Chemical
SAFETY AND SECURITY TRAINING

Chemical Safety and Security Workshop

Kuala Terengganu, Malaysia, 7-8 June 2010

Kota Kinabalu, Malaysia, 10-11 June 2010

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Sandia National Laboratories

Chemical Management Best Practices

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Environmental & Chemical Safety Educational Institute

Chemical SAFETY AND SECURITY TRAINING

Chemical and Waste Management

Best Practices

References

"Less is Better," American Chemical Society, Washington DC, 2003, available online: http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2230&use_sec=false&sec_url_var=region1&__uuid=ef91c89e-8b83-43e6-bcd0-ff5b9ca0ca33

"School Chemistry Laboratory Safety Guide," US NIOSH Publication 2007-107, Cincinnati, OH, 2006, available on-line: http://www.cpsc.gov/CPSCPUB/PUBS/NIOSH2007107.pdf

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995, available online: http://www.nap.edu/catalog.php?record_id=4911

Chemical Management

Institute a Safety Program

- Have a Safety Manual
- Appoint a chemical safety officer for each major area/section/group/building
- Form a Safety Committee
- Have periodic safety training (films, etc)
- Have safety inspections
- Investigate serious accidents/incidents
- Follow-up!

Cradle - to - grave care of chemicals

Receipt → **Storage** →

Use → **Disposal**

Plan experiments in advance!

What chemicals are needed?

How much is needed?

How will the chemicals be handled?

What are the reaction products?

How will the chemical be stored?

How will disposal take place?

Inventory management

Less is Better !

- **Order only what you need**
- **Reduce size of experiment**
  - **It cost less to store**
  - **It cost less to dispose**

"Less is Better: Guide to minimizing waste in laboratories", Task Force on Laboratory Environment, Health and Safety, American Chemical Society, 2002. http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2230&use_sec=false&sec_url_var=region1&__uuid=ef91c89e-8b83-43e6-bcd0-ff5b9ca0ca33

Inventory management

Less is Better !

It's Safer!

It may be cheaper to order diethyl ether in large containers

But, if it's opened for a long time—peroxides can form!

Chemical SAFETY AND SECURITY TRAINING

Inventory management

-R-O-O-R-

Peroxide Forming Chemicals

Even with inhibitors they can become dangerous over time

Examples: ethers, dioxane, tetrahydrofuran

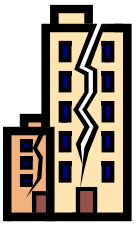
- **discard or test if unsure**
- **label & date when received, when opened, and provide expiration date**

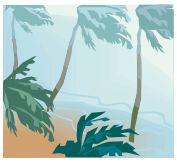
References: See for example, http://www.med.cornell.edu/ehs/updates/peroxide_formers.htm

Chemical SAFETY AND SECURITY TRAINING

Chemical storage

- Protect chemicals during normal operations
- Protect chemicals during unexpected events
  - Floods
  - Tidal waves
  - Earthquakes
  - Typhoons
  - Hurricanes





Chemical storage: Basic concepts

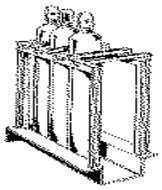
- Separate incompatible chemicals
- Separate flammables/explosives from ignition sources
- Use flammable storage cabinets for large quantities of flammable solvents
- Separate alkali metals from water
- Separate acids and bases

Use flammables storage cabinets

Chemical storage: Basic concepts

- Store nitric acid separately
- Store large containers on bottom shelves
- Lock up drugs, chemical surety agents, highly toxic chemicals
- Do not store food in refrigerators with chemicals

Chemical storage: Gas cylinders



- Secure (chain/clamp) and separate gas cylinders
- Screw down cylinder caps
- Store in well-ventilated area
- Separate & label empty cylinders
- Store empty cylinders separately
- Separate flammable from reactive/oxidizing gases

