

Part 1 DOT- U.S. Department of Transportation

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Reference Guides:

HM-181 1991 / HM-126F 1992 / HM-232 2003 / TITLE 49 CFR

This information is intended to apply o anything transported by: Rail, Air, Ocean, Highway

Training Requirements

Who are Hazmat Workers?

- Railroad workers
- Loaders
- Unloaders
- Handlers
- Safety officers
- Drivers
- Supervisors
- Manufacturers of containers used for hazmat

Regulatory

The **DOT Hazardous Material Regulations** are found in **Title 49** of the **Code of Federal Regulations (CFR) Parts 100-185**

100-110 include information on enforcement, getting special permits, and hazmat registration.

Hazmat Registration

Anyone who transports or ships the following hazmat must register with PHMSA and pay annual fees:

- A highway route-controlled quantity of a Class 7 radioactive material.
- More than 55lbs of a division 1.1, 1.2, or 1.3 explosive in a motor vehicle, rail car, or freight container.

- More than 1 L of an extremely toxic by inhalation material meeting the criteria of Hazard Zone A.
- A shipment in a package having a capacity greater than 3,500 gallons for liquids or gasses or more than 428 cubic feet for solids.
- Any shipment over 5,000lbs of one class of hazmat loaded at one facility requires placarding.
- **Any shipment in quantities that require placarding (excluding farming operations)**

Subchapter B (Part 130)- includes requirements for oil spill prevention.

This only applies to shipments of:

- Petroleum oil in a packaging having a capacity of 3,500 gallons or more; or
- Petroleum or non-petroleum oil in a quantity greater than 42,000 gallons per packaging.

Subchapter C (Part 171)- includes information on:

- Applicability
- Definitions
- Incident reporting
- International requirements

Subchapter C (Part 172)- includes information on:

- The hazmat table (172.101)
- Shipping document requirements (beginning with 172.200)
- Marking, labeling, placarding requirements (172.300, 400, & 500, respectively)
- Emergency response (beginning with 172.600)
- Training (beginning with 172.700)
- Security (beginning with 172.800)

Subchapter C (Part 173)- includes information on:

- General packaging requirements (173.24)
- Hazard class definitions (beginning with 173.50)
- Packaging rules (beginning with 173.158)
- Other important things (e.g., precedence table, 173.2a)

Subpart C (Parts 174-177)- includes information on:

- Modal specification
- Rail (174), Air (175), Vessel (176), & Highway (177)
- Requirements related to
 - Loading and unloading
 - En route safety
 - Additional training

Subpart C (Parts 178-180)- includes information on:

- Packaging specification requirements

- Packaging testing criteria and maintenance requirements
- Very useful to packaging manufacturers.

Safety Overview & Emergency Response

“Hazardous materials” are capable of causing harm to either people, property, or the environment.

Routes of entry

There are four routes of entry by which chemicals can enter our bodies. If we know what they are for the materials that we work with, we can take the necessary steps to block them from entering our bodies in high doses, and thus work safely around the materials.

1. Skin absorption
2. Ingestion
3. Inhalation
4. Injection

Inhalation Route: Inhalation is the most vulnerable route to the worker. When you inhale, almost everything has a pathway directly into our bodies. The materials in many cases go in directly to the blood supply through the lungs. This is a very rapid action and happens every time you breathe. When this does, your lungs, which have a huge surface area, much larger than that of your skin, transfer the materials at very rapid rates into your blood. This creates many problems.

Absorption/Contact: This route involves contact with our bodies. The eyes and mucous membranes have significant rates of absorption and exposure is high so be careful working around splash hazards. Skin covers most of our body and is a good barrier against many types of chemical hazards except when exposed to corrosives (nitric acid, sodium hydroxide) and solvents (water, ethanol) which are particularly well suited to breaking down the skin barrier and being absorbed by the body. **Absorption Protection: Proper use of Personal Protective Equipment (PUPPE). Proper Storage. Eyewash stations. Showers.**

Ingestion: The next route of entry is ingestion. Most of us do not intentionally eat or drink hazardous materials this is usually a secondary exposure caused when materials first contact our hands and then we place our hands into our mouth or on the foods we eat. **Ingestion protection:**

1. **Proper Hygiene- wash hands before you eat, drink, or smoke.**
2. **Common Sense- don't eat, drink or smoke in areas where chemicals are used, dispensed or stored.**
3. **Proper Decontamination- after working around chemicals.**

Injection: The last route we need to discuss is the injection route. If the barrier that is your skin is in some way damaged, then materials can pass through that barrier and enter our bodies. The mechanism by which this happens is generally something as simple as a wound, scrape or cut. Even a minor wound that has scab is still a weak spot in your skin. **Injection Protection: Assess the area and be cautious around sharp**

objects, tools, and compressed air. Do not put yourself in the line of fire whenever there are pressurized lines (hydraulic, pneumatic, etc.)

Two major effects of chemical exposure

Local- these effects are those that happen at the point of contact with the hazardous material. Examples include many types of acids that contact the skin and can cause skin burns.

Systemic- these effects can occur anywhere in the body where by a body system or organ is the target of the exposure. The best examples of systemic effects are dizziness or confusion caused by breathing vapors which effect the brain, or by breathing low levels of oxygen.

Time frames of chemical exposure effects

Immediate- occurs within minutes or hours of exposure. Example- Sulfuric acid burn produces immediate redness and burning. Intoxication effect from drinking alcohol.

Delayed- occurs hours to days following the exposure. Example- Hangover effect from alcohol intoxication. Disease caused by exposure to pathogens.

Long-Term- Occurs months to years later such as effects from smoking cigarettes. Example- Cancer, organ damage, reproductive harm.

