones.

(6) An audible alarm shall be sounded prior to dropping. A visual alarm shall also be activated.

(7) Remove refractory support backup bars and knockout the refractory from the side access door.

(8) The drop zone shall not be entered until it is determined to be safe by a qualified person.

(9) Quench the drop with water.

(10) The drop must be cooled sufficiently to prevent hot hazard exposure to equipment operators or other personnel prior to cleaning up the drop area.

9.1.14.3 Procedures and methods shall be established that cover all of the hazards for the removal of bottom materials or a drop that does not fall out of the cupola. Use remote controlled knockout machines for bottom poking when possible. Only authorized and qualified person(s) shall be permitted to enter the drop zone prior to a full drop or complete cooling, and only then when wearing proper PPE.

9.1.14.4 Cupola drop procedures shall be reviewed annually.

9.2 *Electric Furnaces—Induction Melting and Induction Holding*

9.2.1 *Electric Furnaces—General Safeguards:*

9.2.1.1 *Bare Conductors*—Bare conductors, except those used for grounding, shall be guarded;

9.2.1.2 *Furnace Shells*—Shells shall have provision for the escape of moisture or water vapor;

9.2.1.3 *Tilting Actuating System*—In the event of a failure in the tilting actuating mechanism, the furnace shall return to a non-pour position at a controlled rate or tilting action and shall cease at the furnace holding position;

9.2.1.4 *Tilt Controls*—Furnace tilt control device shall automatically return to its "off" position when the manual initiating force is removed. Furnace tilt control shall be located such that the operator is able to monitor the molten metal transfer;

9.2.1.5 *Tilting Furnaces*—Tilting furnaces shall be equipped with limit switches or positive stops or both at the extremes of the travel of the tilting mechanism to prevent overtravel;

9.2.1.6 *Slag and Working Doors*—Slag and working doors shall have an integral operating mechanism (examples of "integral operating mechanisms" include handles, cylinders, chains, and so forth);

9.2.1.7 *Wiring and Piping*—Wiring and piping shall be located to minimize their exposure to potential molten metal runout and resultant radiant heat;

9.2.1.8 *Furnace Molten Bath Contact*—Furnace power shall be de-energized before any unguarded metallic tool or material is introduced into the molten bath. Unguarded metallic tools or materials are either ungrounded or not insulated from the furnace operator. Guarding of a metallic tool or material shall be accomplished by either grounding it or electrically insulating the operator from the metal in contact with the molten bath. Guarding insulation methods include:

(1) electrically insulating tool handles,

(2) electrically insulating potential contact surfaces, and

(3) using thermal/electrical insulating protective gloves and clothing.

9.2.1.9 *Temperature Measurement*—An accurate temperature measuring device shall be used to determine the temperature of the molten bath to avoid overheating the metal in the furnace.

9.2.1.10 *Ground Fault Protection*—Furnaces with ground current detectors/monitors, indicating a failure or fault condition, shall not be operated until the failure or fault condition is corrected. (Do not bypass or jumper any portion of the ground current detector/monitor).

(1) Discussion—The ground fault trip shall be evaluated before resetting and resuming operations.

9.2.1.11 *Molten Metal Grounding*—Ground bonding jumpers embedded in the refractory of a furnace shall not be covered with refractory patching material (Covering or disconnecting the grounding wires effectively insulates the molten bath from ground during normal operation and produces an electrical shock hazard condition in the event of a lining failure).

9.2.1.12 *Crucible Handling Equipment*—Freestanding crucible lifting and pouring equipment shall provide crucible bottom support at a minimum of two points.

9.2.2 *Crucible Furnaces*—Covers shall be provided and used on runout ports on all crucible furnaces so equipped. The position of a runout port shall be toward an area away from the operator's normal position, aisles or walkways.

9.2.2.1 *Discussion*—Runout port covers serve to deflect metal from a ruptured pot toward the floor.

9.2.3 *Charge Materials and Tools*—Before their use, charge materials and tools, which are to be immersed in molten metal baths, shall be preheated to remove surface and entrained moisture. Rusty tools shall not be used with aluminum.

9.2.4 *Pouring Areas*—Floors in pouring areas shall use materials that minimize molten metal splatter and eruptions during metal transfer, or pouring operations, or both.

9.2.5 *Runout Pits, Curb Procedures*—Means such as runout pits, curbs, procedures, or a combination of the three shall be provided to guard personnel from molten metal in the event of a runout or spill.

9.2.6 *Runout Pit Construction*—The primary purpose of the runout pit is to prevent molten runout metal from coming in contact with personnel in the area or personnel leaving the area. The pit floor and walls must be dry, thermally stable material (not construction-grade concrete) to preclude secondary eruption when molten metal contacts the pit surfaces. The secondary purpose of the pit is to protect the furnace or other molten metal melting or holding device, ancillary equipment, and building. The pit shall have the capacity to retain at least one full furnace charge. All runout pits shall be kept free of debris and inspected on a regular, at least daily basis to verify the above conditions.

9.2.7 *Liquids in Runout Areas*—Areas provided to receive runouts or spills shall be kept dry and free of accumulation of liquids.

9.2.7.1 *Discussion*—For a better understanding, water when it changes from liquid to steam expands 1600 times. If the molten metal spills and encapsulates a puddle of water, the violent release of energy is almost instantaneous because of the tremendous temperature differential between the two.

9.2.8 *Personnel in Runout Pits*—Access to runout pits shall be controlled. No person shall be in or enter a pit during charging, pouring, tapping, or slagging operations in that pit area.

9.2.8.1 *Discussion*—Furnace runout pits are confined spaces as defined by 29 CFR 1910.146. However, it is possible that under some conditions, a furnace pit would be considered a "permit-required confined space." Refer to 29 CFR 1910.146 for additional OSHA requirements.

9.2.9 Fire protection sprinkler systems shall not be installed above molten metal areas. Water from these systems shall not enter the hazard zone at any time.

9.2.10 *Hazardous Atmospheres*—The employer shall determine whether a hazardous atmosphere exists, or has the potential to exist, within runout pits and shall establish and enforce the necessary precautionary measures including personal protective equipment, against such hazard(s) and entry procedures before an employee is permitted to enter the pit.

9.2.10.1 *Discussion*—Consider the possibility of a hazardous ambient condition such as insufficient oxygen, toxic gases, or explosive mixtures. If the possibility of a serious safety or health hazard exists, the pit is a "permit-required confined space" and all of the requirements of 29 CFR 1910.146 apply.

9.2.11 *Hazard Zone Around Induction Melting and Holding Furnace*—The area adjacent to the induction melting and holding furnace is a hazard zone because of the possibility of molten metal splash.

9.2.11.1 *Discussion*—It is possible for molten metal splash to occur at any time that there is molten metal in the induction melting or holding furnace. The causes include the introduction of foreign material or moisture into the molten bath and refractory lining failure. Whenever molten metal is present in the induction melting furnace, this hazard exists.

9.2.12 *Identification of Hazard Zone Around Induction Melting Furnace*—The employer shall identify the extent of this hazard zone and mark it with color coding or post signs warning of the hazard. Signs shall be clearly visible at all points of entrance to the hazard zone.

9.2.12.1 This zone extends from the edge of the induction melting furnace to a distance of approximately 20 ft or five times the crucible ID (whichever is greater) radially from the center of the furnace. The extent of this area is to be bounded by physical barriers to entry. Railings shall be painted yellow. Entry points shall have a yellow line on the floor the entire width of the opening and at least 4 in. wide.

9.2.13 *Personnel in Hazard Zone Around Induction Melting Furnace*—Entry to the hazard zone adjacent to an operating induction melting furnace shall be restricted to authorized persons and only then to perform authorized tasks. The time spent in this hazard zone shall be kept to the minimum needed to perform required tasks.

9.2.13.1 All personnel, including furnace operators, shall stay out of the hazard zone around the induction melting furnace as much as possible. Remotely controlled charging, slagging, pouring, sampling, and temperature measuring devices must be used whenever practical.

9.2.14 *Protection of Personnel in Hazard Zone Around Induction Melting Furnace*—Personnel within the hazard zone around the melting furnace shall be protected against molten metal splatter by the appropriate personal protective equipment and guarding where the guards do not interfere with the operation of the equipment. All personnel in the hazard zone around the induction melting furnace shall wear proper personal protective equipment whenever molten metal is present in the furnace. Such clothing shall comply with Specification F1002. When the hazard assessment indicates that personal protective equipment complying with Specification F1002 provides insufficient protection, personal protective equipment indicated by the hazard assessment shall be used.

9.2.14.1 *Discussion*—For further information refer to Guide for Selection and Use of Personal Protective Equipment and Special Clothing for Foundry Operations and Guide F1449.

9.2.15 *Melting and Pouring Procedures*—The employer shall implement and enforce written procedures for melting and pouring within each hazard zone. The written procedures shall include which employees are authorized to enter the zone and specify what personal protective equipment is to be worn while in the hazard zone.

9.2.16 *Transfer Cars*—Where movement of the transfer car creates a hazard to personnel, an audible or visual warning device or both shall be operated continuously during car movement.

9.2.16.1 *Remote Controlled*—Remote-controlled transfer cars shall have warning signs on the car as well as along the path of travel to warn personnel that it is possible for car movement to occur at any time.

9.2.17 *Track Wheels*—Track wheels, which are hazardous to personnel, shall be guarded.

9.2.17.1 *Discussion*—The most common method of guarding track wheels is with rail sweeps. In certain cases additional hazards exist between the wheel and rail sweep or between adjacent wheels that require more extensive guarding than just rail sweeps alone.

9.2.18 *Hydraulic Fluids*—Fire-retardant hydraulic fluids shall be used in the hydraulic systems of all equipment used in the melting and pouring area and covered by this practice.

9.2.19 *Hazard Alert Signs*—Where guarding cannot provide personnel protection from a hazardous situation, a hazard alert sign shall be provided.

9.2.19.1 All danger, caution, safety instruction, and hazard alert signs shall be designed and applied in accordance with 29 CFR 1910.145 and ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.

9.2.19.2 *Responsibilities for Hazard Alert Signs—Manufacturer*—The manufacturer shall provide a hazard alert sign on each new piece of equipment to which there is a known hazard associated with its use.

9.2.19.3 *Responsibilities for Hazard Alert Signs—Employer*—The employer shall maintain and replace damaged hazard alert signs if needed. If existing equipment is involved and no hazard alert signs on the equipment are apparent, it is the responsibility of the employer to insure that hazard alert signs are provided. Hazard alert signs shall be provided in the language required for all employees accessible to the hazard. The manufacturer shall be contacted to obtain hazard alert signs.

