Toxic Chemical Emergencies Responder Awareness and Precautions

UMV MRC Training
Lowell, MA
June 16, 2010

You

- EMS (5)
- Med Tech (2)
- RN/RNP (13)
- Admin./Industrial Hyg./Ham Radio (5)

Me

- Laboratory (1)

Medical Reserve Corps (MRC) and Emergency Response

- Natural disasters or man-made emergencies can overwhelm the capabilities of first responders (first 12-72 hrs.)
  - Medical staff shortages at local medical and emergency facilities
  - Medical and other health "surge" capacity needed
- MRC
  - Recruit
  - Train
  - Mobilize
  - Supplement
- Thus, medically trained individuals and other MRC volunteers can fill in the gaps in emergency response plans to improve response capabilities overall.

Chemicals

- Necessary
- Dangerous
- Ubiquitous
  - Fixed site
  - Transported (air, highway, rail, pipeline)

HAZMAT Definition (USDOT)

"Any substance which may pose an unreasonable risk to health and safety of operating or emergency personnel, the public, and/or the environment if not properly controlled during handling, storage, manufacture, processing, packaging, use, disposal, or transportation."

What's Out There?

EVERYTHING!!!

TOXICS **FLAMMABLES** ***REACTIVES***
CORROSIVES ***RADIOACTIVES***
HIGH PRESSURE GASES
HOT MATERIALS ***CRYOGENICS***
EXPLOSIVES ***BIO-HAZARDS***

And Materials That Exhibit Multiple Hazards

Scenarios

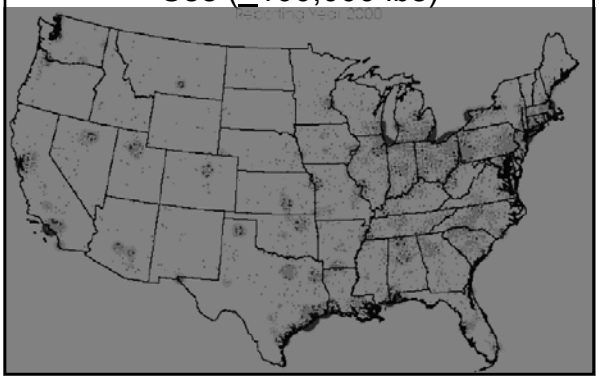
Accidental or intentional

- Large-scale outdoor release of toxic substance
- Release of a toxic chemical into a confined space
- Acute or delayed poisoning by contamination of food, water, or a highly trafficked venue

What is the Risk from Hazardous Materials in the Northeast?

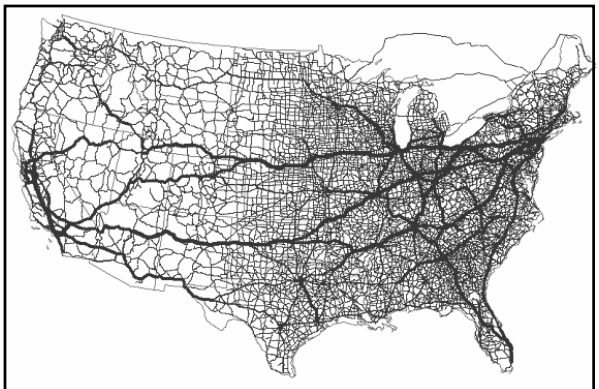
- Communities and residences located near industries or other property that use hazardous materials have a higher risk of a hazardous materials incident.
- Many hazardous materials are transported regularly over our highways and by rail, and if released during transport these materials can spread quickly to any nearby community.
- Human error is the probable cause of most transportation incidents involving the release of hazardous materials.

High Volume Chemical Production & Use (≥100,000 lbs)



Toxic Industrial Chemicals (TICs) Fixed Facilities

- Varying quantities of hazardous materials are manufactured, used, or stored at ~ 4.5 million facilities in the U.S.
- EPA report: > 100 chemical plants across U.S. have enough toxic chemicals to kill/injure 1 million
- U.S. army study: terrorist attack on chemical plant in densely populated area could result in 2.4 million fatalities or injuries

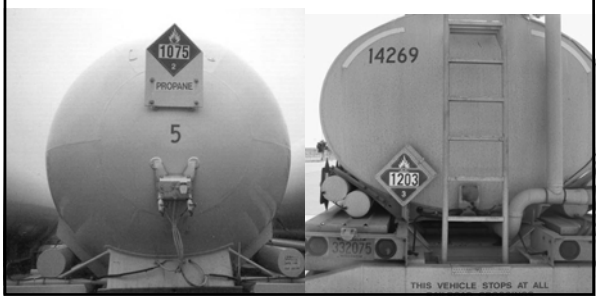


http://ops.fhwa.dot.gov/freight/presentations/images/faf_06.gif

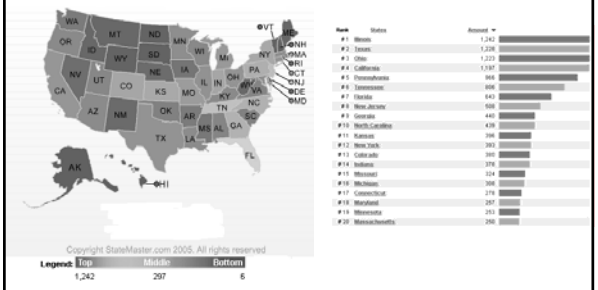
How Much HazMat is Transported in the USA?

