

PPE

Fourth Edition

PERSONAL PROTECTIVE EQUIPMENT

GUIDE FOR METALCASTING OPERATIONS



Compiled by: The AFS Safety & Health Committee (10-Q)
Edited by: Susan P. Thomas

A Publication of the American Foundry Society

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Note: The original version was developed by the American Foundry Society (AFS) Safety and Health Committee (10-Q) September, 1998, and revised September 2005 and 2012. This 2015 version supersedes all prior versions.

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Published and distributed by the



Schaumburg, Illinois 60173-4555
www.afsinc.org

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ISBN 978-0-87433-444-9

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Ch. 1 / Scope

1.1 Introduction

This guide describes special considerations for selection and use of personal protective equipment (PPE) and special clothing for work situations that present a risk of exposure to metalcasting hazards.

Use this guide as a tool in completing the PPE hazard assessments for your facility. Company personnel, with their knowledge and familiarity with their specific melting and pouring and other metalcasting processes are in the best position to determine what PPE is the most appropriate, practical, effective and useful for employee health and safety.

1.2 Regulations

This guide does not take the place of other standards and requirements such as OSHA regulations, ANSI standards, and manufacturer recommendations as listed on Safety Data Sheets (SDSs) and product information, or other standards that relate to personal protective equipment (PPE).

This guide frequently refers to federal OSHA regulations. Facilities in state-plan states or outside of the United States should refer to the applicable local, state and federal regulations.

OSHA Standard 29 CFR 1910.132(h), Personal Protective Equipment Standard provides details on the issue of employer payment for PPE or special clothing and equipment. The final rule contains exceptions for certain ordinary protective equipment, such as safety-toe foot-wear, prescription safety eyewear, everyday clothing, and weather-related gear.

The final rule also clarifies OSHA's intent regarding employee-owned PPE and replacement PPE:

- It provides that, if employees choose to use PPE they own, employers will not need to reimburse the employees for the PPE. The Standard also makes clear that employers cannot require employees to provide their own PPE and employee's use of PPE they already own must be completely voluntary. Even when an employee provides his or her own PPE, the employer must ensure that the equipment is adequate to protect the employee from hazards at the workplace.
- It also requires that the employer pay for replacement PPE used to comply with OSHA Standards. However, when an employee has lost or intentionally damages PPE, the employer is not required to pay for its replacement.

Ch. 2 / How to Use This Guide

2.1 Workplace Assessment

Each employer has a responsibility to assess the workplace to determine if hazards may be present that would require the use of PPE. The facility's Hazard Assessment for Personal Protective Equipment Selection must be written. For example, see OSHA Regulation 29 CFR 1910.132(d)]. See Appendix 1 for a sample PPE Hazard Assessment Form.

Identify the potential hazards of the job being evaluated. The assessment should identify potential hazards that require primary protection. Refer to the "Hazards," "Considerations for Hazard Assessment," and "Recommendations and Comments" sections for additional information.

2.2 Identify PPE

Locate the section(s) in the guide for the specific operation(s) in your workplace. Identify the recommended primary and secondary PPE for the potential hazards.

This PPE guide adopts the terminology of primary and secondary protection as used by PPE manufacturers. Secondary, or basic protection is the minimum requirement that applies to everyone in the work area—workers, supervisors, engineers, technicians, observers, etc. Primary protection is designed for significant exposure to specific hazards.

Ch. 3 / Reference Documents

3.1 ASTM (American Society for Testing and Materials) Standards

- E 2349 Standard Practice for Safety in Metal Casting Operations: Sand Preparation, Molding, and Core Making; Melting and Pouring; and Cleaning and Finishing
- F 955 Standard Test Method for Evaluating Heat Transfer Through Materials for Protective Clothing upon Contact with Molten Substances
- F 1002 Standard Performance Specification for Protective Clothing for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards
- F 1449 Standard Guide for Industrial Laundering of Flame, Thermal and Arc Resistant Clothing
- F 2412 Standard Test Methods for Foot Protection
- F 2413 Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear
- F 2913 Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces

3.2 ANSI (American National Standards Institute) Standards

- ANSI/ISEA 105 (International Safety Equipment Association) American National Standard for Hand Protection Selection Criteria
- ANSI Z87.1 American National Standard for Occupational and Educational Personal Eye and Face Protection Devices
- ANSI/AIHA Z88.2 (American Industrial Hygiene Association) Practices for Respiratory Protection
- ANSI/ISEA Z89.1 American National Standard for Industrial Head Protection
- ANSI/ASSE (American Society of Safety Engineers) Z359 Fall Protection Code

3.3 OSHA (Occupational Safety and Health Administration) Standards

- 29 CFR 1910 Subpart I-Personal Protective Equipment
- 29 CFR 1910 Subpart S-Electrical
- 29 CFR 1910 Subpart F-Powered Platforms, Manlifts and Vehicle Mounted Work Platforms

3.4 NFPA (National Fire Protection Association) Standard

- NFPA 70E Standard for Electrical Safety in the Workplace
- NFPA 484 Standard for Combustible Metals
- NFPA 2112 Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire
- NFPA 2113 Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures

3.5 AFS (American Foundry Society) Publication

- “Health and Safety Guides,” Fourth Edition, A Publication of the American Foundry Society, (2012)

3.6 ISO (International Organization for Standardization)

- ISO 9185 Protective Clothing—Assessment for Resistance of Materials to Molten Metal Splash
- ISO 11612 Protective Clothing—Clothing to Protect Against Heat and Flame

Ch. 4 / Terminology and Acronyms

4.1 Terminology

Chaps—a garment designed to protect the front and sides of the leg, usually worn over pants from the waist to the ankle, often open in the back.

Ferrous—in general, metals or alloys that consist primarily of iron.

Flame Resistant (FR)—the characteristic of a fabric to resist ignition and to self-extinguish if ignited. Flame Resistant (FR) fabrics fall into two categories: Inherently FR and fabrics that are specially treated to become FR.

Flame Retardant—a chemical substance used to impart flame resistance.

FR Cotton (Flame Resistant Cotton)—a cotton fabric that has been treated to self-extinguish upon the removal of an ignition source.

Hazard Zone—that area where the potential for bodily injury exists.

Leggings—a garment designed to protect the lower leg (usually extending from the knee to the ankle). Some leggings include built in spats.

Nonferrous, Aluminum—any metal or metal alloys whose principal constituent is aluminum (Al).

Nonferrous, Copper-based—any metal or metal alloy whose principal constituent is copper (Cu), includes brass and bronze. Alloys often contain lesser amounts of zinc, lead, tin or other metals.

Nonferrous, Magnesium—any metal or metal alloys whose principal constituent is magnesium (Mg).

Nonferrous, Other Special Metals—includes zinc (Zn), gold (Au) and silver (Ag).

Personal Protective Equipment (PPE)—includes a variety of devices and garments to worn by workers as protection from hazards.

Primary Protection—clothing or personal protective equipment (PPE) designed for activities where significant exposure to hazards such as molten metal splash, radiant heat, flame, noise or flying particles is likely to occur.

Secondary Protection—clothing or personal protective equipment designed as basic protection for continuous use in areas where intermittent exposure to hazards is possible.

Spats—a covering for the top and sides of the boot (metatarsal, instep, and ankle area).