9.2.20 *Tools*—When sampling, slagging, skimming, or drossing, or a combination thereof, only tools specifically designed for these functions shall be used. Tools with refractory coating shall be dry before usage. Tools shall be free of rust.

9.2.21 *Unguarded Tools*—Any electrically uninsulated tools and equipment that have the potential to come into contact with molten metal within an energized electric furnace shall be effectively grounded to the equipment ground with a bonding jumper of insulated or uninsulated, flexible grounding cable.

9.2.21.1 Furnace power shall be de-energized before any unguarded metallic tool is introduced into the molten bath. Unguarded metallic tools are either ungrounded or not electrically insulated from the furnace operator. Means of guarding are indicated in 9.2.19.

9.2.22 *Operator Work Zone:*

9.2.22.1 The operator work zone shall be established to minimize the exposure to a hazard zone(s).

9.2.22.2 This means the operator shall stand away from the furnace when the melting process does not require operator involvement near the furnace. The employer needs to make use of peripheral equipment such as automatic charging systems, slagging devices, preheating systems, or other systems that are feasible so as to minimize operator exposure to a hazardous condition.

9.2.23 *Transformers:*

9.2.23.1 *Electric Welding*—When electric welding is to be performed on the lower voltage side of a furnace transformer power circuit:

(1) the transformer disconnecting means shall be locked open (off) and

(2) the higher voltage circuit shall be guarded to protect personnel from contact.

9.2.24 Emergency Cooling—Means for emergency cooling of hot spots on induction holding furnaces shall be provided and maintained at all times.

9.3 *Electric Furnaces—Direct Arc Furnaces*

9.3.1 *Furnace tilt angle*—Furnace tilt shall be interlocked to prevent tilting an energized furnace where the furnace or its electrodes has the potential to contact other equipment or personnel;

9.3.2 *Roof Operation*—Top charge electric furnaces shall be interlocked to prevent moving the roof with the furnace energized;

9.3.3 *Electrode Additions*—A work platform shall be provided for changing or adding electrodes. Refractory roofs shall not be used as work platforms;

9.3.4 *Energized Electrodes*—Means shall be provided to inform the operator when the electrode(s) is energized and allow the operator to open the power circuit to the electrodes;

9.3.5 *Electrode (Roof) Cooling Glands*—Cooling glands shall be secured against falling into the furnace in the event of a roof failure; and

9.3.6 Direct arc furnaces shall meet the requirements of NFPA 86 Chapter 9 “Safety Devices for Arc Melting Furnaces.”

9.3.7 *Emergency Cooling*—Means for emergency cooling of hot spots on the furnace shall be provided and maintained at all times.

9.3.8 *Electrode Adding/Changing—Direct Arc*—When adding or changing electrodes on direct arc furnaces, the electrode power circuits, furnace tilt, roof lifts, and roof swing shall be de-energized and locked off. A work platform shall be provided and used for changing or adding electrodes. Refractory roofs shall not be used as work platforms.

9.3.9 *Electrode Adding/Changing—Resistance or Indirect Arc*—When adding or changing electrodes or elements on

resistance or indirect arc furnaces, both the electrode and the tilt power circuits shall be de-energized and locked off.

9.3.10 *Pouring Areas*—Floors in pouring areas shall use materials that minimize molten metal splatter and eruptions during metal transfer, or pouring operations, or both.

9.3.11 *Runout Pits, Curb Procedures*—Means such as runout pits, curbs, or procedures, or a combination of the three shall be provided to guard personnel from molten metal in the event of a runout or spill.

9.3.12 *Runout Pit Construction*—The primary purpose of the runout pit is to prevent molten runout metal from coming in contact with personnel in the area or personnel leaving the area. The pit floor and walls must be dry, thermally stable material (not construction-grade concrete) to preclude secondary eruption when molten metal contacts the pit surfaces. The secondary purpose of the pit is to protect the furnace or other molten metal melting or holding device, ancillary equipment, and building. The pit shall have the capacity to retain at least one full furnace charge. All runout pits shall be kept free of debris and inspected on a regular, at least daily, basis to verify the above conditions.

9.3.13 *Liquids in Runout Areas*—Areas provided to receive runouts or spills shall be kept dry and free of accumulation of liquids.

9.3.13.1 *Discussion*—For a better understanding, water when it changes from liquid to steam expands 1600 times. If the molten metal spills and encapsulates a puddle of water, the violent release of energy is almost instantaneous because of the tremendous temperature differential between the two.

9.3.14 *Personnel in Runout Pits*—Access to runout pits shall be controlled. No person shall be in or enter a pit during charging, pouring, tapping, or slagging operations in that pit area.

9.3.15 *Hazard Alert Signs*—Hazard alert signs shall be provided and used to indicate the presence of personnel in the runout pit.

9.3.16 *Hazardous Atmospheres*—The employer shall determine whether a hazardous atmosphere exists, or has the potential to exist, within runout pits and shall establish and enforce the necessary precautionary measures including personal protective equipment, against such hazard(s) and entry procedures before an employee is permitted to enter the pit.

9.3.16.1 *Discussion*—Consider the possibility of a hazardous ambient condition such as insufficient oxygen, toxic gases, or explosive mixtures. If the possibility of a serious safety or health hazard exists, the pit is a "permit-required confined space" and all of the requirements of 29 CFR 1910.146 apply.

9.3.17 *Hazard Zone Around Electric Arc Furnace*—The area adjacent to the electric arc furnace is a hazardous zone because of the possibility of molten metal splash.

9.3.17.1 *Discussion*—It is possible for molten metal splash to occur at any time that there is molten metal in the electric arc furnace. The causes are numerous, including the introduction of foreign material or moisture into the molten bath and refractory lining failure. Whenever molten metal is present in the electric arc furnace, this hazard exists.

9.3.18 *Designation of Hazard Zone Around Electric Arc Furnace*—The employer shall designate the extent of this hazard zone and mark it with color coding and signs warning of the hazard. Signs shall be clearly visible at all points of entrance to the hazard zone.

9.3.18.1 *Discussion*—This zone extends from the edge of the electric arc furnace to a distance of approximately 20 ft or five times the crucible ID (whichever is greater) radially from the center of the furnace. The extent of this area is to be bounded by physical barriers to entry. Railings shall be painted yellow. Entry points shall have a yellow line on the floor the entire width of the opening and at least 4 in. wide.

9.3.19 *Personnel in Hazard Zone Around Electric Arc Furnace*—Entry to the hazard zone adjacent to an operating electric arc furnace shall be restricted to authorized persons and only then to perform authorized tasks. The time spent in this hazard zone shall be kept to a minimum.

9.3.19.1 *Discussion*—All personnel, including furnace operators, need to stay out of the hazard zone around the electric arc furnace as much as possible. Use remotely controlled charging, slagging, pouring, sampling, and temperature measuring devices whenever practical.

9.3.20 *Protection of Personnel in Hazard Zone Around Electric Arc Furnace*—Personnel within the hazard zone around the melting furnace shall be protected against molten metal splatter by the appropriate personal protective equipment and guarding where the guards do not interfere with the operation of the equipment. All personnel in the hazard zone around the electric arc furnace shall wear proper personal protective equipment whenever molten metal is present in the furnace. Such clothing shall comply with Specification F1002. When the hazard assessment indicates that personal protective equipment complying with Specification F1002 provides insufficient protection, personal protective equipment indicated by the hazard assessment shall be used.

9.3.20.1 *Discussion*—For further information refer to and Guide F1449.

9.3.21 *Melting and Pouring Procedures*—The employer shall implement and enforce written procedures for melting and pouring within each hazard zone. The written procedures shall include which employees are authorized to enter the zone and specify what personal protective equipment is to be worn while in the hazard zone.

9.4 *Ladles*

9.4.1 *Trunnions*—Ladle trunnions and the devices used to connect them to molten metal handling equipment shall have the following characteristics:

9.4.1.1 For nongeared ladles using detachable hook-type bails, the outside end of each trunnion shaft shall have a flange with a diameter not less than 1½ times the shaft diameter unless the trunnions are of such length as to prevent disengagement from the bail;

9.4.1.2 Trunnion shafts on nongeared ladles used with stirrup-type detachable bails shall have a retainer or stop to prevent the stirrup from coming off the trunnion whenever the ladle is supported by the bail; and

9.4.1.3 When using a hook-type detachable bail, all components shall be constructed to ensure that the hook properly engages the ladle trunnion shaft. The throat opening of the hooking device shall be smaller than the flange.

9.4.2 *Treatment/Ladles*—Ladles used for treatment or inoculation or both of molten metal shall have ample top allowance or shielding or both or shall be guarded by location to protect employees from contact with molten metal during the reaction.

9.4.3 *Tilting Ladles*—Ladles shall have a tilting means such that they are under the control of the operator(s) at all times during pouring operations.

9.4.4 *Bails*

9.4.4.1 The gross load rating shall be legible and marked on all ladle bails; and

9.4.4.2 Nondetachable bails on non-geared ladles shall be provided with a means to prevent uncontrolled lowering of the bail when the lifting hook is disengaged. (One method of accomplishing this is by means of a counterweight on the head beam of the bail. The lifting hook shall be engaged from the counterweight side).

9.4.5 *Transporting of Ladles*

9.4.5.1 Means shall be provided and used to prevent uncontrolled tilting of a ladle when suspended by a hoist (Examples of a suitable means are bail locks and self-righting ladles. It is satisfactory to construct bail locks of a nonweldable material to increase reliable operation under metal splatter conditions.);

9.4.5.2 Powered traveling mechanisms shall be provided with a signal device that is audible above ambient noise (In some environments, the use of flashing or rotating lights provides additional warning effectiveness.); and

9.4.5.3 Means shall be provided to prevent unintentional sliding, or tipping of ladles, or both, while transporting molten metal with vehicular equipment (Some examples of vehicular equipment are fork trucks, platform trucks, and transfer cars).

9.4.6 *Bottom discharge Ladles*

9.4.6.1 Bottom discharge ladles shall be provided with a means to prevent uncontrolled operation of the discharge mechanism (Methods for accomplishing this are means such as stopper rod hold down devices or slide gate.); and

9.4.6.2 Pouring zones and ladle filling area in which bottom discharge ladles are used shall have provisions to accommodate molten metal leakage. (Examples include sand pit(s), pit mold(s), dike(s), and so forth).