800,000 Shipments Per Day
770,000 by Highway

Motor & Heating Fuels are the Most Frequently Transported Hazardous Materials



Number of Hazardous Materials Incidents by State 2003



SOURCE: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Safety, Hazmat Summary by State for Calendar Year 2003, Washington, DC: 2004

Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Substances Emergency Events Surveillance (HSEES) system

- 1998 – 2001, 14 States
- 10 most frequently released chemicals: ammonia, sulfur dioxide, sulfuric acid, hydrochloric acid, carbon monoxide, sodium hydroxide, nitric oxide, mercury, paint or coating not otherwise specified, and ethylene glycol

Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Substances Emergency Events Surveillance (HSEES) system

- 1998 – 2001, 14 States, (facility and trans)
- 28, 787 events
- Most occurred between April and August
  - Peak: June
- ≥ occurred between 6AM and 6PM
  - Peak: facility 10AM
  - Peak: trans 9 AM
- Most occurred on weekdays, peak: Wed

Questions

- What industries, factories, etc. are in your community?
- Do you know what chemicals are transport through your community?
- How do you find out?

Find out about Community Hazards

- Local Hospital Hazard Vulnerability Analysis (HVA)
- LEPC-community hazard assessment, community right-to-know information
- HAZMAT teams
- Fire Departments
- EPA
- National Response Center spill report database
- US Fire Administration's National Fire Incident Reporting System

Emergency Planning & Community Right-to-Know Act (EPCRA)

- Required chemical facilities to provide
  - Information necessary for emergency planning to Local Emergency Planning Committees (LEPCs)
  - annual hazardous chemical inventories to State Emergency Response Commissions (SERCs), LEPCs and local fire departments.
- Required SERCs & LERCs to prepare emergency response plans for chemical accidents.
- Established Toxics Release Inventory (TRI), which requires facilities to annually report quantities of their emissions of toxic chemicals to TRI database.

EPA: Risk Management Program

- Aim: Prevent/minimize consequences of accidental chemical releases from fixed facilities.
- Facilities that manufacture, process, use, store, or otherwise handle any of 140* listed substances at or above specified threshold quantities (range from 500–20,000 pounds) must submit a Risk Management Plan (RMP).

* The no. of chemicals has been increased to 650

Community Planning for Hazardous Materials (Hazmat) Incidents

- Hospitals required participation in community planning for HAZMAT incidents
  - Several federal agencies
  - Joint Commission for Accreditation of Healthcare Organizations (JCAHO)
  - SARA Title III or Emergency Planning and Community Right to Know Law
- **SARA Title III**
  - Facilities manufacturing or storing hazardous chemicals must report inventories & every hazmat release to public officials and emergency health agencies
  - State emergency response commissions (SERC
  - Est. local emergency planning committees (LEPC).
    - local officials, police, fire, emergency medical services, public health authorities
    - representatives of local hospitals, media, and the community.

Local Emergency Planning Committees (LEPC)

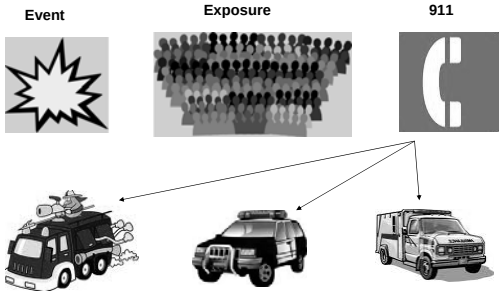
Primary responsibility: develop emergency response plans (ERPs) to do the following:

- Identify local facilities using hazardous substances
- Designate community and industrial coordinators
- Establish mechanisms of emergency notification
- Establish procedures for determining the occurrence of a release and an estimation of the affected population
- Identify community emergency equipment facilities
- Establish evacuation plans
- Establish and schedule training programs for emergency personnel

Responding to Chemical Events

- First responders
- First receivers
- Patient Considerations
- Laboratory

Chemical Release-Initial Stage



Chemical Release Scene Management First Responders

- Recognize event and establish command center
- Establish hot zone
- Identify hazardous material(s)
- Assess hazard risk + degree of personal equipment required
- Rescue victims that are on-site
- Establish crowd control
- Ensure ambulatory exposure victims stay on-site until decon
- Perform decontamination
- Notify healthcare facilities of incident (number and type of victims)
- Provide medical care + transport of patients
- Contain hazardous material (runoff from decontamination)
- Evaluate further public exposure and evacuate if necessary

Notifications: State hazmat, poison control, 1st Civil Support Team, local & state public health, other agencies- Early is better!!

Detecting Chemical Agents at the Scene

- Early detection/identification of agents in a chemical release is essential
  - Determine level of PPE is required to protect EMS personnel
  - Initiate appropriate decontamination procedures for victims
- Final confirmation of the agent usually comes from samples sent to a certified laboratory for analysis
- MA State Hazmat teams are trained to use handheld devices to detect chemicals on-site within seconds.
- These detectors can detect volatile organic compounds (VOCs), explosives and most chemical agents.
- The teams are trained to understand limitations of field chemical testing.

