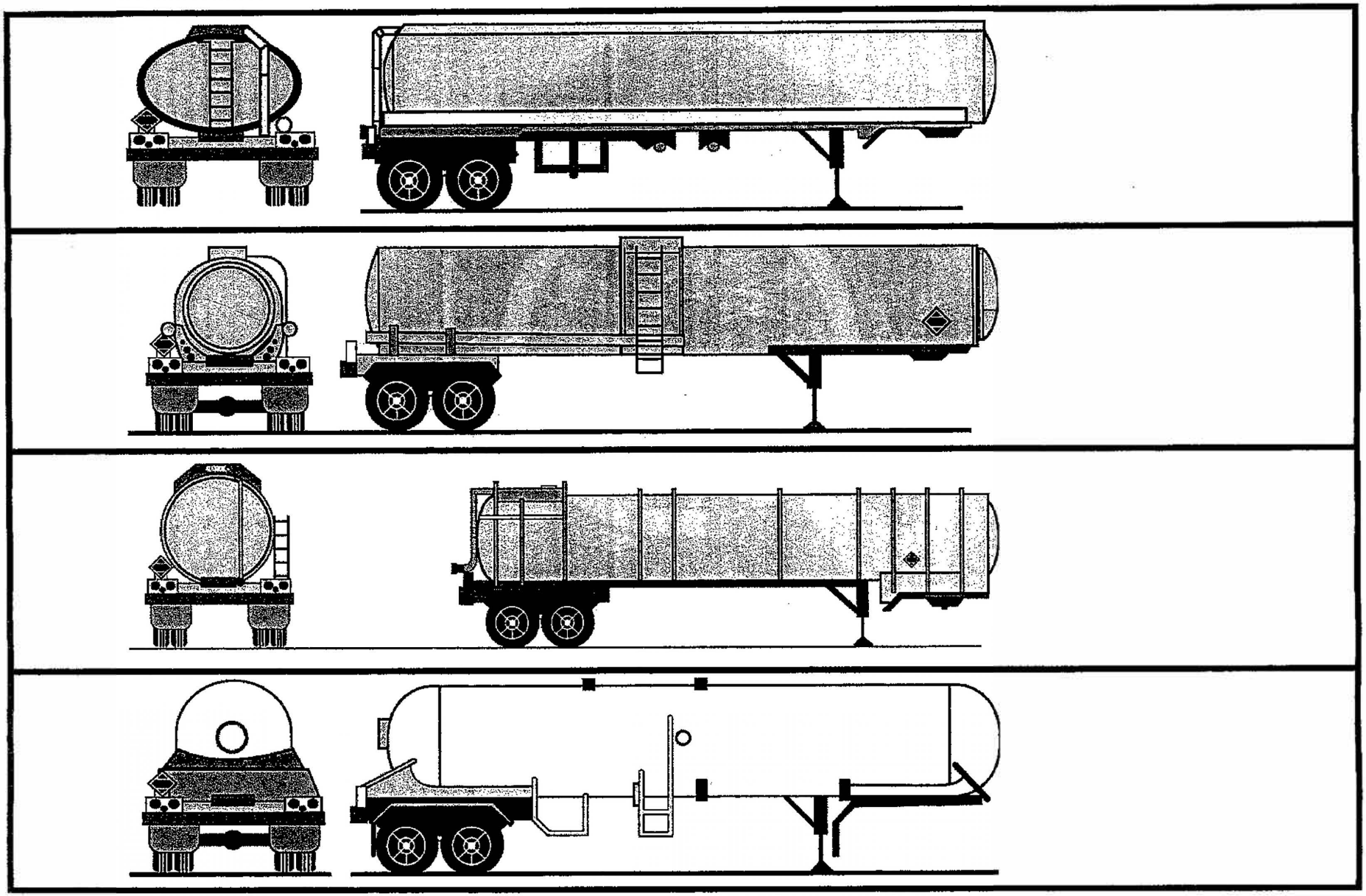

# Durango Fire & Rescue Authority's Hazardous Materials Operations Study Guide

A flip-chart study guide. Using scissors, cut along the dark borders under each picture or text on the next page (total three cuts per page). Cut **only** the even numbered pages. Test yourself by looking at the picture or description, then flip up the panel to see if you know your stuff.



## Nonpressure Liquid Tank (DOT 406/MC306) – Gasoline Tanker

- Typically carries **gasoline (UN/NA 1203), diesel fuel (fuel oil), liquid fuel products, alcohol, and almost any other kind of flammable or combustible liquids. May sometimes carry nonflammable liquids (e.g., milk or molasses). May contain mild corrosives, but not strong corrosives. Cannot contain pressurized gases.**
- Oval in cross-section, with blunt ends.
- Newer tanks are aluminum; older can be steel. Tank is divided into two to five compartments (usually three to four); in some cases, different products may be in different compartments (in most states, mixed loads are not permitted). Typical maximum capacity: 9,000 gallons. **Pressure can't exceed 3 psi.**

## Low-pressure chemical tank truck (DOT-407 or MC-307):

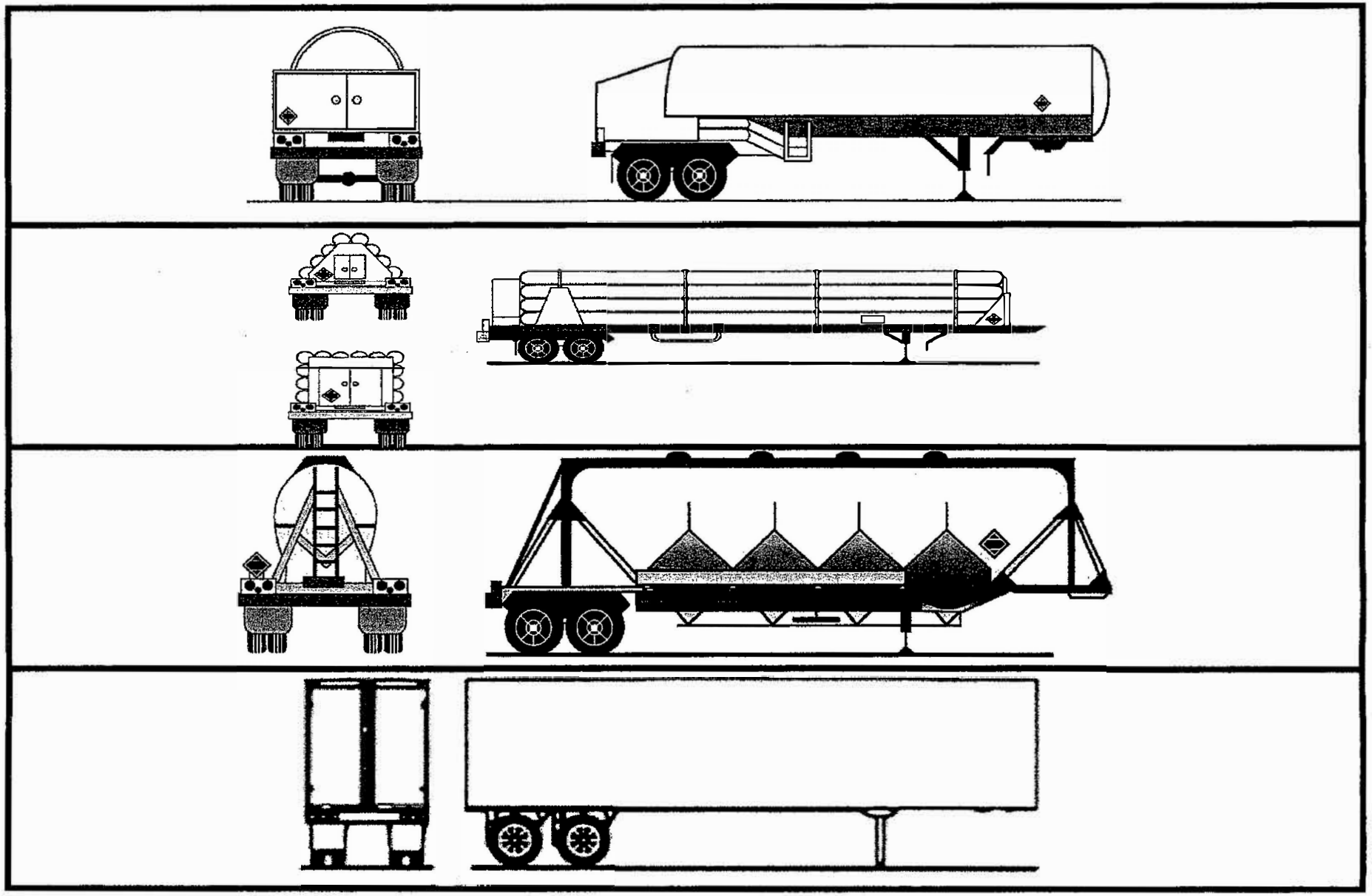
- Typically carries **flammable or combustible liquids, acids, caustics, poisonous liquids.**
- Maximum capacity is typically up to 6,000 gallons. **Pressure can be up to 40 psi.** Can be insulated or uninsulated:
  - Uninsulated tanks are typically circular in cross-section. Typically, there are reinforcing rings around the tank. Tanks are aluminum or steel.
  - Insulated tanks generally carry products that need to be kept either heated or cooled, or products that need to be heated to be off-loaded. They are characteristically horseshoe-shaped when viewed from behind. They are comprised of an outer jacket, generally aluminum or steel, and an inner tank that may be lined (e.g., with fiberglass).