9.5 *Molten Metal Handling and Pouring Equipment*

9.5.1 *Ladle Handler*—The gross load rating shall be legibly marked on all ladle handlers.

9.5.2 *Crucibles*—Crucibles shall have means to prevent disengagement from their cradles during handling and pouring of molten material.

9.5.3 *Pouring Stands*—Pouring stands shall:

9.5.3.1 Be provided with means to prevent disengagement of the ladle trunnions over the tilting range of the pouring stand;

9.5.3.2 Return to a non-pour position or cease tilting action in the event of a failure in the tilting actuating mechanism; and

9.5.3.3 Be located such that the operator is able to monitor the molten metal transfer.

9.5.4 *Overhead equipment for handling of molten materials*

9.5.4.1 *Discussion*—Examples are: power-operated hoists, cranes, and monorail systems. The requirements outlined in this section are in addition to those contained in ANSI/ASME B-30 Standard Series.

9.5.4.2 *Limit Devices*

(1) The lifting mechanism of any hoist handling hot molten materials shall be provided with an upper overtravel limit device to stop lifting motion. This device shall directly interrupt power to the hoist motor without the use of auxiliary devices and shall not be used as an operating control. When a limit switch is used as an operating device, a second switch shall be used as the upper operating limit; and

(2) An electric or air powered hoist shall not be installed where it is possible to lower the loaded hook beyond the rated hook travel under normal operating conditions unless the hoist is equipped with a lower limit device.

9.5.4.3 *Hoist ropes*—All wire ropes used in handling of molten metal shall meet the following requirements:

(1) the rope shall have a wire core center;

(2) the rated load divided by the number of parts of rope shall not exceed 12½ % of the nominal breaking strength of rope (Example: 10-ton hoist having four parts of ⅛-in. diameter extra strength improved plow steel rope rated 20.6-ton breaking strength - 0.125 × 20.6 = 2.575 ton allowable load. 10 ton/4 = 2.5 ton per part of rope, which does not exceed 2.575 ton);

(3) a core and lubricant that will not be damaged by heat to which it is exposed; and

(4) where treatment of molten iron with reactive metals is performed in a hoist-suspended or crane-suspended ladle, the lower block and ropes shall be shielded from the effects of the reaction.

9.5.4.4 *Operator's Cab*—Cabs in melting and pouring areas shall be shielded to prevent injury to operator from molten material splash, or radiant heat, or both in the event of a runout or spill.

9.5.4.5 *Hook(s)*—The hook throat opening and hook radius shall allow the ladle bail to set firmly in the bowl of the hook.

9.5.5 *Underhung Crane and Monorail Systems*—The requirements outlined in this section shall be in addition to those contained in ANSI/ASME B 30.11 for underhung cranes and monorails.

9.5.5.1 *Track or Runway Restraint*—An independent restraining means shall be provided to minimize the drop of the monorail track or crane runway in the event of a failure of a track hanger or bolt. Such limiting device shall not be subject to loading under normal operating conditions. (Typical means are choker cables, chains, or lugs.)

9.5.5.2 *Restraining Means*—Restraining lugs or other positive means shall be provided to minimize the drop of any moving load carrying member in event of wheel, kingpin, or axle failure.

9.5.5.3 *Bolts in Tension*—An independent restraining means shall be provided to minimize the drop of any load supporting member held in place solely by a bolt in tension.

9.5.5.4 *Warning Device*—All power driven underhung crane and monorail handling equipment shall have a warning device for alerting personnel of approaching molten metal.

9.5.5.5 *Ladle Swing*—Monorail carriers used for transporting molten material at speeds in excess of 150 feet per minute

shall be provided with a means to minimize ladle swing in the direction of travel with the ladle in the uppermost position.

9.5.5.6 *Molten Material Spillage*—Means shall be provided to minimize molten material spillage in the event the carrier contacts end stops or other carriers on the same track or runway.

9.5.5.7 *Carrier Speed*—The speed of carriers shall be limited through curves, switches, and transfer points to minimize spillage of molten metal.

9.5.5.8 *Latches—Track Switches*—Latching mechanisms shall firmly hold the movable track frame section during the passage of carriers through track switches. Latches shall be designed to minimize the possibility of track switches being accidentally unlatched and shall not allow inadvertent movement of the movable track frame section.

9.6 *Maintenance and Inspection*

9.6.1 *Trunnion Shaft Inspections*—Trunnion shafts shall be inspected quarterly for distortion, deterioration, grooves, and cracks. Worn or damaged parts shall be repaired or replaced.

9.6.1.1 *Discussion*—Trunnion shafts with properly operating anti-friction bearings are not normally subject to wear. Recommended inspection procedures are as follows:

(*1*) Trunnion shafts showing visible distortion shall be replaced,

(*2*) Visible grooves shall be eliminated by removing material,

(*3*) Trunnion shafts shall be calipered at 45° intervals and replaced if the diameter is less than the minimum recommended by the manufacturer, and

(*4*) Trunnion shafts shall be inspected for minute cracks by a suitable crack detection method, such as; magnetic particle, ultrasonic, dye penetrant, or other equivalent means.

9.6.2 *Bail Assembly Inspections*—All component parts of the bail assembly shall be inspected quarterly for cracks, wear corrosion, or damage. Worn or damaged parts shall be repaired or replaced.

9.6.2.1 *Discussion*—Bail arms, bail loops, and stirrups shall be inspected for cracks by a suitable crack detection method, such as: magnetic particle, ultrasonic, dye penetrant, or other equivalent means.

9.6.3 *Crucible Inspection*

9.6.3.1 Crucibles and pots shall be inspected monthly by qualified personnel on the basis of the following factors:

(1) metal melted,

(2) frequency of use,

(3) refractory material used in the crucible or pot,

(4) severity of service, and

(5) experience gained on normal service life,

(6) metal material used for the crucible or pot.

9.6.3.2 Under some conditions, a crucible is considered a "permit-required confined space." Refer to 29 CFR 1910.146 for OSHA requirements.

9.7 *Molten Metal Treatment*

9.7.1 *Procedures*—The employer shall establish procedures for molten metal treatment that minimize employee exposure to hazards.

9.7.2 *Authorized Personnel*—Molten metal treatment or inoculation or both shall be performed only by authorized personnel.

9.7.2.1 *Discussion*—Some examples of metal treatment are desulfurization and nodularization of ductile iron or bubbling chlorine or other gas through nonferrous metals.

9.7.3 *Personnel Protection*—Ladles used for treatment, or inoculation, or both, of molten metal shall have ample top allowance, or shielding, or both; or be guarded by location to protect employees from contact with molten metal during the reaction.

9.7.4 *Gas-Activated Inoculation Vessel*

9.7.4.1 The lining and plug area shall be inspected frequently and repaired as required. (A gas-activated inoculation vessel is a special purpose hot metal holding vessel. All normal precautions for holding ladles apply to a gas activated inoculation vessel).

9.7.4.2 Excessive gas flow that results in hazardous metal splatter shall be avoided. The optimum gas flow will be unique to each vessel. It will be established by the initial experience. It is possible that excessive gas flow would result in metal splatter.

9.7.4.3 Calcium carbide and materials containing calcium carbide shall be stored and used in dry areas and protected from accidental contact with moisture. Calcium carbide and calcium carbide containing materials (such as desulfurization slag) react with water to generate acetylene gas. Practices for handling and storing calcium carbide shall be in conformance with applicable local, state, and federal regulations and with the specifications in NFPA 49.

9.7.4.4 Procedures shall be written for storage, handling, and use of calcium carbide and its slag.

9.7.5 *Refractory Dry-Out*

9.7.5.1 *Procedure*—The employer shall establish and follow a refractory dry-out procedure to prevent eruptions beyond confines of the vessel during drying, preheating, and introduction of molten metal.

9.8 *Specific Material Handling Equipment*

9.8.1 *General Safeguards*

9.8.1.1 *Clearance*—Where guards are used with mobile charging equipment, there shall be clearance between the guards and this equipment to eliminate pinch points.

9.8.2 *Overhead Cranes*

9.8.2.1 *Limit devices*—An upper limit switch must not be used as an operating device.

9.8.2.2 *Bridge and Runway Conductors*—Hazard alert signs shall be placed at personnel access points and along the runway where there are energized open conductors. The potential for contact with energized open conductors exists from any direction.

9.8.2.3 *Hooks*—A hook handling a magnet shall be equipped with a means to prevent unintended disconnection of the magnet from the hook.

9.8.2.4 *Discussion*—Where the use of a latch is impractical or creates an additional hazard, it is possible that the use of a bail and multilink chains would preclude the bail from coming off the hook under slack conditions.

9.8.2.5 *Lifting Magnets*

(1) Cranes using a lifting magnet shall have a separate magnetic circuit switch of the enclosed type with provision for locking in the open (OFF) position. Means for discharging the inductive energy of the magnet shall be provided. Magnetic disconnect switch shall be connected on the line side of the crane disconnect switch. Indication or signal lights shall be provided to indicate power is "on" or "off." The lights shall be located so that they are visible by the operator and from the floor. Pendant pushbutton operation of lifting magnets is not recommended unless precautions are taken to minimize the possibility of the operator being struck by falling metal. It is advisable to use multiple bulbs to avoid confusion as a result of a burned out bulb;

(2) If the crane is radio controlled, loss of radio control shall not result in demagnetizing the magnet; and

(3) All magnet-connecting plugs shall be of such design that both conductors to the magnet are interrupted simultaneously.

9.8.3 *Buckets*—Charging buckets shall not be carried over personnel. Charging buckets tied with nonmetallic rope shall not be carried over high heat areas except the furnace being charged.

9.9 *Molten Metal Handling and Pouring*

9.9.1 *Ladle Fill Level*—Ladles shall not be filled with molten material above a level at which the potential exists for spillage to occur when normally transported. The minimum freeboard in a ladle shall be six to eight inches.

9.9.1.1 *Discussion*—Training and level indicators are appropriate.

9.9.2 *Transporting Molten Material—Clearance*—Clearance shall be provided to allow unobstructed passage of molten material during transport.

9.9.3 *Transporting Molten Material—Accumulation of Liquids*—The area underneath the molten material being transported inside a building shall be kept free of accumulations of liquids.

9.9.4 *Permanent Molds*—When using water to cool permanent molds care shall be exercised to avoid a condition that results in molten metal encapsulating water.

9.9.5 *Tilting Control*—The means to prevent uncontrolled tilting required in 9.4.5.1 shall be engaged when transporting molten material outside the pouring zone.

9.9.6 *Load Rating and Bails*—The gross load rating for ladle bails required by 9.4.4 shall not be exceeded.