Chemical Release Response Hospital First Receivers

- Implement Emergency Response Plan
- Triage
- Personal protective equipment (PPE)
- Decontamination
- Crowd control
- Treat victims who arrive by private vehicle
- Provide medical care after decontamination
- Notify: Poison control, state public health, others

Additional Considerations

- Patients remote to exposure may exhibit symptoms
  - May develop symptoms on learning of the exposure
- Medical personnel can be affected
  - They can become victims
  - They may react inappropriately
- Treatment for presumed poisoning can be harmful
  - Decontamination in extremely cold weather
  - Adverse effects of antidotes

Expect Large Numbers of Patients after Mass Chemical Exposure

- Types of Patients
- Obvious Medical Needs
  - Poisoned
  - Contaminated
- Nonspecific symptoms
  - With no apparent exposure
- Asymptomatic
  - "Just want to get checked out "

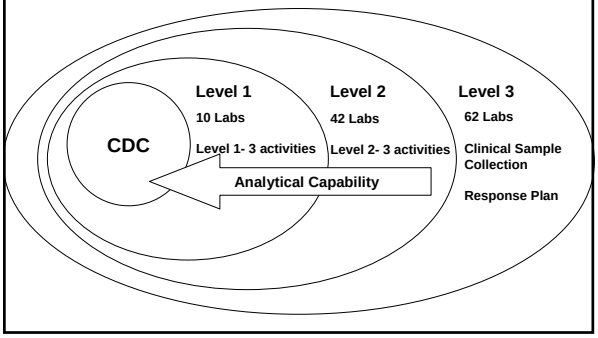
Magnitude of Problem

- Tokyo Sarin Incident 1995
  - 12 died
  - 1,200 required some care
  - 5,500 sought medical care but had no exposure
- Bhopal Disaster 1984
  - >10,000 severe and 5000 died
  - 200,000 sought medical care

Massachusetts Department of Public Health Chemical Terrorism Response Laboratory (CTRL)

- 2003
- Laboratory Response Network Chemical (LRN-C)
- 24/7 response
- Level 1 surge
- National Response Framework

LRN-C Capabilities



CTRL Analytical Capabilities Clinical specimens

- Toxic elements
- Lewisite
- Sulfur mustard
- Nitrogen Mustard
- Ricin
- Abrin
- Organic Phosphate Nerve Agents

- Cyanide
- Volatile Organic Compounds
- Monofluoroacetate (MFA)
- Monochloroacetate (CFA)
- Tetranitromethane
- Tetramine
- Others*

CTRL Analytical Capabilities

- Unknown solids & liquids
  - Identification
  - Confirmation
- Foods & beverages
  - Contamination
  - Tampering
  - Degradation
- Prescription drugs
  - Tampering
- Post-mortem specimens
- Misc. Projects

Panic is Rare During a Disaster

- Observed groups of patients in period of impact
  - "Cool and Collected " (75%)
  - Stunned and bewildered (>20%)
  - Confused, anxious, hysterical crying (<5%)

- Similar to what occurred on 9/11/01

Knowledge and Preparation

- Identify worst-case scenarios (WCS)
- Know what chemicals are in your community
- Identify hazards associated with responder's role
- Develop emergency response plan with community
- Plan for medical resources to be overwhelmed
- Plan for what people will most likely do, not what they should do
- Develop Relationships before emergencies happen
- Training, drills, and exercises

Personal Protective Equipment

- Chemical event Recognition
- Chemical Classification/identification
- Exposure Potential
- PPE Selection
- Training

Chemical Event Recognition

Dead Animals/Birds/Fish
Not just an occasional incident, but numerous animals (wild and domestic, small and large), birds, and fish in the same area

Lack Of Insect Life
Normal insect activity (ground, air, and/or water) missing, dead insects evident in the ground/water surface/shoreline

Physical Symptoms
Numerous individuals experiencing unexplained water-like blisters, wheals (similar to bee stings), pinpointed pupils, choking, respiratory ailments and/or rashes

Mass Casualties
Numerous individuals exhibiting unexplained serious health problems ranging from nausea to disorientation to difficulty in breathing to convulsions and death

Definite Pattern Of Casualties
Casualties distributed in a pattern that may be associated with possible agent dissemination methods

Illness Associated With Confined Geographic Area
Lower incidence of symptoms for people working indoors than outdoors, or the reverse

Unusual Liquid Droplets
Numerous surfaces exhibiting oily droplets/film; numerous water surfaces displaying an oily film (no recent rain)

Areas That Look Different In Appearance
Not just a patch of dead weeds, but trees, shrubs, bushes, food crops, and/or lawns that are dead, discolored, or withered (no current drought)

Unexplained Odors
Smells ranging from fruity to flowery to sharp/pungent to garlic/horseradish-like to bitter almonds/peach kernels to newly mown hay; the particular odor is completely out of character with its surroundings.

