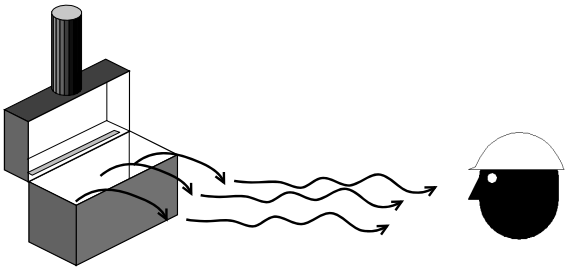
Exposure Control Methods



EMISSION SOURCE

Substitution
Process change
Process elimination
Product reformulation
In-process recycling
Automation
Dry to wet methods
Preventive Maintenance

AIR PATH

Process enclosure
Process isolation
Local exhaust ventilation
Dilution ventilation
Housekeeping
Enclose worker (remote control)

EMPLOYEE

Training and education
Limit Duration of Exposure
(Administrative Rotation)
Personal Protective Equipment
(respirators, gloves, clothing, eyeglasses)

Toxics Use Reduction

- *TUR means in-plant changes in production, process or raw materials tht reduce, avoid or eliminate the use of generation of hazardous by-products per unit of production so as to reduce overall risks to the health of workers, consumers or the environment without shifting risks between workers, consumers or parts of the environment*
- Mass TURA passed in 1989
- Firms encouraged to establish planning teams to analyze production processes, conduct materials accounting programs, audit health and environmental regulations and develop TUR options.

TUR Methods to Reduce Industrial Waste Streams:

- Toxic chemical substitution
  - Substitute soy based ink for petrochemical ink
  - Use aqueous cleaners instead of organic solvents
- Process modification
  - Eliminate unnecessary cleaning steps
  - Install drip racks and drag out recovery tanks
- Product reformulation
  - Replace compressed gas aerosol cans with manual pump sprayers

TUR Methods to Reduce Industrial Waste Streams:

- Process modernization
  - Install thermostats and automatic flow controls
  - Install high pressure low volume spray nozzles
- Improve operations and maintenance
  - Tighten and repair gaskets, faucets etc
  - Install lids to reduce evaporation and spills
- In-process recycling and reuse
  - Capture and recycle solvents and rinse water

Protecting Employees from Workplace Hazards

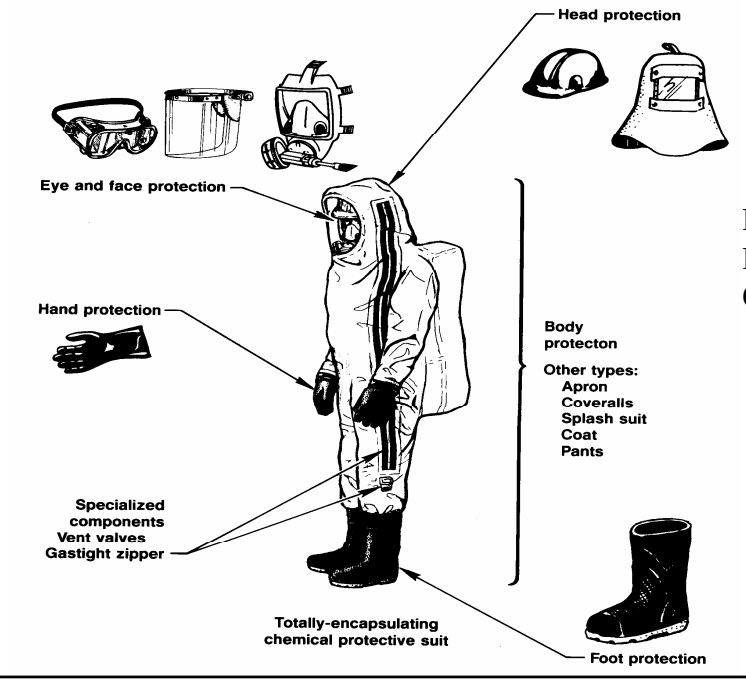
- Employers must protect employees from workplace hazards such as machines, hazardous substances, and dangerous work procedures that can cause injury
- Employers must:
  - Use all feasible engineering and work practice controls to eliminate and reduce hazards
  - Then use appropriate personal protective equipment (PPE) if these controls do not eliminate the hazards.
- **Remember, PPE is the last level of control!**

Establishing a PPE Program

- Sets out procedures for selecting, providing and using PPE as part of an employer's routine operation
- First -- assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of PPE
- Once the proper PPE has been selected, the employer must provide training to each employee who is required to use PPE

PPE

- Employers must assess hazards, select appropriate PPE, train workers in use, assure fit, maintain equipment and assure usage.
- Training includes:
  - When PPE is necessary;
  - What PPE is necessary;
  - How to properly don, doff, adjust, and wear PPE;
  - The limitations of the PPE; and,
  - The proper care, maintenance, useful life and disposal of the PPE.