Cancer

There are many materials that cause cancer but OSHA limits the exposure to these materials at work so our off-the-job exposure is likely to be higher. Occupational exposure to cancer causing substances is declining with the rates at about 2% of all cancer. There are four agencies commonly listed on SDSs that list cancer causing substances: 1. The Occupational Safety and Health Administration. 2. The International Agency for Research on Cancer. 3. The National Toxicology Program. 4. American Conference of Governmental Industrial Hygienists.

Organ Failure

Organ damage is the second prevalent long-term health effect. As you review the large number of materials that are in the workplace, we do find a variety of target organs for those materials. There are three organs which are significantly at risk from long-term exposure to chemicals: Lungs, Liver, and Kidneys. Each of these filters out the materials that enter our body and because of that, suffer some significant health effects over the long term.

Reproductive Harm

The last area of concern relative to chemical exposure is the damage to our reproductive system. In summary, this damage primarily involves affecting our ability to product offspring, or in somehow damaging the offspring. Birth defects can be caused by chemical exposure to either mutagenic or teratogenic materials. While these materials affect us differently, the results are the possibility of producing offspring that are damaged by the exposure to the materials.

The Dose Makes the Poison

It is not the chemical, but rather the dose of the material that produces the health effect. An early toxicologist named Paracelsus stated that **“All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy.”**

Permissible Exposure Limit (PEL)

OSHA has set permissible exposure limits (PELs) on the amount or concentration of a substance in the air. These limits are enforceable by law. Most OSHA PELs are based on a 8-hour work shift of a 40-hour work week time-weighted average (TWA) exposure that an employee may be exposed to for working lifetime without adverse effects.

Short-term Exposure Limit (STEL)

A short-term exposure limit (STEL) is the acceptable average exposure over a short period of time, usually 15 minutes as long as the time-weighted average is not exceeded.

Immediately Dangerous to Life or Health (IDLH)

NIOSH also provides concentrations for chemicals that it considers Immediately Dangerous to Life or Health (IDLH). These values are more useful for emergency planning and response and under no circumstances should anyone be exposed to concentrations near the IDLH. NIOSH defines an IDLH condition as a situation “that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.”

Flash Points

Flash Point: The minimum temperature where a liquid will give off vapors in sufficient quantity to be ignited if an ignition source is present.

Yes, materials can be ignited at this temperature, but only if an ignition source is present. Flash point simply tells us at which point vapors are present and that our efforts need to be directed toward limiting the ignition sources present.

Gasoline is almost always used and stored at temperatures above the flashpoint. In the event of a leak, there would be vapors present that could be ignited by an ignition source if one was present. This means that open flames, arcs from electrical sources, and even static electricity could pose a problem.

Gasoline: flash point of -44°F.

Diesel, on the other hand, is not so easy to ignite. At normal temperatures Diesel could not be released and not pose a fire hazard to us given that there would be no flammable vapors present since the material is below its flash point. This does not mean diesel will not burn, it means that two things are needed to have a fire problem: an ignition source and a means of heating up the diesel liquid to its flash point of 120 °F.

Vapor Density

1. First of all, we need to think about the hazards associated with gases themselves. Remember when we reviewed toxicology. We were reminded that the inhalation route is the highest concern. Therefore, where the gases are is where the inhalation hazard is.
2. From the fire perspective, we review that it is the vapors that burn, not the liquid. So, where the vapors are is where the fire hazard is.

Three things that influence the movement of gases/vapors

1. Ventilation systems or wind: Mechanical ventilation will move gases and vapors around.
2. Temperature: if the vapors are heated, they likely will want to rise. If the materials are cooled, such as is the case of liquefied gas or cryogenic material, the coolness will give them a tendency to sink when released until they reach ambient temperatures.
3. Vapor Density: the third factor that influences the movement of gases is the material's vapor density.

Vapor Density- the weight of the materials vapor, relative to air.

- Air receives a value of 1.
- **Sinkers**- materials heavier than air receive a value greater than one.
*More of a hazard outdoors since these vapors are likely to stick around.
- **Risers**- materials lighter than air have a vapor density value of less than one. *Less of a hazard outdoors.

Specific Gravity

Liquids, like vapors, possess certain properties that if understood, will provide some help in working safely with them. Some of the more important properties involve what the liquids do when they contact water. One of three things will happen when liquid chemicals contact water: dissolve, sink, or float.

Miscibility/Solubility- The terms **Miscibility or Solubility** denote whether one material will mix with, or dissolve in another.

Specific gravity is the weight of a liquid compare to the weight of water.

Water is assigned a specific gravity value of 1.

Things that are lighter and have a specific gravity less than 1 will float on water. Things that are heavier and have a specific gravity greater than one, will sink.

Swimmers- materials that will mix or dissolve in the water.

Floaters- materials lighter and have a specific gravity **less** than 1 will float on top of the water. Ex.: Oil has a specific gravity of .8 will float.

Sinkers- materials heavier and have a specific gravity **greater** than one, will sink. Ex.: carbon disulfide which has a specific gravity of 1.3 will sink.

Safety Data Sheets

SDS's are intended to provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner.

SDS Section Descriptions

- Section 1: Product Identification
- Section 2: Hazard Identification
- Section 3: Hazardous Ingredients
- Section 4: First Aid
- Section 5: Firefighting Measures
- Section 6: Accidental Release
- Section 7: Handling and Storage
- Section 8: Exposure Control
- Section 9: Chemical and Physical Properties
- Section 10: Stability and Reactivity
- Section 11: Toxicity
- Section 12: Ecological Info
- Section 13: Disposal Options
- Section 14: Transportation
- Section 15: Regulations
- Section 16: Other Information (such as SDS revision date)

First Responder Awareness Training is required when your duties only involve discovery and notification.

First Responder Operations Training is required when, in addition to discovery and notification, you will respond in a defensive fashion (e.g. activate shut-off switches, deploy diking from a safe distance)

Hazmat Technician Training is required if your duties will involve actions such as stopping the spill at the source.

