All 9 Hazard Classes Explained

Start with these fundamentals to simplify hazardous materials shipping compliance.

LION TECHNOLOGY INC.®

All 9 Hazard Classes Explained

Have you ever wondered, “Hey, is this stuff hazmat?” If so, this is for you.

Get to know the 9 categories of hazardous materials recognized around the world, and why each class is regulated in transportation.

What’s Inside

What is a Hazardous Material?

All hazardous materials are regulated by the US Department of Transportation (DOT) because they pose an unreasonable risk to health, safety, and property during transportation.

There are 9 categories of hazmat, called hazard classes, with some classes separated into sub-categories called divisions. These 9 classes cover explosives, gases, flammable liquids and solids, oxidizers, poisons, radioactives, corrosives, and miscellaneous material, all commonly referred to as "hazmat."

When you offer hazmat into the cycle of transportation, you are responsible for complying with the applicable US DOT Hazardous Materials Regulations (HMR) found at 49 CFR 172–180—and compliance begins with accurate classification! Everything you subsequently do to prepare your shipment will depend on the material's classification.

Class 1: Explosives

Hazard Class 1 is the explosives class, and it's made up of six divisions that cover a broad range of materials and articles, from flat-out weapons of war that pose a "mass explosion hazard" to consumer fireworks big and small.

An explosive is "any substance or article, including a device, which is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or...which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion..."

Also in Class 1, you will find chemical propellants, dynamite, detonators, gunpowder, gun ammunition, grenades, flares, rockets, and more. This includes materials you might not think of as "hazardous," like some car airbag and seatbelt systems that use a pyrotechnic means to initiate in the event of a crash.

Divisions 1.1–1.6

Compatibility Groups

- **A** "Primary explosive substance"
- **B** "Article containing a primary explosive and not containing two or more effective protective features..."
- **C** "Propellent explosive substance or other deflagrating explosive substance or article containing such explosive substance"
- **D** "Secondary detonating explosive substance or black powder or article containing a secondary explosive substance"
- **E** "Article containing a secondary detonating explosive substance, **without** means of initation..."
- **F** "Article containing a secondary detonating explosive substance, **with** means of initation..."
- **G** "**Pyrotechnic substance** or article containing a pyrotechnic substance, or..." (also, smoke-producing explosive devices)
- **H** "Article containing both an explosive substance **and white phosphorus**"
- **J** "Article containing both an explosive substance **and flammable liquid or gel**"
- **K** "Article containing both an explosive substance **and a toxic chemical agent**"
- **L** "Explosive substance or article containing an explosive substance **and presenting a special risk** (e.g., due to water-activation...")
- **N** "Article predominantly containing **extremely insensitive substances**"
- **S** "Substance or article so packed or designed that **any hazardous effects arising from accidental functioning** are limited to the extent that they **do not significantly hinder or prohibit fire fighting or other emergency response efforts** in the immediate viscinity of the package."

49 CFR 173.50; 49 CFR 173.152

Class 2: Gases

Division 2.1: Flammable gas

Division 2.1 materials are flammable gases like butane, propane, and methane.

Division 2.2: Non-flammable compressed gas

Division 2.2 hazardous materials are non-flammable, non-poisonous gases—things like cryogenic gases and liquids, and gases that act as asphyxiants or oxidizers.

The HMR defines "non-flammable, nonpoisonous compressed gas" as "any material (or mixture) which—

1. Exerts in the packaging a gauge pressure of 200 kPa (29.0 psig/43.8 psia) 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."

Division 2.3: Poisonous gas

Division 2.3 gases are poison by inhalation—these include sulfur dioxide, chlorine gas, and carbon monoxide.

Hazard Zones

Hazard zones for Division 2.3 materials are assigned in Column 7 of the §172.101 Hazmat Table, with Special Provisions 1–4 corresponding to Zones A–D as defined in §172.102. When the table provides more than one hazard zone or indicates that the hazard zone shall be determined on the basis of the grouping criteria for Division 2.3, apply the following criteria to determine the material's hazard zone.