## Corrosive liquid tank truck (DOT-412/MC-312):

- Typically carries **strong corrosives, such as sulfuric or nitric acid. Typically carries acids, also may carry bases. Sometimes may carry flammable liquids (e.g., grain alcohol), poison liquids, or oxidizing liquids. Cannot carry pressurized gases.**
- Circular in cross-section, with up to 10 reinforcing rings around the tank. May be very long. Often there is black, tar-like, corrosion-protective coating around the manhole.
- Carries a single tank, generally with a single compartment, usually of steel and lined, with capacity up to 7,000 gallons. Tank pressures between **35 and 50 psi**.

## High-pressure tank truck (MC-331):

- Typically carries **gases liquefied by pressure, such as anhydrous ammonia, LPG, propane, butane.**
- Circular in cross-section, with blunt ends: tank looks like bullet. Surface is smooth; typically painted white or silver to reduce heating by sunlight.
- Tank can carry up to 11,500 gallons; tank pressure **is generally above 100 psi.**
- Shorter "bobtail" version of MC-311 tank can carry up to 3,500 gallons.
- High BLEVE potential.



## Cryogenic liquid tank truck (MC-338):

- Typically carries **gases liquefied by refrigeration, such as liquid oxygen, nitrogen, argon, carbon dioxide, and hydrogen. Product likely to be corrosive or flammable gas, or poisonous or oxidizing liquid.** Temperature of product -150 degrees F or below.
- Outer shell surrounds insulated inner tank, with vacuum space between. Large compartment mounted at rear of tank. Capacity of inner tank up to 7,000 gallons.
- When sun heats tank and raises internal pressure, vapor may discharge from relief valves. Internal pressure up to 25 psi.
- Very high BLEVE potential.

## Tube trailer (compressed gas trailer):

- Typically carries **pressurized gases such as air, helium, and oxygen, in pressurized tubes.**
- Pressure may be up to 5,000 psi (3000 – 500 range).
- Doghouse in the rear usually ties all tanks together also contains valving
- Individual steel cylinders stacked and banded together

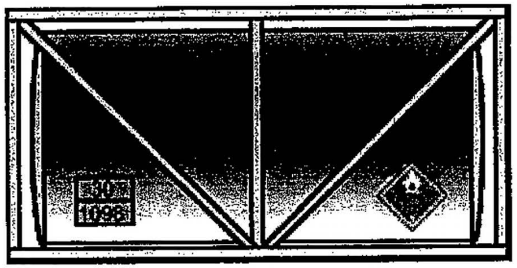
## Dry bulk cargo tank truck:

- Typically carries **dry bulk cargo such as calcium carbide, oxidizers, corrosive solids, cement, plastic pellets, or fertilizers.**
- Pressure less than 22 psi; Topside manway with bottom unloading valves
- Pneumatically loaded and unloaded
- Shape can vary but always includes bottom hoppers.

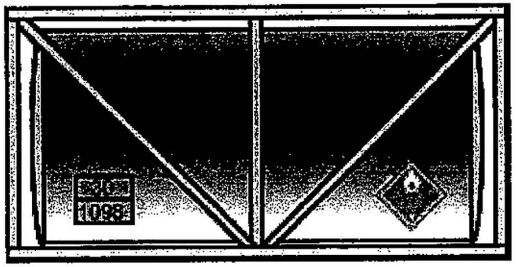
## Box trailer (mixed cargo):

- Typically contains **mixed cargo, which may be packed in bags, boxes, drums, tanks, cylinders, or other containers.**
- The presence of several placard holders on the truck indicates it may commonly carry hazardous materials.
- Check labels and tags on individual containers to identify their contents.

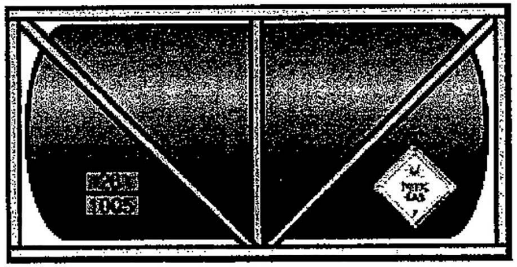
**IM-101**

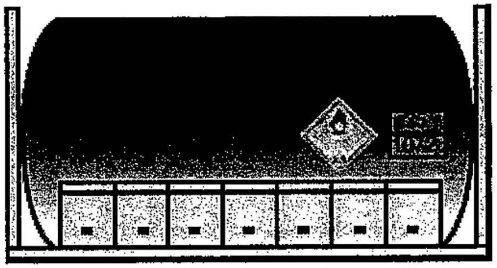


**IM-102**



**Spec 51 or IMO Type 5**





## IM-101 intermodal tank (or IMO Type 1):

- Transports both hazardous and nonhazardous liquids and solids. May contain toxic, corrosive, or flammable materials with flash points *The lowest temperature at which a liquid gives off enough vapor to be ignited at its surface* below 32 degrees F.
- Classified as nonpressurized, but can have a working pressure from **25.4 to 100** PSIG *pounds per square inch gauge; pressure relative to atmospheric pressure*.
- Capacity ranges from 5,000 to 6,300 gallons.
- Most Common type of intermodal tank container.

***IM-101 and 102 tanks are similar in appearance. Check the nameplate to see tank type.

## IM-102 intermodal tank (equivalent to IMO Type 2):

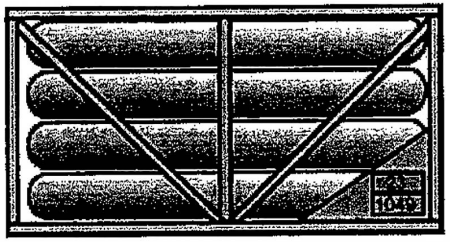
- Transports both hazardous and nonhazardous liquids and solids. Most likely to contain non-regulated materials such as food-grade commodities, but may contain alcohols, some corrosives, pesticides, resins, solvents, and flammable materials with **flash points *The lowest temperature at which a liquid gives off enough vapor to be ignited at its surface* between 32 and 140 degrees F.**
- Classified as nonpressurized, but can have a working pressure from **14.5 to 25.4** PSIG *pounds per square inch gauge; pressure relative to atmospheric pressure*.
- Capacity ranges from 5,000 to 6,300 gallons.

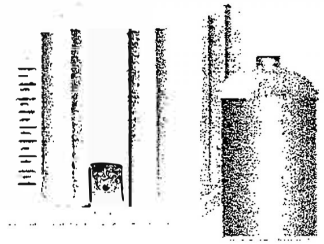
## Spec 51 (DOT Specification 51, or IMO Type 5):

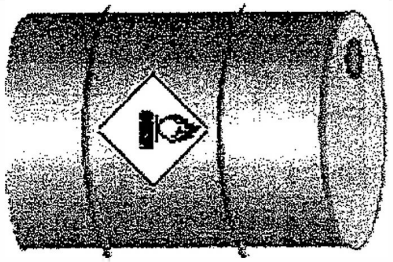
- Typically contains gases liquefied by pressure, such as LPG *(Liquefied petroleum gas)* and ammonia. Also may contain high vapor pressure *(A measure of a substance's tendency to evaporate); liquids with higher vapor pressures evaporate faster* liquids such as motor fuel antiknock compounds and pyrophoric *(Capable of igniting on contact with air at ordinary ambient temperatures)* liquids such as aluminum alkyls.
- Classified as pressurized. Working pressure may range from **100 to 500** PSIG *pounds per square inch gauge;(pressure relative to atmospheric pressure)*.
- A nameplate must be fixed to each end of the tank. It lists DOT specification number (Spec 51), manufacturer's name and serial number, capacity, weight, and design pressure.
- Tank capacity can range from 50 to 5,500 gallons, and tank dimensions may vary.

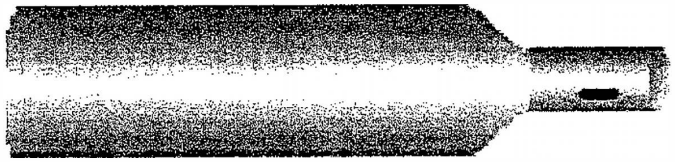
## Cryogenic tank container (or IMO Type 7):

- **Transports gases liquefied by refrigeration, such as argon, oxygen, and helium (these gases are also called cryogenic** *very low temperature* **gases).**









**Tube module:**

- Transports gases in high-pressure cylinders tested to **3,000 or 5,000 PSI** *pounds per square inch*, such as oxygen, nitrogen, helium, and hydrogen.

**Portable tanks and bulk totes**

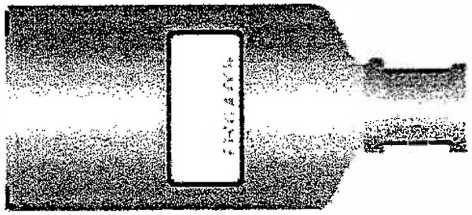
- **May contain flammable, combustible, toxic, or corrosive liquids, as well as non-hazardous materials.**
- Capacities and dimensions vary. Some portable tanks hold up to 550 gallons; a common tote capacity is 300 gallons.
- Typically transported on flatbed trucks, box trailers, and rail flatcars.
- May be composed of ABS plastic, steel, aluminum, or other materials.