Hazmat Specialist Training is required if you will be called upon to provide technical support to hazmat techs and others during an incident (e.g. chemical compatibility information and process equipment operation)

Incident Command Training is required if you are the individual responsible for managing emergencies.

The OSHA regulations governing emergency response can be found at 29 Code of Federal Regulations Section 1910.120. If your state has its own OSHA program, the program will be equally or more stringent than the Federal program; you must, therefore, comply with your State-specific emergency response regulations.

DOT's regulations also require, with few exceptions, that emergency response phone numbers be entered on shipping papers and that the emergency response information

be documented and maintained in the same manner as shipping papers. The emergency response information must be available with and away from hazardous material shipments.

Hazard Identifications

DOT is “the law of the land,” when it comes to hazmat transportation to, through, and within the U.S. Therefore, you must understand DOT terminology in order to fully comply with DOT requirements.

Hazardous Material- means a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

Hazardous Waste- means any material that is subject to the Hazardous Waste Manifest Requirements of the U.S. Environmental Protection Agency (EPA) as specified in 40 CFR part 262.

Hazardous Substance- are materials designated by EPA in 40 CFR 302.4, which are contained in a single packaging in an amount by weight that equals or exceeds a “reportable quantity” (RQ). The list of hazardous substances is also found in DOT’s regulation, 49 CFR 172.101, Appendix A.

Packaging- means components of a containment system needed for the container to function properly. E.g. drums, lids, bungs, rings bolts, boxes, tape, Styrofoam, a roll off, cargo tank etc.

Package- means packaging and content. In other words, once you place something in the packaging, you have a package.

Large Packaging- means a packaging that consists of an outer packaging that contains articles or inner packagings and is designated for mechanical handling. Exceeds 400kg net mass of 450 liters (118.9 gallons) capacity. Has a volume of not more than 3 cubic meters (m³) (792.5 gallons); and conforms to the DOT requirements for the construction, testing, and marking of Large Packagings.

Bulk Packaging- means a packaging, other than a vessel or barge (but including a transport vehicle or freight container) in which hazmat is loaded with no intermediate containment. (A Large Packaging, however, in which hazmat is loaded with an intermediate form of containment, such as one or more articles or inner packagings, is also a bulk packaging.) A bulk packaging has:

- A maximum capacity greater than 450 L (119 gallons) as a receptacle for a liquid.
- A maximum net mass greater than 400 kg (882 pounds) and a maximum capacity greater than 450 L (119 gallons) as a receptacle for a solid; or
- A water capacity greater than 454 kg (1000lbs or 119.8 gallons) as a receptacle for a gas.

Non-Bulk Packaging- is equal to or less than everything we just said about bulk packaging.

Single packaging- means a non-bulk packaging serving as the primary containment for the hazmat (i.e. no inner items)

Combination Packaging- means a combination of packaging, for transport purposes, consisting of one or more inner packagings secured in a non-bulk outer packaging.

Overpack- means an enclosure that is used by a single consignor (sender) to provide protection or convenience in handling of a package or (to) consolidate two or more packages. (ex. Wrapping a pallet)

Salvage Packaging- means a special packaging into which damaged, defective, leaking, or non-conforming hazardous materials packages, or hazardous materials that have spilled or leaked, are placed for purposes of transport for recovery or disposal. (49 CFR 173.3)

Composite Packaging- means a packaging consisting of an outer package and an inner receptacle, so constructed that the inner receptacle and the outer packaging for an integral packaging.

Packing group- is the grouping of hazardous materials according to the degree of danger. Packing Group I, indicates great danger; Packing Group II, medium danger; Packing Group III, minor danger.

Marine Pollutant- is an aquatically toxic material that is listed in Appendix B to the 49 CFR 172.101 hazmat table and when in a solution or mixture is packaged in a concentration $\geq 10\%$ for a marine pollutant or $\geq 1\%$ for a severe marine pollutant.

Marine Pollutant regulations apply when you are shipping by any mode of transportation in bulk packaging, or you are shipping in non-bulk packaging by vessel.

In addition to container marking, special notations are required on shipping papers for marine pollutant consignments.

Elevated Temperature Materials

Elevated temperature material means a material which, when offered for transportation or transported in bulk packaging:

1. Is in a liquid phase at a temperature of $\geq 100^{\circ}\text{C}$ (212°F)
2. Is in a liquid phase with a flash point of $\geq 38^{\circ}\text{C}$ (100°F) that is intentionally heated and offered for transportation or transported at or above its flash point; or
3. Is in a solid phase and at a temperature of $\geq 240^{\circ}\text{C}$ (464°F)

Materials of Trade

The Materials of Trade (MOT) exception is found in **49 CFR 173.6** and is an extremely important exception for companies that transport hazmat to support their principal form of business (such as paints, pesticides, fire extinguishers, auxiliary fuel cans).

The “official” MOT definition is as follows:

- Material of trade means a hazardous material, other than a hazardous waste, that is carried on a motor vehicle-
 1. For the purpose of protecting the health and safety of the motor vehicle operator or passengers;
 2. For the purpose of supporting the operation or maintenance of motor vehicle (including its auxiliary equipment); or
 3. By a private motor carrier (including vehicles operated by a rail carrier) in direct support of a principal business that is other than transportation by motor vehicle.

Only the following hazard classes, divisions, and categories may be shipped under the MOT exception:

- Division 2.1
- Division 2.2
- Class 3
- Division 4.1 (no Self-reactive materials)
- Division 4.3 (PG II & III Only)
- Division 5.1
- Division 5.2
- Division 6.1 (No poison inhalation hazards)
- Division 6.2
- Class 8
- Class 9
- ORM-D
- Limited Quantity

MOT Packaging:

- Must be leak-tight, sift-proof, securely closed, prevented from shifting, and protected from damage.
- Manufacturer’s original packaging or packaging of equal or greater strength and quality must be used.
- Containers holding gasoline must be metal or plastic and conform to OSHA requirements.
- Gas cylinders must be DOT-approved and maintained in accordance with 49 CFR. (Outer packagings are not required). Cylinder manifolding is authorized provided all valves are tightly closed.