Personal Protective Clothing

Use of PPE

Dept of Labor reports….

- Hard hats worn by only 16% of workers with head injuries
- 1% of 770 workers with face injuries wore face protection
- 23% of workers with foot injuries wore safety shoes or boots
- 40% of workers with eye injuries wore eye protection

Head Protection

- **1910.135(a)(1)**
- The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects.
- **1910.135(a)(2)**
- The employer shall ensure that a protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head.

Classes of Hard Hats

Class A

- General service (e.g., mining, building construction, shipbuilding, lumbering, and manufacturing)
- Good impact protection but limited voltage protection

Class B

- Electrical work
- Protect against falling objects and high-voltage shock and burns

Class C

- Designed for comfort, offer limited protection
- Protects heads that may bump against fixed objects, but do not protect against falling objects or electrical shock

Examples of Hearing Protectors



Foot Protection

- **1910.136(a)** General requirements. The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards. Protective footwear shall comply with ANSI Z41-1991.

Safety Shoes

- Have impact-resistant toes and heat-resistant soles that protect against hot surfaces common in roofing, paving, and hot metal industries
- Some have metal insoles to protect against puncture wounds
- May be designed to be electrically conductive for use in explosive atmospheres, or nonconductive to protect from workplace electrical hazards

Eye Protection

- **1910.133(a)(1)**
- The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

Safety Spectacles

- Made with metal/plastic safety frames
- Most operations require side shields
- Used for moderate impact from particles produced by such jobs as carpentry, woodworking, grinding, and scaling

Goggles

- Protect eyes, eye sockets, and the facial area immediately surrounding the eyes from impact, dust, and splashes
- Some goggles fit over corrective lenses

Welding Shields

Protect eyes from burns caused by infrared or intense radiant light, and protect face and eyes from flying sparks, metal spatter, and slag chips produced during welding, brazing, soldering, and cutting.

Face Shields

- Protect the face from nuisance dusts and potential splashes or sprays of hazardous liquids
- Do not protect employees from impact hazards

Eye Protection

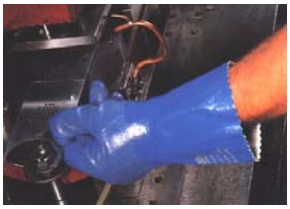
Source	Assessment of Hazard	Protection
IMPACT - Chipping, grinding, machining, drilling, chiseling, riveting, sanding, etc.	Flying fragments, objects, large chips, particles, sand, dirt, etc.	Spectacles with side protection, goggles, face shields. For severe exposure, use face shield over primary eye protection.
CHEMICALS - Acid and chemicals handling	Splash Irritating mists	Goggles, eyecup and cover types. For severe exposure, use face shield over primary eye protection Special-purpose goggles
DUST - Woodworking, buffing, general dusty conditions	Nuisance dust	Goggles, eyecup and cover types.

Eye Protection

Source	Assessment of Hazard	Protection
LIGHT and/or RADIATION		
Welding - electric arc	Optical radiation	Welding helmets or welding shields. Typical shades: 10-14
Welding - gas	Optical radiation	Welding goggles or welding face shield. Typical shades: gas welding 4-8, cutting 3-6, brazing 3-4
Cutting, torch brazing, torch soldering	Optical radiation	Spectacles or welding face shield. Typical shades: 1.5-3
Glare	Poor vision	Spectacles with shaded or special-purpose lenses, as suitable.

Hand Protection

- **1910.138(a)**
- General requirements. Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.