4.2 Acronyms

AFS—American Foundry Society

AIHA—American Industrial Hygiene Association

ANSI—American National Standards Institute

ASSE—American Society of Safety Engineers

ASTM—American Society for Testing and Materials

CFR—Code of Federal Regulations

FR—Flame Resistant

ISO—International Organization for Standardization

NFPA—National Fire Protection Association

OSHA—Occupational Safety and Health Administration

PAPR—Powered Air Purifying Respirators

PEL—Permissible Exposure Limit

PPE—Personal Protective Equipment

Ch. 5 / Considerations for Selection & Use of PPE & Special Clothing

5.1 Control Strategies

In safety and health practice the hierarchy of controls specifies elimination of the hazard. Other control strategies such as substitution, engineering controls, work practices, and administrative controls should also be considered. Personal protective equipment is often at the bottom of the hierarchy due to issues associated with comfort, fit, acceptability, reliability and effectiveness. In fact, reliability and performance issues are also associated with engineering controls. In certain situations as explained in Chapter 11, some forms of respiratory PPE can provide superior protection. In situations where exposures are generally controlled, PPE is often used for the following reasons:

- as a backup precaution in case other controls fail;
- in situations where exposure variability means that occasional overexposures are possible; or
- as additional protection to reduce exposures to below the levels possible with other controls.
- while higher level controls are implemented
- while waiting for test verification
- to augment other controls

5.2 Requirements

PPE requirements shall be based on a hazard assessment as required by OSHA Standard 29CFR 1910.132. Each job and related work activity shall be evaluated. The hazard assessment shall be reviewed when job hazards change and shall be modified as necessary. The hazard assessment should be reviewed annually. The hazard assessment shall be documented and reviewed with employees.

5.3 Training

Employees who are required to wear PPE or specialized clothing shall be trained in its limitations, proper inspection, use, care and storage. An employee must be retrained when:

- Work habits or demonstrated knowledge indicates a lack of the necessary understanding, motivation, and skills required to use the PPE (i.e., improper usage of PPE);
- Workplace changes require updated training (i.e., when employees change jobs or new equipment is introduced); or
- PPE updates require more advanced training.
- Periodic refresher training

5.4 PPE Usage

PPE must be correctly fitted, worn, maintained, cleaned and disposed of properly. In situations where contaminated clothing or equipment may pose a risk to persons other than the user (i.e., laundry or cleaning personnel) those individuals shall be provided with appropriate hazard warning information.

5.5 Additional Precautions

Wearing jewelry, including exposed body piercing jewelry, should be prohibited in hazard zones. Clothing should be properly sized so as not to get caught in moving machinery. Hair longer than 4 inches can be drawn into machine parts such as suction devices, blowers, chains, belts, and rotating devices. Hair must be securely restrained with a bandana, hair net, soft cap or pulled back.

5.6 Heat Stress Potential

Protective clothing may add to the heat load of the worker and increase body temperature. Recognize the potential for heat stress when selecting special clothing. A heat stress program may be necessary to manage the potential heat stress hazard.

5.7 Additional Protection

Fall protection may be necessary for work activities performed at heights above 4 feet without adequate railings, guards, or near pits or open-sided floors. It is addressed in this guide only in connection with maintenance activities, but may be a consideration for other activities such as cleaning or clearing jams or accessing equipment.

Ch. 6 / Clothing and PPE: Melting and Pouring Operations

6.1 Secondary Protection: Melting and Pouring Operations

Secondary Protection—clothing or personal protective equipment designed as basic protection for continuous use in areas where intermittent exposure to hazards is possible.

Recommended minimum specialized clothing and personal protective equipment (PPE) for all melting and pouring operations include the following:

The following items are secondary (basic) protection:

- 100% cotton or wool socks
- 100% cotton undergarments
- 100% cotton or wool outer garments
- Safety glasses with side protection.
- Leather safety shoes with toe protection and a smooth toe.

Hearing protection and respiratory protection may be necessary depending on degree of potential exposure.

For employees in a hazard zone (i.e., near a furnace or ladle containing molten metal or other known hazards) additional primary protection is required.

6.2 Primary Clothing Protection: Melting and Pouring Operations

Primary Protection—clothing or personal protective equipment (PPE) designed for activities where significant exposure to hazards such as molten metal splash, radiant heat, flame, noise or flying particles is likely to occur.

6.2.1 Primary Clothing Protection: Ferrous Metals

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment some operations may require primary protection beyond the secondary (basic) protection.

Hazards

- Burns from physical contact with molten metal splash, molten metal run-out, spills, sparks, flames, hot surfaces, cold tools or liquid introduction into molten metal (explosion).
- Burns and heat stress from exposure to radiant heat.

Materials

- Aluminized Material
- Leather
- Flame Resistant (FR) Cotton
- Wool
- Other fabrics which are acceptable as determined by testing described in ASTM Standard F1002 or other accepted test methods.

Types of PPE

- Coats
- Jackets
- Aprons
- Cape, sleeve(s) and bib
- Leggings
- Chaps
- Spats

(See Sections 6.3, 6.4, 6.5 & 6.6 for additional PPE requirements for eye and face; head, hand and foot; hearing; and respiratory protection.)

6.2.2 Primary Protection: Nonferrous Metals

<p><u>Potential Hazards</u></p> <p>Evaluate the applicability of these items when performing the hazard assessment.</p>
<p><u>Primary Protection</u></p> <p>Based on the results of the hazard assessment some operations may require additional clothing and PPE beyond the basic secondary protection.</p>
<p><u>Hazards</u></p> <ul style="list-style-type: none">• Burns from physical contact with molten metal splash, molten metal run-out, spills, sparks, flames, hot surfaces, cold tools or liquid introduction into molten metal (explosion).• Burns and heat stress from exposure to radiant heat.• Magnesium only—spontaneous ignition of dust.
<p><u>Materials</u></p> <ul style="list-style-type: none">• Aluminized material• Leather• Wool• Other fabrics which are acceptable as determined by testing as described in ASTM Standard F1002 or other accepted test methods.
<p><u>Types of PPE</u></p> <ul style="list-style-type: none">• Coats• Jackets• Aprons• Cape, sleeve(s) and bib• Leggings• Chaps• Spats <p>(See Sections 6.3, 6.4, 6.5 and 6.6 for additional PPE requirements for eye and face; head, hand and foot; hearing; and respiratory protection.)</p>

6.2.3 Considerations for Hazard Assessment (Ferrous and Nonferrous)

- Presence of molten metal in furnace, ladle and/or mold.
- Temperature of the metal or hot surface.
- The level of the metal and area of the body that could be impacted by a splash, runout, sparks, flames, or hot surfaces.
- Proximity to molten metal and hot surfaces (i.e., work inside hazard zone around induction furnaces).
- Material being handled (i.e., additives, chilling blocks)
- Amount of metal will affect the amount of radiant heat and quantity of metal, melted or poured, that could impact the body.
- Potential for molten metal explosion due to moisture in charge materials, failure of furnace cooling lines, or bursting molds.

6.2.4 Recommendations and Comments

- Reference OSHA Standard 29 CFR 1910.132 for General PPE requirements.
- Refer to ASTM Standard F 1002 Standard Performance Specification for Protective Clothing for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards and request to see the results of the ASTM Standard F 955 Standard Test Method for Evaluating Heat Transfer for specific fabrics.
- ASTM Standard F 955 Standard Test Method for Evaluating Heat Transfer tests are conducted using pure metals and results may be different with various alloys. Users should use test data from their own alloys to compare fabric performance. Combinations of primary and secondary clothing/protective garments used at a facility should be tested to ensure that the combination performs satisfactorily using the Stoll curve test (Appendix 2)
- For molten metal splash hazards, clothing may be rated for levels of protection according to ISO 9185 (D1, D2, or D3 for aluminum; E1, E2 or E3 for ferrous metals).
- Wear pants or leggings that cover the top of the boot (and spats, if worn) to prevent molten metal and sparks from entering the boot. Never tuck pant legs inside the boot or spats. If leggings are worn over pants a long protective coat must be worn which covers the top portion of the legging.
- If laced boots are worn, spats or leggings that cover the lacings must be used whenever molten metal or sparks could lodge in the tongue area of the boot.
- **DO NOT** wear Nomex™ because all molten metals tend to stick to the fabric.
- Nonferrous Metals—**DO NOT** wear phosphorus treated cotton because molten metal tends to stick to the fabric. Many flame resistant (FR) cotton fabrics use a phosphorous-based treatment.
- **DO NOT** wear polyester, nylon, and other man-made materials that can melt and readily ignite.
- Long pants are required and long sleeved shirts are recommended.
- For pouring operations the use of spats, leggings, and chaps should be evaluated.
- Wear clothing that does not trap molten metal and sparks (i.e., no cuffs, open pockets, loose legging tops, etc.).