9.9.7 *Load Rating—Ladle Handlers*—The load rating for ladle handlers required by 9.5.1 shall not be exceeded.

9.9.8 *Unattended Ladles*—Ladles containing molten materials shall be lowered as close to the floor as possible when unattended.

9.10 *Overhead Handling of Molten Material*

9.10.1 The operator shall only respond to signals from the person who is directing the lift. However, the operator shall obey a stop signal at all times, no matter who gives it (see ANSI/ASME B30.2 for hand signals).

9.10.2 Contacts with runway stops or other cranes shall be avoided.

9.10.3 The person directing the lift shall see that the load is well secured, balanced, and positioned in the bowl of the hook.

9.10.4 During lifting and traveling, care shall be taken that:

9.10.4.1 There is no sudden acceleration or deceleration of the moving load and

9.10.4.2 Load does not contact any obstructions.

9.10.5 Ladles containing molten material shall not be carried or positioned over personnel. The audible device required in 9.4.5.2 shall be activated each time before traveling and when approaching personnel.

9.10.6 Personnel shall not be allowed under any suspended load.

10. Cleaning and Finishing

10.1 *Care of Cleaning and Finishing Equipment*

10.1.1 *Abrasive Blasting* Proper maintenance of equipment is essential for safety of operating personnel. Abrasive blast equipment is subject to severe wear due to the abrasive action of the blast media.

10.1.1.1 Abrasive hoses shall be inspected frequently for weak spots evidenced by soft spots and bulges. Defective hoses shall be repaired or replaced.

10.1.1.2 All abrasive conveying metal pipe and fittings shall be frequently inspected for excessive wear. Defective pipe and fittings shall be repaired and replaced.

10.1.1.3 Internal floors, ledges, and shelves shall be cleaned of hazardous accumulations of spent abrasive and debris on a frequent basis. All floor surfaces shall be examined for deterioration and distortion. Defective floor surfaces shall be repaired or replaced to lessen slipping, tripping, and falling accidents.

10.1.1.4 Broken or severely eroded wear liners and their fasteners shall be replaced.

10.1.1.5 All seals whose purpose is to prevent the escape of abrasive shall be replaced when found defective.

10.1.1.6 All mechanisms that support load shall be replaced when found defective.

10.1.2 *Abrasive Wheel Machinery*

10.1.2.1 *Discussion*—Refer to ANSI B7.1.

10.1.2.2 *Lubrication of Bearings*—The machine spindle bearings shall be properly lubricated to prevent overheating or other conditions that might damage the abrasive wheel. (Improperly lubricated spindle bearings could cause the mounting spindle to expand because of heat generated, thus exerting a stress in the arbor hole area.)

10.1.2.3 *Grinding Machines and Equipment*

10.1.2.4 *Discussion*—Further information is contained in ANSI Standards B107.4, B186.1, B11.9, B7.1, Z43.1, B5.35, and 29 CFR 1910.215.

10.1.3 *Hooks and Below-the-hook Lifting Devices Designed for Handling Castings*—Inspection, removal from service, and repair shall comply with the requirements of ANSI/ASME B30.10 and ANSI/ASME B30.20.

10.1.3.1 *Inspection*—Inspection of hooks and below-the-hook lifting devices shall be performed as required. (There are circumstances in which both inspection intervals and procedures are already governed by the specific kind of equipment in which they are used. Since those intervals and procedures would take precedence, refer to the appropriate standard pertaining to a specific kind of equipment.)

10.1.3.2 *Removal from Service*—Defective below-the-hook lifting devices shall be removed from service. Hooks having any of the following deficiencies shall be removed from service:

(1) Cracks. Repairs shall be permitted when performed by a designated person by grinding longitudinally following the contour of the hook.

(2) Nicks and gouges exceeding the repair criteria that no dimension is reduced more than 10 % of its original value.

(3) Wear exceeding 10 % of the original dimension.

(4) A bend or twist exceeding 10° from the plane of an unbent hook.

(5) Increase in throat opening exceeding 15 % of the original dimension.

10.1.3.3 *Repairs*—All repairs except where specified above shall be performed by the manufacturer or other qualified person.

10.1.3.4 *Welding*—When a handle or latch support is welded to a hook or below-the-hook lifting device whose design requires heat treating, welding shall be done before final heat treating.

10.1.4 *Slings*

10.1.4.1 *Discussion*—For additional information, refer to 29 CFR, 1910.184.

10.1.4.2 *Inspection*—Each day before being used, the sling and all fastenings and attachments shall be inspected for damage or defects by a qualified person designated by the employer. Additional inspections shall be performed during sling use, where service conditions warrant.

10.1.4.3 *Removal from Service*—Damaged or defective slings shall be immediately removed from service.

10.1.5 *Grinding Equipment for Magnesium Castings*

10.1.5.1 Pipes, ducts, and interior surfaces of the dust collection unit shall be cleaned on a frequent basis to avoid hazardous accumulation of dry dust and possible explosions.

10.1.5.2 Only nonsparking tools and explosion-proof portable lights shall be used when cleaning dust collection systems.

10.1.5.3 Dust shall not be permitted to accumulate on floors, benches, ledges, overhead structures, or other surfaces.

10.1.5.4 Compressed air shall not be used for cleaning. It is recommended that dust be removed by wet sweeping or using an air-operated grounded vacuum cleaner.

10.2 *Specific Equipment Safeguards—Cleaning and Finishing*

10.2.1 *Walking and Working Surfaces*—Floor openings, elevated work platforms, and other walking and working surfaces shall be guarded in accordance with existing mandatory safety standards.

10.2.1.1 *Discussion*—For additional information, refer to 29 CFR 1910.23 of the General Industry Standards. Also ANSI A12.64.1.

10.2.2 *Operating Controls*—When work stations are immediately adjacent to the equipment, operating controls shall be located such that:

10.2.2.1 Personnel are not exposed to hazards from discharged material;

10.2.2.2 Personnel has unobstructed access to the operating controls;

10.2.2.3 Personnel have optimum visibility to the work area; and

10.2.2.4 All operating controls shall be legibly identified as to their intended function.

10.2.3 *Emergency Stops and Restarts*—Controls shall be arranged such that if emergency stops are initiated from remote locations, restarting shall only be possible when initiated from the main control panel.

10.2.4 *Hoppers and Chutes*

10.2.4.1 *Openings*—All openings to hoppers and chutes that are hazardous to personnel shall be guarded.

10.2.4.2 *Gates*—Means shall be provided to prevent the discharge of material endangering personnel. Power positioned gates shall be designed normally closed (OFF) in the event of power failure or interruption.

10.2.5 *Transfer Cars, Powered*

10.2.5.1 *Position-Locking Devices*—Transfer cars shall be provided with a brake, rail clamp(s), or other position-locking devices where the omission of such devices creates a hazard to personnel.

10.2.5.2 *Overtravel Stops*—Stops shall be provided beyond the normal travel limits to stop the transfer car in the event of overtravel.

10.2.5.3 *Warning Device*—Where movement of a transfer car creates a hazard to personnel, an audible or visual warning device or both shall be operated continuously during car movement. Remote controlled transfer cars shall have hazard alert signs on the car as well as along the path of travel to warn personnel that car movement has the potential to occur at any time.

10.2.5.4 *Power Conductors*—Electrical power conductors shall be guarded in such a manner as to prevent accidental contact by personnel.

10.2.5.5 *Personnel Platform*—When personnel are required to ride a transfer car, a proper work platform shall be provided.

10.2.5.6 *Discussion*—If the transfer car moves close to or under adjacent equipment or building structures that could present a hazard to these personnel, consider a cab or full enclosure.

10.2.6 *Hazardous Substances*—The handling and storage of hazardous substances and the issuance of personal protective equipment and clothing shall be in conformance with existing standards and regulations.

10.2.6.1 *Discussion*—A variety of substances, which might have flammable, explosive, or toxic properties, or a combination of the three might be used during the cleaning and finishing of castings. Detailed and individual safety requirements for these substances are considered to be beyond the scope of this practice.

10.2.7 *Shakeout*

10.2.7.1 *Spillage*—If material could fall or bounce out of the shakeout endangering personnel, spill guards, pan guards, or equivalent protection shall be provided.

10.2.7.2 *Moving Components*—Moving components that create hazards to personnel shall be guarded.

10.2.8 *Gating System Removal Equipment*

10.2.8.1 *Discussion*—The most efficient way to remove the gating system (down sprue, runner bars, risers, ingates, and pressure gates) from the casting is to sever it into the largest pieces possible. The best method to accomplish this will be determined by the type of metal and the shape of the casting to name a few. For example, most gray iron gating systems are removed through the impact action of shakeout equipment. This is not the case with all metals; therefore, other methods are used. Some of the most common methods used by both ferrous and nonferrous foundries are:

(*1*) Degating or knock-off (flogging),

(*2*) Shears and presses,

(*3*) Abrasive cutoff equipment,

(*4*) Torch cutting, and

(*5*) Band and friction sawing.

The degating or knock-off method, sometimes called flogging, is a manual operation where an employee strikes the gating system with a hammer to sever it from the casting. Therefore, specific equipment safeguards are not applicable for this operation. It is not the intent of this practice to cover all the possible machine and equipment applications that could be in use to remove gating systems. Consult the listing of ANSI standards in Section 2 that pertains to the type of machinery or equipment being used.

10.2.8.2 *Shears and Presses*—The point of operation on shears and presses shall be safeguarded in accordance with 6.3 of this practice.

10.2.8.3 *Abrasive Cutoff Equipment*

(1) Guard exposure angle—The maximum exposure angle for abrasive wheel guards used on cutoff machines shall not exceed 180°. The top half of the wheel shall be enclosed at all times. The exposure angle of the guard determines to what extent it is acceptable for the wheel periphery and sides to be outside the guard and still have optimum protection if the wheel were to break.) Guarding shall be in conformance with ANSI B7.1.

(2) Wheel flanges:

(*1*) Type 1 cutoff wheels shall be mounted between properly relieved flanges that have matching bearing surfaces. Such flanges shall be at least one fourth the wheel diameter.

(*2*) Type 27A cutoff wheels shall be mounted between flat unrelieved flanges having matching bearing surfaces and which shall be permitted to be less than one third, but shall not be less than one fourth the wheel diameter.

10.2.8.4 *Band and Friction Sawing*

(1) Guarding—Hazardous areas and zones on band and friction sawing equipment shall be guarded.

(2) Blade repairs—Brazed joints in band saw blades shall be flush with the saw blade.

