
Personal Protective Equipment (PPE)

Primary Knowledge

Instructor Guide

Note to Instructor

Personal Protective Equipment (PPE) is the primary knowledge unit for the *PPE Learning Module*. This instructional unit could be assigned either before or after the activity on PPE.

The purpose of this learning module is to familiarize participants with the types of PPE found in manufacturing and laboratory environments, the purpose of PPE and what type of PPE is required for different tasks.

PPE Learning Module content:

- **Personal Protective Equipment Primary Knowledge**
- Personal Protective Equipment Activity
- Personal Protective Equipment Final Assessment

A PowerPoint presentation is provided for a classroom presentation. The PowerPoint is a summary of the PG.

Review of the Hazardous Materials Learning Module would be beneficial to the participant in providing additional information as to why PPE is required. The HazMat Learning Module consists of the following:

- Hazardous Materials Knowledge Probe (pre/post test)
- Hazardous Materials I Primary Knowledge
- Hazardous Materials II Primary Knowledge
- Hazardous Materials I and II Activity
- Hazardous Materials Final Assessment

These safety modules and more can be downloading from the SCME website (<http://scme-nm.org>).

Disclaimer

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Description and Estimated Time

When manufacturing microsystems in a cleanroom environment there are many hazardous materials involved. The purpose of this learning module is to familiarize you with the types of PPE found in manufacturing and laboratory environments, the purpose of PPE and what type of PPE is required for different tasks.

This unit will discuss the following concepts:

- Why PPE is important in microsystems manufacturing
- Types of PPE used in microsystems manufacturing
- How to use the PPE appropriately

Estimated time required:

Allow approximately 30 minutes

Purpose

This PPE unit provides an introduction to the personal protective equipment that must be worn when working with hazardous materials in microsystems manufacturing.

This information should be discussed before performing any activities involving the handling hazardous materials.

Introduction



There are many chemical processes involved in the manufacturing of microsystems. Large amounts of acids, bases, and solvents are used for a variety of cleaning, developing, and etching processes. Chemical use can be dangerous therefore a high level of preventative practices must be employed. Exposure to many chemicals used in these processes could result in serious injury or can even be fatal. When working with chemicals, PPE must be used to prevent exposure.

*Acid PPE required for corrosives used in
Microsystems manufacturing
[Photo courtesy of Bob Willis]*

Objectives

- State why PPE should be used when handling hazardous materials.
- State the types of PPE commonly used in microsystems manufacturing.
- Describe the appropriate use of PPE for a specific situation.

Dependencies

It would be helpful to review the following SCME units.

Hazardous Materials I
Hazardous Materials II

Key Terms

Hazardous Material (HazMat)
Personal Protective Equipment (PPE)
Health Hazard
Physical Hazard
Equipment Hazard
Respirator

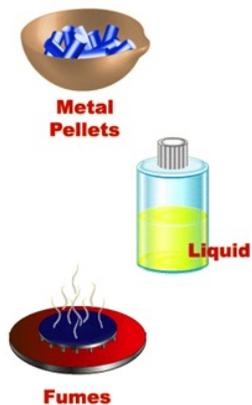
Types of Hazards Present in Microsystems Manufacturing

When manufacturing microsystems, you may encounter many hazards from which you must be protected. The following are potential hazards that exist in a microsystems manufacturing environment:

- Health Hazard due to chemical exposure - Exposure may cause acute or chronic health effects.
- Physical Hazard due to chemical exposure - Chemical produces a violent change when subjected to external factors such as heat, vibration, or oxygen, or in some cases, standard temperature and pressure.
- Equipment Hazard - Exposure to dangerous equipment and/or equipment supplies or tools (e.g. electrical, mechanical movements, radiation, punctures, cuts, burns).

Hazardous materials can be in the following forms:

- Liquids
- Solids
- Gases
- Vapors
- Fumes
- Mists
- Fibers
- Dust



States of Hazardous Materials used in Microsystems Manufacturing

It is very important to use the appropriate protective equipment when working with or around any hazardous chemical or equipment.

Routes of Entry of Hazardous Chemicals

Hazardous chemicals may cause bodily damage by one or more of the following routes of entry:

- Inhalation - breathing it in
- Dermal (Adsorption) - penetrating or irritating the skin or eye
- Ingestion - swallowing

Common Health Effects Caused by Exposure to these Hazardous Chemicals

When exposed to a hazardous chemical, the primary concern is whether the exposure damages the body or the environment. There are a variety of health effects resulting from exposure to a hazardous substance. These effects range from a simple rash to the most extreme, death. The following list contains some common health hazards associated with chemicals.

- Irritant - irritating effect
- Sensitizer - allergy developed over time
- Asphyxiant - suffocation
- Carcinogen - cancer causing
- Mutagen - changes genetic makeup in fetus
- Teratogen - affects developing fetus

Common Everyday Personal Protective Equipment (PPE)



*Common types of PPE
[Photo courtesy of Barb Lopez]*

Personal Protective Equipment (PPE) includes all clothing and other accessories designed to protect against hazards during work and/or play. People use PPE to protect themselves during many jobs and activities. Above are several types of PPE.

