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.”

Medical Roles

- Size up incident
- Establish command
- Activate IMS
- Assess toxicological risks
- Evaluate decontamination methods
- Treat, transport patients
- Support HAZMAT team members (medical monitoring, rehab)

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)

EMS HAZMAT Training Levels

- Awareness
- Level 1
- Level 2

Awareness

- All responders who may arrive first on scene and discover hazardous substance
- EMS, Fire, Law enforcement
- Focus
  - Recognition of HAZMAT incidents
  - Basic identification techniques
  - Personal protection
**EMS Level I**

- Patient care in cold zone with **NO** significant 2o contamination risk
- Focus
  - Hazard assessment
  - Assessment, management of previously 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

**Incident Size Up**

- Safety
- Incident stability (Stable vs. Unstable)
- Property conservation
  - Exposures—people, property
  - Run-off

**Size-Up Priorities**

- Personal risk of exposure, contamination
- Delayed product effects
- Scene topography
- Wind direction
- Decontamination corridor(s)
- Incident facility location contingency plans

**Incident Awareness**

- Size-Up Special Considerations
Transportation
- Transport incidents = HAZMAT risk
- Do NOT rely on placards!
- Passenger vehicles transport HAZMAT
- Know, preplan rail lines

Fixed Facilities
- Manufacturers
- Warehouses
- Hardware stores
- Agricultural stores
- Water treatment plants
- Loading docks
- Pipelines
- Silos
- Barns
- Greenhouses

Terrorism
- Weapons
  - Chemical
  - Biological
  - Nuclear
- Potential Targets
  - Public buildings
  - Multinational HQs
  - Shopping centers
  - Workplaces
  - Public assembly places
  - Places of worship
  - Schools

Terrorism
- Preplan potential targets
- Multiple patients with similar signs, symptoms = High index of suspicion
- Consider secondary device, attack risk

HAZMAT Recognition
- Occupancy, location
- Vehicle, container shape
- Placards, other markings
- Labels
- Scene appearance
- Other sensory information
Occupancy/Location

- What do you know about the activities at this location?
- Are hazardous materials likely to be manufactured, stored, used there?
- Highway incidents are by definition a high risk situation!

Vehicle/Container Shape

External ring stiffeners frequently are present on vehicles transporting corrosives or poisons.

Vehicle/Container Shape

Rounded ends on highway transport vehicles suggest presence of pressurized contents.

Vehicle/Container Shape

Dome covers on rail tank cars suggest that the contents are under pressure.

Tank cars with flat ends have been insulated to control product temperature changes.

Vehicle/Container Shape

Placards

- DOT (transport vehicles)
- NFPA 704 (fixed facilities)

DOT Hazard Classes

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Explosives: Designed to function with instantaneous release of gas and heat (i.e., by exploding).
Blasting Agents: Designed to explode, but require a blasting cap to trigger the explosion.

Gases:
Poison A: Gases or liquids producing vapors highly hazardous to human health.
Anhydrous Ammonia is classified as a non-flammable gas, however, it is flammable and highly toxic!
Chlorine gets its own placard because it is toxic, corrosive, and an oxidizer!

Liquids:
Flammable Liquid: Flash point < 100°F
Combustible Liquid: Flash point > 100°F

Solids:
Any solid material other than an explosive that is liable to cause fires through friction, through retained heat from manufacturing, or which can be ignited readily and when ignited burns vigorously and persistently.

Oxidizers:
Liquid oxygen is an oxidizer and a cryogenic agent.
Oxidizers will readily give up oxygen and support combustion.
Organic oxidizers will readily give up oxygen, support combustion, and will burn!

Poisons:
Class B Poisons: Solids and liquids known to be so toxic as to afford a risk to human health or which, in the absence of adequate data are assumed to be toxic to man.
Irritants, substances that give off irritating fumes when heated or exposed to air, are included in Class 6, but are placarded only as DANGEROUS and only if >1000 pounds is present.
Etiologic agents are included in Class 6 but are not placarded.
Radioactive Materials

Vehicles transporting radioactive materials are placarded ONLY if the packages contain material measures >50 millirem/hr on the entire package surface or >3 millirem/hr at 3 feet. (Radioactive III package labeling)

Defense material being moved under authority of the Department of Energy or Department of Defense is NOT placarded.