10.3 *Abrasive Blasting*

10.3.1 *Discussion*—Additional requirements are contained in 29 CFR Section 1910.94(a) abrasive blasting.

10.3.2 *Guarding*—The equipment shall be guarded in accordance with ANSI B15.1.

10.3.3 *Blasting—Enclosed and Nonenclosed*

10.3.3.1 *Enclosed*—The abrasive blasting enclosure shall minimize the escape of flying abrasive and be properly ventilated to maintain a continuous inward flow of air in the enclosure during the blasting operation and for a suitable time thereafter. The air exhausted from the blast cleaning enclosure shall be discharged into a dust collecting system.

10.3.3.2 *Nonenclosed*—When abrasive blasting is performed without an enclosure, all of the requirements of this and applicable referenced standards shall be followed to protect personnel exposed to the hazards generated by the blasting operation.

10.3.4 *Explosion Safeguards*—When flammable or explosive dust mixtures exist, the blast enclosure ventilating ducts and dust-collecting system shall be provided with explosion venting means in accordance with NFPA 68. All electrical equipment and wiring shall be in conformance with the National Electrical Code, Articles 500, 502, NFPA 70 (ANSI C-1), and ANSI Z33.1.

10.3.4.1 NFPA 68 shall be followed for guidance on the protection against flammable or explosive dust mixtures. The blasting of materials such as aluminum, magnesium, titanium, and so forth will produce a fine metallic dust that has the potential to be flammable or explosive. Organic abrasives produce flammable and explosive dust mixtures.

10.3.5 *Ductwork and Dust Collectors*—Ductwork and dust collectors shall be constructed and maintained in accordance with the requirements of ANSI Z9.2 and where applicable, NFPA 484. An abrasive separator shall be used to remove fines from the abrasive in systems in which the abrasive is recirculated for subsequent use.

10.3.6 *Manual Abrasive Blasting*—This section deals with blasting by use of handheld nozzles and where there is no protective separation between the operator and the blasting media except an abrasive blasting helmet and other protective clothing.

10.3.6.1 *Operator controls:*

(1) Blast initiation and termination shall be under the sole control of the operator using deadman controls.

(2) The blast control shall be securely mounted to the hose or nozzle in the operator's gripping area.

(3) Abrasive blast shall be initiated and maintained by the squeezing action of the operator's hand(s) on the blast control.

(4) The blast control shall be guarded such that abrasive flow cannot be accidentally initiated when not in control of the operator. (An example is dropping the nozzle.)

(5) Abrasive agents shall be chosen in order to minimize the health hazard from exposure to crystalline silica.

10.3.6.2 *Personal Protective Equipment*—The operator shall wear:

(1) An abrasive-blasting respirator approved by NIOSH/MSHA and supplied with breathable air and meets the OSHA requirements for breathable air, which includes 24-h monitoring or periodic CO monitoring.

(2) Protective clothing as specified in ANSI Z9.4.

(3) Abrasive hose—The abrasive hose shall be provided with a means to discharge static electricity from the blasting nozzle. (It is preferred that the grounding means be built into the hoseline.)

10.3.7 *Manual Abrasive Blasting in an Enclosure (Operator Inside Enclosure)*—In addition to the following, the requirements of 10.3 apply.

10.3.7.1 *Ventilation*—Ventilation shall be sufficient to provide adequate visibility for the operator.

10.3.7.2 *Entrance and Exit from the Blast Enclosure*—All door(s) on blast cleaning enclosures, shall be operable from both inside and outside, except that where there is a personnel access door, the work access door(s) shall be operable from the outside only.

10.3.7.3 *Interlocks—Doors*—The door(s) shall be interlocked with the blasting nozzle controls such that blast cannot be initiated unless the doors are closed. (These are considered secondary protection.)

10.3.7.4 *Lockout of Blast Wheel(s)*—When manual blasting is performed in an enclosure equipped with centrifugal blast wheel(s), the wheel power source shall be locked out. Each employee performing the operation shall have his or her own padlock applied to the lockout, group lockout device, group lockbox, or comparable mechanism. When inch controls are used to move the work-pieces, they shall be applied in such a manner that they do not create a hazard.

10.3.8 *Airless Abrasive Blasting (Centrifugal Wheels)*

10.3.8.1 *Interlocks, Doors, and Access Openings*—Door opening(s) that will permit the physical entry of personnel into the blast compartment shall be interlocked with the blast wheel(s) control(s) so as to preclude starting the blast wheel(s) unless these doors are in the closed position. Door openings into the blast compartment shall have suitable hazard alert signs affixed to them. (These are considered secondary protection.)

10.3.8.2 *Bucket Loaders*—Bucket loader/blast machine combinations have the potential to create hazardous work areas. Personnel shall never enter the area between the loader bucket and blast machine unless the equipment has been properly locked out, in accordance with 29 CFR 1910.147.

10.3.8.3 *Working Surfaces*—Stray shot causes hazardous walking conditions around blasting equipment. Caution and good housekeeping practices shall be used around the blasting equipment.

10.3.8.4 *Elevators/Abrasive Shot*—Jammed elevator belts shall not be dislodged by placing hands into the elevator section even when the elevator is locked out. Operators shall use a readily available scoop or rake.

10.4 *Chipping*

10.4.1 *Storage of Equipment*—Tools shall be kept off the floor to reduce tripping hazards.

10.4.2 *Holding Devices*—Castings light enough to be moved out of position by the chipping tool action shall be restrained during the chipping operation.

10.4.3 *Chisels*—Chipping chisels shall carry a metallurgical specification of a grade high enough to prevent breakage.

10.4.3.1 *Discussion—Recommended Specifications:*

(*1*) *Material*—AISI or SAE 1070 through 1090 steel or equivalent, AISI 1055 being acceptable.

(*2*) *Surface Condition*—Free from scale, seams, laps, gouges, and other defects that will affect the service of the part.

(*3*) *Heat Treatment*—Austemper or quench and temper to Rockwell C45-22 through the section.

(*4*) *Microstructure*—Tempered martensite or low temperature isothermal products or both. No surface decarburization. Microscopic examination shall not reveal marked banding, segregation, pipe, internal ruptures, or other defects. Refer to OSHA Field Information Memorandum No. 100-93.

10.4.4 *Tool Retainers*—A tool retainer shall be used when, without such a retainer, the tool could eject with sufficient force to injure an employee.

10.4.4.1 *Exception*—A tool retainer shall not be required under either of the following conditions provided that work practices are posted and enforced that insure that employees are not exposed to the danger of an ejected tool:

(1) The work piece provides the necessary protection for both the tool operator and other employees and

(2) Partitions or shields that protect employees (including the operator) not protected by the work piece are used.

10.5 *Abrasive Wheels*

10.5.1 *Replacing Safety Guard*—At the completion of wheel mounting, the safety guard shall be in place and shall be checked for condition and adjustment. All safety guard fasteners shall be in place and properly tightened.

10.5.1.1 *Exception*—This requirement shall not apply to the following wheels and conditions. Type 16, 17, 18, and 19R cones and plugs and threaded hole pot balls in which the work offers protection or the wheel size does not exceed three inches in diameter by five inches long.

10.5.2 *Wheel Breakage*—Wheel breakage shall be investigated by the employer to determine and correct the cause.

10.5.2.1 *Discussion*—It is recommended to contact the vendor/manufacturer in case of any wheel breakage.

10.5.3 *Work Rests*—An offhand grinder shall be equipped with a work rest or other device that shall prevent the work piece from jamming between the abrasive wheel and the wheel and the wheel guard.

10.5.3.1 *Discussion*—Jamming of the work piece is a cause of wheel breakage and operator injury. Where work rests are not useable, such machines shall be identified by hazard alert signs, locked out when not in use, or closely supervised as to use. (OSHA Program Directive #100-39 allows for work rest removal where jamming is precluded by the size of the work piece.)

10.6 *Operating Procedures for Abrasive Wheels*

10.6.1 *Discussion*—Further details are contained in ANSI B7.1.

10.6.2 *Inspection*—Abrasive wheels shall be inspected before mounting by trained personnel. Methods of inspection are:

10.6.2.1 visual and ring test,

10.6.2.2 visual and vibration test, and

10.6.2.3 other equivalent means.

10.6.3 *Exception*—Fiberglass-reinforced wheels shall only be visually inspected for the presence of the reinforcing material.

10.6.4 *Limitation*—The ring and vibration test is not applicable to certain wheels because of their shape or size. Examples are:

10.6.4.1 small wheels (4-in. diameter and smaller),

10.6.4.2 plugs and cones,

10.6.4.3 mounted wheels,

10.6.4.4 segments,

10.6.4.5 plate-mounted wheels, and

10.6.4.6 inserted nut and projecting stud disc wheels.

10.6.5 A wheel showing evidence of cracks, abusive storage, or handling shall not be mounted. it is possible for a damaged or cracked wheel to disintegrate while in operation resulting in personal injury. If cracks or other damage are found, the wheel shall be destroyed or the information reported to the manufacturer and arrangements made for an inspection. Defects such as broken wheels, chips, and gouges caused from improper transit, handling, and storage are usually detectable visually. Cracks, however, are not always visible to the naked eye, but inspection methods, such as the ring test and vibration test, have been developed to reveal minute cracks.

10.6.6 *Ring Test*—The ring test, when used, shall be performed as specified in ANSI B7.1, or shall be performed as follows:

10.6.6.1 Suspend the wheel from its mounting hole on either a small pin or the finger. Heavier wheels shall be positioned vertically on a clean hard floor or surface;

10.6.6.2 Gently tap the side of the wheel with a nonmetallic object approximately 45° each side of the vertical center line and 1 to 2 in. from the periphery; and

10.6.6.3 Rotate the wheel in 45° increments and repeat the test back to the starting point.

10.6.6.4 *Discussion*—A sound and undamaged wheel will give a clear tone. If cracked, there will be a dead sound not a clear ring, and the wheel shall not be used. (The ring test depends on the damping characteristics of a cracked wheel to alter the sound emitted when the side of the wheel is tapped lightly with a nonmetallic object. A good wheel will give a clear ring when tapped, while a cracked wheel will yield a dead sound. Some disadvantages to this test are:

(*1*) The emitted sound from tapping the wheel could be subject to interpretation by the person performing the test.

(*2*) The emitted sound from tapping the wheel could be masked by high ambient noise levels in the area in which the test is performed.

(*3*) The ring test is primarily applicable to vitrified bonded wheels, not wheels reinforced by fibrous glass.