Improper gas cylinder storage/handling

Gas Cylinders

Exploded nitrogen cylinder

Chemical storage: Cryogenics

- Store gases & cryogenics separately from other chemicals
- Store cryogenics (liquid nitrogen) & dry ice in well ventilated areas
- Use proper PPE (including eye protection) when handling & moving cryogenics
- Do not use cryogenics in closed areas

Chemical storage: Good practices

- Limit access
  - Label "Authorized Personnel Only"
  - Lock area/room/cabinets when not in use
- Be sure area is cool and well ventilated
- Secure storage shelves to wall or floor
- Shelves should have a ¾" front lip
  - In earthquake territory, have a rod several inches above shelf

- Separate incompatible chemicals
  - Organize chemicals by compatible groups
  - Alphabetize chemicals only within compatible groups

Chemical storage: Bad practices

- Do Not Store Chemicals
  - on top of cabinets
  - on floor
  - in hoods
  - with food or drinks
  - in refrigerators used for food
  - where there are wide variations in temperature, humidity or sunlight

Chemical storage: Containers

- Don't use chemical containers for food
- Don't use food containers for chemicals
- Be sure all containers are properly closed
- Wipe off outside of container before returning to storage area
- Transport/carry all containers safety
  - Preferably use outer protective container

Improper chemical storage

Never use hallways for storage

Safety Hazard!!

Blocks exit path in emergencies!!!

Suggested shelf storage groups: Organics

- Acids, anhydrides
- Alcohols, amides, amines
- Aldehydes, esters, hydrocarbons
- Ethers, ketones, halogenated hydrocarbons
- Epoxies, isocyanates
- Azides, peroxides
- Nitriles, sulfides, sulfoxides
- Cresols, phenols

Suggested shelf storage groups: Inorganics

- Metals, hydrides
- Halides, halogens, phosphates, sulfates, sulfides
- Amides, azides, nitrates, nitrites
- Carbonates, hydroxides, oxides, silicates
- Chlorates, chlorites, perchlorates, peroxides
- Arsenates, cyanides, cyanates
- Borates, chromates, manganates
- Acids
- Arsenics, phosphorus, sulfur

Waste management: General guidelines

- Secure and lock waste storage area
- Post area
- Keep area well ventilated
- Provide fire extinguishers and alarms, spill kits
- Provide suitable PPE
- Provide eye wash, safety showers
- Do not work alone

Waste management: General guidelines

- Insure against leakage; dyke area if possible
- Label all chemicals, containers, vials
- Separate incompatible chemicals
- Keep gas cylinders separate
- Keep radioactive material separate
- Know how long waste can be stored
- Provide for timely pick up

Dangerous waste management

Waste management

- Recycle, reuse, redistill if possible
- Dispose by incineration, if possible
- Incineration is NOT the same as open burning

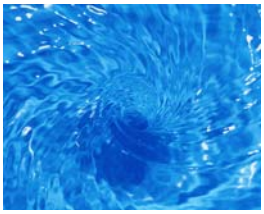
Waste management: Waste disposal service

- Is disposal service licensed?
- How will waste be transported?
- How will waste be packaged?
- Where will material be disposed?
- How will it be disposed?
- Maintain written records

Waste management: Down the drain?

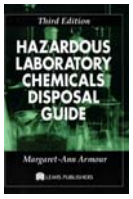
If legally allowed:

- Deactivate & neutralize some liquid wastes yourself
  - e.g., acids & bases
  - Don't corrode drain pipes
- Dilute with lots of water while pouring down the drain
- Be sure that you do not form more hazardous substances



Waste management: Treatment in Lab?