Hazard Classification

The DOT has created 9 hazard classes which reflect the major types of problems presented by hazardous materials

1. Explosive
2. Gases
3. Flammable and combustible liquids
4. Flammable solids
5. Oxidizers
6. Poison and infectious substances
7. Radioactive
8. Corrosives
9. Miscellaneous

Class 1- Explosives

Divisions

- 1.1- Explosives that have a mass explosion hazard (one which affects almost the entire load instantaneously). (e.g., THT, PETN, dry picric acid)
- 1.2- Explosives that have a projection hazard but not a mass explosion hazard. (e.g. boosters with detonators, rocket motors)
- 1.3- Explosives that have a fire hazard and either a minor blast hazard or a minor project hazard or both, but not mass explosion hazard. (e.g. smokeless powder, fireworks)
- 1.4- Explosives that present a minor explosion hazard. (e.g. airbag inflators, ammunition)
- 1.5- Very insensitive explosives that have a mass explosion hazard. (e.g. primer caps, blasting agents)
- 1.6- Extremely insensitive articles that do not have a mass explosion hazard.

Class 2-Gases

Divisions

- 2.1- Flammable Gases
- 2.2- Non-flammable Gases
- 2.3- Toxic Gases

2.1- Flammable Gases

DOT defines a “flammable gas” as material that is gaseous at standard temperature and pressure and either:

1. Has a lower flammable limit (LFL) of 13% or less. For example: Propane is a gas at 68°F and 14.7psia and has an LFL of 2.1% (which is less than 13%) and is, therefore, a DOT Division 2.1 flammable gas. Or:
2. Has a flammable range of $\geq 12\%$, regardless of its LFL. For example: “Gas X” has an LFL of 23%. This property alone does not make “Gas X” a flammable gas, because

23% is greater than the 13% LFL mentioned above. "Gas X" has an upper flammable limit (UFL) of 58%, giving it a flammable range of 35% (58 minus 23). "Gas X" is a DOT Division 2.1 flammable gas, because 35 is \geq 12.

2.2- Non-flammable Gases

Any material (or mixture) which-

1. Exerts in the packaging a gauge pressure of 200kPa (29.0psig/43.8psia) or greater at 20°C (68°F), is a liquefied gas or is a cryogenic liquid, and
 2. Does not meet the definition of Division 2.1 or 2.3
- Examples of non-flammable gases include argon, carbon dioxide, and nitrogen.

2.3- Toxic Gases

A DOT Division 2.3 toxic gas is a gas that.

1. Is known to be so toxic to humans as to pose a hazard to health during transportation, or
2. In the absence of adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals is has a LC50 value of not more than 5000mL/m³ (e.g. arsine, chlorine, and sulfur dioxide)

Class 3- Flammable Liquid

In general, any liquid having a flashpoint of \leq 140°F that sustains combustion is a DOT, Class 3 flammable liquid.

Examples include- acetone, benzene, ethyl ether, gasoline, hexane, isopropyl alcohol, and oil-based paints.

Combustible Liquid- A combustible liquid with a flashpoint greater than 140. But less than 200°F. (Example: diethylene glycol monoethyl ether).

Note: DOT allows shippers, shipping by ground, to reclassify flammable liquids with flashpoints from 100 to 140°F as combustible liquids (e.g. diesel).

Class 4- Flammable Solid

Divisions

- 4.1-Flammable solid
- 4.2- Spontaneously combustible
- 4.3- Dangerous when wet

4.1-Flammable solid

Means any of the following three types of materials:

- Desensitized explosives (e.g. picric acid, wet)

- Self-reactive materials (materials that are thermally unstable and that can undergo a strong exothermic decomposition even with out the participation of oxygen [air]). (e.g. benzene sulphohydrazide)
- Readily combustible solids (e.g. matches, silicon powder)

4.2- Spontaneously combustible

- A pyrophoric material (e.g. yellow phosphorus, zirconium powder)
- A self-heating material (e.g. raney nickel, activated carbon)

4.3- Dangerous when wet

A material that, by contact with water, is liable to become spontaneously flammable or to give off flammable or toxic gas at the rate of greater than 1L per kilogram of the material, per hour. (Sodium and potassium metal, calcium carbide, aluminum powder [uncoated])

Class 5- Oxidizer

Division 5.1- Oxidizers

Oxidizer means a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials (e.g. ammonium nitrate fertilizer, calcium hypochlorite [pool disinfectant], hydrogen peroxide [8% or greater], potassium bromate)

Division 5.2- Organic Peroxides

Organic peroxide means any organic compound containing (O) in the bivalent-O-O-structure and which may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals, unless otherwise classed as an explosive, forbidden for shipment, or does not contain enough hydrogen peroxide nor oxygen to pose a danger when transported.

Class 6-Poisons: Poison and Toxic are used interchangeably when shipping DOT. Shipping internationally only the term toxic may be used.

Division 6.1- Poisonous Materials (solids or liquids)

A poison means a material, other than a gas, which is known to be so toxic to humans as to afford a hazard to health during transportation, or which, in the absence of human toxicity data

- It has a oral LD₅₀ of ≤300 mg/kg
- It has a dermal LD₅₀ of ≤1000 mg/kg
- It has an inhalation LC₅₀ (as a dust or mist) of ≤4 mg/L; or
- It is an irritating material, with properties similar to tear gas which causes extreme irritation, especially in confined spaces.
- Examples: arsenic trioxide, chloroacetophone, chloroform, lead acetate, mercuric chloride, phenol, sodium cyanide.