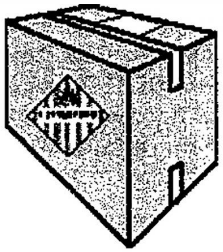
**Drums** contain a wide variety of solid and unpressurized liquid hazardous materials. The construction material of a drum is a clue to its contents:

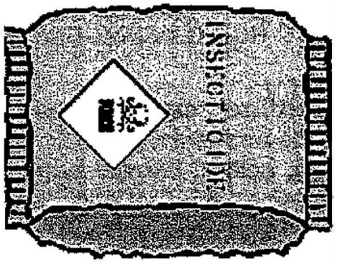
- Unlined fiberboard: Dry granular materials (e.g., fertilizer, sawdust, grain)
- Plastic-lined fiberboard: Wet materials such as foods and slurries.
- Plastic: corrosive materials (e.g., sodium hydroxide, acids), combustible materials, some foods
- Steel: Flammable and combustible materials (e.g., alcohols, fuel oils), mild corrosives, food liquids
- Stainless steel: strong corrosives such as oleum
- Aluminum: Pesticides; materials that react with steel and cannot be shipped in plastic containers
- Drums vary from 1 to 95 gallons in capacity; a typical capacity is 55 gallons.

**Cylinders**

- Cylinders transport and store many different hazardous pressurized gases (e.g., chlorine, hydrogen). Cryogenic *very low temperature* gases are carried in special insulated cylinders.
- Cylinders range in capacity from about 1 pound to thousands of pounds, and internal **pressures range from about 200 to 5,000 psi** *pounds per square inch*. (Higher than 40 psi).
- Most cylinders have pressure relief values that allow gas to escape if the cylinder is overpressurized *Increase of pressure within a container beyond the pressure the container is designed to contain; can lead to explosion of the container* or heated in a fire, preventing dangerous pressure buildup.








## Bottles

- **Bottles, which can be of glass, metal, or plastic, can contain hazardous liquids.** They range in capacity from about an ounce to a gallon. Bottles are often transported packed within cardboard boxes.

## Cardboard boxes

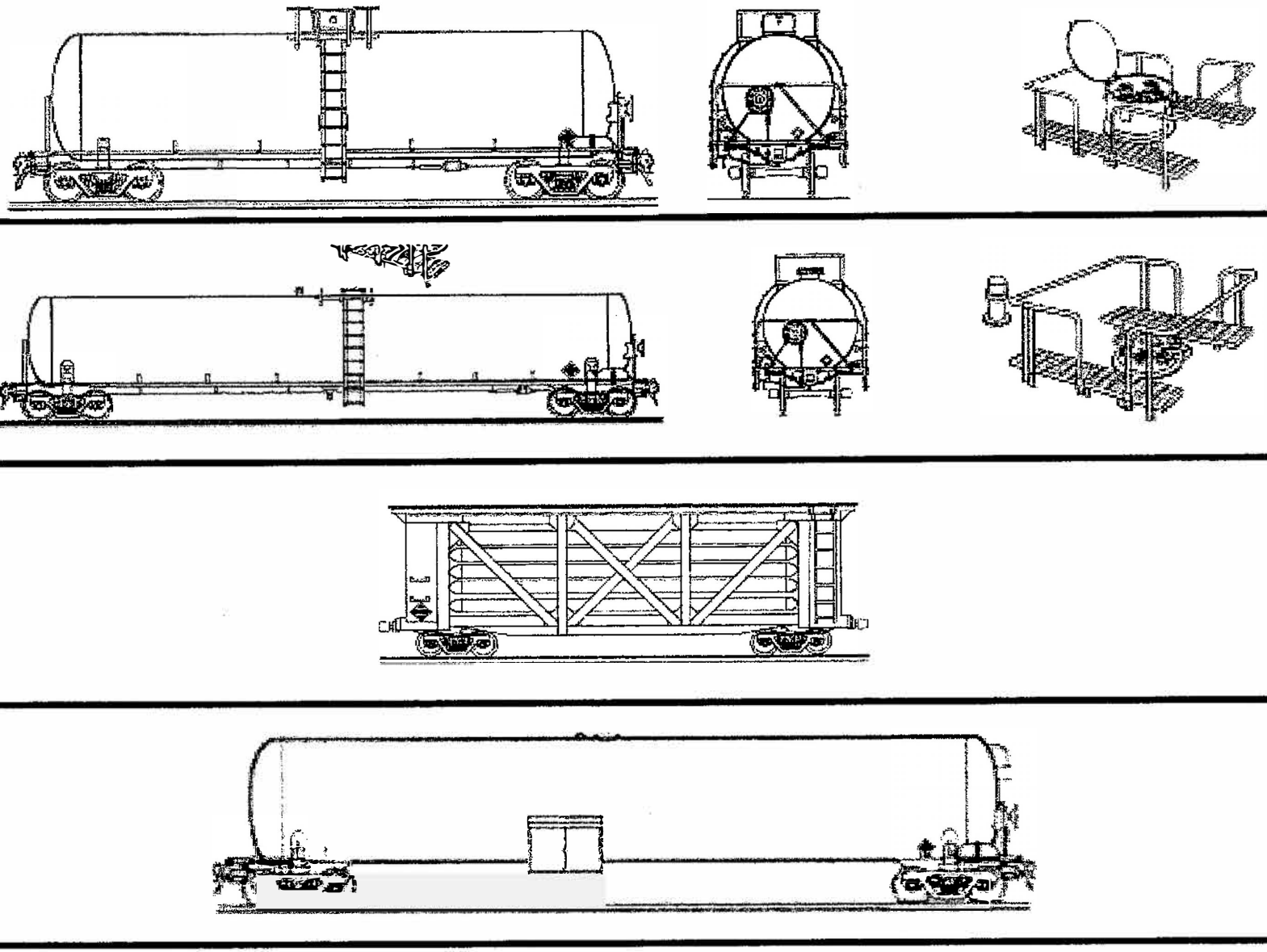
- Cardboard boxes can carry hazardous materials such as pesticides and household products, as well as hazardous liquids packed in bottles.
- Cardboard boxes lined in plastic may carry hazardous liquids.

## Bags

- Bags--which can be paper, plastic, or fiber, reinforced or not--are often used as containers for chemicals and pesticides, as well as food.
- Very large reinforced polypropylene bags, called "supersacks," may carry hazardous solids.

## Carboy

- A carboy is a large glass or plastic bottle encased in a basket or box primarily used to store corrosive materials (acids and bases).
- Deep Rock Water Bottle



## Pressurized tank car:

- Typically carries **pressurized flammable gases (e.g., propane, liquefied petroleum gas), poisonous gases (e.g., chlorine, sulfur dioxide, vinyl chloride), or nonflammable gases (e.g., argon, carbon dioxide)**.
- Round in cross section. Capacity up to 33,500 gallons; **pressure 100 to 600 psi** ,Generally steel or aluminum
- A cylindrical protective housing at top of car encloses valves and piping. Most tank cars carrying pressurized flammable gases are insulated.

## Non-pressurized (general service) tank car:

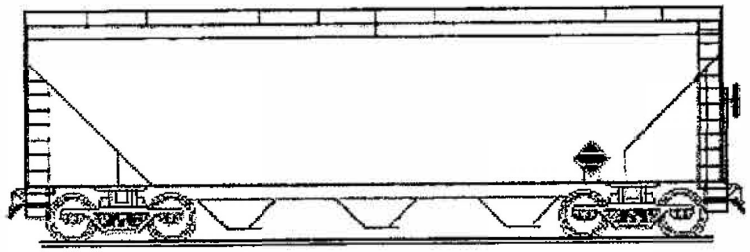
- Typically carries **chemicals such as combustible or flammable liquids (e.g., gasoline, fuel oil), corrosives, oxidizers and organic peroxides, slurries, or poisons, or food liquids (e.g., juice, tomato paste, tallow)**.
- Cannot transport substances classified as inhalation hazards.
- Capacity up to 30,000 gal. May be compartmentalized and/or insulated. **Pressure can be up to 100 psi.**
- Valves and fittings are exposed. Often, a small dome cover is located at the top of the car, but relief valves and piping are outside of this cover.