Corrosives

Materials that attack and destroy living tissue or that produce severe corrosion of steel.

Frequently are also toxic and reactive.

Dangerous

Class C Explosives

Irritants

Mixed motor vehicle loads of >1000 but <5000 pounds of all HAZMAT except Poison A, Poison B, Solid Dangerous when Wet, Explosive A, Explosive B, and Radioactive

UN Numbers

When hazardous materials are transported in Tank Cars, Cargo Tanks and Portable Tanks, UN or NA numbers must be displayed on appropriate placards.

DOT Placard Limitations

- ALL product hazards NOT indicated
- Incorrect placards
- Absent placards
DOT Placard Limitations

- “DANGEROUS”
  - Rail flat car containers, motor vehicles, freight containers containing >1000, but <5000 pounds of:
    - Nonflammable gases
    - Chlorine, Fluorine
    - Liquid oxygen
    - Flammable gases
    - Flammable liquids
    - Combustible liquids
    - Flammable solids
    - Oxidizers, organic peroxides
    - Poison B
    - Corrosives

- Irritants
- Class C Explosives

NFPA 704

- Used at fixed facilities
- HEALTH
  - 4 = Too dangerous to enter
  - 3 = Extreme danger—Full protective clothing
  - 2 = Hazardous—Breathing apparatus
  - 1 = Slight hazard
  - 0 = No hazard

- FIRE
  - 4 = Extremely flammable
  - 3 = Ignites at normal temperatures
  - 2 = Ignites when moderately heated
  - 1 = Must be preheated to burn
  - 0 = Will not burn

- Reactivity
  - 4 = May detonate—Evacuate area if fire present
  - 3 = Shock, heat may detonate—Take cover
  - 2 = Violent chemical change possible
  - 1 = Unstable if heated
  - 0 = Normally stable

- Specific Hazard
  - OX = Oxidizer
  - ACID = Acid
  - ALK = Alkali (Base)
  - COR = Corrosive
  - No = Use NO Water
DOT Labels
- Placed on packages/containers

Other Sensory Information
- What do you see? Hear? Smell?
- Is there a vapor cloud?
- Is there a fire?
- Can you hear escape of a pressurized product?
- Any unusual odors?
- Are your eyes watering, burning?
- Are there dead animals, birds, fish observable?

HAZMAT Identification
- Often most difficult part of incident
- ALWAYS use at least TWO concurring sources

HAZMAT References
- Emergency Response Guidebook
- Container Markings
- Shipping Papers
- Material Safety Data Sheets
- Monitors/Chemical Tests
- Computer Databases
- Telephone Hotlines
- Poison Centers
- Chemists
- Toxicologists
- Reference Books

Emergency Response Guidebook
- U.S., Canada, Mexico
- Lists >1000 products with placards, UN numbers, chemical names
- Cross references emergency, evacuation procedures
- Medical information is limited, very generic
- Multiple chemicals share UN numbers
**Container Markings**

“Candystriper” HCN Tank Car

**Shipping Papers**
- List specific substances
- Indicate quantities carried
- Operators may not take papers with them
- Scene may be too unstable to retrieve
- Papers may be incomplete, inaccurate

**Material Safety Data Sheets**
- Present at fixed facilities
- Available for ALL hazards on site
- Cover wide range of common, simple products
- Typically list:
  - Material name
  - Characteristics
  - Manufacturer
  - Health, fire, reactivity dangers
  - Safe handling considerations
  - Emergency procedures
Monitors and Testing
- Radioactivity
- Combustibility
- Oxygen availability
- pH (Corrosiveness)
- Carbon monoxide
- Hydrogen sulfide
- Organic vapors