Dermal Hazards

Hazard	*Examples*
Chemical	irritants
	allergens
	corrosives
	dermal toxins
	systemic toxins
	cancer causing agents
Physical	trauma producing
	thermal hazards (hot/cold)
	fire
	vibration
	radiation
Biological	human pathogens
	animal pathogens
	environmental pathogens

Body Protection

- Intense heat
- Splashes of hot metals and other hot liquids
- Impacts from tools, machinery, and materials
- Cuts
- Hazardous chemicals
- Contact with potentially infectious materials, like blood
- Radiation

Body Protection

Sleeves and Apron

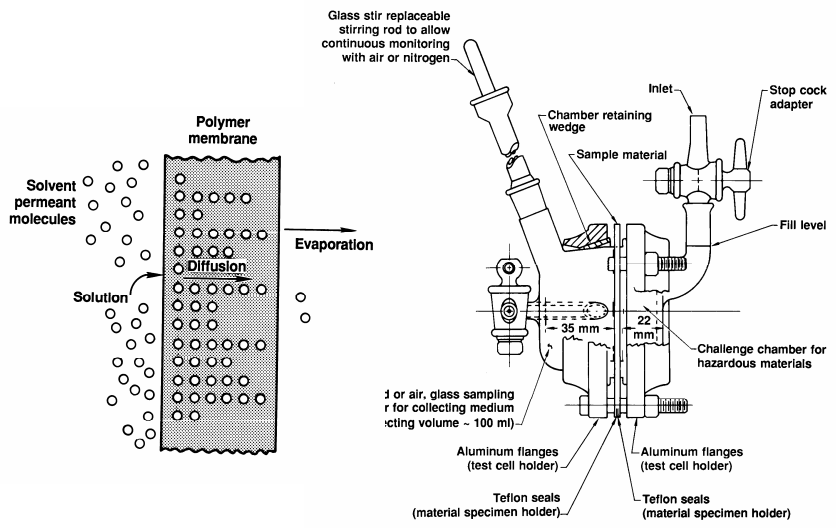
Coveralls

Full Body Suit

Common Physical, Chemical, and Biological Performance Requirements

Hazard	*Performance Characteristic Required*	*Common Protective Clothing Materials*
Thermal	insulation value	heavy cotton or other natural fabrics
Fire	insulation and flame resistance	aluminized gloves; fire retardant; aramid fiber and other special fabrics
Mechanical	abrasion resistance; tensile strength	heavy fabrics; leather with metal studding
Cuts	cut resistance	metal mesh; aromatic polyamide fiber and other special fabrics
Punctures	puncture resistance	leather; fabric coated with filled plastic; thick elastomers
Vibration	damping	natural or polymeric gloves with elastomeric linings
Chemical/toxic	permeation resistance	polymeric materials; elastomeric materials
Biological	“fluid-proof;” puncture resistant	latex or polymer
Radiologic	usually fluid resistant or particle	polymer gloves; lead lined resistant for radionuclides or shield containing

ASTM Permeation Test Cell



Glove Selection

Type	Advantages	Disadvantages	Use Against
Natural rubber	Low cost, good physical properties, dexterity	Poor vs. oils, greases, organics. Frequently imported; may be poor quality	Bases, alcohols, dilute water solutions; fair vs. aldehydes, ketones.
Natural rubber blends	Low cost, dexterity, better chemical resistance than natural rubber vs. some chemicals	Physical properties frequently inferior to natural rubber	Same as natural rubber
Polyvinyl chloride (PVC)	Low cost, very good physical properties, medium cost, medium chemical resistance	Plasticizers can be stripped; frequently imported may be poor quality	Strong acids and bases, salts, other water solutions, alcohols
Neoprene	Medium cost, medium chemical resistance, medium physical properties	NA	Oxidizing acids, anilines, phenol, glycol ethers
Nitrile	Low cost, excellent physical properties, dexterity	Poor vs. benzene, methylene chloride, trichloroethylene, many ketones	Oils, greases, aliphatic chemicals, xylene, perchloroethylene, trichloroethane; fair vs. toluene

Glove Selection

Type	Advantages	Disadvantages	Use Against
Butyl	Speciality glove, polar organics	Expensive, poor vs. hydrocarbons, chlorinated solvents	Glycol ethers, ketones, esters
Polyvinyl alcohol (PVA)	Specialty glove, resists a very broad range of organics, good physical properties	Very expensive, water sensitive, poor vs. light alcohols	Aliphatics, aromatics, chlorinated solvents, ketones (except acetone), esters, ethers
Fluoro-elastomer (Viton) ™ *	Specialty glove, organic solvents	Extremely expensive, poor physical properties, poor vs. some ketones, esters, amines	Aromatics, chlorinated solvents, also aliphatics and alcohols
Norfoil (Silver Shield)	Excellent chemical resistance	Poor fit, easily punctures, poor grip, stiff	Use for Hazmat work