- **Destruction / neutralization of hazardous chemicals**
  - **May or may not be allowed by regulations**
  - **Must be done by trained chemist**
  - **Specific to each chemical**
- References:
  - "Procedures for the Laboratory-Scale Treatment of Surplus and Waste Chemicals, Section 7.D in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995, available online: http://www.nap.edu/catalog.php?record_id=4911
  - "Destruction of Hazardous Chemicals in the Laboratory, 2nd Edition", George Lunn and Eric. B. Sansone, Wiley Interscience, 1994, ISBN 978-0471573999
  - "Hazardous Laboratory Chemicals Disposal Guide, Third Edition", Margaret-Ann Armour, CRC Press, ISBN 978-1566705677
  - "Handbook of laboratory Waste Disposal", Martin J. Pitt and Eva Pitt, Ellis Horwood, 1985, ISBN 0-85312-634-8 (out of print)



Chemical management

- **Proper chemical management is an important part of laboratory safety and security**
- **Helps protect people, laboratories and the environment**
- **Can save money by avoiding duplicate chemical purchases**

REACH and the Global Harmonized System for the Labeling of Chemicals

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REACH

Registration, Evaluation, Authorisation of Chemicals

2007 EU regulation; replaces 40 existing acts to create a single system for all chemicals

- requires authorization to use, manufacture and import
- to track and manage chemical risks and provide safety information
- proposes to integrate REACH with GHS
- creates European Chemical Agency (ECHA, Helsinki, Finland

REACH

Life of the chemical from

Cradle-to-the-Grave

Manufacturing

Importing

Marketing

Use

Waste stream

REACH

- **Comprehensive legislation to ensure European authorities know and condone what chemicals are used as they enter the EU supply train**
- **Objective is to protect human health and the environment by recognizing and classifying hazardous chemicals so they are handled safely**
- **REACH & GHS are not equivalent or optional but separate legislation with parallel requirements**

REACH

- The responsibility for proving whether a chemical is hazardous or non-hazardous is on the manufacturer and supplier not the government
- The responsibility also includes documentation, tests, classification, risk exposure, labeling, safety data sheets
- ECHA will store the information in the International Uniform Chemical information Database (IUCLID)

REACH

Four Steps

1. Registration
2. Evaluation
3. Authorization
4. Restriction

ECHA maintains database

REACH: Registration

Importers and manufacturers of substances in quantities over 1 ton/yr must register their substance with ECHA

Registration began June 2007

December 1, 2010

≥ 1000 tons per year

- **carcinogenic, mutagenic, or reproductive toxin ≥ 1 ton per year**
- **substances classified as dangerous for aquatic environment ≥ 100 tons per year**

June 1, 2013

- **manufactured or imported at 100-1000 tons per year**

June 1, 2018

- **manufactured or imported at 1-100 tons per year**

REACH: Evaluation

Authorities will review registration and request further information or testing to determine the impact of the substance on human health and the environment

Decides next steps:

-- action for authorization

-- align classification & label

-- other action

REACH: Authorization

Decisions on what substances require an authorization or restriction are carried out for substances that pose the most concern, such as carcinogens and mutagens

Three steps:

- SVHC (Substances of Very High Concern)
  - carcinogenic, mutagenic and reprotoxic substances, persistent, bio-accumulative and toxic
- Prioritize
- Authorization provided

REACH: Restriction

- Limit uses
  - Where no viable alternative exists, a research and development plan to derive a suitable alternative is developed
- Ban substance
  - where there is an unacceptable risk to human health and the environment.

REACH: Concern

A potential concern may be creating country specific safety data sheets and labels that are compatible with the GHS proposal

REACH: Resources

About REACH: http://guidance.echa.europa.eu/

http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

REACH Help:
http://echa.europa.eu/help_en.asp#helpdesks

About ECHA: http://ec.europa.eu/echa

Globally Harmonized System

for Classification and Labeling of Chemicals (GHS)

International UN standardization for classification, safety data sheet format, and labeling of chemicals using pictograms, signal words, and hazard warnings

US OSHA is reviewing GHS for adoption

GHS

- **United Nations proposed system to internationally standardize chemical communication**
- **Countries will adopt on their own timeframe**
- **2008 - UN goal for world-wide implementation**

GHS Implementation

Intergovernmental Forum on Chemical Safety (IFCS)- adopted GHS implementation goal of 2008. The US participates and agreed to work toward this goal