- Maintain all protective clothing in serviceable condition. No holes, rips or tears. Refer to ASTM Standard F 1449 Standard Guide for Industrial Laundering of Flame, Thermal and Arc Resistant Clothing.
- Fabric repair must be done in a way that maintains the flame resistant properties.
- Wear types of PPE in any combination as needed to protect body parts that are exposed to heat or metal splatter as determined by the hazard assessment for each work activity.
- Protective clothing may add to the heat load of the worker. Recognize the potential for heat stress when selecting special clothing. A heat stress program may be necessary to manage the potential of heat stress.
- Aluminized PPE should be considered for exposure to high heat and spark producing areas such as lancing, tapping, slagging or activities where molten metal splash is possible. It is not universally required when pouring metal into molds.

6.3 Eye and Face Primary Protection: Melting and Pouring Operations

<p><u>Potential Hazards</u></p> <p>Evaluate the applicability of these items when performing the hazard assessment.</p>
<p><u>Primary Protection</u></p> <p>Based on the results of the hazard assessment some operations may require additional PPE beyond the secondary (basic) protection.</p>
<p><u>Hazards</u></p> <ul style="list-style-type: none"> • Eye and face injuries from foreign bodies, molten metal splash, chemicals • Damage from infrared and/or ultraviolet radiation or heat.
<p><u>Eye Protection</u></p> <ul style="list-style-type: none"> • Goggles • Full face shield—thermal/IR (gold tint, wire mesh) • Full face shield—molten metal splash (polycarbonate or #40 steel wire mesh) • Tinted glasses (specific for metal poured): <p><u>Iron</u> Shade #3-#5 Green</p> <p><u>Steel</u> Shade #8 Green or Shade #6 Cobalt Blue <u>Brass/Bronze</u> Shade #3-#5 Green or Shade #3 Green with #3 Aluminized Face Shield or Shade #6 Cobalt Blue (half-lenses)</p> <p><u>Aluminum</u> Clear, No Tint</p> <p><u>Magnesium</u> Clear, No Tint</p>

Considerations for Hazard Assessment

- High temperature surfaces emit infrared radiation
- Electric arcs emit ultraviolet radiation

Recommendations and Comments

- Reference OSHA Standard 29 CFR 1910.133 Eye and Face Protection.
- Refer to ANSI Standard Z87.1 American National Standard for Occupational and Educational Personal Eye and Face Protection for protection specifications.
- Use the appropriate darker lenses to protect against intense infrared radiant energy.
- Eye protection that is too dark may reduce visibility and create hazards such as tripping. Switch to lower shade numbers or clear lenses when leaving the molten metal area or during extended periods when no molten metal viewing is required.
- Higher shade numbers are for direct viewing of molten metal for extended periods of time such as for making quality checks, pouring, or slagging.
- Lower shade numbers can be used where molten metal viewing is momentary or incidental.
- Ultraviolet (UV) and Infrared (IR) radiation exposure follows the inverse square law; therefore, the exposure level rapidly diminishes at greater distances.
- A full face shield (such as polycarbonate or #40 steel mesh) must be worn where workers are exposed to a potential hazard of molten metal splash or high heat.
- When face protection is worn, safety glasses with side protection must also be worn.
- A reflective face shield can reduce radiant heat load and increase worker comfort.

6.4 Head, Hand and Foot Primary Protection: Melting and Pouring Operations

<p><u>Potential Hazards</u></p> <p>Evaluate the applicability of these items when performing the hazard assessment.</p>
<p><u>Primary Protection</u></p> <p>Based on the results of the hazard assessment some operations may require additional PPE beyond the secondary (basic) protection.</p>
<p><u>Hazards</u></p> <ul style="list-style-type: none">• Head injuries from falling objects, moving equipment and/or overhead obstructions.• Burns from physical contact with molten metal splash, sparks, flames and/or hot surfaces.• Foot injuries from falling or rolling objects.• Scrapes, cuts, and abrasions.• Hand injuries from vibrating tools or equipment.
<p><u>Head Protection</u></p> <ul style="list-style-type: none">• Hard hat (thermal rated)• Cotton cap• Wool cap• Aluminized Hood <p><u>Hand Protection</u></p> <p>Materials:</p> <ul style="list-style-type: none">• Leather• Cotton• Wool• Kevlar™• Wool lined Kevlar™• Aluminized Fabric• Other heat resistant materials <p>Types of PPE:</p> <ul style="list-style-type: none">• Mitts• Cover mitts• Cover pads• Gloves• Shock or vibration resistant glove liners <p><u>Foot Protection</u></p> <ul style="list-style-type: none">• Metatarsal safety shoe• Heat resistant soles

Recommendations and Comments

Head Protection

- Reference OSHA Standard 29 CFR 1910.135 Personal Protective Equipment, Head Protection.
- Refer to ANSI/ISEA Standard Z89.1 American National Standard for Industrial Head Protection for hard hat specifications.
- Cotton or wool caps may provide protection where minor metal splatter may contact head.

Hand Protection

- Reference OSHA Standard 29 CFR 1910.138 Personal Protective Equipment, Hand Protection.
- Reference ANSI/ISEA American National Standard for hand protection
 - Consider permeation breakthrough, permeation rate and degradation rating when evaluating chemical resistance
 - Consider ANSI cut resistance performance level
- Consider need for dexterity and grip security when operating equipment.
- Do not use gauntlet type gloves unless there is no chance of metal being spilled into the glove.
- The sleeve should cover the end of the glove unless reaching overhead.
- **DO NOT** wear Nomex™ gloves as molten metal tends to stick to the fabric.
- Do not use asbestos-containing gloves
- Try insulated tools rated for electrical protection to reduce electrical shock hazard from contact with molten metal in induction furnaces.

Foot Protection

- Reference OSHA Standard 29 CFR 1910.136 Personal Protective Equipment, Foot Protection.
- Refer to ASTM F 2412 Standard Test Methods for Foot Protection and ASTM F 2413 Standard Specification for Performance Requirement for Protective (Safety) Toe Cap Footwear for foot protection specifications.
- If metatarsals are worn select built in design or wear spats or leggings that cover areas where molten metal or sparks could lodge.
- A 6-inch or 8-inch engineer's boot is recommended. (An engineer's boot has no laces or zipper.)
- If lace boots are worn, wear spats or leggings that cover the lacings whenever molten metal or sparks could lodge in the tongue area of the boot.
- Wear pants or leggings that cover the top of the boot to prevent molten metal and sparks from entering the boot. **NEVER TUCK** pant legs inside the boot or spat. If leggings are worn over pants a long protective coat must be worn which covers the top portion of the legging.
- **DO NOT** use shoes with exposed zippers or elastic materials that could melt or ignite.
- Consider slip resistance of footwear

6.5 Hearing Primary Protection: Melting and Pouring Operations

<p><u>Potential Hazards</u></p> <p>Evaluate the applicability of these items when performing the hazard assessment.</p>
<p><u>Primary Protection</u></p> <p>Based on the results of the hazard assessment, including noise level monitoring results, some operations may require hearing protection.</p>
<p><u>Hazards</u></p> <ul style="list-style-type: none">• Hearing loss due to noise exposure• Inability to hear warnings
<p><u>Hearing Protection</u></p> <ul style="list-style-type: none">• Materials• Ear plugs• Ear muffs• Ear caps

Considerations for Hazard Assessment

- Review results of noise level monitoring.