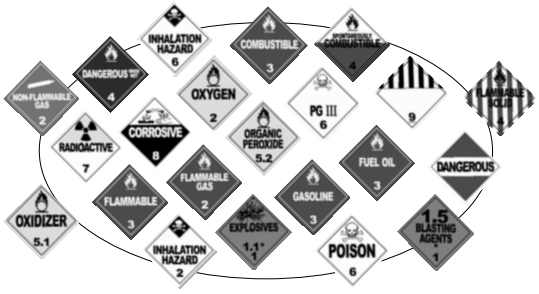
Low-Lying Clouds
Low-lying cloud/fog-like condition that is not explained by its surroundings.

Unusual Metal Debris
Unexplained bomb/munitions-like material, especially if it contains a liquid (no recent rain).

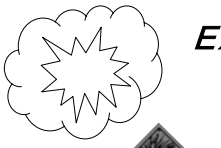
Chemical Recognition

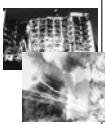
- Occupancy and Location
- Container shape
  - Stationary bulk storage-fixed facilities
  - Bulk transport - rail & tank cars
  - Smaller quantities - fiberboard boxes, drums, cylinders.
- Markings & colors
  - DOT markings, NFPA diamonds
- Placards (bulk), labels (smaller amounts)
- Shipping Papers-required all hazmat shipments
- Senses

DOT Hazard Classes



Explosives (Class 1)



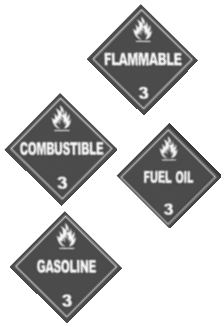


- **Commercial Explosives**
- **Fireworks**
- **Ammunition**
- **Fertilizer Bombs** (Ammonium nitrate & fuel oil)
- **Hydrazine** (Flammable liquid. Forms explosive mixtures [hypergolic] - a high energy rocket fuel, corrosive and poisonous)

Compressed Gases (Class 2)

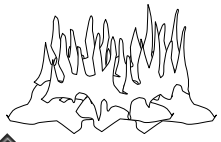
- **Hydrogen Sulfide**
- **Phosgene**
- **Methyl Bromide**
- **Ammonia**

Flammable/ Combustible Liquids (Class 3)



- Gasoline
- Hydrazine
- Methanol
- Diesel
- Acetone

Flammable Solids (Class 4)

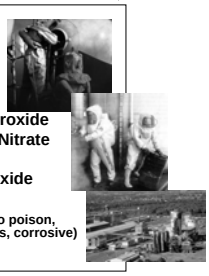


- Aluminum Phosphide
- Naphthalene
- Sodium

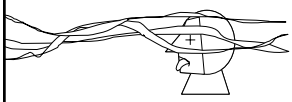
- Carbon
- Magnesium

Oxidizers & Organic Peroxides (Class 5)

- Red Fuming Nitric Acid (corrosive)
- Nitrogen Tetroxide
- Ammonium Nitrate
- Methyl Ethyl Ketone Peroxide
- Fluorine, Chlorine (also poison, compressed gas, corrosive)



Poisonous & Infectious Materials (Class 6)

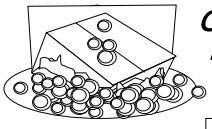


- Pesticides
- WMD (Sarin, VX)
- Solvents
- Bioterrorism
- Tear Gas
- Vesicants (Mustard, Lewisite)

Radioactive Materials (Class 7)

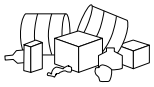
- Terrorist Use
- Military Facilities
- Nuclear Reactors
- Commercial/ Research Facilities
- Industrial X-Ray Material

Corrosive Materials (Class 8)



- Pool chemicals
- Sulfuric acid
- Nitric acid
- Muriatic acid
- Sodium Hydroxide
- Chlorine, Fluorine

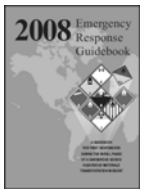
Miscellaneous Hazardous Materials
(Class 9)



- **Pepper Spray & Mace**
- **Molten Sulphur**

NFPA 704 Marking System

- Developed by National Fire Protection Association
- Used for hazards in facilities and may be found on non-bulk packaging.
- Uses a diamond shaped symbol divided into four smaller diamonds.
  - Blue (left) indicates health hazard
  - Red (top) indicates flammability hazard
  - Yellow (right) indicates reactivity hazard
  - Lower quadrant contains symbols indicating special hazards
  - Number from 0 to 4 indicating the relative degree of hazard within the container.

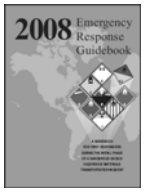


Yellow gives the reference number as assigned by the United Nations (UN) for the hazardous material.

UN 2590

Asbestos

Guide No. 171

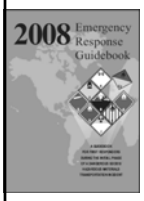


Blue Section lists all hazardous materials alphabetically and then gives the corresponding UN number which can then be referenced in the orange section.