Computer Databases
- CAMEO®
- ALOHA®
- MARPLOT®
- OHMTADS®

Telephone Hotlines
- Chemical Transportation Emergency Center (CHEMTREC)
- Sponsored by Chemical Manufacturer's Association (CMA)

CHEMTREC Services
- Emergency response information
- Access to manufacturer’s representatives
- Activation of specialized teams to deal with chlorine, phosphorus, vinyl chloride, HCN, HF, and LPG
- Activation of CHEMNET response teams

CHEMTREC Limitations
- Communicators NOT technical personnel
- Will NOT interpret data or go beyond what information sheets say
- Must have product trade or chemical name to provide assistance
- Cannot provide information on effects of mixing of several products

CHEMTREC Information Needed
- What has happened?
- Where?
- When?
- Chemical(s) involved
- Container type condition
- Shipper/origin
- Carrier
- Consignee/destination
- Nature/extent casualties
- Nature/extent property damage
- Prevailing weather
- Nature of incident area
- Caller name/location
- Call-back number
Federal, State, Local Resources

- Federal
  - US EPA
  - Coast Guard
- State
  - TNRCC
  - TDH
  - Railroad Commission
  - Parks & Wildlife
  - Agriculture Department

Reference Books

- NIOSH Pocket Guide to Chemical Hazards
- Farm Chemical Handbook
- Chemical Hazards Response Information System (CHRIS)
- American Association of Railroads Emergency Action Guides

Reference Books

- Condensed Chemical Dictionary
- Dangerous Properties of Industrial Chemicals (Sax)
- Chemical Synonyms and Trade Names
- Merck Index

HAZMAT Terms

Boiling Point

- Temperature at which a liquid becomes a gas
- More technically, temperature at which a substance’s vapor pressure equals atmospheric pressure

HAZMAT Zones

- Hot Zone
  - Contamination Present
  - Appropriate PPE
  - Limited number of personnel
  - Everything inside considered contaminated

- Warm Zone
  - Contamination Control Zone
  - Appropriate PPE
  - Decon Corridor
  - Life-Saving Emergency Care

- Cold Zone
  - CP Location
  - Treatment/Transport Areas
  - Staging
  - Medical Monitoring/Rehab
Flammable/Explosive Limits
- Lower Explosive Limit = Lowest concentration of chemical that burns in air
- Upper Explosive Limit = Highest concentration of chemical that burns in air

Flash Point
- Lowest temperature at which a liquid will give off enough vapors to ignite

Ignition Temperature
- Lowest temperature at which a liquid will give off enough vapors to support ongoing combustion
- Slightly higher than flash point

Specific Gravity
- Density of a liquid compared to water (water = 1)
- Specific gravity >1 = Liquid sinks in water
- Specific gravity <1 = Liquid floats on water

Vapor Density
- Density of a vapor or gas compared to air (air = 1)
- Vapor Density >1 = Gas sinks
- Vapor Density <1 = Gas rises

Vapor Pressure
- Pressure of vapor against container walls
- Indicates how fast a liquid evaporates
- Higher vapor pressures = Rapid evaporation
### Parts per million/Parts per billion
- \( \text{ppm} \)
- \( \text{ppb} \)
- Concentration of substance expressed in number of units of substance per \( 10^6 \) or \( 10^9 \) units of air or solution

### Threshold Limit Value/Time Weighted Average
- \( \text{TLV/TWA} \)
- Maximum concentration of toxin a person can be exposed to 8 hours a day, 40 hours per week without suffering adverse effects
- Lower TLV/TWA = Higher toxicity

### Threshold Limit Value/Short-Term Exposure Limit
- \( \text{TLV/STEL} \)
- Maximum concentration of toxin a person can be exposed to for 15 minutes without suffering adverse effects
- Not to be exceeded or repeated >4x daily with 60 minute rests between each exposure

### Threshold Limit Value/Ceiling Level
- \( \text{TLV/CL} \)
- Maximum concentration of a toxin that should **NEVER** be exceeded, even for a moment