Recommendations and Comments

- Reference OSHA Standard 29 CFR 1910.95 Occupational Noise Exposure.
- Select hearing protection that provides sufficient noise reduction for the exposure.
- Proper fitting and wearing of hearing protection is necessary to obtain adequate noise reduction.
- When calculating noise reduction, the noise reduction rating (NRR) of the ear protector must be discounted as described in the OSHA Standard 29 CFR 1910.95 Appendix B - Methods for Estimating the Adequacy of Hearing Protector Attenuation.
- Select hearing protection materials that will not ignite on contact with hot metal sparks.
- In some cases double hearing protection (muffs over plugs) may be required to reduce high noise levels.

6.6 Respiratory Primary Protection: Melting and Pouring Operations

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment, including industrial hygiene monitoring results, some operations may require specific respiratory protection.

Hazards

- Exposure to toxic metals (for example- lead, cadmium, arsenic, beryllium, hexavalent chromium) either as part of the alloy or as a contaminant of the scrap being melted
- Exposure to toxic gases (i.e., carbon monoxide, benzene, phenol)
- Crystalline silica exposures from handling refractory materials, such as furnace and ladle tear-out and relining, and from other metalcasting areas
- Magnesium only—**Acid gases when sludging**
- Aluminum, chlorine or fluorides used for degassing

Respiratory Protection

Select the appropriate filter media for the type of contaminant (particulate, metal fumes, organic vapor, acid gas, etc.). For example, a N95 particulate respirator will not be effective for vapor exposure.

- Half mask respirator
- Full face piece respirator
- Filtering face piece respirator (Air-purifying respirator)
- Powered air-purifying respirator (PAPR)
- Air supplied helmet or hood

Considerations for Hazard Assessment

- Review results of industrial hygiene monitoring of noise, dusts, metal fumes, gases and vapors when performing your Hazard Assessment.
- Safety Data Sheets (SDS)
- “Health and Safety Guides”, American Foundry Society, Schaumburg, IL (2012)

Recommendations and Comments

- Reference OSHA Standard 29 CFR 1910.134 Respiratory Protection and substance specific standards (i.e., OSHA Standard 29 CFR 1910.1025 for lead).
- Refer to NIOSH certification 42 CFR 84 Selection and Use of Particulate Respirators for respirator selection.
- Respirator selection and use must be part of an effective respiratory protection program.
- Respirator assigned protection factor should be sufficient to reduce exposures below the relevant occupational exposure limit (OEL).
- Refer to chapter 11 for more information on respiratory protection.

Ch.7 / Clothing and PPE: Molding and Coremaking Operations

7.1 Secondary Protection

Recommended minimum protection for all molding and coremaking operations: For employees in a hazardous zone application specific protection is required.

The following are secondary (basic) protection:

- Clothing—100% cotton shirt and long pants if working around hot equipment
- Eye Protection—Safety glasses with side shields
- Foot Protection—Safety toe footwear

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment some operations may require additional clothing and PPE beyond the secondary (basic) protection.

Hazards

- Heat and hot surfaces
- Rolling and pinching exposures (cores, coreboxes, lifting devices)
- Sharp objects and edges
- Flying and falling objects (sand, cores, plywood separators)
- Dust from coremaking and cleaning
- Chemical contact, splash and spray (resins, catalysts, parting sprays)
- Acids and caustics from scrubbers
- Noise
- Airborne contaminants (i.e., silica, formaldehyde, ammonia, amines, CO₂, SO₂, phenol, isocyanates)
- Combustible dust (mixing phenolic resins, organic molding material)

Protective Clothing

- Long sleeved shirts
- Flame resistant (FR) fabrics
- Sleeves
- Coveralls
- Apron

Hand Protection

- Gloves (heat, chemical, cut resistant)
- Anti-vibration gloves

Head Protection

- Hard hat/bump cap

Foot Protection

- Metatarsal safety shoes

Eye and Face Protection

- Goggles (impact, chemical resistant)
- Face shield

Hearing Protection

- Ear plugs, caps and muffs

Respiratory Protection

- Select the appropriate filter media for the type of contaminant (particulate, metal fumes, organic vapor, acid gas, etc.). For example, a N95 particulate respirator will not be effective for vapor exposure.
- Half mask respirator
- Full face piece respirator
- Filtering face piece respirator
- Air-purifying respirator (APR)
- Powered air-purifying respirator (PAPR)
- Air supplied hood or helmet

Considerations for Hazard Assessment

- Review results of industrial hygiene monitoring of noise, dusts, metal fumes, gases and vapors when performing your Hazard Assessment.
- Materials used (refer to Safety Data Sheets for hazardous ingredients and recommended precautions).
- Results of combustible dust assessment of materials used (e.g. phenolic resins, organic binders).
- Arrangement of job (overhead work, machine guarding, size and weight of core).

Recommendations and Comments

Protective Clothing

- Reference OSHA Standard 29 CFR 1910.132 General Requirements for OSHA PPE requirements.
- 100% cotton or FR clothing should be worn when working around hotbox or shell core machines to protect against open flame.
- FR clothing rated for flash fire protection (NFPA 2113) should be worn when combustible dust hazard is present.

Hand Protection

- Reference OSHA Standard 29 CFR 1910.138 Personal Protective Equipment, Hand Protection.
- Consider need for dexterity and grip security when operating equipment. Consider permeation breakthrough, permeation rate and degradation rating when evaluating chemical resistance
- Consider ANSI cut resistance performance level
- Using finger exposed anti-vibration gloves is not recommended since hand-arm vibration syndrome usually begins at the fingertips moving towards the palm.
- Select gloves that provide chemical resistance to materials in use.

Head Protection

- Reference OSHA Standard 29 CFR 1910.135 Personal Protective Equipment, Head Protection.
- Refer to ANSI/ISEA Z89.1 American National Standard for Industrial Head Protection for hard hat specifications.

Foot Protection

- Reference OSHA Standard 29 CFR 1910.136 Personal Protective Equipment, Foot Protection.
- Refer to ASTM F 2412 and F 2413 for foot protection specifications.

Eye and Face Protection

- Reference OSHA Standard 29 CFR 1910.133 Personal Protective Equipment, Eye and Face Protection.
- Refer to ANSI Z87.1 American National Standard for Occupational and Educational Personal Eye Protection for eye protection specifications.

Hearing Protection

- Reference OSHA Standard 29 CFR 1910.95 Occupational Noise Exposure.
- Select hearing protection that provides sufficient noise reduction for the exposure.

Respiratory Protection

- Reference OSHA Standard 29 CFR 1910.134 Personal Protective Equipment, Respiratory Protection.
- Refer to NIOSH Certification 42 CFR 84 Selection and Use of Particulate Respirators for respirator selection.
- Respirator selection and use must be part of an effective respiratory protection program.
- An air-supplied hood or helmet may also provide protection from heat and eye hazards (See Section 11).

Ch. 8 / Clothing and PPE: Cleaning and Finishing

8.1 Secondary Protection

Recommended minimum protection for all cleaning and finishing operations:
For employees in a hazardous zone application specific protection is required.