PPE Compatability Data

- NIOSH database
  - http://www.cdc.gov/niosh/ncpc/ncpc2.html
  - http://www.cdc.gov/od/ohs/manual/pprotect.htm
- **Glove Compatibility Resources**
  - Lab Safety http://www.labsafety.com/refinfo/ezfacts/default.htm look under references…Factsheet **166 Chemical Compatibility Guide for Gloves**
  - **Best Glove Manufacturing, Inc.: http://www.chemrest.com**
  - **North Safety: http://www.northsafety.com**
  - **MAPA Professional: http://www.mapaglove.com/pro/chemicalsearch.asp**
- **Clothing Compatibility Resources**
  - **Tyvek Clothing: http://www.dupont.com/tyvek/protective-apparel**
    Kappler Apparel: http://www.kappler.com

Summary

- Assess the workplace for hazards
- Use engineering and work practice controls to eliminate or reduce hazards before using PPE
- Select appropriate PPE to protect employees from hazards that cannot be eliminated
- Inform employees why the PPE is necessary and when it must be worn
- Train employees how to use and care for their PPE and how to recognize deterioration and failure
- Require employees to wear selected PPE in the workplace

Permissible Practice for use of Respirators

- The primary means to control occupational diseases caused by breathing contaminated air is through the use of feasible engineering controls, such as enclosures, confinement of operations, ventilation, or substitution of less toxic materials
- When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this standard
- Employer shall provide respirators, when necessary, which are applicable and suitable for the purpose intended
- Employer shall be responsible for establishment and maintenance of a respirator program

Respirator Program Elements

1. Selection
2. Medical evaluation
3. Fit testing
4. Use
5. Maintenance and care
6. Breathing air quality and use
7. Training
8. Program evaluation

Respirator Program

- Must develop a written program with worksite-specific procedures when respirators are necessary or required by the employer
- Must update program as necessary to reflect changes in workplace conditions that affect respirator use
- Must designate a program administrator who is qualified by appropriate training or experience to administer or oversee the program and conduct the required program evaluations
- Must provide respirators, training, and medical evaluations at no cost to the employee

Respirator Program (cont'd)
Where Respirator Use is Not Required

- Employer may provide respirators at employee's request or permit employees to use their own respirators, if employer determines that such use in itself will not create a hazard
- If voluntary use is permissible, employer must provide users with the information contained in Appendix D
- Must establish and implement those elements of a written program necessary to ensure that employee is medically able to use the respirator and that it is cleaned, stored, and maintained so it does not present a health hazard to the user

  Exception: Employers are not required to include in a written program employees whose only use of respirators involves voluntary use of filtering facepieces (dust masks).

Two Main Types of Respirators

Air Purifying

chemical cartridge
mechanical filter
combination
includes PAPR

Air Supplied

Air from compressor
Air from tanks
Self-contained (SCBA)

Respirators can deliver air in various ways….

Negative Pressure = Demand Flow (as you breathe air is delivered)

APR …you are pump
ASR….pressure actuated valve lets air in

Positive Pressure = Constant Flow (air always provided)

APR…pump pulls through filter or cartridge (Powered Air Purifying Respirator PAPR)
ASR…Compressor or tank on a constant flow rate

Pressure Demand = During Inhalation (full flow rate during inhalation, reduced flow at other times)

ASR…used for self contained breathing apparatus SCBA)

Air-Purifying Respirator (APR)

A respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

Choosing a Filter/Cartridge

- Air purifying respirators can not be used for Immediately Dangerous to Life and Health (IDLH) atmospheres
- Can only be used with adequate oxygen (>19.5%)
- Chemical must have warning properties or a end of service life indicator must be available
  - Methyl chloride odorless
  - Methanol odor threshold more than 10x TLV
  - Hydrogen sulfide paralyzes olfactory nerve
- Not all gases/vapors can be collected by cartridges
  - Carbon monoxide

Cartridges, and Canisters

- filters, cartridges and canisters used in the workplace must have color coded NIOSH label
- Standard color codes:
  - Black = organic vapors
  - White = acid gases (chlorine, sulfur dioxide, hydrogen chloride)
  - Yellow = organic vapors and acid gases
  - Green = ammonia or methylamine
  - Olive = formaldehyde or organic vapors
  - Orange = metallic mercury vapor and chlorine
  - Magenta = HEPA dusts/fumes/mists