### Lethal Concentration/Lethal Dose
- Concentration or dose of toxin that results in death of a defined % of test subjects
  - \( LC_{50} \) = Concentration in air that kills 50% of test subjects
  - \( LD_{50} \) = Ingested, injected, absorbed dose that kills 50% of test subjects

### Immediately Dangerous to Life and Health
- \( \text{IDLH} \)
- Concentration of toxin that causes immediate threat to life
- May cause delayed or irreversible effects
- May interfere with person’s ability to self-rescue
Contamination and Toxicology

Contamination Types
- Primary = Direct exposure
- Secondary = Indirect exposure via a contaminated person or object

Liquids, solids are most likely to produce secondary contamination.

Exposure Routes
- Inhalation (most common)
- Absorption
- Injection, including entry via open wounds
- Ingestion (least common)

Poison Actions
- Acute Effects = Appear rapidly following exposure
- Delayed Effects = May not develop for hours, days, weeks, months, years

Poison Actions
- Local Effects = Involve areas immediately around exposure site
- Systemic Effects = Occur throughout body as toxin is distributed by bloodstream

Poison Actions
- Major organs for handling toxins
  - Liver, metabolizes (biotransforms) toxins
  - Kidney, excretes toxins
- Since liver, kidney must concentrate toxins to manage them, damage frequently occurs
Poison Actions
- Synergism = Interaction of substances to produce greatly enhanced effects. (2+2 = 40)
- Medications given to poisoned patients may produce unanticipated effects
- Try to confirm medication safety with at least two independent sources

Medications given to poisoned patients may produce unanticipated effects. Try to confirm medication safety with at least two independent sources.

Common Exposures

Corrosives
- Acids, alkalis
- Can be inhaled, ingested, absorbed, injected
- Severe skin burns, respiratory burns with pulmonary edema
- Some have systemic effects

Management
- Brush off dry particulates
- Flush with large amounts of water
- Ophthalmic anesthetics to facilitate eye irrigation
- Tincture of green soap for skin contamination
- Albuterol for bronchospasm
- Do NOT induce vomiting in ingestions
- If patient can swallow/is not drooling, dilute with 5cc/kg up to 200cc

Pulmonary Irritants
- Include chlorine, ammonia
- Gases react with water in respiratory secretions to form acids, alkalis
- Tissue damage, pulmonary edema may result

Management
- Removal of clothing
- Flushing of skin, eyes
- High concentration oxygen
- Albuterol for bronchospasms
- Possible intubation to protect airway
- PEEP for non-cardiogenic pulmonary edema

Pulmonary Irritants
**Pesticides**
- Organophosphates
- Carbamates

**AChE Inhibitor Pesticides**
- Salivation
- Lacrimation
- Urination
- Defecation
- GI Cramping
- Emesis

**Acetylcholinesterase (AChE) Inhibitors**
- Bradycardia
- Bronchospasm
- Increased respiratory secretions
- Sweating
- Pinpoint pupils
- Muscle fasciculations
- Paralysis

**AChE Inhibitor Pesticides**
- Management
  - Support ABCs
  - Remove all clothing, jewelry
  - Decontaminate with H₂O, tincture of green soap
  - Atropine to reverse SLUDGE
  - Pralidoxime for organophosphates, but NOT carbamates
  - Diazepam to control seizures
  - Do NOT induce vomiting if ingested

**Chemical Asphyxiants**
- Carbon monoxide
- Cyanide

**Carbon monoxide**
- Mechanism
  - Binds to hemoglobin
  - Affinity 200x > O₂
  - Reduces oxygen transport capacity

**Management**
- High concentration O₂
- Hyperbaric oxygen therapy

**Cyanide**
- Sources
  - HCN
  - KCN
  - Sodium nitroprusside
  - Bitter almond oil
  - Wild cherry syrup

- Mechanism
  - Inhibits cytochrome oxidase
  - Stops electron transport, ATP production
Oxidative Phosphorylation