The following are secondary (basic) protection:

- Clothing—long pants and long sleeved shirts
- Eye Protection—safety glasses with side protection
- Foot Protection—safety toe footwear

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment some operations may require additional clothing and PPE beyond the secondary (basic) protection.

Hazards

- Heat, sparks and hot surfaces
- Rolling, pinching and abrasive exposures (castings, grinding equipment, hand tools, lifting devices)
- Sharp objects and edges (gating and flashings)
- Vibration (hand, swing and stand grinding and chipping)
- Flying and falling objects (sand, castings, shattering grinding wheels)
- Dust and particles from shakeout, shot blast, grinding and cleaning
- Noise
- Airborne contaminants (Silica, dust, metal particulate)
- Hazards associated with welding, cutting, and scarfing (arc air)
- Combustible dust (baghouses, aluminum or magnesium dust)

Protective Clothing

- Cotton or FR long sleeved shirts
- Flame Resistant (FR) fabrics
- Sleeves
- Coveralls, apron
- Welding apparel

Hand Protection

- Gloves (heat, cut resistant)
- Anti-vibration gloves

Head Protection

- Hard hat/bump cap
- Hair net, shroud or snood

Foot Protection

- Metatarsal safety shoes

Eye and Face Protection

- Dust sealed glasses/goggles
- Goggles (impact resistant)
- Face shield
- Air supplied hood
- Welding helmets

Hearing Protection

- Ear plugs, caps and muffs

Respiratory Protection

- Select the appropriate filter media for the type of contaminant (particulate, metal fumes, organic vapor, acid gas, etc.). For example, a N95 particulate respirator will not be effective for vapor exposure.
- Half mask respirator
- Full face piece respirator
- Filtering face piece respirator
- Air-purifying respirator (APR)
- Powered air-purifying respirator (PAPR)
- Air supplied hood or helmet (See Chapter 11)

Considerations for Hazard Assessment

- Review results of industrial hygiene monitoring of noise, dusts, metal fumes, gases and vapors when performing your Hazard Assessment.
- Results of combustible dust assessment (e.g. abrasive blast dusts, fine dust from grinding or polishing combustible metal such as aluminum and magnesium).
- Size, weight and configuration of castings.
- Content of alloy

Recommendations and Comments

Protective Clothing

- Reference OSHA Standard 29 CFR 1910.132 General Requirements, for OSHA PPE requirements.
- 100% cotton clothing should be worn when working around hot castings or sparks from scarfing, cutting, welding or grinding operations.
- Flame resistant (FR) clothing rated for flash fire protection (NFPA 2113) should be worn when combustible dust hazard is present.
- Sleeves should protect against hot surfaces.

Hand Protection

- Reference OSHA Standard 29 CFR 1910.138 Hand Protection.
- Consider need for dexterity and grip security when operating equipment. Using finger exposed anti-vibration gloves is not recommended since hand-arm vibration syndrome usually begins at the fingertips moving downward towards the palm
- Hand protection may provide a combination of cut and vibration protection or may be layered. Consider ANSI cut resistance performance level.

Head Protection

- Reference OSHA Standard 29 CFR 1910.135 Head Protection.
- Refer to ANSI Z89.1 American National Standard for Industrial Head Protection for hard hat specifications

Foot Protection

- Reference OSHA Standard 29 CFR 1910.136 Foot Protection.
- Refer to ASTM F 2412 Standard Test Method for Foot Protection and F 2413 Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear for foot protection specifications.
- Consider slip resistance of footwear

Eye and Face Protection

- Reference OSHA Standard 29 CFR 1910.133 Eye and Face Protection.
- Refer to ANSI Z87.1 American National Standard for Occupational and Educational Personal Eye and Face Protection for eye protection specifications.
- Refer to ANSI Z49.1 Safety and Welding and Cutting and Allied Processes for welding protection.

Hearing Protection

- Reference OSHA Standard 29 CFR 1910.95 Occupational Noise Exposure.
- Select hearing protection that provides sufficient noise reduction for the exposure.

Respiratory Protection

- Reference OSHA Standard 29 CFR 1910.134 Respiratory Protection.
- Refer to NIOSH Certification 42 CFR 84 Selection and Use of Particulate Respirator for respirator selection.
- Respirator selection and use must be part of an effective respiratory protection program.
- An air-supplied hood or helmet may also provide protection from heat and eye hazards. (See Section 11).

Ch. 9 / Clothing and PPE: Machining

9.1 Secondary Protection

Recommended minimum protection for all machining operations: For employees in a hazardous zone application specific protection is required.

The following are secondary (basic) protection:

- Clothing—long pants
- Eye Protection—safety glasses with side protection
- Foot Protection—safety toe footwear

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment some operations may require additional clothing and PPE beyond the secondary (basic) protection.

Hazards

- Rolling and pinching exposures (castings, rotating machinery, lifting devices)
- Sharp objects and edges
- Flying and falling objects
- Entanglement hazard from gloves, loose clothing, hair, etc.
- Dust and particles (inhalable or ingestible) from machining
- Chemical exposures (coolants and lubricants)
- Noise
- Airborne contaminants (metal particulates, metalworking fluids)
- Burns from hot chips or parts
- Combustible dust hazard (machining, grinding or polishing combustible metals such as aluminum and magnesium)

<p><u>Protective Clothing</u></p> <ul style="list-style-type: none"> • Cotton or FR long sleeved shirts • Sleeves
<p><u>Hand Protection</u></p> <ul style="list-style-type: none"> • Gloves
<p><u>Head Protection</u></p> <ul style="list-style-type: none"> • Caps • Shrouds • Hair net or snood
<p><u>Foot Protection</u></p> <ul style="list-style-type: none"> • Metatarsal safety shoes
<p><u>Eye and Face Protection</u></p> <ul style="list-style-type: none"> • Goggles (impact, chemical resistant) • Face shield
<p><u>Hearing Protection</u></p> <ul style="list-style-type: none"> • Ear plugs, caps and muffs
<p><u>Respiratory Protection</u></p> <ul style="list-style-type: none"> • Select the appropriate filter media for the type of contaminant (particulate, metal fumes, organic vapor, acid gas, etc.). For example, a N95 particulate respirator will not be effective for vapor exposure. • Half mask respirator • Full face piece respirator • Filtering face piece respirator • Air-purifying respirator (APR) • Powered air-purifying respirator (PAPR)

Considerations for Hazard Assessment

- Review results of industrial hygiene monitoring of noise, dusts, metal fumes, gases and vapors when performing your Hazard Assessment.
- Results of combustible dust assessment (e.g. machining magnesium, fine dust from grinding or polishing combustible metal such as aluminum and magnesium).
- Size, weight and configuration of castings.

Recommendations and Comments

Protective Clothing

- Reference OSHA Standard 29 CFR 1910.132 General Requirements for OSHA PPE requirements.
- Machine operators should never wear jewelry or loose fitting clothing, especially loose sleeves or jacket cuffs and neckties.
- Flame resistant (FR) clothing rated for flash fire protection (NFPA 2113) should be worn when combustible dust hazard is present.

Hand Protection

- Reference OSHA Standard 29 CFR 1910.138 Hand Protection.
- Reference ANSI/ISEA American National Standard for Hand Protection.
- Gloves may be worn as long as another hazard is not created. Gloves should not be worn on some machine operations (i.e., with exposed rotating tools or parts)
- Where worn, gloves with a tight fitting knitted cuff may reduce the possibility of snagging on equipment and may help keep chips out.
- Barrier creams and personal hygiene may reduce skin irritation.
- Impervious glove materials may be required for prolonged exposure to chemicals or metalworking fluids. Consider permeation breakthrough, permeation rate and degradation rating when evaluating chemical resistance.