Asbestos

Guide No. 171

UN ID No 2950



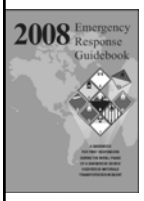
Orange Section tells emergency workers what the procedures are in the first 30 minutes of an accident. Will give

Asbestos
Guide No. 171
UN ID No 2950

Potential hazards: health and fire / explosion dangers

Public Safety: Notification, scene safety, PPE, Evacuation (spill or fire)

Emergency Response: Fire or Spill / leak, First Aid



Green Section suggests initial evacuation procedures for any buildings within a certain proximity of the accident. Evacuation distances will vary with each hazardous material

UN 2590

EMS Responders May Become Exposed to Chemicals in the Field

- Direct airborne or physical contact with the contaminant at the scene
- Secondary contact while caring for a patient who became contaminated with the substance at the scene.

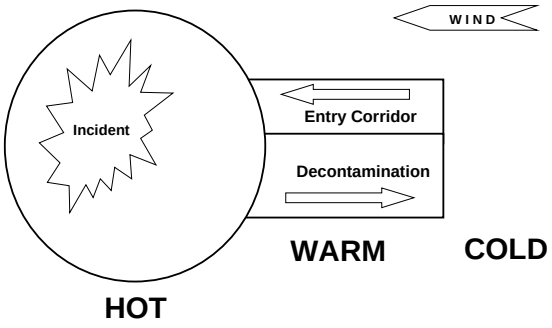
PPE for EMS

- Minimum PPE to offer protection against a reasonably anticipated worse case scenario
  - release of *unidentified or uncharacterized* hazardous substances with potential for secondary contamination.
  - could include the possibility that the unidentified substance would be a *CBRNE substance*.
- Once a hazardous substance is identified or characterized, the PPE can be adjusted to appropriate levels, as determined by the incident commander.
- Must be trained on proper use of PPE and annually fit-tested for respirators

PPE for EMS

- EMS responders must also consider anticipated airborne hazards when selecting respiratory protection for EMS responders.
- Factors to consider include identifying the substance, making a reasonable estimate of exposure levels, and predicting the contaminant's chemical state and physical form.
- When it is not possible to identify the contaminant or estimate worker exposure levels, the employer must consider the atmosphere to be immediately dangerous to life and health (IDLH).

Control Zones



OSHA Level A

– Fully encapsulating chemical-resistant suit, gloves and boots, and a pressure-demand self-contained breathing apparatus (SCBA) or a pressure-demand supplied-air respirator (SAR) with air hose and escape SCBA.

IMAGE: USCG

OSHA Level B

– Non-encapsulating, splash-protective, chemical-resistant (splash) suit that provides Level A protection against liquids, but is not airtight.

IMAGE: CDC

OSHA Level C

– Splash suit with a full-face positive- or negative-pressure respirator (a filter-type gas mask)

IMAGE: SAIC

OSHA Level D

– Coveralls or other work clothes, boots and gloves

IMAGE: USAF

PPE Complications

- Limited visibility
- Reduced dexterity
- Claustrophobia
- Restricted movement
- Suit breach
- Insufficient air supply
- Dehydration
- Effects of heat and cold

PPE for Hospital Personnel

- OSHA PPE best practices recommendation: first receivers exposed to limited amounts of toxic substances.
- Removing and bagging victim's clothing significantly diminishes the risk for secondary exposure. (~90% contaminants eliminated).
- Level C: hooded, air-purifying respirator (PAPR), with additional chemical filter, chemical resistant protective garment, head covering, double-layer of protective gloves, chemical protective boots.
- Must be trained on proper use of PPE and annually fit-tested for respirators

Training

Requirements and Standards

- OSHA: CFR 1940.120
- EPA: 40 CFR 311
- NFPA: Standard 473

(*Standard for Competencies of EMS Personnel Responding to Hazardous Materials Incidents*)

Hazmat Training Goals

Level 1: First Responder awareness

- Witnesses or discovers a release of a hazardous material
- Trained to notify the proper authorities.
- Training includes
  - recognition and identification of hazardous materials
  - proper notification procedures
  - and the employee' s role in the Emergency Response Plan.

Level 2: First Responder Operations

- Responds to the release of hazardous substances in a defensive manner without actually trying to stop the release.
- Requires level 1 competency and 8 hrs of additional training
  - basic hazard and risk assessment
  - PPE selections
  - containment and control procedures
  - Decontamination
  - standard operating procedures.

Awareness-Level 1

- All responders who may arrive first on scene and discover hazardous substance
- EMS, Fire, Law enforcement

EMS Level I

- Patient care in cold zone with **NO** significant 2º contamination risk
- Focus
  - Hazard assessment
  - Assessment
  - Management of contaminated patients

EMS Level II

- Patient care in warm zone with significant risk of 2º contamination
- Focus
  - Personal protection
  - Decontamination procedures
  - Assessment, management during decon

Hospital ED Training

- Minimally, all hospital personnel (docs, nurses, security, triage) who have a designated role in HazMat emergency operation must be trained to OSHA's First Responder Awareness Level
- Personnel who are expected to decontaminate patients or handle them before thorough decontamination must be trained to the First Responder Operations Level and receive additional training in decontamination

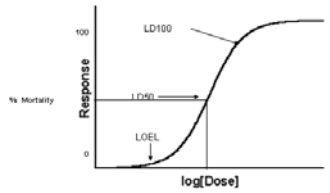
Which of the following would best be characterized as a toxic industrial compound?