Japan, Korea, New Zealand – various stages of adopting & implemented GHS

European Union – 2010 deadline for GHS substance classification

Canada – Assessing how to adopt and implement GHS

United States – Assessing impact of GHS, plans to adopt GHS by 2009. DOT expects to have changes in place by 2009

GHS Benefits

- Uniform Communication
- Better Safety

- Improved International Trade
- Lower cost

GHS Changes

MSDS now named: “SDS” (Safety Data Sheet)

Labels will be standardized with:

- signal words
- hazard statements
- precautionary statements
- pictograms
- elimination of US, Canadian and EU labels

GHS Labeling

Information required on a GHS label:

- **Pictograms**
- **Signal words**
- **Hazard statements**
- **Precautionary statements and pictograms**
- **Product identifier**
- **Supplier information**

Changes to (M)SDS

GHS name: Safety Data Sheet (SDS)

- Format:
  - 16 sections required in specified order (as per ANSI MSDS format in US Regulations presentation)
- Reclassification:
  - (MSDS) Health & Physical Hazards
  - (SDS) Environmental Hazards
- Building Block Approach
  - each country can select portions of GHS to adopt
  - Not every country will require all categories or all hazards

Examples of GHS Pictograms

Differences between REACH and GHS

- REACH and GHS have different scopes but there are many links between the two regulations
- REACH aims to produces information on hazards, risks, and risk management
- GHS aims to harmonize classification and labeling of materials
- GHS is a UN recommendation which applies across countries, including the EU

Differences between REACH and GHS

- REACH intends to replace current EU classification criteria with GHS. REACH has provisions for safety data sheets based on GHS.
- GHS intends to apply classification and labeling beginning December 1, 2010, when the new GHS regulation will be available.
- Substances will be phased in the first 3.5 years. Mixtures will be given an additional 4.5 years for reclassification.

Globally Harmonized System

Resources

http://www.unece.org/trans/danger/publi/ghs/ghs_rev02/02files_e.html

http://www.unece.org/trans/danger/publi/ghs/presentation_e.html

http://www.osha.gov/SLTC/hazardcommunications/global.html

Controlling Hazards:

Personal Protective Equipment (PPE) and Safety Equipment Performance Specifications

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Personal Protective Clothing (PPE)

- **Evaluate task, select appropriate type and train to use it properly**
  - **eye protection**
  - **outer protection**
  - **gloves**
  - **respirator**
  - **noise**
  - **safety shoes**
  - **hard hat**

Hazard Assessment

Hazard Type	Hazard Type	Common related tasks
Impact	**Flying objects such as large chips, fragments, particles, sand, and dirt**	**Chipping, grinding, machining, masonry work, wood working, sawing, drilling, riveting, sanding,…**
Heat	**Anything emitting extreme heat**	**Furnace operations, pouring, casting, hot dipping, welding, …**
Chemicals	**Splash, fumes, vapors, and irritating mists**	**Acid and chemical handling, degreasing, plating, and working with blood or OPIMs**
Dust	**Harmful dust**	**Woodworking, buffing, and general dusty conditions**
Optical Radiation	**Radiant energy, glare, and intense light**	**Welding, torch-cutting, brazing, soldering, and laser work**

Personal Protective Equipment (PPE)

Greater hazard ←

Level A	Level B	Firefighter Bunker Gear	MOPP4	Level C	Level D
					

Higher burden ←

Shield or isolate from chemical, physical or biological Agents

Training and Qualification

People should be trained to know

- **When PPE is necessary?**
- **What PPE is necessary?**
- **How to properly don, doff, adjust and wear PPE**
- **Limitations of PPE**
- **Proper care, storage, maintenance, useful life, and disposal of PPE**
- **When is retraining necessary?**
  - change in the task
  - change PPE used
  - inadequate employee knowledge or use of PPE
  - retrain to reinforce understanding or skill

Personal Protective Equipment (PPE)