10.6.7 *Vibration Test*—The vibration test, when used, shall be performed as specified in ANSI B7.1.

10.6.8 *Wheel Balance*—Out-of-balance wheels that set up vibrations have the potential to result in marred work surfaces, machine damage, and also cause stresses that could contribute to wheel failure. Wheels that cannot be corrected for imbalance by the user shall not be used.

10.6.9 *Wheel Speed*—It shall be determined at time of mounting a wheel that the spindle speed does not exceed the maximum operating speed marked on the wheel or wheel package by comparison of the rpm ratings or by using a tachometer.

10.6.9.1 *Discussion*—On some variable speed machines, the spindle speed is interlocked with the guard or some other device that allows the rpms to increase as the wheel diameter decreases. Exercise care that these devices are in good working order to prevent the possibility of overspeeding the wheel, which could cause breakage. Machine builders usually offer maintenance literature that is often useful in preventing wheel failure caused by overspeed conditions. Machines with variable pitch pulleys require continual maintenance to remain in proper working order.

10.6.10 *Work Rests*—A work rest or similar device shall not contact a rotating abrasive wheel. When a work rest is used, the following conditions shall be maintained whenever possible:

10.6.10.1 The work rest shall be adjusted such that the gap between the work rest and the grinding face of the abrasive wheel shall not exceed ⅛ inch.

10.6.10.2 The work rest height shall be on the horizontal centerline of the machine spindle. (Exception: If the work piece is large, it is possible that the work rest height will have to be lower to contact the wheel properly. Use OSHA Directive STD 1-12.8-29 CFR 1910.215(a)(4), Abrasive Wheel Machinery Work Rests October 30, 1978 to obtain proper guidance. This directive allows an exemption to the horizontal center line adjustment when interference's with the work rest or contacts with the wheel below the horizontal plane of the spindle are unavoidable.)

10.6.10.3 The work rest shall not be adjusted while the abrasive wheel is rotating unless the work rest is designed to safely allow such adjustment.

10.6.10.4 The work rest shall be securely tightened after each adjustment. When a work rest cannot be used in accordance with (1) and (2) above, because of job requirements, it is satisfactory to relocate or remove the work rest to accommodate the operation. In these cases, a means shall be provided to prohibit the use of the grinder for other operations.

10.6.11 *Wheel Wear*—A wheel shall not be worn beyond the wheel discard size that would allow the mounting flange assembly to contact the work piece or work piece holding fixture.

10.6.11.1 *Discussion*—Worn wheels shall be permitted to be remounted on a machine using a smaller diameter wheel, provided that proper mounting, speed, and guarding requirements are observed.

10.6.12 *Large Hole Inorganic Bonded Wheels*—Inorganic bonded wheels with a mounting hole greater than ¼ (25 %) of the outside diameter of the wheel shall not be used for snag-grinding operations.

10.6.12.1 *Discussion*—The cross-sectional strength of an abrasive wheel decreases as the outside diameter wears and approaches the diameter of the mounting hole. The use of reinforced abrasive wheels such as those with steel rings results in minimization of wheel breakage in the majority of applications that affect the cross-sectional strength. Inorganic bonded wheels with extremely large mounting holes cannot be manufactured with a reinforcing media, therefore, are not recommended for snag-grinding operations.

10.6.13 *Starting the Wheel*—Abrasive wheels shall be run at operating speed with safety guard in place or in a protected enclosure for a least one minute before applying work during which time no one shall stand in front of or in line with the wheel.

10.6.13.1 *Discussion*—Wheels that have been damaged in shipment, storage, or are subjected to excessive stress through mounting are likely to fracture within the first minute of rotation at operating speed. While this procedure is most important at the time of mounting, it is also possible for

damage to occur to a wheel when the machine on which it is mounted has been inoperative for extended periods of time. The employer shall evaluate the circumstances and the duration of machine shut down to establish additional times that this work practice be followed. It is recommended that the start button on floor stand grinding machines be located so the operator cannot stand in front of the wheel while starting the machine.

10.6.14 *Wet Grinding*—Before shutting down a wet grinding operation, the coolant shall be shut off and the wheel allowed to rotate until the coolant has spun out. The concentration and alkalinity of the coolant shall be checked regularly and adjusted in accordance with the recommendations of the coolant and wheel manufacturer.

10.6.14.1 *Discussion*—Coolants have the potential to affect the strength of organic bonded wheels. The reason for this is that uneven accumulation of coolant has the potential to cause excessive out of balance in a wheel. The concentration and alkalinity of coolants determines the degree to which they affect organic bonded wheels. To avoid injurious effects upon these wheels, it is important to follow the recommendations of the coolant and wheel manufacturer.

10.6.15 *Side Grinding*—Side grinding shall only be performed with wheels designed for this purpose.

10.6.15.1 *Discussion*—Extreme caution shall be exercised to avoid excessive side pressure because wheels designed for peripheral grinding do not have sufficient support to withstand excessive side pressure. This does not preclude their use in applications such as form grinding in which a limited amount of side grinding is performed. Wheels designed for side grinding such as abrasive discs are mounted with one flat side against a suitable steel-machined plate to withstand safely side pressure. Form grinding is not considered to be side grinding.

10.6.16 *Safety (Tongue) Guard Exposure Adjustment*—When grinding operations require the operator to stand in front of the guard opening on bench and floor-stand grinders, the safety (tongue) guard shall be adjusted so that the distance between the wheel periphery and the adjustable tongue or the end of the peripheral member at the top of the guard opening shall not exceed ¼ in. See Fig. 3.

10.6.16.1 *Exception*—On bench grinders with wheels not greater than 5 in. in diameter operating at peripheral speeds of less than 5000 SFPM with rated outputs not greater than 1/10 HP, the ¼-in. maximum clearance requirements shall only apply to the maximum diameter wheel for which the grinder is designed. The adjustable clearance requirement is not mandatory.

10.6.16.2 *Discussion*—Fig. 3 shows two satisfactory methods of accomplishing exposure adjustment. These sketches are for purposes of illustration only. Other methods that agree with the basic rule are also acceptable. Fig. 3 also shows a condition that does not comply with the requirements. Note that the exposure angle is always measured from the center of the wheel spindle.

10.6.17 *Arbor Hole Size*—Abrasive wheels shall fit freely on the spindle (wheel sleeves or adapters) and remain free fitting under all grinding conditions.

10.6.17.1 *Discussion*—A controlled clearance between the wheel arbor hole and the machine spindle (or wheel sleeve or adapter) is essential to avoid excessive pressure from mounting and spindle expansion. The machine spindle or adapter size must be maintained by the user. Worn or undersize adapters have the potential to cause an out-of-balance condition, contributing to wheel failure.

10.6.18 *Surface Condition*—All surfaces between the wheel, blotters, and flanges that come in contact with each other during mounting shall be flat and free of foreign particles.

10.6.18.1 *Discussion*—Flanges are potentially distorted by excessive tightening or burred by dropping and shall be checked periodically. Inspect wheels, blotters, and flanges for foreign particles. Presence of foreign particles in these areas has the potential to result in uneven mounting pressure against the sides of the wheel causing stresses that sometimes lead to wheel failure.

10.6.19 *Reducing Bushings*—Reducing bushings shall be specifically designed, properly manufactured, and fitted when used in abrasive wheels. The bushing shall fit freely on the spindle and maintain proper clearance under all conditions. Reducing bushings shall not be used to mount a larger abrasive wheel on a grinder than the wheel for which the grinder was designed. When a reducing bushing is used in the wheel arbor hole, it shall not exceed the width of the wheel and shall not contact the flanges.

10.6.19.1 If a reducing bushing is wider than the wheel in which it is used, it will interfere with proper tightening of the flanges against the wheel. The power required to drive a grinding wheel is transferred through the flanges. If this power is partially or completely transferred through the reducing bushing, it is possible for wheel failure to result. Only an appropriate reducing bushing shall be permitted to be used to compensate for an oversize arbor hole, and substitutes such as flat shim stock must not be used.

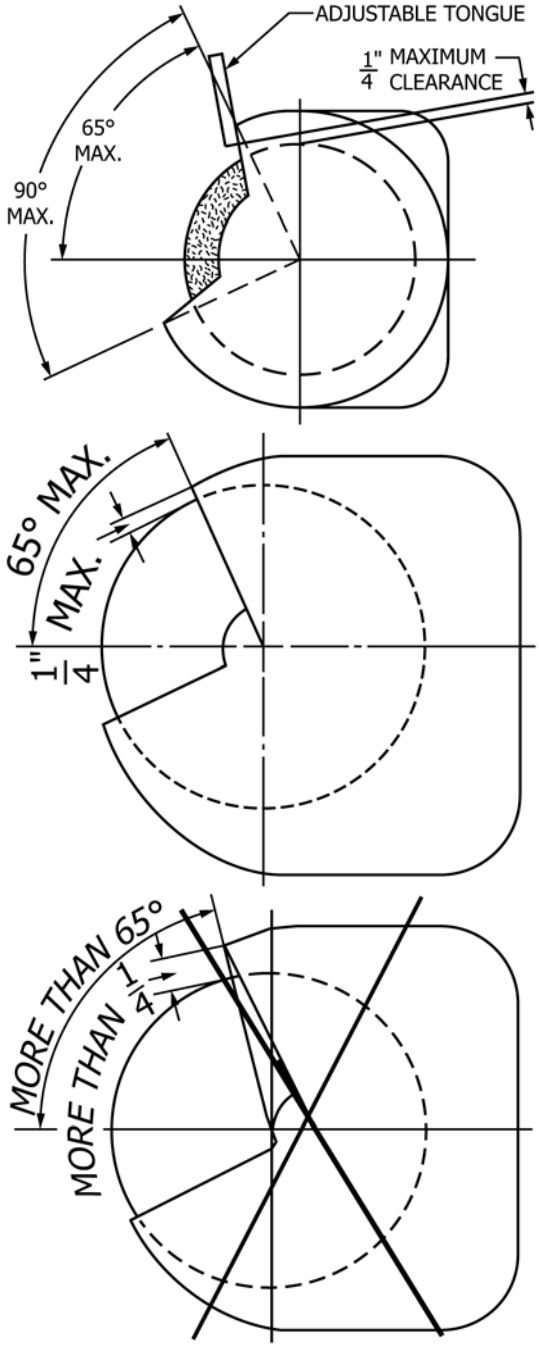
10.6.20 *Blotters*—When blotters or flange facings of compressible material are required, they shall cover the entire contact area of wheel flanges. Highly compressible material, such as commonly used blotting paper shall not exceed 0.025 inch in thickness. If greater blotter thickness is used, compressibility of the material shall be less.