Division 6.2- Infectious Substances

- An infectious substance means a material known or reasonably expected to contain pathogen. (e.g. bacteria, viruses, rickettsiae, parasites, fungi)
- Category A infectious substances are capable causing permanent disability or life-threatening or fatal disease in otherwise healthy humans or animals when exposure occurs.
- Category B infectious substances not in a form generally capable of causing permanent disability or life-threatening or fatal disease in otherwise healthy humans or animals when exposure to it occurs.

Class 7-Radioactive

In general, radioactive material contains elements or elemental compounds with unstable (decaying) nuclei (a.k.a radionuclides).

The DOT “Class 7” definition is fairly complex: *Radioactive material means any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 173.436 or values derived according to the instructions in 173.433.*

In 49 CFR 173.436, DOT offers two exemptions for radioactive material:

- *One exemption associated with the activity of the specific radionuclide(s); and*
- *Another exemption for the total activity in the consignment.*
- If the shipper is ineligible for either exemption, **then** the material is classified as radioactive.
- 49 CFR 173.433 offer calculations to determine whether a mixture meets the definition of “Class 7.”

Exposure to ionizing radiation (i.e. alpha, beta, gamma, neutron, and x-ray) can produce a range of symptoms and illnesses, such as nausea, hair loss, skin burns, reduced organ function, and cancer. Acute exposure to radiation can be fatal.

Remember the acronym A.L.A.R.A: Keep your exposure As Low as Reasonably Achievable through Time, Distance, and Shielding.

- Limit your exposure **time**
- Maintain a safe **distance** from the radioactive source as possible
- Use protective **shielding** suitable for the type of radiation being emitted.

Class 8- Corrosives

Corrosive materials are capable of deteriorating skin tissue and corroding metal.

Examples of Class 8 materials include:

- Battery electrolyte (Sulfuric acid)
- Caustic soda (sodium hydroxide)
- Ethanolamine
- Hydrochloric acid

- Nitric acid

Class 9 Miscellaneous

A *miscellaneous hazardous material* (Class 9) means a material which presents a hazard during transportation, but does not meet the definition of any other hazard class and

1. That has an anesthetic, noxious or other similar property which could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties; or
2. Is an elevated temperature material, a hazardous substance, a hazardous waste, or a marine pollutant.

Ex. Asbestos, dry ice, lead contaminated soil (with enough lead to make it a “hazardous waste,” but not enough to render it Division 6.1 toxic), lithium batteries, polychlorinated biphenyls, self-defense spray (non-pressurized).

Hazard Classifications

- There is more to hazard classification than determining a material’s hazard class.
- Most hazard classes and divisions also have “**Packing Groups**”
- There are three packing groups (PG), PG I, II, & III.
- All hazard classes and divisions have packing groups with the exception of Classes 1, 2, & 7 and Divisions 5.2 & 6.2. **Note: While Class 1 and Division 5.2 are not assigned to packing groups (PG), they must be packed in PG II containers.**

Packing Groups communicate the degree of danger given hazard class.

- PG I indicates “great danger”- Diethyl ether= Class 3 PG I
- PG II indicates “medium danger”- Acetone= Class 3 PG II
- PG III indicates “minor danger”- Diesel= Class 3 PG III

There are specific criteria for determining packing groups.

Class 3 Packing Group Assignment Criteria- Based on Flash Point and Initial Boiling Point. **Flammable**

Packing Group	Flash Point (closed-cup)	Initial Boiling Point
I		≤35°C (95°F)
II	<23°C (73°F)	>35°C (95°F)
III	≥23°C, ≤60°C (≥73°F, ≤140°F)	>35°C (95°F)

Division 6.1 Packing Groups are assigned based on route of entry and the associated lethal dose (LD)₅₀ or lethal concentration (LC)₅₀. **Poison**

Packing Group	Oral toxicity LD ₅₀ (mg/kg)	Dermal toxicity LD ₅₀ (mg/kg)	Inhalation toxicity by dusts and mists LC ₅₀ (mg/L)
I	≤5.0	≤	≤0.2
II	>5.0 and ≤50	>50 and ≤200	>0.2 and ≤2.0
III	>50 and ≤300	>200 and ≤1000	>2.0 and ≤4.0

LD₅₀ is the dose that was administered to laboratory animals (based upon milligram per kilogram body weight) that killed 50% of the test population.

LC₅₀ is the airborne concentration to which the laboratory animals were subjected (based upon milligram per liter of air) that killed 50% of the test population.

Division 8 Packing Group Assignment Criteria **Corrosive**

Packing Group I- Materials that cause full thickness destruction of intact skin tissue (goes all the way through the skin) within an observation period of up to 60 minutes starting after the exposure time of three minutes or less.

Packing Group II- Materials that cause full thickness destruction of intact skin tissue within an observation period of up to 14 days starting after the exposure time of more than three minutes but not more than 60 minutes.

Packing Group III- Materials that cause full thickness destruction of intact skin tissue within an observation period of up to 14 days starting after the exposure time of more than 60 minutes but no more than 4 hours; or

Materials that exhibit corrosion on either steel or aluminum surfaces exceeding 6.25 mm (0.25 inch) a year at a test temperature of 55°C (130°F)

If a material meets more than one hazard class definition, you must establish which hazard class is the “primary” hazard and which is “subsidiary” (secondary).

This is done by determining the packing group for each hazard class and the use of the “Precedence Table” (49 CFR 173.2a).