- A last resort, but necessary when
  - engineering controls inadequate or can't be used
  - (like ventilation, containment, e.g., dykes)
  - emergency response or spill cleanup
- Depends upon human behavior
  - proper selection, fit and comfort issues
- Hazard is still present with PPE

Eye and Face Protection

- Thousands blinded each year from work-related eye injuries
- Nearly three out of five workers are injured while failing to wear eye and face protection

Protective Equipment Works

Impact Hazards

Eye protection shields eyes from flying fragments, objects, large chips, and particles

- **use safety glasses with side shields to protect from flying objects**
- **use goggles to prevent objects from entering under or around the safety eyewear**
  - surrounding the eyes and form a protective seal
- **use face shields in combination with safety spectacles or goggles for additional protection**
  - do not protect from impact hazards

Dust Hazards

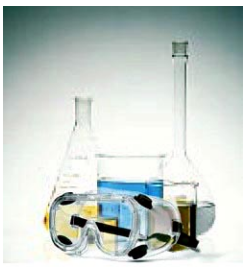
Eye protection can act as primary protection to shield the eyes and face from dust hazards

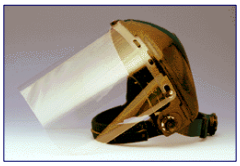
- **goggles form a protective seal around the eyes, preventing nuisance dust from entering under or around the the safety eyewear**
- **ventilation should be adequate, but protected from dust**

Chemical Hazards

Eye protection is the primary protection to shield the eyes and face from chemical hazards

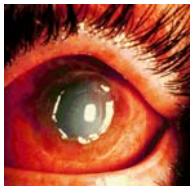
- **safety glasses with side shields protect eyes from chemical exposure**
- **goggles prevent objects or liquids from entering under or around the safety eyewear**
- face shields **offer additional protection**
  - *considered secondary*





Protective Equipment Works

It was only a **small amount** of a concentrated alkali (sodium hydroxide)
Always use PPE and a fume hood



This is an actual alkali burn —
the person lost their sight in this eye

Protective Equipment Works

"It's a hot day, why wear a lab coat?"

A flaming solvent in a lab hood splashed out onto the bottom of the lab coat

The same thought applies to all PPE

Eye & Face Protection

- eye wash stations
  - minimum 0.4 to 3.5 gal/min
    - flush for 15 minutes
  - provide flow for both eyes
    - hold eyes open
    - tepid, pH match eye (preferred)
  - easily accessible locations
    - 33 to 45 inches from floor
    - 6 inches from wall
  - test weekly
    - portable: clean/refill (6 mo – 2 yrs)
  - various types

Safety Showers

- within 55 feet or 10 seconds
  - Normal walking = 3.8 mph
- test monthly
- pull within reach (highly visible)
  - 82 to 96 inches high
  - deliver 20 inch column @ 60” above floor
- 20 - 30 gal/min (tepid: 60 to 100 °F)
- drains
- blankets/modesty curtains
- avoid or protect electrical outlets
- ANSI Z358.1-2004

Glove Selection

- **Considerations:**
  - chemicals (splashes vs immersion)
  - thermal (extreme heat/cold)
  - abrasion; cuts; snags; splinters; punctures
  - grip: oily, wet, dry
  - comfort, fit, size
  - ergonomics

Chemical Protective Gloves/Clothing

- **Permeation** ("silent killer")
  - Substances pass through intact material on a molecular level
- **Penetration**
  - Substances pass through seams, zippers, stitches, pinholes, or damaged material
- **Degradation**
  - Substance damages material making it less resist or resulting in physical breakdown
- **Contamination**
  - Substances transferred inside material (improper doffing or decontamination)

Gloves

- It's important to have the *right glove* for the job and know *how long* it will last

- **Glove Charts:**
  - Consider several glove manufacturer's data before final selection
  - www.bestglove.com/site/chemrest/
  - ***When is doubt consult a chemist or safety professional!***

The first square in each column for each glove type is color coded. This is an easy-to-read indication of how we rate this type of glove in relation to its applicability for each chemical listed. The color represents an overall rating for both degradation and permeation. The letter in each square is for Degradation alone…

GREEN: The glove is very well suited for application with that chemical.