- 1. Ammonia
- 2. Anthrax
- 3. Sarin
- 4. Mustard Gas
- 5. Water

Paracelsus (1493 -1541)

"Poison is in everything, and no thing is without poison. The dosage makes it either a poison or a remedy."

The Dose Makes the Poison



LD 50: Lethal Dose 50%

LD 100: Lethal Dose 100%

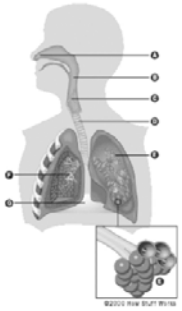
LOEL: Lowest Observable Effect Level

Chemical Accidents in US Industry RMP for 1994-1999

#1	**Anhydrous Ammonia**	**656**
#2	**Chlorine**	**518**
#3	**Hydrogen Fluoride**	**101**
#4	Flammable Mixture	99
#5	Chlorine Dioxide	55
#6	Propane	54
#7	Sulfur Dioxide	48
#8	**Ammonia (>20%)**	**43**
#9	Hydrogen Chloride	32
#19	**Phosgene**	**12**

Inhalational Exposure: Determinants of Toxicity

- Individual exposed
  - Health
  - Respiratory rate x tidal volume
- Exposure circumstances
  - Concentration
  - Duration
- Properties of Agent
  - Water solubility
  - pH
  - Volatility/Vapor density
  - Mixtures and particle size of possible carriers



Clinical Effects Based on Properties of Agent

	High Solubility	Low Solubility
Onset of Symptoms	Rapid	Delayed
Warning Properties	Good	Poor
Airway Injury	Upper with irritation	Lower with lung injury

Anhydrous Ammonia (NH_3)

- Used mainly in manufacture of fertilizer as nitrogen source (>80%)
- Other uses include plastics, fibers and resins, explosives, cleaning disinfectants, refrigeration
- Third highest production volume chemical in U.S.
  - ~9 million metric tons
- Transported as liquefied gas under pressure via pipeline, railcar, tanker truck, and refrigerated barge

Ammonia: Physical Properties

- Colorless gas with pungent odor
- Low odor threshold
  - good warning properties
- Highly water soluble
- Boiling point – 33°C
- Vapor density 0.6 (lighter than air)
- Combustible in narrow range
- Highly reactive gas

Ammonia: Clinical Effects

- Damage from alkali burn and thermal reaction
- Low concentration: irritant to nose, throat, upper respiratory tract

$$NH_3 + H_2O \Rightarrow NH_4OH$$

- Higher concentrations or more prolonged contact
  - Skin burns: 30% of admitted chemical burns attributed to ammonia (variable by extent of clandestine drug labs)
  - Lower airway inflammation with pneumonitis and pulmonary edema

Chlorine (Cl_2)

- Manufacturing of non–agricultural chemicals
- Pulp and paper industry
- Commercial & household bleaching agents
- Water purification & waste treatment
- US production > 12 million tons
- 3 million tons shipped as liquefied compressed gas by rail in 90 ton pressurized tank cars
- Although rail accidents involving chlorine are exceedingly rare, when chlorine tank cars are breached, the consequences often are fatal.

Chlorine: Physical Properties

- Green-yellow, pungent gas
- Low odor threshold
  - moderate warning properties
- Intermediate water solubility
- Boiling point –31°F
- Vapor density 2.5 (heavier than air)
- Reacts explosively with many compounds

Chlorine: Clinical Effects

- Intermediate water -solubility
- Low concentrations:
  - irritant to eyes, nose, throat, upper respiratory tract
- Higher concentrations:
  - acute pulmonary edema, chemical pneumonitis
- Chronic sequelae:
  - RADS

Phosgene ($Cl_2C=O$)

- Used in the manufacture of
  - Organic chemicals: dyestuffs, isocyanates
  - Plastics
  - Insecticides
  - Pharmaceuticals
- 80% used for isocyanate production
- US production: estimated 1 million tons/year
- Also formed as a combustion product when chlorine-containing compounds are burned

Phosgene: Community Threat Assessment

- 99.9% of production is “used on-site”
- Stored or shipped off-site in liquid form in pressurized steel cylinders

Phosgene: Physical Properties

- Colorless gas with odor of musty hay
- Higher odor threshold
  - poor warning properties
- Low water solubility
- Boiling point 8.2ºC
- Vapor density 3.5 (heavier than air)

Phosgene: Clinical Effects

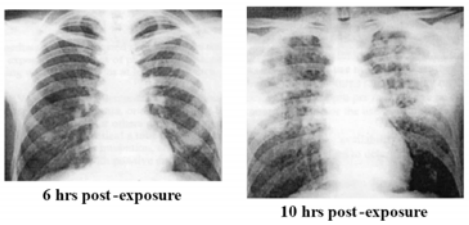
- Odor threshold: 0.5 - 1.5 ppm
- Limited initial symptoms
  - Irritation of eyes, nose, upper airways
  - Higher concentrations cause airway spasm
- Low water solubility – slow hydrolysis to HCl