PRECEDENCE OF HAZARD TABLE

[Hazard class or division and packing group]

	4.2	4.3	5.1 I ¹	5.1 II ¹	5.1 III ¹	6.1, I dermal	6.1, I oral	6.1 II	6.1 III	8, I liquid	8, I solid	8, II liquid	8, II solid	8, III liquid	8, III solid	
3 I ²		4.3					3	3	3	3		(3)	3	(3)	3	(3)
3 II ²		4.3					3	3	3	3	8	(3)	3	(3)	3	(3)
3 III ²		4.3					6.1	6.1	6.1	3 ⁴	8	(3)	8	(3)	3	(3)
4.1 II ²	4.2	4.3	5.1	4.1	4.1	6.1	6.1	4.1	4.1	(3)	8	(3)	4.1	(3)	4.1	
4.1 III ²	4.2	4.3	5.1	4.1	4.1	6.1	6.1	6.1	4.1	(3)	8	(3)	8	(3)	4.1	
4.2 II		4.3	5.1	4.2	4.2	6.1	6.1	4.2	4.2	8	8	4.2	4.2	4.2	4.2	
4.2 III		4.3	5.1	5.1	4.2	6.1	6.1	6.1	4.2	8	8	8	8	4.2	4.2	
4.3 I			5.1	4.3	4.3	6.1	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
4.3 II			5.1	4.3	4.3	6.1	4.3	4.3	4.3	8	8	4.3	4.3	4.3	4.3	
4.3 III			5.1	5.1	4.3	6.1	6.1	6.1	4.3	8	8	8	8	4.3	4.3	
5.1 I ¹						5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	
5.1 II ¹						6.1	5.1	5.1	5.1	8	8	5.1	5.1	5.1	5.1	
5.1 III ¹						6.1	6.1	6.1	5.1	8	8	8	8	5.1	5.1	
6.1 I, Dermal										8	6.1	6.1	6.1	6.1	6.1	
6.1 I, Oral										8	6.1	6.1	6.1	6.1	6.1	
6.1 II, Inhalation										8	6.1	6.1	6.1	6.1	6.1	
6.1 II, Dermal										8	6.1	8	6.1	6.1	6.1	
6.1 II, Oral										8	8	8	6.1	6.1	6.1	
6.1 III										8	8	8	8	8	8	

To use the Precedence Table:

- Locate the hazard class and packing group of one of the hazards along the vertical or horizontal axis.
- Locate the hazard class and packing group of the other hazard along the opposite axis.
- The hazard class appearing where the two axes intersect is the primary hazard.

Determining the primary hazard class is essential to selecting the proper shipping names. Ex.) 85% glacial acetic acid is a liquid and is both flammable (PG III) (class 3) and corrosive (PG II) (class 8). The primary hazard for this substance is Class 8 (corrosive) and the subsidiary hazard is Class 3 (flammable). This makes it a corrosive, flammable.

Hazardous Materials Table (HMT) & Proper Shipping Names (PSN)

Selecting a PSN is an extremely important step, because the PSN is directly associated with marking, labeling, packaging, special provisions and shipping paper requirements.

Column One- Special Symbols

- The plus “+” sign fixes the proper shipping name, hazard class and packing group for that entry without regard to whether the material meets the definition of that class, packing group or any other hazard class definition.
- The letter “A” denotes a material that is DOT-regulated only when offered or intended for transportation by aircraft, unless the material is a hazardous substance or hazardous waste.
- The letter “W” denotes a material that is DOT-regulated only when offered or intended for transportation by vessel, unless the material is a hazardous substance or hazardous waste.
- The letter “D” identifies proper shipping names that are appropriate for describing materials for domestic transportation, but may be inappropriate for international transportation under the provisions of international regulations.
- The letter “I” identifies proper shipping names that are appropriate for describing materials in international transportation.
- The letter “G” identifies proper shipping names for which one or more technical names of the hazardous material must be entered in parentheses, in association with the basic description.

Column Two- PSN

The PSN is the information found in bold or non-italicized type.

In this example, the PSN is “Acetic acid solution,” and everything else is optional for use.

If the exact concentration was known (e.g. 60%), the shipper could use “Acetic acid solution, 60 percent acid by mass” as a PSN, but is not obligated to do so.

There are also instance when italicized information CANNOT be used:

- In this excerpt, neither “acetylene tetrabromide” nor “acid butyl phosphate” may be used as PSNs.

<i>Acetylene tetrabromide, see Tetrabromoethane</i>
<i>Acid butyl phosphate, see Butyl acid phosphate</i>

- In this last example, both “Acid, sludge” and “Sludge acid” are acceptable PSNs. Why??? Because neither is italicized.

Acid, sludge, see Sludge acid

Option 2: If the technical name of the hazmat that you are shipping is not listed on the HMT (or perhaps it is listed, but the hazard class and/or packing group does not match), then look for a “material application” PSN (if appropriate), such as “Compounds, cleaning liquid,” or “Disinfectant liquid, corrosive, n.o.s.,” or “Pesticides, liquid, toxic, n.o.s.” NOTE: “n.o.s.” stands for “not otherwise specified.”

Option 3: if a “material application” PSN, is not available or inappropriate, select a “chemical family” PSN, such as “Alcohols, n.o.s.,” or “Ketones, liquid, n.o.s.,” or “nitrates, inorganic, n.o.s.”

Option 4: if a “chemical family” PSN, is not available, then select a “hazard class” PSN, such as “Flammable liquids, n.o.s.,” or “Corrosive solids, acidic, inorganic, n.o.s.”

Mixtures or solutions not specifically listed on the HMT, but consisting of a listed and non-hazardous component, which exhibit the hazardous characteristics of the listed hazmat, shall be described by the listed technical name with the addition of the word “mixture” or “Solution” as applicable.

- For example: A mixture of formic acid and glycerol that still meets a Class * definition would be described as “Formic acid mixture.”
- NOTE: This requirement does not apply if there are significant differences between the mixture and the pure material (e.g. physical form, packing group, emergency response requirements etc.)

If the word “waste” is not a part of the PSN selected for hazardous waste, then the word “Waste” must precede the selected PSN.