Selected Chemical and Physical Properties of Organic Chemicals

Chemical	*Mol. Wt.*	*Boiling Point °C*	*Vapor Pressure torr (20°C)*	*IDLH[14] (ppm)*	*Threshold Limit Value[15] (ppm)*	*Geometric Mean Odor Threshold[16] (ppm)*	*Range of Odor Threshold[16] (ppm)[A,B]*	*Laboratory Break-through Time[17] (min.)[C]*
Benzene	78.11	80.1	75	3000	10	61	34–119	88.6
Toluene	92.1	110.6	22	2000	50	1.6	0.16–37	114
m-Xylene	100.6	139.1	9	10,000	100	20	20	116
Methanol	32.04	64.7	97	25,000	200	160	4.2–5960	3.2
Ethanol	46.07	78.5	44	—	1000	180	49–716	45.3
Isopropanol	60.09	82.5	33	20,000	400	43	37–610	81.8
n-Butanol	74.12	117	6	8000	C 50	1.2	0.12–11	141
3-methyl-1-butanol	88.15	131.4	2.8	8000	100	121		
Methylene chloride	84.94	40.1	349	5000	50	160	160	15.8
Chloroform	119.4	61.3	160	1000	10	192	133–276	52.4
Methyl chloroform	133.4	74.1	100	1000	350	390	390	58.9
Trichloroethylene	131.4	87	58	1000	50	82	82	83
Carbon tetrachloride	153.8	76.75	91	300	5	252	140–584	90

Filtering Facepiece
(Dust Mask)

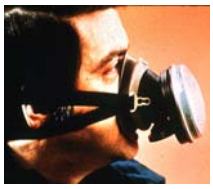
A negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium.

Description of Filter Classes Certified under NIOSH 42 CFR 84 (take the place of HEPA)

Filter Class (Test Agent)	*Efficiency (%)*	*Test Maximum Loading (mg)*	*Use*
N-series (NaCl[A])		200	nonoil aerosols
N-100	99.97		
N-99	99		
N-95	95		
R-series (DOP oil[B]) restriction may apply[C])		200	oil and nonoil aerosols (time use
R-100	99.97		
R-99	99		
R-95	95		
P-series (DOP oil[B])		stabilized efficiency	oil and nonoil aerosols
P-100D	99.97		
P-99	99		
P-95	95		

[A]NaCl = sodium chloride.
[B]DOP oil = dioctyl phthalate.
[C]In the presence of oil aerosols, service time may be limited to 8 hours of use or up until the total mass loading is less than 200 mg
(100 mg/filter for dual filter respirators).
[D]The P-100 filter must be colored magenta.
HEPA = Filter that is at least 99.97% efficient in removing monodisperse particles of 0.3 micrometers in diameter.

Tight -Fitting Coverings




Powered Air-Purifying Respirator (PAPR)

An air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

Atmosphere-Supplying Respirator

- A respirator that supplies the user with breathing air from a source independent of the ambient atmosphere
- Includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units




Loose-Fitting Coverings




Breathing Air Quality and Use

- Compressed breathing air must meet at least the requirements for Type 1 - Grade D breathing air described in ANSI/CGA G-7.1-1989:
  - Oxygen content (v/v) of 19.5 - 23.5%
  - Hydrocarbon (condensed) content of 5 milligrams per cubic meter (mg/m^3) of air or less
  - CO content of 10 parts per million (ppm) or less
  - CO_2 content of 1,000 ppm or less
  - Lack of noticeable odor
- Compressors supplying breathing air to respirators must be equipped with suitable in-line air-purifying sorbent beds and filters that are maintained and replaced or refurbished per manufacturer's instructions

Breathing Air Quality and Use
(cont'd)

- For compressors not oil lubricated, CO levels in the breathing air must not exceed 10 ppm
- For oil-lubricated compressors, a high-temperature or CO alarm, or both, must be used to monitor CO levels
  - if only high-temperature alarms are used, the air supply must be monitored at sufficient intervals to prevent CO levels from exceeding 10 ppm

Protection Factor =

$$\frac{\text{Concentration of a substance in ambient air}}{\text{Concentration inside the respirator when worn}}$$

If concentration is 10ppm outside respirator and 1 ppm inside respirator then the PF = 10/1 = 10

Maximum Use Level (MUL) or Maximum Use Concentration (MUC)=

MUC = PF x OEL

If PF = 10 and OEL = 500 ppm then MUC = 10 x 500 = 5000ppm
This is the maximum concentration where the respirator can be safely worn.