Phosgene: Delayed Effects

- Latent development of pulmonary edema
  - Onset 1 to 24 hours after exposure
  - Pulmonary function abnormalities
  - May be fatal
- Chronic airway disease

$COCl_2 + 2\ R\text{-}NH_2 \Rightarrow CO(NH\text{-}R)_2 + 2HCl$

Phosgene: Delayed Lung Injury



6 hrs post-exposure

10 hrs post-exposure

Methyl Isocyanate (MIC): $H_3C–N=C=O$

- Used as a chemical intermediary for many products, including carbamate insecticides, polyurethane foam and a variety of plastics
- Usually produced by reacting methylamine and phosgene with release of hydrochloric acid
- A high production volume chemical, as are its reagents
- Combustion products from MIC may include cyanide and carbon monoxide

Methyl Isocyanate: Physical Properties

- Colorless, flammable liquid at room temperature, but easily vaporizes
  - Vapor pressure 348 mm Hg
  - Boiling point 39.5 °C
- Has a pungent odor; inadequate warning
- Water soluble, but with exothermic reaction
- Vapor density: 1.4

Methyl Isocyanate: Clinical Effects

- Dermal/ocular
  - Irritation and ulceration
- Respiratory
  - Mucosal irritation of upper and lower respiratory tract
  - Life-threatening pulmonary edema
  - Residual chronic lung disease
- Reactive Airways Dysfunction Syndrome (RADS)

Reactive Airways Dysfunction Syndrome (RADS)

- Non-immunologic asthmatic condition following large exposure to certain irritants
- Syndrome diagnosis requiring:
  - No prior chronic respiratory illness (including asthma)
  - Documented exposure to chemical irritant in significant amount
  - Onset of symptoms (cough, dyspnea, wheezing) within 24 hours and persistence for >3 months
  - Demonstrated airway obstruction and bronchial hyper – responsiveness by pulmonary function testing
  - Lack of other competing pulmonary diagnosis

Prehospital Care

- Remove the individual from the toxic environment.
- Bring container, if applicable, so medical personnel can identify toxic agent.
- Commence primary decontamination of the eye and skin, if necessary.
- If gas is denser than air it accumulates close to the ground. People should be instructed to seek higher altitudes to avoid excessive exposure.

Treatment for Irritive Gas Exposure

- Remove from exposure
- Irrigation of eyes or skin if involved
  - Extensive decontamination usually not necessary unless liquid exposure
- Providing supportive medical care
- Oxygen
- Nebulized beta-agonists (e.g. albuterol) for wheezing or dyspnea
- For phosgene exposure, people should be observed for up to 48 hours, because it may take that long for symptoms to develop or reoccur

Hydrofluoric Acid (HF)

- HF is used for a variety of industrial processes and consumer products (dilute), including
  - Catalyst in oil refineries
  - Manufacture of silicon semiconductor chips
  - Separating uranium isotopes
  - Etching glass or enamel
  - Cleaning brass, crystal and as a rust remover
- Production in U.S. is < 1 million tons/year
- Transported as pressurized anhydrous liquid by rail
- More than 1000 cases of hydrofluoric acid exposure are reported annually

HF: Physical Properties

- Colorless, non -flammable, fuming liquid or gas with irritating odor
- Low odor threshold
  - good warning property
- Highly water soluble - with release of heat
- Weak acid
  - Not highly dissociated, but penetrates tissue well
- Boiling point 20 °C
- Vapor density 0.7

HF: Clinical Effects

- Highly corrosive depending on concentration and irritating to all tissues
- Onset of pain and skin changes may be delayed for hours with dilute (<20%) solutions
- Release of fluoride ion results in binding to calcium and magnesium, with unique and severe systemic effects
  - Tissue necrosis
  - Hypocalcemia , hypomagnesemia , hyperkalemia leading to cardiac dysrhythmia and death

HF: Prehospital Care

- Basic life support
- Appropriate decontamination with copious amounts of water
- Neutralization of the acid by use of calcium gluconate.
- Treat inhalation injuries with oxygen and 2.5% calcium gluconate nebulizer.
- Control pain with opioid agents
- If exposure occurs at an industrial site, obtain and transport any available treatment literature

HF: Emergency Department Care

- Remove soiled clothing
- Decontaminate by irrigation with copious amounts of water
- Assess and manage life-threatening conditions
- Commence comprehensive monitoring for significant exposures
- With any evidence of hypocalcemia, immediately administer 10% calcium gluconate IV

Summary: Toxic Gas Characteristics

AGENT	PHYSICAL PROPERTIES			EXPECTED CLINICAL EFFECTS		
	H_2O Solubility	Odor / Warning	Vapor Density	Mucosal / Upper Airway	Lower Airway	Systemic
MIC	High	Pungent / Inadequate	1.4	Yes	Possible	No
NH_3	High	Pungent / Good	0.5	Yes	Possible	No
Cl_2	Interm .	Pungent / Fair	2.5	Yes	Yes	No
$COCl_2$	Low	Mown Hay/ Inadequate	3.5	Unlikely	Yes	No
HF	High	Pungent / Good	0.7	Yes	Possible	Electrolyte & Cardiac Rhythm