Head Protection

- Reference OSHA Standard 29 CFR 1910.135 Head Protection.
- Refer to ANSI Z89.1 American National Standard for Industrial Head Protection for hard hat specifications
- Keep long hair that could be caught by moving parts covered.
- Caps and shrouds should not have dangling parts

Foot Protection

- Reference OSHA Standard 29 CFR 1910.136 Foot Protection.
- Refer to ASTM F 2412 and F 2413 for foot protection specifications.

Eye and Face Protection

- Reference OSHA Standard 29 CFR 1910.133 Eye and Face Protection.
- Refer to ANSI Z87.1 American National Standard for Occupation and Education Personnel Eye and Face Protection for eye protection specifications.

Hearing Protection

- Reference OSHA Standard 29 CFR 1910.95 Occupational Noise Exposure.
- Select hearing protection that provides sufficient noise reduction for the exposure.

Respiratory Protection

- Reference OSHA Standard 29 CFR 1910.134 Respiratory Protection.
- Refer to NIOSH Certification 42 CFR 84 Selection and Use of Particulate Respirator for respirator selection.

Note: An effective Respirator Protection Program will also provide guidelines for proper respirator selection and use.

Ch. 10 / Clothing and PPE: Maintenance and Other Operations

10.1 Secondary Protection

Recommended minimum protection for all maintenance operations: For employees in a hazardous zone application specific protection is required.

- The following are secondary (basic) protection:
- Clothing—100% cotton shirt and long pants
- Eye Protection—safety glasses with side shields
- Foot Protection—safety toe footwear

Potential Hazards

Evaluate the applicability of these items when performing the hazard assessment.

Primary Protection

Based on the results of the hazard assessment some operations may require additional clothing and PPE beyond the secondary (basic) protection.

Refer to specific process requirements listed in previous sections for appropriate clothing and PPE when performing tasks in those areas.

For example when working in the melting and pouring area refer to Sections 6.1 through 6.6.

Hazards

- Heat and hot surfaces
- Rolling and pinching exposures
- Sharp objects and edges
- Flying and falling objects
- Electrical hazards including arc flash
- Weld flash
- Slips, trips and falls
- Work at elevations
- Dust and particles
- Compressed air
- Confined spaces
- Mechanical, manual handling
- Combustible dust hazard

Hazards (cont'd)

- Chemical splash and spray (resins, catalysts, parting sprays)
- Acids and caustics from scrubbers
- Noise and vibration
- Airborne contaminants (for example- Silica, formaldehyde, ammonia, amines, CO₂, SO₂, phenol, isocyanates, welding fume)

Protective Clothing

- Long sleeved shirts
- Flame resistant (FR) fabrics
- Sleeves
- Coveralls, apron
- Clothing suitable for arc flash protection

Hand Protection

- Gloves (heat, chemical, cut resistant, welding)
- Anti-vibration gloves
- Electrically insulated gloves and overgloves

Head Protection

- Hard hat/bump cap

Foot Protection

- Metatarsal safety shoes (internal metatarsal)
- Non-conductive shoes

Fall Protection

- Personal fall arrest system

Eye and Face Protection

- Goggles (impact, chemical resistant)
- Face shield
- Welding helmet

Hearing Protection

- Ear plugs, caps and muffs

Respiratory Protection

- Select the appropriate filter media for the type of contaminant (particulate, metal fumes, organic vapor, acid gas, etc.). For example, a N95 particulate respirator will not be effective for vapor exposure.
- Half mask respirator
- Full face piece respirator
- Filtering face piece respirator
- Air-purifying respirator (APR)
- Powered air-purifying respirator (PAPR)

Considerations for Hazard Assessment

- Refer to specific process requirements listed in previous sections of this guide for suggestions of appropriate clothing and PPE when performing tasks in those areas.
- Results of combustible dust assessments.
- Review results of industrial hygiene monitoring of noise, dusts, metal fumes, gases and vapors when performing your Hazard Assessment.

Recommendations and Comments

Protective Clothing

- Reference OSHA Standard 29 CFR 1910.132 General Requirements for OSHA PPE requirements.
- Maintenance personnel perform a wide variety of tasks in different areas of the metalcasting facility. Appropriate clothing and PPE must be available for performing work in these different areas, especially when performing non-routine tasks. PPE must be appropriate both for the task being performed and the area where it is being done.
- Flame Resistant (FR) Clothing
 - Arc Flash Protection - Refer to NFPA 70E Standard for Electrical Safety in the Workplace for PPE and other electrical protection requirements and NFPA 2112 Standard on Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire
 - Molten Metal Splash – Refer to ASTM F1002 Standard Performance Specification for Protective Clothing for Use by Workers Exposed to Specific Molten Metal Substances and Related Thermal Hazards or ISO 9185 Protective Clothing – Assessment of Resistance of Materials to Molten Metal Splash
 - Combustible Dust Flash Fire – Refer to NFPA 2113 Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel against Short-Duration Thermal Exposures

Hand Protection

- Reference OSHA Standard 29 CFR 1910.138 Hand Protection.
- Reference ANSI/ISEA American National Standard for Hand Protection
- Gloves may be worn as long as another hazard is not created. Gloves should not be worn on some machine operations (i.e., with exposed rotating tools or parts)
- Where worn, gloves with a tight fitting knitted cuff may reduce the possibility of snagging on equipment and may help keep chips out.
- Barrier creams and personal hygiene may reduce skin irritation.
- Impervious glove materials may be required for prolonged exposure to chemicals or metal-working fluids. Consider permeation breakthrough, permeation rate and degradation rating when evaluating chemical resistance.

Head Protection

- Reference OSHA Standard 29 CFR 1910.135 Head Protection.
- Refer to ANSI Z89.1 American National Standard for Industrial Head Protection for hard hat specifications
- Keep long hair that could be caught by moving parts covered.
- Caps and shrouds should not have dangling parts

Foot Protection

- Reference OSHA Standard 29 CFR 1910.136 Foot Protection.
- Refer to ASTM F 2412 Standard Test Method for Foot Protection and F 2413 Standard Specifications for Performance Requirements for Protective (Safety) Toe Cap Footwear for foot protection specifications.

Eye and Face Protection

- Reference OSHA Standard 29 CFR 1910.133 Eye and Face Protection.
- Refer to ANSI Z87.1 Personal Eye and Face Protection for eye protection specifications.

Hearing Protection

- Reference OSHA Standard 29 CFR 1910.95 Occupational Noise Exposure.
- Select hearing protection that provides sufficient noise reduction for the exposure.

Respiratory Protection

- Reference OSHA Standard 29 CFR 1910.134 Respiratory Protection.
- Refer to NIOSH Certification 42 CFR 84 Selection and Use of Particulate Respirator for respirator selection.
- Respirator selection and use must be part of an effective respiratory protection program.
- An air-supplied hood may also provide protection from heat and eye hazards. See Section 11.

Fall Protection

- Consider permeation breakthrough, permeation rate and degradation rating when evaluating chemical resistance.
- Consider ANSI cut resistance performance level.
- Reference ANSI/ASSE Z359 Fall Protection Code.
- Consider fall clearance when selecting anchorage point and lanyard (shock absorbing, self-retracting).
- Consider providing suspension trauma relief straps to increase fall rescue time.

Ch. 11 / Use of Air Supplied Hoods and Powered Air Purifying Respirators (PAPRS)

11.1 Respiratory Protection

In safety and health practice the hierarchy of controls specifies elimination of the hazard as the preferred strategy. Other control strategies such as substitution, engineering controls, work practices, and administrative controls should also be considered. Personal Protective Equipment (PPE) is regarded as the last option due to issues associated with comfort, fit, acceptability, reliability and effectiveness.