- For example: If a PSN of “flammable liquids, n.o.s.” was selected for a mixture of waste acetone and methanol, the material must be described as “**waste flammable liquids, n.o.s. (acetone, methanol).**”

Column 3- Hazard Class or Division number

Column 4- Identification Number

Each proper shipping name has an identification number assigned to it.

- If a “UN” precedes the number, that material has a proper shipping name appropriate for international and domestic shipping.
- If the number is preceded by an “NA”, that material has a proper shipping name not appropriate for international shipping, except to and from Canada.

Column 5- Packing Group: Based on the hazard of the material when transported.

- PG I indicates “great danger”
- PG II indicates “medium danger”
- PG III indicates “minor danger”

Column 6- Labels: Provides labels that must be on the outside of the package. If more than one label appears in this column. The first label listed is the primary hazard class. Those listed in parenthesis are subsidiary hazards.

Column 7- Special Provisions or rules to hazardous materials. Located in CFR 49 172.102. Lettered provisions apply to specific modes of transportation.

Alpha Prefix	Definition
A	refers to a special provision that applies only to transportation by aircraft.
B	refers to a special provision that applies only to bulk packaging requirements. These special provisions do not apply to UN, IM Specification portable tanks or IBCs (unless otherwise indicated in 49 CFR).
IB or IP	refers to a special provision that applies only to transportation in IBCs.
N	refers to a special provision that applies only to non-bulk packaging requirements.
R	refers to a special provision that applies only to transportation by rail.
T	refers to a special provision that applies only to transportation in UN or IM Specification portable tanks.
TP	refers to a portable tank special provision for UN or IM Specification portable tanks that is in addition to those provided by the portable tank instructions or the requirements in part 178 of this subchapter.
W	refers to a special provision that applies only to transportation by water.

Note: IBC = intermediate bulk container
IM = Intermodal packaging
IP = Industrial packaging

Column 8- Packaging

1. 8A lists exceptions to packaging exceptions: 49 CFR 173.306.
2. 8B lists the prescribed packaging requirements for non-bulk packaging. 49 CFR 173.304.
3. 8C specifies the prescribed requirements for bulk packaging. 49 CFR 173.314 & 315.

Column 9- Quantity Limitations

- 9A offers the quantity limitations for passenger carrying aircraft of passenger carrying rail car.
- 9B offers the quantity limitations of cargo aircraft only.
- NOTE: the quantity limitations are “net” of the whole material, not only its hazardous components (less packaging and packaging materials).

Column 10- Vessel Stowage Requirements

10A stowage locations on board cargo and passenger vessels.

- A- “on deck” or “under deck” on a cargo or passenger vessel.
- B- “on deck” or “under deck” on a cargo or passenger vessel with limitations.
- C- “on deck” only on a cargo or passenger cargo vessel.
- D- “on deck” only on a cargo or passenger vessel with limitations.
- E- “on deck” or “under deck” on a cargo or passenger vessel with limitations.

10B specifies codes for stowage requirements for specific hazardous materials.

PSN Selection

So how are PROPER shipping names selected? Select the most descriptive PSN available as follows:

Option 1:

- Search the Hazmat Table (HMT) for the technical name of the material that you are shipping.
- If you find the technical name and the associated hazard class and packing group to match (except where the “+” symbol appears in column 1), that is your PSN.
- Example: You are shipping paint having a flash point of 76°F and a boiling point of 278°F; the paint meets the definition of “Class 3, Packing Group III.”

There were several paint entries on the HMT, but many of them has a corrosive (Class 8) primary or subsidiary hazard.

The others are either not as specific as “Paint,” or are assigned to a different packing group.

Only one entry matched our paint: “UN1263, Paint, 3, PG III”

Packaging

Packaging is the first line of defense to ensure that people who handle the materials that we ship don’t get hurt. This includes everyone from your staff to the recipient to whom the material is sent.

Proper packaging also protects those involved in transporting hazardous materials and the environment from the effects of the materials that we ship.

Proper packaging is also essential should a transportation accident occur. You would not want to expose public safety response personnel to improperly packaged materials.

Packaging also ensures the material being shipped gets there in one piece and is usable to the person to whom you sent it.

8 - Packaging



• Indicates that the packaging is constructed to “United Nations” specifications:

- The number indicates packaging type:
 - “1” means a drum.
 - “2” means a wooden barrel.
 - “3” means a jerrican.
 - “4” means a box.
 - “5” means a bag.
 - “6” means a composite packaging.
 - “7” means a pressure receptacle.

8 - Packaging

The letter indicates what the packaging is made of:

- "A" means steel (all types and surface treatments).
- "B" means aluminum.
- "C" means natural wood.
- "D" means plywood.
- "F" means reconstituted wood.
- "G" means fiberboard.
- "H" means plastic.
- "L" means textile.
- "M" means paper, multi-wall.
- "N" means metal (other than steel or aluminum).
- "P" means glass, porcelain or stoneware.

A numeral "1" or "2" following these codes in sequence indicates a non-removable or removable head drum respectively.

For composite packaging, the first letter represents the inner component and the second letter represents the outer component.

An "X" marked container can be used to hold PG I, II, & III hazmat.

A "Y" marked container can be used to hold PG II & III hazmat.

A "Z" marked container can be used to hold PG III hazmat only.

The letter "S" indicates a packaging that can be used as a "single packaging" for solids or to hold inner items (i.e. as a "combination packaging")

When the letter "S" is present the number preceding the "S" indicated the maximum gross weight in kilograms. Ex.) 4G/Y2.8/S/12/USA- The maximum gross weight for this package is 2.8kg or 6.174lbs.)

For containers with non-removable heads, there are two numbers that follow the packing group: the first is "specific gravity" and the second is "hydrostatic test pressure" in kilopascals.

The last three codes in sequence represent the year of manufacture, the country of authorization, and the manufacturer or tester of the packaging.