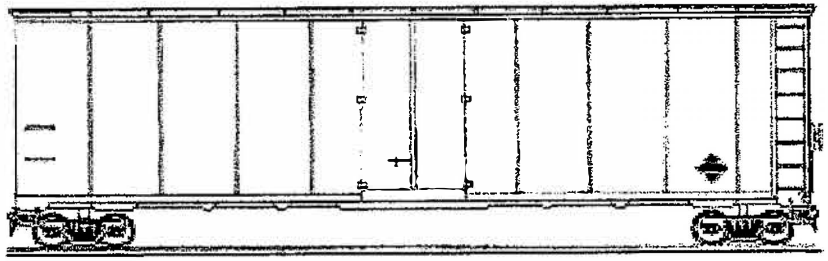
## High-pressure tube car

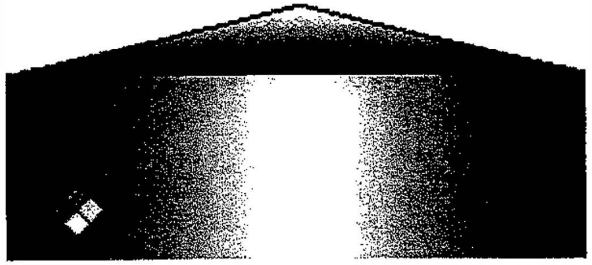
- Carries **gases such as oxygen, helium, hydrogen, nitrogen in high-pressure cylinders.**

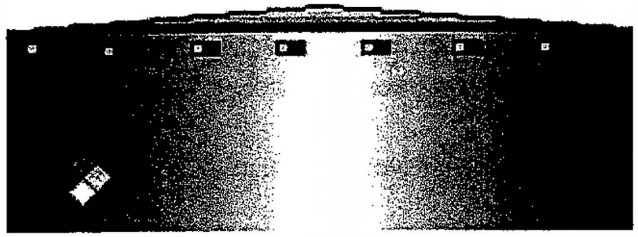
## Cryogenic liquid tank car

- Typically contains **gases liquefied by refrigeration, such as liquid hydrogen and nitrogen.**
- Pressure within tank is low; temperature is -130 degrees F or below. Tank is generally double walled and insulated. Test pressures from 60 to 175 psi
- Valves and fittings are enclosed in a cabinet at the lower side or end of the car.









## Hopper car

- Typically contains **dry bulk chemicals such as calcium carbide, sodium chlorate, ammonium nitrate, lime, other dry chemicals; also sand, gravel, fertilizers, plastic pellets.**
- Hopper cars may be covered or open top.

## Box car

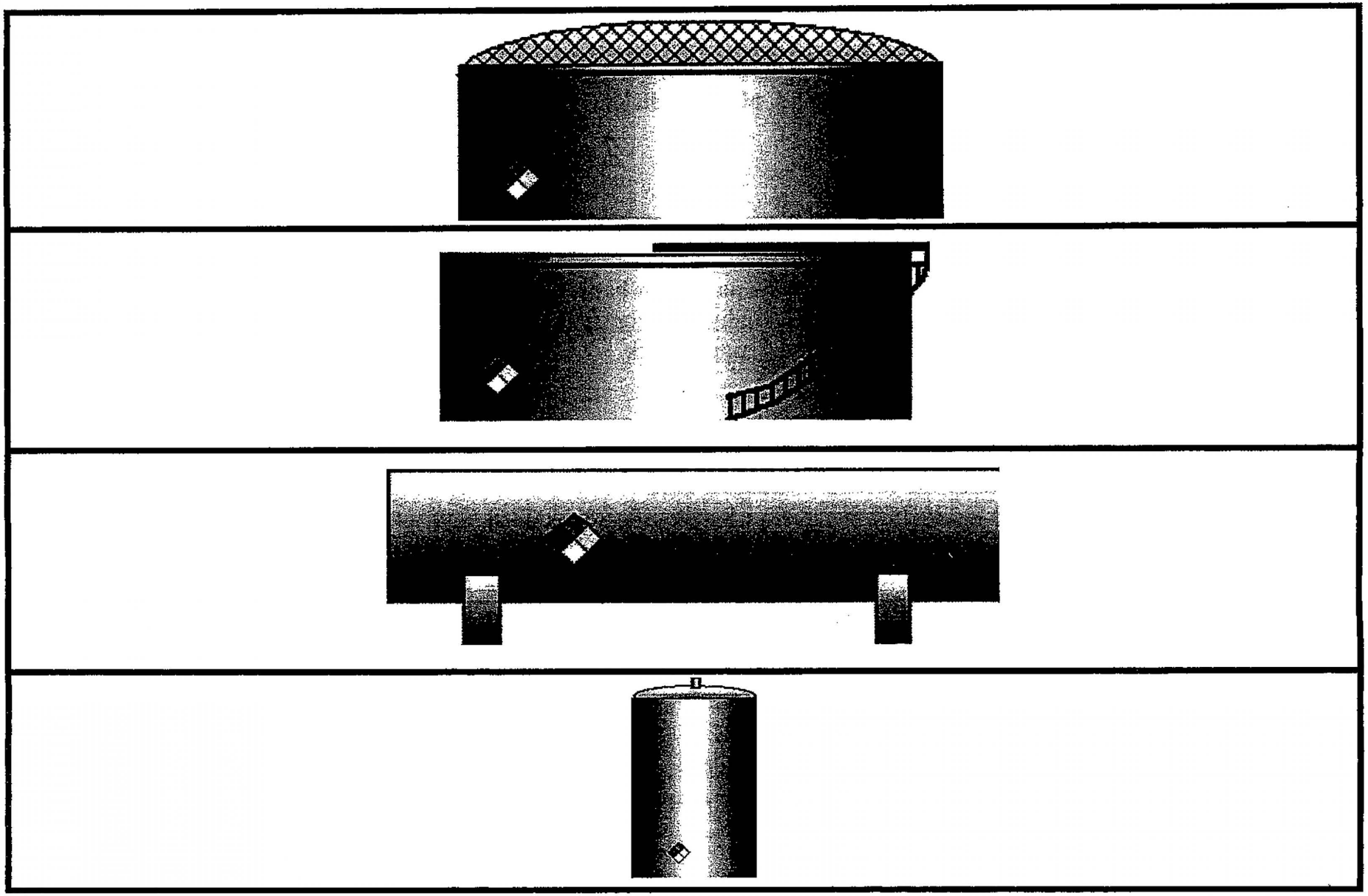
- Typically contains **mixed cargo, which may be packed in bags, boxes, drums, tanks, cylinders, liquid bladders, or other containers**. Check labels and tags on individual containers to identify their contents.
- Car class AAR204XT is a box car carrying a cryogenic tank.

## Cone Roof Tank (Atmospheric or non-pressure):

- Atmospheric tanks come in a variety of shapes. Contents are stored under atmospheric pressure: internal tank pressures range from 0 to 1 PSIG *; pressure relative to atmospheric pressure*.
- **Designed to store liquids of low volatility** *(Readiness to evaporate)*. **Typically stores fuel oils such as diesels and heating oil. Contents may be flammable, combustible , or corrosive**
- Contents stored at atmospheric pressure (0 to 1 PSIG *pounds per square inch gauge; pressure relative to atmospheric pressure*). Tank can be up to 300 feet in diameter and 64 feet high.

## Covered top floating roof tank (non-pressure):

- Typically stores flammable and combustible liquids.
- Contents stored at atmospheric pressure (**0 to 1 PSIG** ).
- **An internal roof floats on top of the liquid**; an additional roof protects tank contents from the elements.



**Covered top floating roof tank with geodesic dome (non-pressure)::**

- Typically stores gasoline and other volatile flammable liquids.
- Contents stored at atmospheric pressure (0 to 1 PSIG ).
- An internal roof floats on top of the liquid; an additional domed roof protects tank contents from the elements.

**Open top floating roof tank (non-pressure)::**

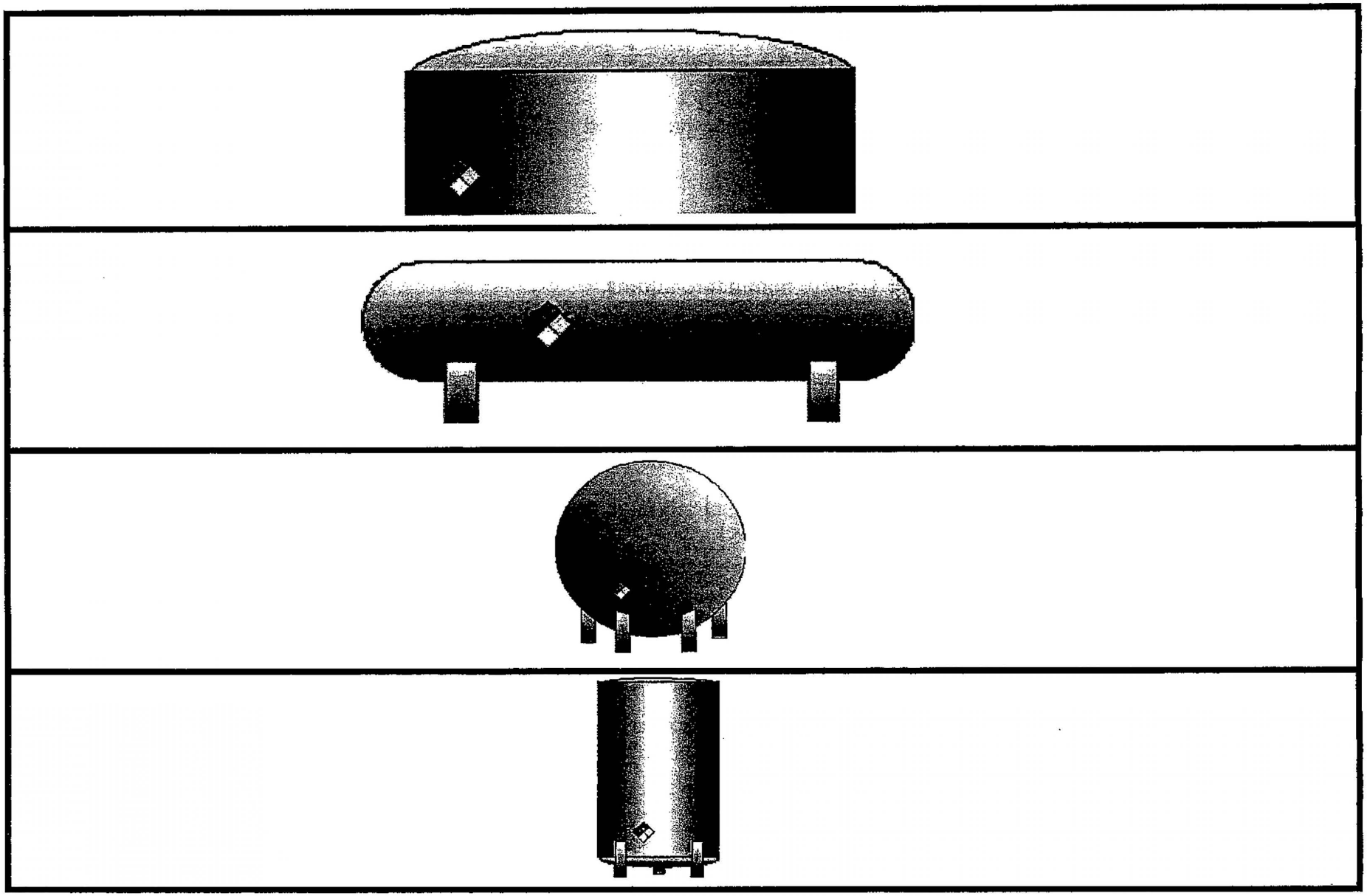
- Typically stores gasoline and other volatile flammable liquids.
- Contents stored at atmospheric pressure (**0 to 1 PSIG** ).
- Tank is typically large.