When it comes to choosing respiratory protection in metalcasting facilities there is a need to consider the advantages of air supplied helmets or hoods. Air supplied hoods are treated as respirators because they do provide respiratory protection; however, they lack many of the deficiencies of other respirators. Moreover, air supplied hoods can be used for more than just respiratory protection, such as for cooling and for eye and face protection from grinding particles.

Rationale for Hierarchy of Controls

In safety and health practice, the hierarchy of controls specifies elimination of the hazard (or substitution) as the primary strategy for exposure reduction, followed by engineering controls, and work practice and administrative controls.

In the case of most forms of personal respiratory protection, the following issues place negative pressure respirators at the bottom of the hierarchy:

- Poor fit can cause leakage and compromise protection.
- Respirators can be hot, uncomfortable to wear, and irritating to the skin.
- Respirators are incompatible with beards and mustaches.
- Facial deformities (i.e., lack of dentures) can cause poor seals.
- Poor maintenance of seals, valves, etc., can cause reliability problems.
- Storage practices may lead to contamination.
- It is not practical to measure exposure inside the respirator, so a protection factor must be relied upon.

These issues apply to negative pressure respirators, but they are less valid arguments for air supplied hoods. Poor fit and leakage problems with air supplied hoods are minimal except for gross and easily monitored abuses such as removal of the face piece or shroud. Air supplied hoods are comfortable; indeed, they are often requested where not required.

Facial hair and facial deformities have no impact on effectiveness. Maintenance, reliability, and contamination are less of a problem with air supplied hoods than with most negative pressure respirators. Air supplied hoods are less likely to interfere with other PPE, especially eye protection. Finally, it is often possible to measure exposures inside the hood to determine the actual protection achieved.

Effectiveness and Reliability of Air Supplied Hoods

Air supplied hoods are effective and reliable. When ventilation systems are used to control exposures, the ventilation is usually designed to control exposures to the

Permissible Exposure Limit (PEL) or below. This approach is not always effective in achieving a reduction to below the PEL. Even when ventilation successfully reduces exposures to below the PEL, the control may be inconsistent. Air supplied hoods can achieve exposure levels 2 or 3 orders of magnitude lower than the PEL. Air supplied hoods may thus provide more effective and consistent protection than negative pressure respirators, and in some cases can achieve lower exposure levels than ventilation systems.

Exhaust ventilation systems require maintenance and work procedures to control exposures properly. Ventilation performance problems can often occur without detection. In some cases, work procedures or job parameters may disrupt the efficiency of ventilation systems. For example, a work piece may be too large for a booth or heat loads may require fans for cooling that disrupt air movement needed for contaminant capture. Air supplied hoods do not suffer from these problems with engineering control performance. Failure of the air supply is readily detected in air supplied hoods and job activities or heat loading do not impact the efficiency of the hoods. Air supplied systems with a vortex component can provide heating and cooling for personal comfort.

Multipurpose Application of Air Supplied Hoods

Air supplied hoods are useful for a variety of purposes, not merely for reducing respiratory exposures. Eye protection and heat protection are two notable functions of air supplied hoods. In dusty environments like metalcasting facilities it is important to minimize dust particles on the face and in the hair because these secondary sources may get rubbed into the eye. Because they keep the whole head clean, air supplied hoods are much more effective in preventing eye injuries than goggles or face shields. Some employers use air supplied hoods mainly for the eye protection benefits.

Vortex controls allow practical personal heat and cooling control for the wearer for all season comfort. Employees often choose to wear air supplied hoods for comfort reasons when not required to do so for dust exposure protection.

Disadvantages of Air Supplied Hoods

Air supplied hoods suffer from several disadvantages:

- The air must be supplied through a hose that limits mobility of the user, so the hood is only practical where the job is relatively stationary and the hose can be protected from damage. Hoses must be arranged to minimize tripping hazards.
- Human factor issues related to the weight of the helmet, vision limitations, and claustrophobic responses on the part of a few employees.
- There are requirements for a safe and reliable air supply. A breathing air compressor is required or a filter panel is needed to purify plant air to a Grade D breathable quality. In addition, if an oil lubricated compressor is used a high temperature or carbon monoxide alarm is needed to ensure that breathing air is acceptable. If only a high temperature alarm is used, carbon monoxide must be monitored periodically.
- Air supplied hoods require regular maintenance and frequent parts replacement.

Powered Air Purifying Respirators (PAPR)

Powered Air Purifying Respirators (PAPR) provide most of the same advantages as air supplied hoods but do not have a vortex component for temperature control. PAPRs are also limited in use by the availability of appropriate filter media for some specific contaminants. In general, PAPR units require more maintenance due to battery life and component reliability issues. However, newer designs have made improvements on battery life and reliability. PAPR units have an additional advantage of mobility that can be extremely valuable for many operations including maintenance and non-routine tasks. Engineering controls are not possible for many maintenance, repair or clean-up operations that require mobility or that are not performed repeatedly in a fixed location.

Conclusion

Air supplied hoods and powered air purifying respirators (PAPR) should be considered as important options when choosing respiratory and other personal protection for employees.

Appendix 1 / Sample Hazard Assessment Form

The PPE Hazard Assessment form should be evaluated and certified by someone who is competent in recognizing the hazards of each individual job classification.

PPE Hazard Assessment

(Page 1 of 3)

Department: _____

Job/Task: _____ Date: _____

Hazards Present	General Body Parts Affected							Potential Hazard Sources
	Trunk	Arm/Hand	Head	Leg/Foot	Eyes	Ear	Respiratory	
Impact								
Penetration								
Foreign Bodies								
Pinch/Caught								
Falling, rolling objects								
Sharp objects								
Heat/Hot Surfaces								
Molten Metal								
UV/IR radiation (Ultraviolet/Infrared)								
Chemicals								
Dust/Fume								
Noise								
Electrical hazards								
Other								

PPE Hazard Assessment

(Page 2 of 3)

	Check if Applicable	Specification
TRUNK		
Coats		
Jackets		
Apron		
Cape/Sleeve/ Bib		
Coveralls		
Reflective vest		
ARM/HAND		
Long sleeved		
Mitts		
Cover mitts		
Cover Pads		
Gloves		
HEAD		
Hard hat		
Cotton cap		
Wool cap		
Aluminized hood		
Shroud		
Hair net		
LEG/FOOT		
Legging		
Chaps		
Spats		
Leather safety toe shoe		
Metatarsal		
Other		

PPE Hazard Assessment

(Page 3 of 3)

	Check if Applicable	Specification
EYE/FACE		
Safety glasses with side protection		
Goggles		
Face shield		
Full face shield		
Tinted glasses		
HEARING		
Ear plugs		
Ear muffs		
Ear caps		
RESPIRATORY		
Dust mask		
Half mask		
Full facepiece		
Powered air purifying (PAPR)		
Supplied air		
SCBA (self-contained breathing apparatus)		
FALL PROTECTION		

Evaluated by: _____ Date: _____

Certified by: _____ Date: _____

Appendix 2 / Flame Resistant (FR) Clothing

Flame resistant clothing provides vital protection against several different types of hazards. These include protection from molten metal splash, arc flash, and flash fire hazards. In addition FR clothing may also be used to protect against radiant heat or heat from flames. Each of these applications requires a different design strategy, and FR clothing that protects well against one hazard may not protect well against another. For example, clothing rated high for arc flash protection may not be highly effective against molten metal splash. It is important to select FR clothing that is designed to protect against the hazard of concern.

Most FR selection processes involve a trade-off between features. In addition to the specific FR protection needs, other important factors to consider include flexibility, comfort, durability, abrasion resistance, heat load, maintenance, cleaning and static control. For example, FR clothing should not tear too easily, wear too fast, or restrict essential movement. Foundries must assess the demands of their working environments to determine their needs and how best to balance these factors. Sometimes, testing samples in real world conditions will help to determine how well they will perform in the work environment.