8 - Packaging

If you answered,

- A UN-spec drum made of plastic;
- with a removable head;
- PG I-rated;
- having a maximum gross weight capacity of 200 kg (or 441 lbs);
- made in 2016
- by a company having a DOT-registered code of ABC-1234, **then..**





1H2/ X200/S/16/USA/ABC1234



Marking and Labeling

Marking for non-bulk packaging:

- The name and address of the shipper or destination facility (for air shipments, both must be entered);
- The UN or NA Identification number; and
- The proper shipping name (including technical names, where applicable)
- The identification number marking preceded by “UN”, “NA”, or “ID” as appropriate must be marked in characters $\geq 12\text{mm}$ (0.47inches) high.
- Packages with a maximum capacity of 30 liters (8 gallons) or less, 30kg (66 pounds) maximum net mass, or cylinders with a water capacity of 60 liters (16 gallons) or less must be marked with characters $\geq 6\text{mm}$ (0.24inches) high.
- Packages with a maximum capacity of 5 liters (1.32 gallons) or 5kg (11 pounds) or less must be marked in a size appropriate for the size of the package.
- Marking and labeling generally are only required on ONE side of a non-bulk packaging.
- Liquids in combination packaging must be marked **on two opposing sides** with orientation arrows. When arrows are required, the inner items must be orientated in the direction that the arrow points.
- The orientation arrow requirements do not apply to:
 - 1. A non-bulk package containing cylinders.

- 2. Packages containing flammable liquids in inner packagings ≤1L shipped as a limited quantity of consumer commodity (except when shipped by air).
- 3. When offered or intended for transportation by aircraft, packages containing liquid hazardous materials in inner packagings ≤120mL (4 fluid oz.) when packed with sufficient absorption material to completely absorb the liquid contents.
- 4. Liquids contained in manufactured articles (e.g., alcohol or mercury in thermometers) which are leak-tight in all orientations.
- 5. A non-bulk package with hermetically sealed inner packagings not exceeding 500mL each.
- 6. Packages containing liquid infectious substances in primary receptacles not exceeding 50mL (1.7oz)
- 7. Class 7 radioactive material in Type A, IP-2, I[-3, Type B(U), or Type B (M) packages.
- Each non-bulk **plastic** outer packaging used as a **single** or **composite packaging** for Division 6.1 materials shall be permanently marked, by embossment or other durable means with the word “**POISON**” in letters at least 6.3mm (0.25inch) in height, within 150mm (6 inches) of the closure of the packaging.
- Materials that are poisonous-by-inhalation (PIH) shall be marked with the words “inhalation hazard,” except in cases where the words appear on the label.
- Limited Quantity shipments offered for transportation by air must be marked with the following mark:
 
- Limited Quantity shipments offered by all other modes must be marked with the following mark:
 
- ORM-D (consumer commodity) mark must be applied to packages prepared pursuant to the ORM-D exception. ORM-D stands for “other regulated materials, Class D. **NOTE: ORM-D air has been discontinued, and ORM-D will be discontinued via all other mods of transportation on December 31, 2020.**
- Non-bulk packages of marine pollutants, when transported by vessel, must bear the marine pollutant mark in association with the warning label, or in the absence of a warning label, the proper shipping name.
- **LABELING IS SIMPLE:** when you’ve selected the **PROPER** shipping name, required labels will be found in Column 6 of the HMT.
- Labels may be printed on or placed a securely affixed tag, or may be affixed by other suitable means to:
 - A package that does not contain radioactive materials
 - A cylinder
 - A package with a irregular surface incapable of bearing a label.

- Labels must be located on the same surface of the package and near the proper shipping name marking, if the package dimensions are adequate.
- Labels must be applied to the surfaces of contrasting color.
- Labels must be applied to surfaces of contrasting color.
- Labels must be clearly visible and may not be obscured by markings or attachments.
- When primary and subsidiary hazard labels are required, they must be displayed within six inches of each other.

Shipping Papers

Shipping papers are the required documentation that accompanies a shipment of hazardous materials and are the most frequently cited.

Hazardous material must be listed first or in a contrasting color or highlighted or indicated by an "X" entry in the HM column; or in the case of hazardous substance shipment, placing the "RQ" in the "HM" column.

A shipping paper may consist of more than one page, if each page is consecutively numbered and the first page bears a notation specifying the total number of pages included in the shipping paper. Ex.) Page 1 of 4 pages.

A shipping paper must include an emergency response phone number that is monitored the entire time the shipment is in transit.

Shipping papers must contain the DOT "basic description" that consists of the four components that must be entered onto the shipping papers: ISHP

- I- **Identification number**
- S- proper **shipping name**
- H- **hazard class** and/or division number
- P- **packing group**, where applicable

When a hazmat meets more than one hazard class definition, the subsidiary hazard must appear in parentheses.

Except where otherwise specified, the total quantity of the hazardous material, including the unit of measurement, must be listed after the hazmat.

Must be printed legibly and in English.

Must not contain any codes or abbreviations, unless DOT-approved.

Must include shipper's certification and be signed.

Additional Requirements:

- Empty packaging that has not been “cleaned or purged” may be described on a shipping paper as would a full package, modified with the words, “RESIDUE: LST CONTAINED,” inserted before or after the basic description.
- When the letter “G” appears in Column 1 of the selected PSN, technical names must appear in parentheses in association with the basic description.

If the material contains two or more hazardous substances, at least two hazardous substances, including the two with the lowest reportable quantities (RQs), must be identified.

The words “Poison-Inhalation Hazard” or “Toxic-Inhalation Hazard” and the words “Zone A”, “Zone B”, “Zone C”, or “Zone D” for gases or “Zone A” or “Zone B” for liquids, shall be entered on the shipping paper immediately following the shipping description.

Load Segregation

Placarding

Security