NAD → NADH

FAD → FADH₂

2H⁺

2H⁺

ADP + Pₐ → ATP

FAD → FADH₂

Ox. Cyt. b → Red. Cyt. b

ADP + Pₐ → ATP

Ox. Cyt. c → Red. Cyt. c

Ox. Cyt. a → Red. Cyt. a

ADP + Pₐ → ATP

Ox. Cyt. a₃ → Red. Cyt. a₃

1/2O₂ → H₂O

Cytochrome Oxidase

Cytochrome a

Fe²⁺ → Fe³⁺

2e⁻ → 2H⁺

1/2O₂ → H₂O

Cytochrome a

CN⁻

Cyanide Toxicity

Cytochrome a

Fe²⁺ → Fe³⁺

2e⁻ → 2H⁺

1/2O₂ → H₂O

Cyanide

Management

- High concentration oxygen
- Cyanide kit
  - Amyl nitrite
  - Sodium nitrite
  - Sodium thiosulfate

Cyanide Antidote

Cytochrome a

NO₂⁻ → CN⁻ → SCN⁻

Fe²⁺ → Fe³⁺

2e⁻ → 2H⁺

1/2O₂ → H₂O

Hydrocarbon Solvents

Examples

- Xylene
- Toluene
- Methylene chloride
- Gasoline
- Kerosene
- Naptha

Effects

- Pulmonary edema
- Respiratory failure
- Arrhythmias
- CNS depression
- Seizures
- Liver, kidney damage
- Skin irritation
Hydrocarbon Solvents

- Management
  - Support ABC’s
  - High concentration oxygen
  - Wash skin with water, tincture of green soap
  - Generally, do NOT induce vomiting if ingested
  - Diazepam for seizures
  - Glucose for hypoglycemia 2o to liver damage
  - Use caution with all catecholamines; ventricular arrhythmias may occur

Decontamination

Decon Purposes

- Reduce patient exposure/dose
- Reduce secondary contamination risk

Decon Types

- Physical
- Chemical

Decon Methods

- Dilution
- Absorption
- Neutralization
- Isolation

Dilution

- Washing with large amounts of water
- Lowers chemical concentration to non-hazardous level
- May be aided by use of a soap
- Some chemicals should NOT be mixed with water
Absorption
- Use of pads/towels to “blot” up material
- Usually absorbed after washing
- Not used as primary method of decon
- Commonly used to clean environment

Neutralization
- Chemical decontamination method
- Reaction with another substance neutralizes hazard
- Seldom used
  - Difficult to select proper neutralizer
  - Difficult to apply in correct amount
  - Reactions frequently generate heat

Isolation/Disposal
- Separating people, equipment from hazardous substance
- Removal of clothing, jewelry, etc.

Decon Decision Making
- Fast Break
- Long Term

Fast Break
- Quick decisions to prevent rescuer, equipment contamination
- Used on incidents with:
  - Patients who have self-rescued
  - Critical patients out of hot zone needing immediate care
  - Unknown materials
  - Potentially life-threatening materials

Fast Break
- Do NOT expose yourself
- Contain, isolate patients
- Remove clothing, if possible by having them undress themselves
- Wash with large amounts of water
- Wrap completely in blankets (human burrito)
Fast Break

- What are the risks associated with immediate care?
- What are the benefits of the patient receiving immediate care?

As incident evolves:
- Can/should runoff be contained?
- Controlled decon facilities?
- Patient privacy?
- Reclothing patients? (scrub suits)

Long Term

- Occurs when patients remain in hot zone
- Rescue performed by hazmat team
- IMS, decon corridor will have to be established before rescue is attempted
- Set-up can take up to 60 minutes

Allows for:
- More complete decontamination
- Better PPE
- Less risk of secondary contamination
- Greater environmental consideration
- Fewer opportunities for error

Access/Decon Corridor

- Cold
- Warm
- Hot
- Access Corridor
- Decon Corridor

Access/Decon Corridor

- Command Post
- Medical Monitoring
- Rehab
- Treatment Area
- Transport Area
Decon Agents
- Water
- Tincture of Green Soap
- Isopropyl Alcohol (isocyanates)
- Vegetable Oil (water-reactive substances)