The FR designation for clothing can be achieved in several different ways. These differences may affect service life and laundry requirements. Manufacturers have become adept at combining fibers and treatments to maximize various features. It is difficult to judge performance from simply looking at a fabric. Nevertheless some general comments about these different approaches are as follows:

- **Treated Fabric**—fabrics that are treated with a Flame Retardant chemical to make them Flame Resistant. The fibers used in these fabrics, such as cotton, are not normally considered protective and become flame resistant because of the treatment. Laundering procedures are important to the durability of the treatment which can vary from very limited to the life of the garment. Many treated fabrics are not suitable for use against molten aluminum splash because molten aluminum may stick to the fabric.
- **Treated Fiber**—fabrics made from synthetic fibers that are extruded with a flame retardant chemical in the fiber-forming process. These fabrics become flame-resistant for the life of the garment because the flame retardant cannot be removed by wear or laundering. However, abrasion resistance and durability may be limited.
- **Inherently FR Fibers**—fabric made from synthetic fibers whose flame resistance is an essential characteristic of the fiber chemistry (i.e., NOMEX®). The flame-resistant property of these fabrics cannot be removed by wear or laundering. Inherently FR Fibers are **NOT RECOMMENDED** for use around molten substances or welding operations or in critical static control applications.
- **Blends of Treated and Inherently FR Fibers**—fabrics made of a mixture of inherently flame-resistant fibers with fibers that are treated in the fiber-forming process. These fabrics become flame-resistant for the life of the garment because the flame retardant cannot be removed by wear or laundering.

There are numerous brand names of fibers and fabrics, and garment manufacturers and distributors may add their own trade names or other descriptors that may be confusing for someone trying to select FR clothing for a foundry application. Fabrics with the same name also often come in different weights (ounces per square foot) which can change the protection and complicate selection. Heavier versions of the same fabric provide greater protection but may not be as comfortable as lighter weight fabrics. Aluminized fabrics offer radiant heat protection for jobs, such as hot patching, with intense heat loads. Aluminized fabrics need to be evaluated for FR protection. A layer of aluminum adds protection, but some non-aluminized garments may provide better molten metal splash protection than some aluminized garments.

Following are some testing and rating systems that can help with the selection process for specific applications.

Molten Metal Splash Protection

Selecting clothing for molten metal splash depends on the alloy being melted. The primary feature for molten metal splash is the ability to shed metal. In addition, fabrics need to provide some thermal protection and in many applications radiant heat protection may be required. Other features, such as abrasion resistance and flexibility may also be important. Some of these features, such as abrasion resistance, may require field testing of samples in order to assess performance. For molten metal splash protection there are two testing or rating standards that may be of use for evaluating performance.

1. *ASTM F955 Standard Test Method for Evaluating Heat Transfer through Materials for Protective Clothing Upon Contact with Molten Substances.*

This test method is used to evaluate a material's thermal resistance to heat transfer when exposed to a molten substance pour. In this test method a material specimen is mounted on a vertical incline and is exposed to a molten substance pour of prescribed minimum temperature, volume, pour rate, and vertical height. The amount of heat energy that is transmitted through the test specimen during and after the molten substance exposure is measured and assessed versus the Stoll curve, an approximate human tissue model that projects the onset of a second-degree skin burn injury as manifested by a blister.

A specific set of subjective evaluations is also performed on the test specimen in response to the molten substance exposure using a standardized rating scale for appraisal. This test method rates materials that are intended for primary protective clothing against potential molten substance contact for their thermal insulating properties and their reaction to the test exposure. Visual inspection of the specimen subjectively notes the material's resistance to molten substance contact. This test method does not measure the flammability of materials, nor is it intended for use in evaluating materials exposed to any other thermal exposure.

Foundries may conduct a subjective simulation of their own to visually compare the performance of different fabrics using a set-up similar to the standard procedure. This can be done by mounting 12 by 16 inch fabric samples on a 70° inclined wooden board. A cotton t-shirt material with plastic film behind it may be placed underneath the fabric samples to help simulate effects on skin. About 2.2 lbs. of molten metal (at typical pouring temperature) can be applied to each sample in identical fashion. The

results can be used to visually compare charring, sticking, shrinkage, breakthrough and damage to the backing materials. Although not as precise as the formal test, the results can provide dramatic and useful visual comparisons and may also be helpful for employee education and training.

2. *ISO 11612 Protective Clothing—Clothing to protect against heat and flame—Minimum performance requirements.*

ISO 11612 standard specifies the performance requirements for garments that protect the body from heat and flame, including molten metal splash. As listed below, there are six categories of hazard corresponding to different ISO standards. Categories D and E rate fabrics for molten metal splash according to ISO 9185.

- *Category A—Surface or Edge Ignition* Tests and ratings are defined by ISO 15025A or B.
- *Category B—Convective Heat* The garment's protection against convective heat transfer is tested and approved under ISO 9151. Convective heat means the heat that passes through the garment on contact with flame.
- *Category C—Radiant Heat* The garment's protection against radiant heat transfer is tested under ISO 6942.
- *Category D—Molten Aluminum Splash* The protection provided by the fabric against molten metal splash is tested under ISO 9185 (Assessment of resistance of materials to molten metal splash). Even though the fabric does not burn or disintegrate when in contact with molten metal, burn injury to the wearer can nevertheless occur. This test gives an indication of how much metal splash the garment can take while still affording the wearer protection. Fabrics are rated D1 to D3 if they prevent heat penetration from a specified amount of molten metal. D3 is the highest rating corresponding to the largest amount of metal.
- *Category E—Molten Iron Splash* As for aluminum, materials are tested and rated according to ISO 9185. Fabrics for iron splash are rated E1 to E3 if they prevent heat penetration from a specified amount of molten metal. E3 is the highest rating corresponding to the largest amount of metal.
- *Category F—Contact Heat* The garment's protection against contact heat transfer is tested under ISO 12127 at a temperature of 250°C.

Not all manufacturers test and rate their garments for molten metal splash protection according to ISO 9185 and ISO 11612 standards. Even those who do test may not publish or provide the rating unless asked for it. However, it is a useful measure for comparing performance of different fabric types and weights and users should ask for the rating. Asking for the rating may encourage more suppliers to test and rate their products.

Arc Flash Protection

Protective clothing for arc flash protection requires an assessment of hazard/risk category according to NFPA 70E. Clothing and PPE is specified for risk categories 0 through 4, with a risk category of 4 requiring the greatest protection. The hazard/risk category applies to the entire clothing system (shirt, pants, shoes, gloves, hard hat, eye and ear protection, etc.). Arc-rated clothing manufacturers commonly provide the arc-rating for their particular element of the clothing system.

Flash Fire Protection

Protective clothing for flash fire hazards is appropriate for hazards such as vapor flash fire or combustible dust flash fire risk. NFPA 2113 specifies the selection, care, use, and maintenance requirements for flame-resistant garments for use by industrial personnel in areas at risk from flash fires or short-duration flame exposure that are compliant with NFPA 2112, Standard on Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire. Flame-resistant garments are available from a variety of manufacturers, in a range of items (coveralls, pants, shirts, vests, parkas, rainwear, disposable garments, aprons, etc.). Flame-resistant garments are made out of a variety of either inherently flame-resistant fabrics or fabrics that have been treated with a flame retardant. NFPA 2112-compliant clothing is intended to reduce the probability and extent of burn injury during exposure or escape.



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ISBN: 978-0-87433-444-9

EC1600PDF