**Horizontal cylindrical tank (non-pressure):**

- Used to store liquids of low volatility , typically fuel oils such as diesel fuel and heating oil.
- Contents stored at atmospheric pressure (0 to 1 PSIG ).
- Tank typically has dished ends, and can be up to about 12 feet in diameter and 60 feet long.

**Dome roof tank (Pressure tank)**

- Typically stores flammable or combustible , volatile liquids, such as gasoline, liquid fertilizers, and solvents.
- Contents stored at low pressure (**0.5 to 15 PSIG** ).



**Hemispheroid tank:**

- Typically stores volatile liquids, such as gasoline.
- Contents stored at low pressure (0.5 to 15 PSIG).

**High pressure horizontal tank (or "bullet"):**

- Typically stores gases liquefied by pressure, such as LNG (liquefied natural gas), LPG (liquefied petroleum gas), propane, butane, hydrogen, and ammonia. Also may store volatile flammable liquid. Will not contain low-volatility liquids.
- Contents stored at high pressure (above 15 psig ).

**High pressure spherical tank:**

- Typically stores gases liquefied by pressure, such as LNG *Liquefied natural gas* and LPG *Liquefied petroleum gas.* Also may contain ammonia, propane, butane, or hydrogen.
- Contents stored at high pressure (above 15 PSIG ).

**Cryogenic liquid tank:**

- Typically stores liquid nitrogen, oxygen, carbon dioxide, argon, or other cryogenic gases.
- Tank is heavily insulated and at low pressure; normally vents some vapor.

**Hazard Class 1**
Division 1.1

**Hazard Class 1**
Division 1.2

**Hazard Class 1**
Division 1.3

**Hazard Class 1**
Division 1.4

# Hazard Class 1: Explosives

**Division 1.1:** Explosives with a **mass explosion hazard** A mass explosion is one which affects almost the entire load instantaneously. Examples: dynamite, TNT, black powder.


**Division 1.2:** Explosives with a **projection hazard;** Explosives in this division have a projection hazard but not a mass explosion hazard. Examples: aerial flares, power device cartridges, detonating cord.


**Division 1.3:** Explosives with **predominately a fire hazard;** have a fire hazard and either a **minor blast hazard or a minor projection hazard or both,** not a mass explosion hazard. Examples: propellant explosives, liquid-fueled rocket motors.


**Division 1.4:** Explosives with **no significant blast hazard;** These explosives present a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. Examples: signal cartridges, practice ammunition, line-throwing rockets.

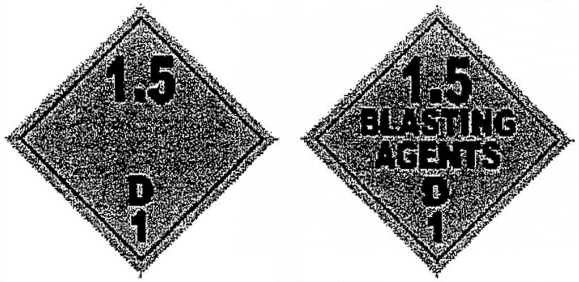
**Hazard Class 1**
Division 1.5

**Hazard Class 1**
Division 1.6

**Hazard Class 2**
Division 2.1

**Hazard Class 2**
Division 2.2

**Division 1.5:** Very insensitive explosives; blasting agents; These explosives have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport. Example: pilled ammonium nitrate fertilizer-fuel oil mixtures (ANFO).




**Division 1.6: Extremely insensitive detonating substances;**
These articles contain only extremely insensitive detonating substances and demonstrate a negligible probability of accidental initiation or propagation.


# Hazard Class 2: Gases

**Division 2.1:** Flammable gases:
Examples: propane, methyl chloride, butadienes.


**Division 2.2:** Non-flammable, non-toxic compressed gases;
Examples: cryogenic nitrogen, argon. The yellow placards shown are used for oxidizing gases in Division 2.2.

**Hazard Class 2**
Division 2.3

**Hazard Class 3**

**Hazard Class 4**
Division 4.1

**Hazard Class 4**
Division 4.2

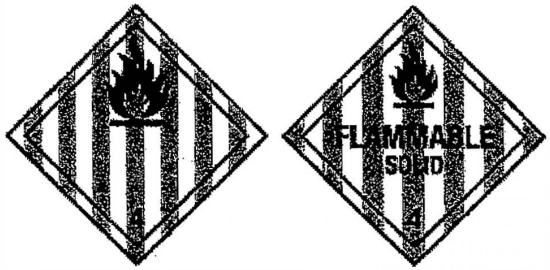
**Division 2.3:** Poisonous gases;
Examples: chlorine, hydrogen fluoride, arsine, methyl bromide. These gases are toxic by inhalation.


## Class 3: Flammable and combustible liquids

**Flammable liquids;** These liquids evolve flammable vapors in air at temperatures of 140 degrees F or below. Examples: acetone, gasoline, toluene. **Combustible liquids;** These liquids evolve combustible vapors in air at temperatures between 140 degrees F and 200 degrees F. Examples: Fuel oil, mineral oil, peanut oil. Can be labeled as **Fuel Oil** or **Gasoline.**


## Class 4 Flammable Solids

**Division 4.1: Flammable solids;** Flammable solids include materials other than explosives that are likely to cause fire by self-ignition through friction, absorption of moisture, spontaneous chemical changes, or as a result of heating. Examples: magnesium, nitrocellulose.




**Division 4.2: Spontaneously combustible materials;**
Examples: charcoal briquettes, phosphorus

**Hazard Class 4**
Division 4.3

**Hazard Class 5**
Division 5.1

**Hazard Class 5**
Division 5.2

**Hazard Class 6**
Division 6.1

**Division 4.3: Dangerous when wet materials;**
Examples: calcium carbide, magnesium powder, sodium hydride.


**Hazard Class 5: Oxidizers and organic peroxides**
**Division 5.1: Oxidizers** can cause or enhance the combustion of other materials, usually by providing oxygen.
Examples: ammonium nitrate, calcium hypochlorite.


**Division 5.2: Organic peroxides:** Organic peroxides are **unstable and may react violently** if mishandled.
Examples: methyl ethyl ketone peroxide, dibenzoyl peroxide.


**Class 6: Poisonous and infectious agents**
**Division 6.1: Poisonous** (toxic) materials: Poisons (also called toxic materials, toxic agents, or toxins) can cause injury or death when they enter the bodies of living things. Also included are irritating materials, which cause extreme irritation.
Examples: aniline, arsenic compounds, hydrocyanic acid, tear gas, chemical warfare agents.

**Hazard Class 6**
Division 6.1

**Hazard Class 7**

**Hazard Class 8**

**Hazard Class 9**

## Division 6.2: Infectious substances

Also called etiologic agents or disease-causing agents. This division includes materials known to contain or suspected of containing a pathogen. A pathogen is a virus or micro-organism or a proteinaceous infectious particle (prion) that has the potential to cause disease in humans or animals. Examples: anthrax, botulism, tetanus.


## Class 7: Radioactive materials

Radioactive materials are materials containing radionuclides where both the activity concentration and the total activity in the consignment exceed specified values. Examples: uranium hexafluoride, cobalt, "yellow cake."


## Class 8: Corrosive materials

Corrosive materials are (a) liquids or solids that can cause full thickness destruction of human skin tissue at the site of contact, within a specified period of time, or (b) liquids that can severely corrode steel or aluminum. Examples: nitric acid, sulfuric acid, sodium hydroxide.


## Class 9: Miscellaneous hazardous materials

This class includes any material which presents a hazard during transportation but does not meet the definition of any other hazard class. Examples: PCBs, molten sulfur.