Two Step Decon Process
- Gross decontamination
- Used for “fast-break” situations
- Procedure
  - Remove all clothing, jewelry
  - Wash, rinse with soap/water x 2
  - Be sure patients do not stay in runoff
  - Wrap in blanket

Eight Step Decon Process
- More thorough
- Requires complete decon corridor

Eight Step Process
- Rescuers enter decon corridor; mechanically remove victim contaminants
- Rescuers drop equipment in tool-drop; remove outer gloves
- Decon personnel shower, scrub all victims/rescuers
- Rescuers remove, isolate SCBA

Eight Step Process
- Rescuers remove protective clothing
- Rescuers, victims receive full-body wash with soft brushes, water, mild soap
- Patients assessed, treated before transport; Rescuers medically monitored
- Genitals
- Groin
- Buttocks
- Behind knees
- Between toes
- Toenails

Difficult Contamination Areas
- Scalp, hair
- Ears
- Nostrils
- Axilla
- Fingernails
- Navel
Transport Considerations

- Patients field decontaminated are only semi-decontaminated
- May harbor latent contaminants, may outgas contaminants in body fluids
- Limit number of ambulances used in transport
- Remove non-essential equipment
- Wrap patient in plastic sheeting, blankets
- Cover floor with plastic sheeting

Transport Considerations

- Better Dirty and Alive than Clean and Dead!

Transport Considerations

- Do NOT assume your hospitals are equipped to handle contaminated patients

Transport Considerations

- Preplan transport of contaminated patients to hospitals
- Hospitals may want contaminated patients delivered to location other than usual ER entrance
- Hospitals need adequate warning to prepare to receive these patients. Alert should come when first EMS unit arrives at the scene.

Protective Equipment and Medical Monitoring

Protective Equipment Types

- Level A
- Level B
- Level C
- Level D
Level A
- Highest level of respiratory/skin protection
- Suit fully encapsulates rescuer, SCBA
- Used in hot zone with:
  - Unknown substances
  - Substances with potential for respiratory and skin absorption hazards

Level B
- Full respiratory protection
- Lower skin protection level
- Suit non-encapsulating, but chemically resistant
- SCBA worn outside of suit
- Typically worn in warm zone by decon team

Level C
- Non-permeable suit, boots, hand, eye protection
- Air-purifying respirator with cartridges for specific substances
- Worn during transport of patients with 2nd contamination risk

Level D
- Firefighter turnout gear
- NOT suitable for HAZMAT incidents

Selection of PPE
- Based on chemical involved
- NO single suit material is appropriate for all chemicals
- Permeability charts should be consulted to determine breakthrough times for suit material
Selection of PPE
- Latex gloves are NOT chemically resistant
- Nitrile gloves have high resistance to most chemicals
- Leather boots will absorb chemicals permanently

Medical Monitoring & Rehab
- A primary role of EMS
- Entry team personnel should have annual physicals with baseline vitals on file

Entry Readiness
- Monitor
  - BP
  - Pulse
  - Respiratory rate
  - Temperature
  - Body weight
  - ECG
  - Mental/neurological status
- Abnormal findings prohibit entry
- Pre-hydrate with 8 to 16 oz of water or diluted sports drink

After-Exit Rehab
- Monitor
  - BP
  - Pulse
  - Respiratory rate
  - Temperature
  - Body weight
  - ECG
  - Mental/neurological status
- Use weight loss to estimate hydration status
- Rehydrate
- Do NOT permit reentry unless:
  - Alert
  - Non-tachycardic
  - Normotensive
  - Normothermic
  - Within reasonable percentage of normal body weight

Hazardous materials questions:
- List five indicators Hazardous Materials may be present.
- The D.O.T. Placarding system is to transportation as the ____________________ is to fixed facilities.
- The three categories of exposure reduction to Hazardous Materials are:
- The four types of decontamination are:
- List three of the six considerations to keep in mind prior to transporting Hazardous materials contaminated patients.

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