YELLOW: The glove is suitable for that application under careful control of its use.

RED: Avoid use of the glove with this chemical.

CHEMICAL	LAMINATE FILM BARRIER			NITRILE SOL-VEX			UNSUPPORTED NEOPRENE 29-865			SUPPORTED POLYVINYL ALCOHOL PVA			POLYVINYL CHLORIDE (Vinyl) SNORKEL			NATURAL RUBBER CANNERS AND HANDLERS*			NEOPRENE/ NATURAL RUBBER BLEND CHEMI-PRO*		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E	P	—	—	E	10	F	NR	—	—	NR	—	—	E	7	F	E	10	F
2. Acetic Acid	■	150	—	G	270	—	E	60	—	NR	—	—	F	180	—	E	110	—	E	260	—
3. Acetone	▲	>480	E	NR	—	—	E	10	F	P	—	—	NR	—	—	E	10	F	G	10	G
4. Acetonitrile	▲	>480	E	F	30	F	E	20	G	■	150	G	NR	—	—	E	4	VG	E	10	VG
5. Acrylic Acid	—	—	—	G	120	—	E	390	—	NR	—	—	NR	—	—	E	80	—	E	65	—
6. Acrylonitrile	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG	P	—	—	P	60	G	E	>10	VG	E	20	VG
8. Ammonia Gas	■	19	E	▲	>480	—	▲	>480	—	—	—	—	■	6	VG	—	—	—	■	27	VG
9. Ammonium Fluoride, 40%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—
10. Ammonium Hydroxide	E	30	—	E	>360	—	E	250	—	NR	—	—	E	240	—	E	90	—	E	240	—
11. Amyl Acetate	▲	>480	E	E	60	G	NR	—	—	G	>360	E	P	—	—	NR	—	—	P	—	—
12. Amyl Alcohol	—	—	—	E	30	E	E	290	VG	G	180	G	G	12	E	E	25	VG	E	45	VG
13. Aniline	▲	>480	E	NR	—	—	E	100	P	F	>360	E	F	180	VG	E	25	VG	E	50	G
14. Aqua Regia	—	—	—	F	>360	—	G	>480	—	NR	—	—	G	120	—	NR	—	—	G	180	—
15. Benzaldehyde	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	G	10	VG	G	25	F
16. Benzene, Benzol	▲	>480	E	P	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—
17. Benzotrichloride	—	—	—	E	>480	E	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—
18. Benzotrifluoride	—	—	—	E	170	G	F	—	—	E	—	—	G	<10	F	P	50	G	—	—	—
19. Bromine Water	—	—	—	E	>480	E	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—
20. 1-Bromopropane	▲	>480	E	■	23	F	■	<10	P	▲	>480	E	■	<10	F	■	<10	P	■	<10	P

Chemical Protection Ratings

permeation rate (PR)	permeation breakthrough (PB)	permeation degradation rate (DR)
E- Excellent; permeation rate of less than 0.9 mg/cm^2/min	>Greater than (time - minutes)	E - Excellent; fluid has very little degrading effect.
VG - Very Good; permeation rate of less than 9 mg/cm^2/min	< Less than (time - minutes)	G - Good; fluid has minor degrading effect.
G - Good; permeation rate of less than 90 mg/cm^2/min		F - Fair; fluid has moderate degrading effect.
F - Fair; permeation rate of less than 900 mg/cm^2/min		P - Poor; fluid has pronounced degrading effect.
P - Poor; permeation rate of less than 9000 mg/cm^2/min		NR - Fluid is not recommended with this material.
NR - Not recommended; permeation rate greater than 9000 mg/cm^2/min		† Not tested, but breakthrough time > 480 min DR expected to be Good to Excellent
		†† Not tested, but expected to be Good to Excellent based on similar tested materials

http://www.hazmat.msu.edu:591/glove_guide/

Types of Respirators

- Air Purifying (APR)
  - half Face
  - full Face
  - PAPR
- Air Supply
  - air line
  - SCBA