**Mixed Load**

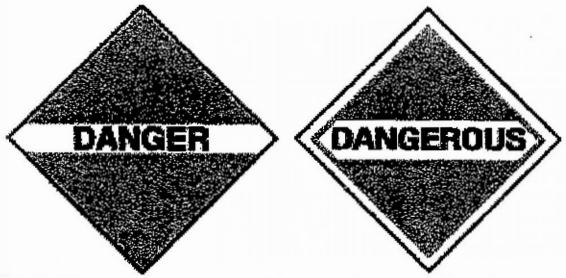
**Marine pollutant**

**US Military Markings**
**Division 1**

**US Military Markings**
**Division 2**

## Mixed load of hazardous materials

This placard indicates a container or vehicle carrying two or more categories of hazardous materials, all in amounts less than 1,000 pounds. Check labels on containers or shipping papers to identify the materials.




## Marine pollutant

One or more materials listed as marine pollutant (s) at Concentration (s) high enough to be harmful to marine life.


## Division 1: Mass explosion


## Division 2: Explosion with Fragment Hazard

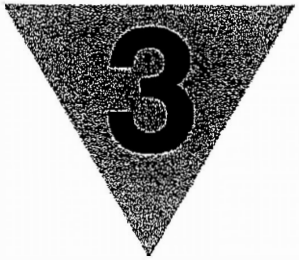
**US Military Markings**
**Division 3**

**US Military Markings**
**Division 4**

**US Military Markings**
**Wear Breathing Apparatus**

**US Military Markings**
**Apply No Water**

**Division 3: Mass Fire**

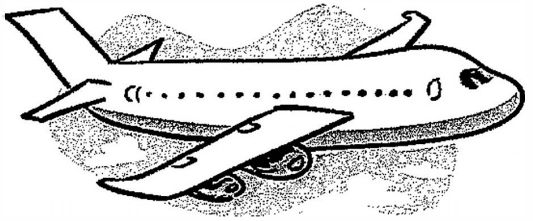



**Division 4: Moderate Fire—No Blast**


**Wear Breathing Apparatus**

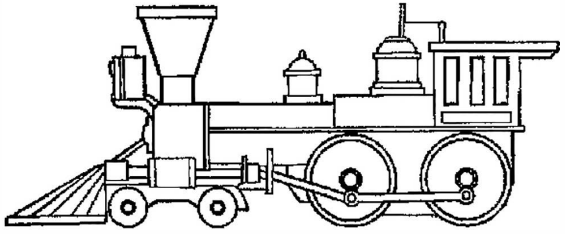
**Apply No Water**

**Shipping Papers**
**Transportation Mode Air**

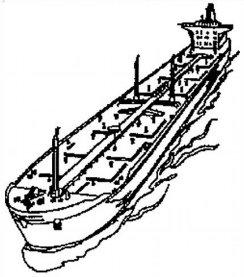


**Shipping Papers**
**Transportation Mode Highway**

**Shipping Papers**
**Transportation Mode Rail**



**Shipping Papers**
**Transportation Mode Water**



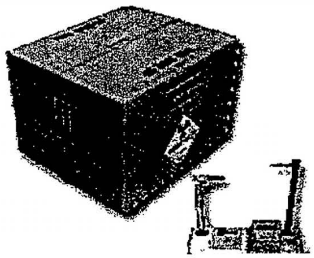
| Shipping Paper Name | Location of Papers | Responsible Party |
|---|---|---|
| Air bill | Cockpit | Pilot |

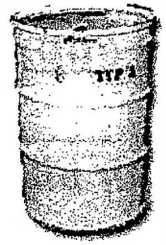
| Shipping Paper Name | Location of Papers | Responsible Party |
|---|---|---|
| Highway | Bill of lading | Vehicle cab |

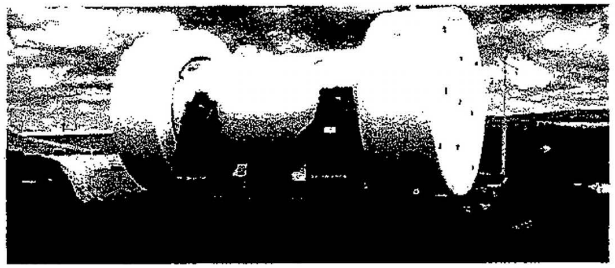
| Shipping Paper Name | Location of Papers | Responsible Party |
|---|---|---|
| Waybill/consist | Engine or caboose | Conductor |

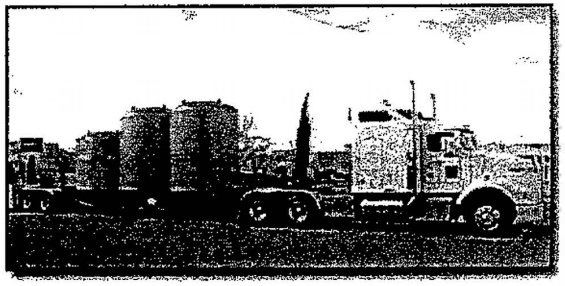
| Shipping Paper Name | Location of Papers | Responsible Party |
|---|---|---|
| Dangerous cargo manifest | Bridge or pilothouse | Captain or Master |

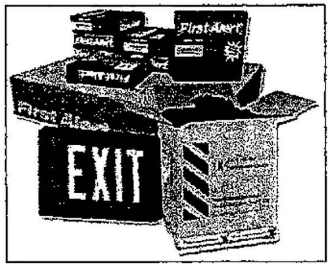
# Radioactive Material Containers

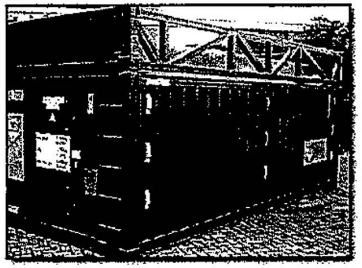










## Type A Packaging

- Carries radiopharmaceuticals and other regulatory industry products
- Able to withstand destructive tests under normal conditions

## Type B Packaging

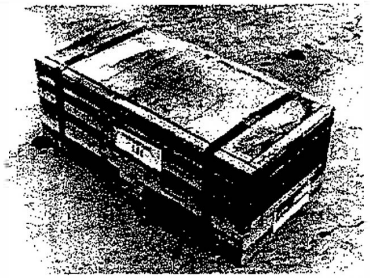
- Carries radioactive materials that would be hazardous if they were released
- Able to withstand extreme destructive tests
- Constructed of steel-reinforced concrete casks, lead pipe, or heavy gauge metal drums
- Size ranges from small containers to those weighing over 100 tons

## Excepted Package:

A package used to transport materials with extremely low levels of radioactivity and would pose a very low hazard if released in accident. These packages are excluded from specific labeling & shipping paper requirements, although they must have the letters "UN" & the appropriate 4-digit UN identification number located on the outside of the packaging.

## Industrial Package:

A package used to transport low activity material and contaminated objects categorized as waste. Regulations require that these packages allow no identifiable release of material to environment during normal transport and handling. These packages are marked with appropriate category (IP-1, IP-2, or IP-3)



**Carcinogens**

**Specific Gravity**

**Vapor density**

## Strong, Tight Container:

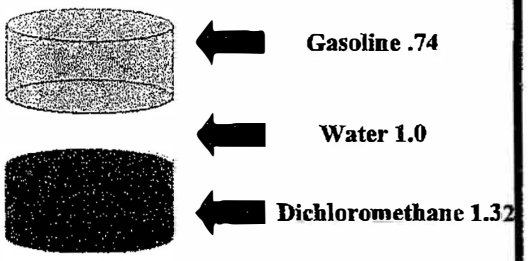
Materials with very low radiation levels may be transported in what the regulations refer to as a "strong, tight container". An example of a strong, tight container is a plywood box secured with steel bands.

## Carcinogens

Cancer-causing agents

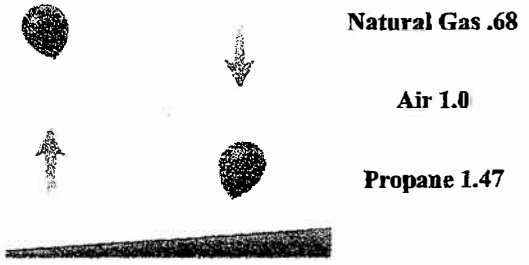
## Specific Gravity:

The weight of a substance when compared to an equal volume of water
Water is given a value of "1"
*A liquid that is <1 will float in water*
*A liquid that is >1 will sink in water*




## Vapor density

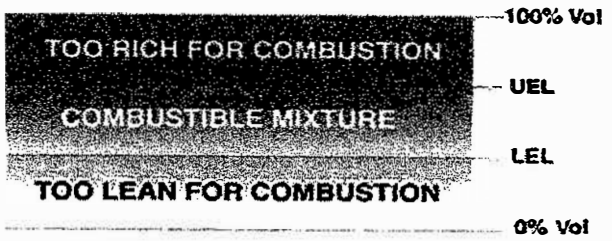
The weight of a given vapor compared to an equal volume of air
Air is given a value of "1".
A vapor that is lighter (rise) than air will have a volume <1.
A vapor that is heavier (sink and collect) than air will have a volume >1.



| |
|---|
| **Flammable Range** |
| **State of Material** |
| **Flash point** |
| **Fire point** |

## Flammable Range

Flammable range is the concentration of fuel and air that will sustain combustion. The Flammable range is the Concentration between the UEL and LEL.