- Bullet proof vests protect police officers from gunshot wounds.
- Fire protective gear protects firemen from burns and exposure to smoke.
- Oven mitts prevent burning while removing food from the oven.
- Helmets prevent potential head injuries from bicycles or motorcycles accidents.
- Seatbelts prevent injury in case of an automobile accident.

These are just a few examples of common, everyday PPE. PPE makes working and playing safer and more productive.

OSHA PPE Standard

Personal Protective Equipment is so important that the Occupational Safety and Health Administration (OSHA) established a Personal Protective Equipment Standard. [OSHA standard 29 CFR 1910.132-138](#) requires that employers must establish and administer an effective personal protective equipment (PPE) program for employees and employees must be trained in the proper use of PPE.

PPE Used in Microsystems Manufacturing

Microsystems manufacturing involves a variety of acid, alkalis, and solvents that are potentially hazardous to the worker's health and safety. Therefore, in addition to the cleanroom garments required for anyone entering a cleanroom, PPE is required for anyone handling hazardous materials.

The purpose of PPE is to protect workers from chemical, physical, and biological hazards that may be encountered in the workplace. Careful selection and use of PPE protects the respiratory system, skin, and eyes. Cleanroom garments protect the environment from human contamination. They do not protect the worker from hazardous materials.

PPE is available for the following parts of the body:

Respiratory system

Several types of respirators protect from atmospheric hazards such as gases, vapors, fumes, and particles.

Hands

A variety of gloves protect from the absorption of harmful substances, severe cuts or lacerations, severe abrasions, punctures, chemical burns, thermal burns, and harmful temperature extremes.

Eyes and face

Safety glasses, goggles, and face shields protect from flying particles, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

Feet

Special footwear protects from falling objects or chemical spills.

Body

Aprons, smocks, and chemical resistant splash suits protect from acid or caustic chemical spills or splashes.

Atmospheric Hazards

There are four states in which an atmospheric hazards may exist:

- Fumes
- Gases
- Vapors
- Particles

Fumes contain both gases (vapors) and dusts. In many cases, the vapors are toxic or corrosive. For example, titanium tetrachloride ($TiCl_4$) reacts immediately and violently with water vapor in the air to form dense white fumes. Inhalation of these fumes is dangerous because each component is hazardous. Hydrochloric acid (HCl) droplets cause chemical burns to the respiratory system, eyes and skin. The fine particles of titania further irritate the damaged tissues.

Fumes generally require more careful attention than simple dusts or vapors. For example, a dust mask might be sufficient protection from some dusts, but it will not protect against fumes such as the highly corrosive HCl.

It is very important to control or eliminate the generation of fumes when working with hazardous materials. Appropriate ventilation such as fume hoods and other engineering controls must be incorporated into the facility infrastructure.

PPE – Protection for Respiratory System

What is a Respirator?

A respirator is a type of PPE that is usually used when ventilation controls such as fume hoods are not available. Respirators are designed to protect the respiratory system from inhalation of atmospheric hazards. They do this by either removing contaminants from the air before they are inhaled or by supplying an independent source of clean air.

A respirator is a type of PPE that is worn over the nose and mouth. Some respirators also cover the eyes and face. Two types of respirators which will be discussed here:

- Air Purifying Respirators
- Supplied Air Respirators



Air Purifying Respirator and Supplied Air Respirator [Photos courtesy of MATEC]

Air Purifying Respirators (APR)

Air purifying respirators use filters to prevent atmospheric hazards in the air from entering the respirator. This ensures that ONLY clean air is breathed in.

Supplied Air Respirators (SAR)

Supplied air respirators prevent air contaminated with an atmospheric hazard from entering the respirator. Clean air comes from a tank worn on one's back or through an airline that brings in clean air from a remote source.

How to Use a Respirator

Concerns Before Using a Respirator

Using a respirator requires the lungs and the heart to work harder. If you have a lung or heart condition, wearing a respirator may be dangerous. If a medical condition prevents you from wearing a respirator, you cannot protect yourself from breathing in harmful contaminants in the air; therefore, you should not work in areas where hazardous fumes, particles or vapors are possible.

Facial hair prevents a respirator from forming a tight seal against the skin allowing contaminants to leak under the respirator. All facial hair that touches the edge of the respirator must be shaved before using the respirator.

Properly Fitting a Respirator

If the respirator does not fit properly, it will not provide proper protection against atmospheric hazards.

- When your job requires a respirator, you should be fit-tested by a qualified person at least once a year.
- Every time you put on the respirator, a seal check should be performed. This makes sure it fits and is properly positioned on your face

Seal Check

To perform a seal check, firmly cover the exhalation ports on the mask with the palms of your hands (see graphic below). Inhale and exhale more strongly than usual. If you do not detect any air flow in or out of the edges around the respirator, then the respirator fits properly.



PPE – Protection for Hands



When working in a cleanroom environment, it is necessary to wear gloves to protect hands from exposure to cleanroom hazards as well as to protect the cleanroom environment from particles from the hands. Latex or nitrile disposable gloves are worn for common cleanroom practices. However, extra hand protection is required when handling acids or solvents. It is important to wear "acid gloves" when working with acids and "solvent gloves" when working with solvents.