10.6.20.1 *Discussion*—Blotters are used for several reasons. They tend to cushion the pressure of the flanges against high points of uneven surfaces and distribute the pressure evenly. They prevent damage to the surfaces of the flanges from the abrasive surface of the wheel. They provide a better coefficient of friction than would be obtained between the flange and the wheel, thereby providing better transmission of the driving power to the wheel. Replace scuffed or damaged blotters.

10.6.21 *Flanges*—Abrasive wheels used on bench and floor stand (pedestal) grinders shall be mounted between flanges that shall not be less than one third the diameter of the wheel.

10.6.21.1 *Discussion*—Flanges drive the wheel and must have sufficient contact area. They must be of proper design to prevent distortion causing damaging stresses in the wheel.

10.6.22 *Tightening of the Mounting Spindle End Nut*—The spindle end nut shall only be tightened sufficiently to drive the wheel and prevent slippage.



NOTE 1—The top figure shows an adjustable tongue giving required angular protection.
NOTE 2—The middle figure shows a moveable guard with an opening small enough to give required protection for the small-sized wheel used.
NOTE 3—The bottom figure shows a moveable guard with size of opening correct for full-sized wheel, but too large for smaller wheels.

FIG. 3 Correct and Incorrect Methods of Accomplishing Exposure Adjustments

10.6.22.1 It is possible that overtightening of the spindle end nut will spring the flange. Moreover, a sprung flange has the potential to cause stress concentrations that would break the wheel. On the other hand, undertightening of the spindle end nut also has the potential to permit wheel slippage that would result in breakage. Torque wrenches are not applicable to tightening single end nuts because normal thread wear causes a continual change in the relationship between torque applied to the nut and flange pressure on the wheel. This means that the procedure recommended by the machine builder for tightening the spindle end nut shall be followed.

10.6.23 *Direction and Length of Thread on Machine Spindle*—If flanges are tightened by means of a central nut, three conditions shall be maintained.

10.6.23.1 Spindles shall be of sufficient length to allow a full nut mounting.

10.6.23.2 The threaded portion shall extend from the spindle end to inside the outer flange, but not more than half

way within the arbor hole of the minimum width wheel for which the machine is designed.

10.6.23.3 The direction of the thread shall be such that, to remove the wheel, the nut must be turned the same direction as the wheel rotates when in use or means shall be provided to prevent the wheel or flanges from working loose as the spindle revolves.

10.6.23.4 *Discussion*—See Fig. 4.

10.7 *Portable Abrasive Wheels*

10.7.1 *General requirements*—Abrasive wheels shall be used only on machines provided with safety guards as defined in paragraph 10.7.2 – 10.7.5 of this section.

10.7.1.1 *Exceptions*—The requirements of this paragraph shall not apply to the following classes of wheels and conditions.

(1) Wheels used for internal work while within the work being ground;

(2) Mounted wheels used in portable operations two inches and smaller in diameter; and

(3) Types 16, 17, 18, 18R, and 19 cones, and plugs, and threaded hole pot balls where the work offers protection.

10.7.2 *Safety Guard*—A safety guard shall cover the spindle end, nut and flange projections. The safety guard shall be mounted so as to maintain proper alignment with the wheel, and the strength of the fastenings shall exceed the strength of the guard.

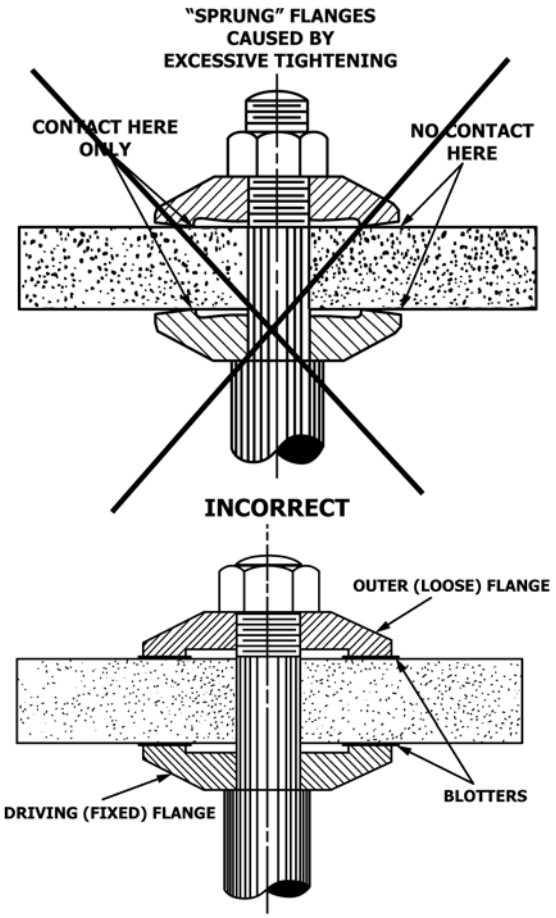
10.7.2.1 *Exception*—Safety guards on all operations where the work provides a suitable measure of protection to the operator shall be permitted to be so constructed that the spindle end, nut and outer flange are exposed. Where the nature of the work is such as to entirely cover the side of the wheel, the side covers of the guard shall be permitted to be omitted.

10.7.2.2 *Exception*—The spindle end, nut, and outer flange shall be permitted to be exposed on portable machines designed for, and used with, Types 6, 11, 27, and 28 abrasive wheels, cutting off wheels, and tuck pointing wheels.

10.7.3 *Cup Wheels*—Cup wheels (Types 6 and 11) shall be protected by:

10.7.3.1 Safety guards as specified in paragraph 10.7.2 of this section; or,

10.7.3.2 Special “revolving cup guards” which mount behind the wheel and turn with it. They shall be made of steel or other material with adequate strength and shall enclose the wheel sides upward from the back for one-third of the wheel thickness. The mounting features shall be in conformance with



NOTE 1—The top spindle illustrates the results encountered when the spindle end nut is excessively tightened.
NOTE 2—The bottom spindle is of sufficient length to accomodate the wheel and flanges.

FIG. 4 Spindles

10.7.6. It is necessary to maintain clearance between the wheel side and the guard. The clearance shall not exceed one-sixteenth inch; or,

10.7.3.3 Some other form of guard that will insure as good protection as that which would be provided by the guards specified in (*1*) or (*2*) above.

10.7.4 *Vertical Portable Grinders*—Safety guards used on machines known as right angle head or vertical portable grinders shall have a maximum exposure angle of 180 degrees, and the guard shall be so located so as to be between the operator and the wheel during use. Adjustment of guard shall be such that pieces of an accidentally broken wheel will be deflected away from the operator.

10.7.4.1 *Discussion*—See Fig. 5.

10.7.5 *Other Portable Grinders*—The maximum angular exposure of the grinding wheel periphery and sides for safety guards used on other portable grinding machines shall not exceed 180 degrees and the top half of the wheel shall be enclosed at all times.

10.7.5.1 *Discussion*—See Fig. 6.

10.7.6 *Mounting and Inspection of Abrasive Wheels:*

10.7.6.1 Immediately before mounting, all wheels shall be closely inspected and sounded by the user (ring test, see 10.6.6) to make sure they have not been damaged in transit, storage, or otherwise. The spindle speed of the machine shall be checked before mounting of the wheel to be certain that it does not exceed the maximum operating speed marked on the wheel.

10.7.6.2 Grinding wheels shall fit freely on the spindle and remain free under all grinding conditions. A controlled clearance between the wheel hole and the machine spindle (or wheel sleeves or adaptors) is essential to avoid excessive pressure from mounting and spindle expansion. To accomplish this, the machine spindle shall be made to nominal (standard) size plus zero minus .002 inch, and the wheel hole shall be made suitably oversize to assure safety clearance under the conditions of operating heat and pressure.

10.7.6.3 All contact surfaces of wheels, blotters, and flanges shall be flat and free of foreign matter.

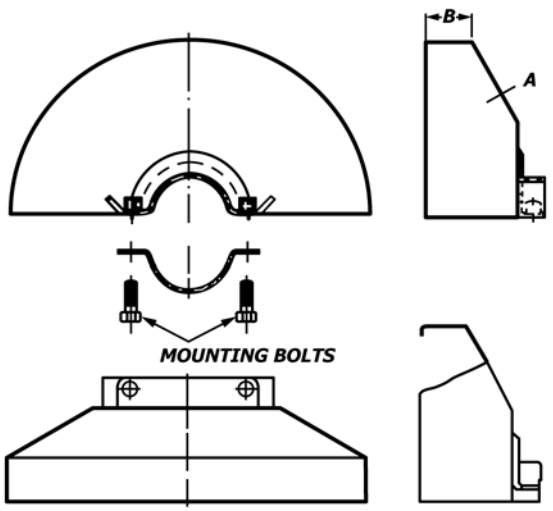


FIG. 5 Vertical Portable Grinder

10.7.6.4 When a bushing is used in the wheel hole it shall not exceed the width of the wheel and shall not contact the flanges.

10.7.6.5 The use of flanges and blotters shall be in conformance with 29 CFR 1910.215(c).

10.7.7 *Excluded Machinery*—Natural sandstone wheels and metal, wooden, cloth, or paper discs, having a layer of abrasive on the surface are not covered by this paragraph.

10.8 *Grinding Magnesium*

10.8.1 *Equipment:*

10.8.1.1 *Discussion*—Grinding equipment includes abrasive wheels, belts, or discs.

10.8.1.2 Grinding equipment shall be equipped with a wet dust collection system. Sufficient liquid shall be present to ensure full immersion of the collected dust.

10.8.1.3 Electrical equipment, including motors, shall be of the type approved for use in Hazardous Locations, Class II, Group E and installed in accordance with the requirements of Article 502 of the National Electrical Code.

10.8.1.4 Pipes and ducts associated with the dust collection system shall be installed with a minimum of turns or bends. A means of cleaning all pipes and ducts shall be provided.

10.8.1.5 The power supply to dust-producing machines shall be interlocked with the motor driving the exhaust blower and the liquid level controller of the wet collector in such a way that improper functioning of the dust collecting system will shut down the machine it serves. A time delay switch or equivalent device shall be provided on the dust-producing machine to prevent the starting of its motor drive until the wet collector is in complete operation and several changes of air have swept out any residual hydrogen.

10.8.1.6 Sludge pits shall be vented. (Ventilation is necessary to avoid accumulation of hydrogen gas that evolves by reaction of magnesium dust with water.)