## State of Material

Solid: Substance that has both a specific shape (without a container) and volume
Liquid: Fluid that has no independent shape but has a specific volume; flows according to gravity
Gas: Fluid that has neither independent shape nor volume and tends to expand indefinitely
**Note:** The **state of matter** can be determined from a **placard** , (Flammable **Liquid** Haz Class 3).


## Flash point

Minimum temperature at which a liquid or volatile solid gives off sufficient vapors to form an ignitable mixture with air near its surface

## Fire point

Temperature at which enough vapors are given off to support continuous burning

**LEL/LFL**

**UEL/UFL**

**Vapor Pressure**

**Atmospheric pressure**

**LEL/LFL**
(Lower explosive limit/Lower flammable limit) — The lowest concentration that will produce a flash of fire when an ignition source is present.

**UEL/UFL**
(Upper explosive limit/Upper flammable limit) — The highest concentration that will produce a flash of fire when an ignition source is present

**Vapor pressure**
Pressure exerted by a saturated vapor above its own liquid in a closed container

- Expressed in psi, kPa, mmHg, or atm
- The higher a substance's temperature, the higher the vapor pressure

**Atmospheric pressure**
Force exerted by weight of the atmosphere at the earth's surface

| |
|---|
| **Boiling point** |
| **Sublime or Sublimation** |
| **BLEVE** |
| **Solubility** |

**Boiling Point**
Temperature at which the vapor pressure of a liquid is equal to or greater than atmospheric pressure. Expressed in degrees Fahrenheit.

**Sublime or Sublimation**
To change directly from a solid into a gas without going into a liquid state in between

**BLEVE**
(Boiling Liquid Expanding Vapor Explosion) — Occurs when a liquid within a container is heated, causing the material inside to boil or vaporize beyond the vessel's ability to relieve the excess pressure. Apply a minimum of **500 gpm water** flow on to a flame impinged tank.

**Solubility**
The percentage of a material (by weight) that will dissolve in water at ambient temperature
Non-water-soluble liquids remain separate when combined with water; water-soluble liquids mix easily when combined with water.

**Miscibility/Immiscibility**

**Polymerization**

Radiation

**Alpha particles**

**Beta Particles**

## Miscibility/Immiscibility

The degree or readiness with which two or more gases or liquids are able to mix with or dissolve into each other

- Miscible — Liquids that dissolve into each other
- Immiscible — Liquids that do not readily dissolve into each other

## Polymerization

Chemical reaction in which a catalyst causes simple molecules to combine to form long chain molecules

## Alpha Particles

Are positively charged particles that lose energy rapidly in matter and do not penetrate very far

- Can be very harmful if the material emitting the alpha particles are ingested or inhaled
- Can be stopped completely by a sheet of paper

## Beta Particles

- Are fast-moving positively or negatively charged electrons
- Are capable of penetrating the skin and causing radiation damage, but are more hazardous when inhaled or ingested
- Can be reduced or stopped by a layer of clothing or a few mm of a substance such as aluminum

**Gamma Rays**

**X-Rays**

**Neutrons**

**Radiation Protection Strategies**

**Gamma Rays**

- Are high-energy photons
- Have no charge but are very penetrating, easily passing through the human body and being absorbed by tissue
- Require several feet of concrete or a few inches of lead to stop the more energetic gamma rays

**X-Rays**

- Are high-energy photons produced by the interaction of charged particles with matter
- Are the single-largest source of manmade radiation exposure
- Are generally lower in energy and thus less penetrating than gamma rays
- Can be stopped with a few millimeters of lead

**Neutrons**

- Are ultrahigh energy particles that have a physical mass like alpha radiation but no electrical charge, are highly penetrating
- Are most likely encountered in research laboratories

**Radiation Protection Strategies**

- **Time:** The amount of radiation exposure increases or decreases according to the time spent near the source of radiation.
- **Distance:** Farther distances equal smaller doses
- **Shielding:** Certain materials prevent penetration of some of the radioactive particles.

**Radiation Inverse Square Law**

**Simple Asphyxiants**

**Chemical Asphyxiants**

**Asphyxiants**

**Radiation Inverse Square Law**

- Doubling the distance from a radiation source decreases the radiation by a level of 4 (1/4 or 25%). conversely, halving the distance increases the radiation level by four (4X or 400%).

**Simple Asphyxiants**

- Gases that displace the oxygen necessary for breathing
- Example: Carbon Dioxide

**Chemical Asphyxiants**

- Substances that prohibit the body from using oxygen
- Example: Carbon Monoxide

**Asphyxiants**

Substances that affect the oxygenation of the body and generally lead to suffocation

**Mutagens**

**Teratogens**

**Allergens**

**Sensitizers**

**Mutagens:**
Substances or agents that are capable of altering the genetic material in a living cell

**Teratogens**
Substances or agents capable of causing developmental abnormalities in utero (In the unborn child).

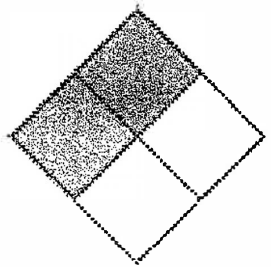
**Allergens**
Substances that cause allergic reactions in people or animals

**Sensitizers**
Chemicals that cause a substantial proportion of exposed people or animals to develop an allergic reaction after repeated exposure to the chemical

**Corrosives**

**Acid**

**Base**



# Corrosives

Chemicals that destroy or burn living tissues and have destructive hazards

# Acid

Any chemical that ionizes to yield hydrogen ions in water; has pH value of 0 to 6

# Base

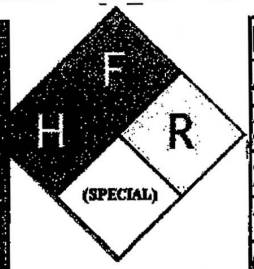
Any water-soluble compound that breaks apart in water to form a negatively charged hydroxide ion; has pH value of 8 to 14

| flammability: | 4: very flammable | 1: combustible |
|---|---|---|
| | 3: readily ignited<br>2: ignited w/ heat | 0: will not burn |

# NFPA 704

Indicates the presence and the potential dangers **at a facility**. Provides very general information and gives no specifics to material(s) present, quantities, properties

| health |
|---|
| 4: deadly |
| 3: extreme danger |
| 2: hazardous |
| 1: slightly hazardous |
| 0: normal materials |




| Reactivity or Instability: |
|---|
| 4: may detonate |
| 3: shock or heat may deton |
| 2: violent chemical change |
| 1:unstable if heated |
| 0: stable |

| NFPA Special Symbols: | OXY = oxidizer | ACID = acid |
|---|---|---|
| | ALK = alkali | COR = corrosive |
| | W = keep away from water | |

**Level A Ensemble**

**Level B Ensemble**

**Level C Ensemble**

**Level D Ensemble**

## **Level A Ensemble** (Highest Level of Protection)

Internal SCBA,
Vapor Protective CPC,
Enclose the wearer completely with internal gloves and footings
May or may not have reflective (Flash protection) exterior

## **Level B Ensemble**

Internal or external SCBA, May or May not be encapsulating
Splash protection (Not vapor tight)
Worn when highest level of respiratory protection is needed
but a lower level of skin protection

## **Level C Ensemble**

Air Purifying Respirator (Cannot use in Oxygen Deficient atmosphere)
Splash protection (Not vapor tight)

## **Level D Ensemble** (Lowest level of Protection)

Typical work Uniform
Chemical resistant gloves and boots
Minimal Splash protection and no respiratory protection
Eye protection and hard hat

**Haz Mat Level I Incident**

**Haz Mat Level II Incident**

**Haz Mat Level III Incident**

**Large Spill Vs. Small Spill**

## Haz Mat Level I(1) Incident

Incident within the capabilities of first responders or organization
Example: Spill of 20 gallons of gasoline.

## Haz Mat Level II (2) Incident

Incident that requires service of formal Hazmat Response Team
Example: Any incident requiring Chemical Protective Clothing; a tanker rollover.

## Haz Mat Level III (3) Incident

Requires resources from state/provincial, federal
and/or private industries and requires unified command.
Example: A train derailment.

## Large Spill: Greater than 55 Gallons

## Small Spill: Less than 55 Gallons

| |
|---|
| **LD 50** |
| **LC 50** |
| **Acute** |
| **Chronic** |

**LD 50:**
The amount of an injected or ingested substance that results in the death of 50% of a test population. Usually described in milligrams per kilogram of body weight (mk/kg).

**LC 50:**
The concentration in air of an inhaled substance that results in the death of 50% of a test population. Usually described in parts per million (ppm).

**Acute Exposure:**
Contact with a substance that occurs once or for only a short time (up to 14 days).
Examples: carbon monoxide or cyanide poisoning.