Toxic Industrial Chemical Exposure: Special Considerations

- Consider adding sodium bicarbonate to nebulizer in chlorine gas exposures
- Intravenous and inhaled calcium gluconate, and continuous cardiac monitoring are important for hydrogen fluoride exposure
- Observe patients for late pulmonary effects, particularly in those with severe early symptoms

Preparedness

- Community threat assessment
- Emergency response planning
- Prevention through zoning and/or substitution of less hazardous processes

Bhopal India, Dec. 1984

- Accidental release of 40 tons of methyl isocyanate (MIC) at a chemical production facility
- 25,000-15,000 deaths
- 60,000 injuries

Bhopal

- Water entered tank containing 57,000 L MIC
- Exothermic reaction
- Release of >40 tons MIC over 2 hrs
- Multiple safety system failures
  - unreliable pressure gauges
  - nonfunctional refrigeration unit
  - inoperable gas scrubber
  - alarm failure
- Inadequate spray “knock-down”

Bhopal

- Gas plume drifted over shanty - town exposing 250,000 people
- Temperature inversion reduced plume dilution
- Extent of risk:
  - Modeled mean MIC ambient concentration: 27 ppm (range 0.12 -85.6 ppm)
  - Median MIC concentration: 1.8 ppm
  - 30 minute Acute Emergency Guideline Level - 3 (AEGL3) 0.40 ppm

Bhopal

- 2500 fatalities within 1 week
- Long term mortality estimated ≥ 6000
- Chronic disability for > 100,000 (?)
  - chronic pulmonary complaints
  - ocular inflammation

Dhara et al, Arch Environ Health 2002; 57:391 -404

Bhopal

- “A quarter century after the world's worst industrial disaster that killed over 15,000 people, a local court on Monday convicted former Union Carbide India Chairman Keshub Mahindra and seven others in the Bhopal Gas tragedy case and awarded them a maximum of two years imprisonment.
- However, 89-year-old Warren Anderson, the then Chairman of Union Carbide Corporation of USA, who lives in the United States, appeared to have gone scot free for the present as he is still an absconder and did not not subject himself to trial.”

Jun 07, 2010

Railway Accident: Minot, ND 2002

- Derailment of 31 cars
- Immediate release of ~150,000 gallons of anhydrous ammonia from 5 of 15 cars
- One car airborne, striking a house
- Plume 300 feet high spreading 5 miles downwind

Texas City, TX Industrial Accident Releasing HF (October 31, 1987)

- ~30,000 pounds of hydrofluoric acid leaked from an HF alkylation reactor drum when a 50 foot long convection unit was dropped on the vessel
- Vapors emitted under pressure for 2 hours
- Estimate of AEGLS 3 at ~3/4 mile away
- ~4000 residents evacuated for 3 days
- >1000 people to hospital with skin, eye, nose/throat irritation and pulmonary symptoms
- No fatalities

AEGLS 3: Acute Exposure Guidelines Level with increasingly severe effects and possible death without treatment

Railway Accident: Response and Outcomes

- Shelter-in-place order
- Difficulty with communication
- Exposed population: 11,600
  - Minor symptoms: 322
  - Serious symptoms: 11
  - Fatal: 1

Sarin Attack-Tokyo March,1995

- Sarin attack on Tokyo subway system
- The results
  - 12 dead
  - Approximately 1,000 hospitalized
  - 5,500 sought medical care
  - 10% of first responders injured
- St. Luke's Hospital (520 beds)
  - Treated 500 patients in first hour; 640 on first day

Sarin Attack-Tokyo

- Aum Shinrikyo attacked five trains of the Tokyo Subway at 8:00 am on March 20, 1995
- Utilized an impure mixture of Sarin Gas in sealed plastic bags
- Punctured the bags with sharpened umbrella tips and quickly exited the trains
- All affected trains were converging on Kasumigaseki Station where the Police headquarters was located

Sarin Attack-Tokyo

- Sarin began affecting people almost instantly
- Most of the injuries occurred on the trains and platforms where the Sarin was left
  - 43% platform, 32% train, 15% station, 10% other places
- Because of non-severe symptoms there was no urgency to evacuate
- During evacuation, the trains were parked, with doors and windows open to the crowded platform
- Because of poor interagency communication there were high levels of secondary contamination

Additional Death Counted in Tokyo Sarin Attack

- Tuesday, March 9, 2010
- Japanese authorities have identified an additional fatality in the 1995 terrorist attack in which sarin nerve agent was released inside the Tokyo subway system,
- The person has become the 13th confirmed death in the strike by the Aum Shinrikyo doomsday cult.
- The newly recognized victim was in the area of the attacks and afterward showed signs of exposure to sarin. The unidentified person died in a bathtub two days after the incident.

Graniteville Train Accident, Jan 2005

- 9 deaths
  - 1 train engineer, 6 mill workers,
  - 1 in home, 1 in truck
- 529 sought medical care
  - 69 hospitalized, 11 critical
  - 18 were treated at area physicians ' offices
- 5,400 evacuated in 1 mile radius of crash
- Initial report : "sodium nitrate"
- Chlorine was not reported to ED for 1 hour