10.8.1.7 Suitable extinguishing materials or fire extinguishers for Class D fires shall be readily available whenever magnesium grinding takes place. If powder (such as graphite) is used, it needs to be spread evenly to provide a ½ to ¾-in. layer over the burning area. Never use water, vaporizing liquids, foam, dry chemical, or carbon-dioxide-type extinguishers on a magnesium fire.

10.8.1.8 Operations that use magnesium or magnesium alloys shall be in conformance with NFPA 480.

10.8.2 *Magnesium Grinding*

10.8.2.1 Grinding of other metals on equipment used for magnesium shall be prohibited. Magnesium grinding equipment shall be marked “For magnesium only” or by a similar legend.

(1) An exception to this rule shall be when magnesium grinding is an infrequent, short duration operation. In this event, the grinding wheel and equipment, dust collection system, and surrounding area shall be thoroughly cleaned before and after grinding magnesium.

10.8.2.2 In addition to personal protective equipment normally required for grinding, operators shall wear smooth textured clothing that minimizes the collection of magnesium dust in clothing or on the body. Such clothing shall comply

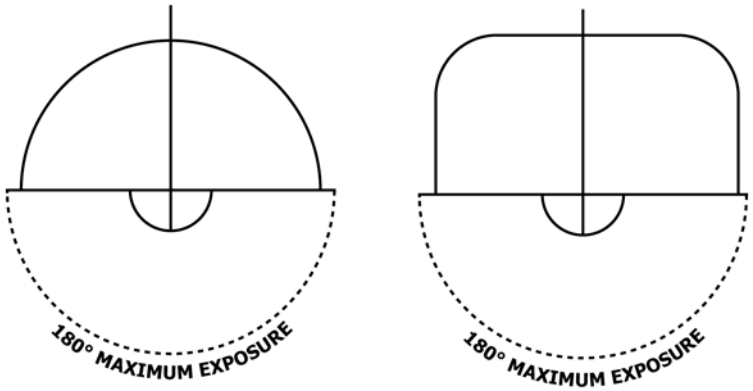


FIG. 6 Portable Grinders

with Specification F1002. When the hazard assessment indicates that personal protective equipment complying with Specification F1002 provides insufficient protection, personal protection equipment indicated by the hazard assessment shall be used. Such clothing shall be brushed frequently.

10.8.2.3 *Discussion*—For further information refer to Guide F1449.

10.8.2.4 Magnesium dust shall be mixed with inert materials before disposal. At least three parts inert material to one part magnesium dust shall be used. Disposal shall be by landfill. An exception to these requirements shall be permitted when magnesium is recycled. (The most commonly used inert material is sand.)

10.8.2.5 Personnel shall be trained in the special hazards associated with magnesium grinding.

10.8.2.6 Storage and handling of magnesium shall be in conformance with NFPA 480.

10.9 *Molten Salts Cleaning*

10.9.1 *Unpreheated Parts*—Parts, which are not preheated, shall be lowered into the bath slowly to allow condensation to evaporate. Water shall not be introduced into molten salts bath.

10.9.2 *Water Rinse*—Where a water rinse is used, parts shall be lowered slowly into the rinse to minimize turbulence.

10.9.3 *Probing*—Only dry, solid ferrous rods shall be used for probing, and so forth.

10.9.4 *Splashes*—Care shall be taken to prevent splashes from parts falling out of baskets.

10.9.5 Cleaning procedures for molten salts shall be in conformance with NFPA 86.

10.10 *Hooks Designed for Handling Castings*

10.10.1 Hooks shall not be loaded in excess of their rated capacities.

10.10.2 Shock loading is prohibited.

10.10.3 Load shall be centered in the base (bowl-saddle) of the hood to prevent point loading of the hook (applies only to hoisting hooks).

10.10.4 A hook shall not be used in a manner other than that for which it was intended.

10.10.5 A load shall not be carried by the device bridging the hook throat.

10.10.6 Hands and fingers shall be kept from between the hook and the load.

10.10.7 Hooks shall not be altered by welding or cutting.

10.10.8 Hooks, including those made in house, shall be made and used according to the ANSI/ASME B30.20 standard for below the hook lifting devices.

10.11 *Slings*

10.11.1 Slings that are damaged or defective shall not be used.

10.11.2 Slings shall not be shortened with knots or bolts or other makeshift devices.

10.11.3 Sling legs shall not be kinked.

10.11.4 Slings shall not be loaded in excess of their rated capacities.

10.11.5 Slings used in a basket hitch shall have the loads balanced to prevent slippage.

10.11.6 Slings shall be securely attached to their loads.

10.11.7 Slings shall be padded or protected from the sharp edges of their loads.

10.11.8 Suspended loads shall be kept clear of all obstructions.

10.11.9 All employees shall be kept clear of loads about to be lifted and of suspended loads.

10.11.10 Hands or fingers shall not be placed between the sling and its load while the sling is being tightened around the load.

10.11.11 Shock loading is prohibited.

10.11.12 A sling shall not be pulled from under a load when the load is resting on the sling.

10.11.13 Refer to 29 CFR 1910.184 for inspection and load capacity of slings.

10.12 *Lighting*—Illumination shall be suitable for the intended operation.

10.12.1 *Discussion*—Some recommended minimum intensities are listed in Table 2.

11. Keywords

11.1 cleaning; core making; finishing; melting; metal casting; molding; pouring; safety; sand preparation

TABLE 2

Intensity In Work Area	Candelas[A]
Catwalks	2
Shakeout	30
Sorting	50
Chipping/Grinding (Hvy)	100
Chipping/Grinding (Fine)	500

[A]Refer to the AFS Foundry Environmental Control Manual, Volume 1, and the IES Lighting Handbook—Application Volume, for recommended intensities for other foundry areas and operations.

APPENDIX

(Nonmandatory Information)

X1. GLOSSARY OF TERMS NOT USED IN THIS STANDARD, BUT USEFUL FOR THOSE IN THE FOUNDRY INDUSTRY

X1.1 Definitions:

X1.1.1 *acoustical treatment, n*—means by which the level of sound, noise, or audible vibration may be attenuated (reduced).

X1.1.2 *airless blast cleaning, n*—form of abrasive blast in which the abrasive media is propelled by centrifugal force.

X1.1.3 *anti-tie-down, n*—requires that the two-hand controls function only when both initiators have been released just before operation. Unauthorized tying down of one initiator to permit one-hand operation by the other initiator prevents operation.

X1.1.4 *auger, n*—rotating screw used to mix, or transport, or both sand, clay, or other media used in core and mold making.

X1.1.5 *automatic mode, n*—method of operation in which each function in the equipment cycle is automatically sequenced and repeated.

X1.1.6 *backcharge, n*—recharging a furnace to produce the desired heat size.

X1.1.7 *charge preheater, n*—device for preheating charge materials before they are added to a furnace.

X1.1.8 *clamp frame, n*—moving frame on a core-blowing machine that moves the corebox and presses it against the blow plate.

X1.1.9 *clearance line, n*—line, which marks the distance, required to prevent contact between a guard(s) and moving parts.

X1.1.10 *drain bed, n*—a dry clean, dry bed of refractory like material, usually sand, that is below the cupola drain and is intended to receive or collect molten iron and/or slag from the cupola.

X1.1.11 *drain box, n*—a large box or vessel that is lined with a dry clean, dry refractory like material, usually green sand or refractory, that is placed below the cupola drain and is intended to receive or collect molten iron, or slag, or both from the cupola.

X1.1.12 *flask clamp, n*—device used to lock together two or more flask sections.

X1.1.13 *foot control—initiators, n*—type of control in which the operator causes a motion or actuation of the machine by depressing a foot switch or pedal.

X1.1.13.1 Discussion-The use of foot controls requires additional guarding or operator restraint, unless the control satisfies hostage control 6.5.7 (3) or 6.5.10.

X1.1.14 *hand ladle, n*—handheld ladle for pouring molten metal.

X1.1.15 *hydraulic blasting, v*—method of cleaning castings through the abrasive action of liquid alone or liquid-bearing solid particles.

X1.1.16 *investment mold, n*—flowable mixture of a graded refractory filler, a binder, and a liquid vehicle which, when applied around the patterns, in conformance with their shape and subsequently sets hard to form the investment mold.

X1.1.17 *ladle shank, n*—handle(s) attached to the side(s) of a hoop or band into which a crucible or ladle is placed for pouring.

X1.1.18 *lip pour ladle, n*—ladle in which the contents are discharged over a lip(s) at the top.

X1.1.19 *lock pin, n*—pin, when installed, designed specifically to stop or limit motion of a machine element to attain OSHA lockout/tagout.

X1.1.20 *minimum guarding line, n*—that distance between the point of entry side of the guard and the hazard point.

X1.1.21 *mode of operation, n*—see automatic, manual, and semiautomatic.

X1.1.22 *reclaimed sand, n*—used foundry sand, which has been reprocessed by thermal, air, or hydraulic methods so that it can be used in place of new sand without substantially changing current foundry sand practice.

X1.1.23 *recuperative hot blast operation, n*—operation of a cupola in which effluent gases escaping from the cupola are used to preheat the blast.

X1.1.24 *reverberatory furnace, n*—shallow bath furnace for melting metal in which the bath is heated by the combustion of hot gases over the surface of the metal and by radiation from the roof.

X1.1.25 *shank ladle, n*—ladle with integral support band and handle or handles to support or manually tilt the ladle or both.

X1.1.26 *slip clutch, n*—shaft-coupling device designed to slip when overloaded.

X1.1.27 *tap changer, n*—switching device on power transformers to change the voltage or reactance.

X1.1.28 *teapot ladle, n*—ladle in which molten metal is discharged from below the metal line into an external or internal spout and up over the lip.

X1.1.29 *trolley ladle, n*—ladle supported by an overhead trolley confined by a track system.

X1.1.30 *zero mechanical state (ZMS), n*—now superseded by OSHA lockout/tagout (29 CFR 1910.147). Discussion-This term was pioneered by the American Foundry Society (AFS) and first appeared in a standard in 1975. This was the first general lockout procedure for machines powered by electric or fluid power or both. ZMS required that potential and kinetic energy be reduced, dissipated, or controlled before servicing to avoid injury from unexpected or inadvertent movement. ANSI Z244.1 Safety Requirements for Lockout/Tagout of Energy Sources was first published in 1982. OSHA Standard 29 CFR 1910.147 Machine Lockout/Tagout, Control of Hazardous Energy Sources, was first published in 1989.