**Chronic Exposure:**
Repeated expose over a long period of time (Months, years) to a particular chemical or hazardous substance.
Example: Asbestosis (Continual exposure to asbestos) Lung cancer from cigarette smoking

| |
|---|
| **IDLH** |
| **PEL** |
| **PEL (C)** |
| **STEL** |

**IDLH:** Immediately Dangerous to Life and Health
Definition: An atmospheric concentration of any toxic ,corrosive or asphyxiant that immediately poses a threat to life.
Exposure Period: Immediate

**PEL:** Permissible Exposure Limit
Definition: The maximum concentration of a substance to which the majority of healthy adults can be exposed over a 40-hour workweek without suffering adverse effects.
Exposure Period: 8 Hours (Time Weighted Average (TWA))

**PEL (C):** Permissible Exposure Limit (Ceiling)
Definition: The maximum concentration that to which an employee may be exposed at any time even instantaneously
Exposure Period: Instantaneous

**STEL:** Short-Term Exposure Limit
Definition: The maximum concentration allowed for a 15-minute exposure period.
Exposure Period: 15 minutes (TWA)

**TLV**

**TLV-TWA**

**TLV-STEL**

**TLV-C**

**TLV:** Threshold Limit Value
Definition: An occupational exposure value recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) to which workers can be exposed day after day for a working lifetime.
Exposure Period: Lifetime

**TLV-TWA:** Threshold Limit Value Time Weighted Average
Definition: The allowable time-weighted average concentration
Exposure Period: 8-Hour day or 40-hour workweek

**TLV:-STEL** Threshold Limit Value-Short-Term Exposure Limit
Definition: The maximum concentration for a continuous 15 minute exposure period (max of 4 periods per day with 60 minutes between exposures provide daily TLV-TWA is not exceeded)
Exposure Period: 15 minutes (TWA)

**TLV-C:** Threshold Limit Value-Ceiling
Definition: The concentration that **should not be exceeded** even for an instant.
Exposure Period: 15 minutes (TWA)

**Absorption**

**Adsorption**

**Blanketing/Covering**

**Dike, Dam Diversion and Retention**

**Absorption:** Contact between materials that have an attraction for each other where one material will be absorbed into (sucked up into) the other. Absorbents tend to swell up.
Example: A dry sponge sucking up water.

**Adsorption:** Molecules adhere to the adsorbent material rather than being sucked up into it. Adsorbent do not swell like absorbents and are often carbon based materials.
Example: Activated charcoal.

**Blanketing/Covering:** Involves blanketing or covering the surface of a spill to prevent dispersion of the materials such as powders or dust.
Examples: Tarps, salvage covers, plastic sheeting

**Dike, Dam Diversion and Retention :** Ways to **Confine** a material. These methods are done to control the flow of material away from the point of discharge and are usually conducted with earthen materials.

**Vapor Suppression**

**Vapor Dispersion**

**Regular Protein Foam**

**Fluoroprotein Foam**

**Vapor Suppression:** Reducing the emission of vapors usually by the application of foam. This is a very effective technique when used on flammable or combustible liquids.
Example: AFFF

**Vapor Dispersion:** Action taken to direct or influence the course of air-borne (gas or vapor) hazardous materials.
Example: Directing a hoseline at the gas being release from a chlorine cylinder.

**Regular Protein Foam:** (Non-existent today) Derived from hoof, horn or feather meal and converted to protein liquid. Good heat stability but not very mobile and won't spread out. Available in 3 & 6% concentrations.

**Fluoroprotein Foam:** Combination based protein and synthetic foam concentrate with fluorochemical surfactants (oil shedding materials that reduces surface tension) and is well suited for **SUBSURFACE INJECTION**: Pumped into the bottom of a petroleum fuel tank then floating to the top to form a fire-extinguishing foam blanket. Available in 3 & 6% concentrations.

**Aqueous Film Forming Foam (AFFF)**

**Alcohol Resistant AFFF**

**High-Expansion Foam**

**Release Shapes**

**Hemispheric Release**
**Vapor Cloud**
**Plume**

**Aqueous Film Forming Foam (AFFF):** Completely synthetic and consists of fluorochemical and hydrocarbon surfactants along with high boiling point solvents and water. The fluorochemical surfactants reduce surface tension of water to a degree less than the surface tension of the hydrocarbon so that a thin film can spread across the fuel preventing vapors (combustible mixture) from forming. Available in 1, 3 & 6% concentrations. Suitable for subsurface injection.

**Alcohol Resistant AFFF (AR-AFFF):** Another class of AFFF concentrates that incorporates alcohol resistant concentrates. This is the foam of choice for alcohol fire and also for alcohol fuel formulations (E-85). Available in 1, 3 & 6% concentrations

**High-Expansion Foam:** High Expansion Foam concentrates are special purpose that are similar to class A foams. Because they are low-water content, the minimize water damage. Generally not advised for use outside because wind can easily disturb the foam blanket. **Expansion ratios of 200:1 to 1000:1 (air to solution ratios)**. Great for use in confined space.

**Hemispheric Release:** Semicircular or dome-shaped pattern of an airborne hazardous material that is still partially in contact with the ground or water.
**Vapor Cloud:** Ball-shaped pattern of an airborne hazardous material that is risen above ground.
**Plume:** Irregularly shaped pattern of airborne hazardous material where wind and topography influence the downrange shape from the point of release.

**Release Shapes Continued:**

Cone
Stream
Pool
Irregular

**Container Stresses:**

Thermal
Chemical
Mechanical

**Container Breach Types:**

Disintegration
Runaway Cracking
Attachment Damage

**Container Breach Types cont'd:**

Puncture
Split or Tear
Metal Reduction

**Cone:** Triangular shaped pattern of a haz mat release from s single point and wide base downwind.
**Stream:** Surface flowing pattern of a liquid affected by gravity and topography.
**Pool:** Liquid that assumes the shape of its containment area and accumulates in low areas.
**Irregular:** Irregular or indiscriminate movement of haz mat (i.e. responder walked through a pool and carried it into a clean area).

**Thermal:** Excessive heat or cold cause expansion, contraction and weakening of the container
**Chemical:** Interactions of the contents of a container and the container itself resulting in deterioration of container integrity
**Mechanical:** Physical application of energy resulting in container damage.

**Disintegration:** Container suffers general loss of integrity (i.e. shattering bottle, exploding grenade).
**Runaway Cracking:** Crack develops in a container as a result of damage breaking into 2 or more pieces (i.e. BLEVE)
**Attachment Damage:** Attachment such as valves or pressure release devices fail, open or break off when subjected to stress.

**Puncture:** Mechanical stress such as a fork lift puncturing a drum or rail car coupling puncturing a rail tank car.
**Split or Tear:** Welded seam on a tank fails or bag of fertilizer is ripped open.
**Metal Reduction:** Corrosive action of an acid on steel

**Incident Command General Staff**

**Incident Commander**

**Operations Section**

**Planning Section**

## Incident Command General Staff

- IC
- Finance
- Logistics
- Operations
- Planning

## Incident Commander

- Has ultimate responsibility for all incident activities
- Manages the overall Incident Action Plan
- Establish incident priorities and objectives

## Operations Section

- Controls tactical portion of the incident
- Assigns tactical functions

## Planning Section

- Gathers and disseminates information for effective decision making
- Assembles IAP and determines needs for next operational period

**Logistics Section**

**Finance Section**

**Command Staff and Duties**

**Safety Officer**

## Logistics Section

- Secures facilities, services and equipment in support of the incident

## Finance Section

- Record keeping, cost tracking, and paying the bills

## Command Staff: Positions that report directly to the IC

- Safety Officer: See Below
- Liaison Officer: Outside Agency Representative
- Public Information Officer (PIO): Media Representative, Public Spokesperson

## Safety Officer:

- Advises IC of unsafe conditions
- Immediately stops unsafe acts
- Monitors conditions of personnel
- If not assigned, IC assumes position

| |
|---|
| **ICS Span of Control** |
| **Hot Zone** |
| **Warm Zone** |
| **Cold Zone** |

## ICS Span of Control:

The optimum span of control is 5:1 with an allowable range of 4-7.

## Hot (Exclusion/Red) Zone:

The hot zone, also referred to as the exclusion zone, is the area where contamination may occur. The primary activities performed in this area are hazard assessment, control of the release or hazard and rescue.

## Warm (Contamination Reduction/Yellow) Zone:

The warm zone is the area where the Contamination Reduction Corridor (CRC) is located and decontamination of people and equipment takes place.

## Cold (Clean/Green) Zone:

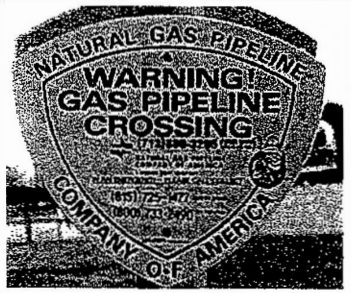
The cold zone site is chosen for accessibility for emergency vehicles, visibility (line of sight to the hot and warm zones) and availability of resources like power lines, water and shelter. The cold zone personnel include the IC, PIO, safety officer, emergency response personnel and the
decontamination officer.

**Required Pipeline Marker Components**
**(4 Items)**

**Protective Action Distance**
**(Define, Shape)**

**Required Placard Components**
**(5 Items)**

## Signal Word (Caution, Warning, Danger)
## Product
## Owner
## Emergency Telephone Number




## Protective Action Distance

- **Shape is Square!**

A downwind distance from a spill/leak source within which protective actions should be implemented (steps taken to preserve the health and safety of emergency responders and the public).