Respiratory Protection Program

- written program
- administered by Safety Office
- medical clearance
- *no beards*
- fit testing
- respirator selection
- training (annual refresher)

Air Purifying Respirators (APR)

- *Must have at least 19.5% oxygen*
  - *Never* use in oxygen ($O_{2)}$ deficient atmospheres
- *Only filters the air*
  - particulate filters
    - removes solids
  - chemical cartridges or canisters
    - remove gases and vapors
  - combination cartridges
    - removes vapors & particulates
- Concentrations must not exceed limitations of filter/cartridge.
- Good warning properties
- PAPR (Powered Air Purifying Respirator)
  - uses a blower to force air through an air purifying element

Dust Masks *vs.* Hospital Masks*

* Only protects patients

Fit Testing

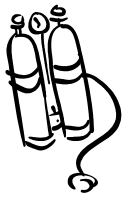
- **Qualitative (pass/fail fit test)**
  - **irritant smoke (stannic chloride)**
  - **isoamyl acetate (banana oil)**
  - **Positive/negative pressure test**
  - *people should perform a user seal check each time they put on a tight-fitting respirator*

Supplied Air

- Supplies breathing air to employee
- Examples
  - SCBA
  - airline
- Grade D Air
- Limitations

Breathing air quality and use

- Compressed breathing air must be at least Type 1 - Grade D [ANSI/CGA G-7.1-1989]:
  - oxygen content = 19.5 - 23.5%
  - hydrocarbon (condensed) = 5 mg/m^3 or less
  - CO of 10 ppm or less
  - CO_2 of 1,000 ppm or less
  - lack of noticeable odor



Breathing air quality and use

- Compressors must be equipped with in-line air-purifying sorbent beds and filters
- non-oil lubricated compressors
  - Carbon monoxide (CO) levels in the breathing air less than or equal to 10 ppm
- oil-lubricated compressors
  - high-temperature and CO alarm

Body protection for emergency response

- Hazardous chemicals
- Biohazards
- Full suits
  - Class A
  - Class B
  - Class C
  - Class D

Level A Protective Suits

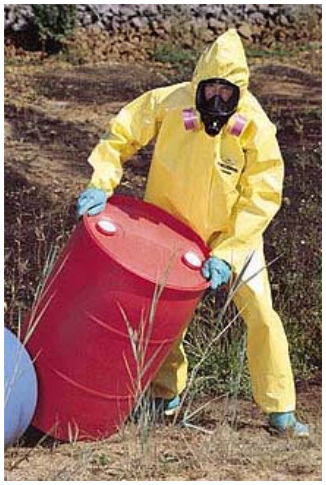
- **potential exposure to unknown**
  - **greatest level of skin, respiratory, and eye protection**
  - **positive-pressure, full face-piece self contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA**
  - **totally encapsulated (air-tight) chemical and vapor protective suit**
  - **inner and outer chemical-resistant gloves, and boots**

Level B Protective Suits

- **Atmospheric vapors or gas levels** not **sufficient to warrant level A protection**
- **Highest level of respiratory protection, with lesser level of skin protection**
  - **positive-pressure, full face-piece self contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA**
  - **hooded chemical resistant clothing or coveralls (non-totally-encapsulating suit), inner and outer chemical-resistant gloves, and boots**

Level C Protective Suits

- Known contaminant
- Full-face air purifying respirator
- Chemical-resistant gloves, hard hat, disposable chemical-resistant outer boots
  - *difference in Level C and level B is respiratory protection*



Level D Protective Suits

- Minimum protection
- *No* respiratory or skin protection
- Used only if no known or suspected airborne contaminants
- May include gloves, coveralls, safety glasses, face shield, and chemical-resistant, steel-toe boots or shoes

Any Questions?