Acid Gloves (orange) and Solvent Gloves (green)
[Photo courtesy of MATEC]

Proper use of Gloves

Acid Gloves

Acid gloves are worn over the common cleanroom disposable gloves. Acid gloves are made of a variety of materials, but the most common material is a thick rubber based composite (nitrile rubber, butyl rubber, natural rubber). Some facilities require two or three pairs of acid gloves to be worn on top of each other.

When putting on the acid gloves, a two inch cuff is made to prevent acid from running down the arm. (See picture below) If multiple gloves are worn, only the last glove requires the two inch cuff.



Acid glove with 2" cuff



Proper glove removal

[Photos courtesy of Bob Willis]

When removing, pull the gloves off from the cuffs, turning the gloves inside out as shown in the picture on the right. Place the gloves into the acid waste container.

Solvent Gloves

Solvent gloves are chemical resistant. They shield the hands from exposure to most chemical cleaners and solvents. When working with solvents they must be worn over the common cleanroom disposable gloves.

Solvent gloves are very similar to acid gloves but are most commonly made of thick nitrile. When putting on the solvent gloves, a two inch cuff is made to prevent solvents from running down the arm. When removing, pull off gloves from the cuffs, turning the gloves inside out. Place gloves into the solvent waste container.

Leak Test

Before using, acid gloves and solvent gloves should be tested to ensure there are no holes or leaks. There are many ways to test for leaks, but the most convenient way is to seal the edges of the glove to your mouth with your hand, blow into it like a balloon, and listen for air leaks. Another method is to inflate with nitrogen, submerge in water and watch for bubbles. If a leak is detected, dispose of the leaky glove and perform the leak test with a new pair of gloves. Repeat this process until no leaks are found.

PPE – Protection for Eyes and Face

Safety Glasses and Eye Goggles

Eye goggles and/or safety glasses are common gowning attire when working in a cleanroom. Safety glasses and goggles must have side shields. Because contact lenses are discouraged when working in a cleanroom, goggles and safety glasses are generally made to fit over eye glasses. Eye goggles and safety glasses can also be made with prescription lenses for those who are exposed to eye hazards for an extended part of the workday.



Safety Glasses, Safety Goggles, and Face Shield
[Photos courtesy of MATEC]

Face Shield

When working with acids and solvents, a special face shield must be worn to further protect the eyes and face against any splashes. The safety goggles or glasses should cover the eyes at all times. The face shield is worn over the goggles or glasses.

PPE – Protection for Body

Acid Aprons

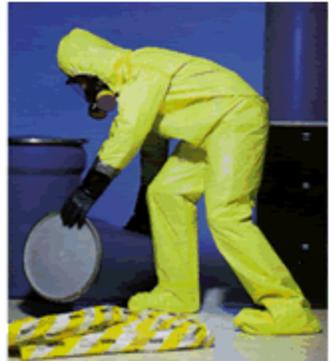
When using acids and solvents in a cleanroom, extra protection is required above and beyond a cleanroom smock or bunnysuit. Full length acid aprons provide the necessary protection. In the case of a splash, acid aprons can be removed much more quickly than a bunnysuit or smock. Acid aprons are commonly made from a rubber based composite.

When finished working with acids or solvents, aprons should be removed carefully to prevent any chemicals on the aprons from contaminating other areas.

Chemical Resistant Splash Suits

Chemical resistant splash suits offer a high degree of protection against a wide range of chemical contaminants. They are most commonly used when cleaning hazardous material spills. These suits are generally made from Neoprene or a rubber based composite.

[Photos courtesy of the MTTC]



PPE – Protection for Feet

When working in a cleanroom it is important to protect the feet from chemical spills and dropped objects. Cleanroom booties are common gowning attire; however, they do not provide adequate protection. Non-porous, closed toe shoes with a closed heel must be worn under the booties.

Chemical Resistant Boots

Vinyl boots are used when cleaning up hazardous chemical spills, usually under the chemical resistant splash suit. These boots provide extra protection against acids and solvents.



*Chemical Resistant Boots
[Photo courtesy of MATEC]*

Summary

Manufacturing microsystems involves the use of hazardous materials. When working with these materials it is essential to understand the dangers involved and the equipment needed to provide the proper personal protection. This unit discussed the hazards in the workplace and the personal protective equipment (PPE) necessary to protect from any bodily injury.

When using PPE, it is important to use it properly.

References

- OSHA - General requirements. - 1910.132. Personal Protective Equipment. <http://bit.ly/2mt40NO>
- MSDS Hyperglossary - <http://www.ilpi.com/msds/ref/>
- OSHA PPE Training - <http://www.free-training.com/osha/ppp/ppemenu.htm>

Related SCME Learning Modules

- Hazardous Materials I and II
- Safety Data Sheets (SDS)

Support for this work was provided by the National Science Foundation's Advanced Technological Education (ATE) Program. For more learning modules related to safety and microtechnology, visit the SCME website (<http://scme-nm.org>).