NIOSH and ANSI Assigned Protection Factors

Type of Respirator	*NIOSH Respirator Decision Logic*[22]	*ANSI Z88.2–1992*[2]
Air-purifying		
Single use or quarter-mask	5	10
Half-mask	10[A]	10
Full-facepiece, D/M or D/F/M	10	100
Full-facepiece, all other media	50	100
Powered air-purifying		
Half-mask	50	50
Full-facepiece	50	1000[B]
Loose-fitting facepiece	25	25
Hood or helmet	25	1000[B]

Type of Respirator	*NIOSH Respirator Decision Logic*[22]	*ANSI Z88.2–1992*[2]
Air-line		
Half-mask		
demand	10	10
continuous flow	50	50
pressure demand	1000	50
Full-facepiece		
demand	50	100
continuous flow	50	1000
pressure demand	2000	1000
Loose-fitting facepiece	25	25
Hood or helmet	25	1000
SCBA		
Demand	50	100
Pressure demand	10,000	10,000[C]

[A]Includes disposable particulate respirators if QNFT is used.
[B]100 if dust/mist filter is used.
[C]For emergency planning where concentrations can be estimated.

Fit Testing

- Employees using tight-fitting facepiece respirators must pass an appropriate qualitative fit test (QLFT) or quantitative fit test (QNFT):
  - prior to initial use,
  - whenever a different respirator facepiece (size, style, model or make) is used, and
  - at least annually thereafter
- Must conduct an additional fit test whenever the employee reports, or the employer or PLHCP makes visual observations of, changes in the employee's physical condition (e.g., facial scarring, dental changes, cosmetic surgery, or obvious change in body weight) that could affect respirator fit

Qualitative Fit Test (QLFT)

A pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent (banana oil (isoamyl acetate), irritant smoke)

Quantitative Fit Test (QNFT)

An assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

Fit Testing (cont'd)

- The fit test must be administered using an OSHA-accepted QLFT or QNFT protocol contained in Appendix A
  - QLFT Protocols:
    - Isoamyl acetate
    - Saccharin
    - Bitrex
    - Irritant smoke
  - QNFT Protocols:
    - Generated Aerosol (corn oil, salt, DEHP)
    - Condensation Nuclei Counter (PortaCount)
    - Controlled Negative Pressure (Dynatech FitTester 3000)

Fit Testing (cont'd)

- QLFT may only be used to fit test negative pressure APRs that must achieve a fit factor or 100 or less
- If the fit factor is determined to be equal to or greater than 100 for tight-fitting half facepieces or equal to or greater than 500 for tight-fitting full facepieces, the QNFT has been passed with that respirator

Use of Respirators
Facepiece Seal Protection

- Respirators with tight-fitting facepieces must not be worn by employees who have facial hair or any condition that interferes with the face-to-facepiece seal or valve function
- Corrective glasses or goggles or other PPE must be worn in a manner that does not interfere with the face-to-facepiece seal
- Employees wearing tight-fitting respirators must perform a user seal check each time they put on the respirator using the procedures in Appendix B-1 or equally effective manufacturer's procedures

User Seal Check

An action conducted by the respirator user to determine if the respirator is properly seated to the face.

Positive Pressure Check

Negative Pressure Check

Training and Information

- Employees who are required to use respirators must be trained such that they can demonstrate knowledge of at least:
  - why the respirator is necessary and how improper fit, use, or maintenance can compromise its protective effect
  - limitations and capabilities of the respirator
  - effective use in emergency situations
  - how to inspect, put on and remove, use and check the seals
  - maintenance and storage
  - recognition of medical signs and symptoms that may limit or prevent effective use
  - general requirements of this standard

Training and Information (cont'd)

- Training must be provided prior to use, unless acceptable training has been provided by another employer within the past 12 months
- Retraining is required annually, and when:
  - changes in the workplace or type of respirator render previous training obsolete
  - there are inadequacies in the employee's knowledge or use
  - any other situation arises in which retraining appears necessary

Program Evaluation

- Must conduct evaluations of the workplace as necessary to ensure effective implementation of the program
- Must regularly consult employees required to use respirators to assess their views on program effectiveness and to identify and correct any problems
  - factors to be assessed include, but are not limited to:
    - respirator fit (including effect on workplace performance)
    - appropriate selection
    - proper use
    - proper maintenance

Recordkeeping

- Records of medical evaluations must be retained and made available per 29 CFR 1910.1020
- A record of fit tests must be established and retained until the next fit test is administered
- A written copy of the current program must be retained
- Written materials required to be retained must be made available upon request to affected employees and OSHA