Hazard Zone	Inhalation Toxicity
A	LC_{50} less than or equal to 200 ppm.
B	LC_{50} greater than 200 ppm and less than or equal to 1000 ppm.
C	LC_{50} greater than 1000 ppm and less than or equal to 3000 ppm.
D	LC_{50} greater than 3000 ppm or less than or equal to 5000 ppm.

49 CFR 173.115

Class 3: Flammable Liquids

Hazard Class 3—Flammable and Combustible Liquids. A Class 3 hazmat is a liquid that is vulnerable to catching fire at temperatures low enough to be a concern during transportation.

Class 3 is the by far most-transported hazard class by weight in the US—it's stacked with heavy-hitter hazardous materials like alcohols, gasoline, fuel and heating oils, and solvents and include widely used chemicals like acetone, benzene, and turpentine.

In general, a liquid is a Class 3 **flammable liquid** if it gives off vapor that forms an ignitable mixture with air (i.e., has a "flast point") at a temperature of 140°F or below.

Combustible liquids are technically not Class 3 materials; they are Hazard Class Combustible Liquids. A **combustible liquid** is a liquid that does not meet the definition of any other hazard class specified in the Hazardous Materials Regulations and has a flash point above 60°C (140°F) and below 93°C (200°F).

Packing Groups

PG I

Boiling point
≤35°C (95°F)

PG II

Boiling point
>35°C (95°F)

Flash point
<23°C (73°F)

PG III

Boiling point
>35°C (95°F)

Flash point
≥23°C (73°F)
≤60°C (140°F)

49 CFR 173.120; 49 CFR 173.121

Class 4: Flammable Solids and Reactive Materials

Division 4.1: Flammable solids

Division 4.1 covers flammable and self-reactive solids—that can be everything from magnesium metal to matchbooks to scraps of rubber to dry vegetable or cotton fibers.

Packing Groups

Packing Group I, II, or III is based on several factors, including:

- Test results per the *UN Manual of Tests and Criteria* (e.g., tests for burning time, rate of burning)
- Is the material powdered? Is it granular? Pasty?
- Is the material a metal powder or a metal alloy?

Division 4.2: Spontaneously combustible materials

Division 4.2 is for spontaneously combustible material. These can be pyrophoric materials that go up in flames within five minutes of exposure to air or self-heating materials, which react with oxygen and generate heat.

Packing Groups

- PG I: Pyrophoric liquids
- PG II and PG III: Self-heating materials. Packing group is based on the results of testing with sample cubes of various sizes; see 49 CFR 173.125(c)(2).

Division 4.3: Dangerous When Wet materials

Division 4.3 materials are Dangerous When Wet materials.

Dangerous When Wet materials are liable to become flammable or give off toxic gas when they contact water. Sodium and zinc metal are examples.

Packing Groups

- PG I: "...reacts **vigorously** with water at ambient temperatures..."
- PG II: "...reacts **readily** with water at ambient temperatures..."
- PG III: "...reacts **slowly** with water at ambient temperatures..."

49 CFR 173.124(a); 49 CFR 173.124(b); 49 CFR 173.124(c); 49 CFR 173.125

Class 5: Oxidizers and Organic Peroxides

There are two divisions to Class 5—oxidizers in Division 5.1 and organic peroxides in Division 5.2.

Division 5.1: Oxidizers

Oxidizers are materials that give off oxygen. What's hazardous about that? Oxygen is one of three things that a fire needs to ignite and survive. If it's near a fuel and a source of ignition, a Division 5.1 material can contribute to a fire starting or make any fire stronger.

Ammonium nitrate fertilizer is a Division 5.1 hazardous material, one that was involved in two tragic disasters in recent memory—in West, Texas in 2013 and Beirut, Lebanon in 2020.

Packing Groups

For solids:
- Packing Group I, II, or III is based on measuring the material's "mean burning time" per the *UN Manual of Tests and Criteria.*

For liquids:
- PG I, II, or III is based on measuring "mean pressure rise time" and/or if the material will ignite under certain conditions.

Division 5.2: Organic peroxides

Organic peroxides are compounds that contain oxygen and have a specific molecular structure. They are unstable by nature and pose a risk of fire and/or explosion when exposed to heat, impact, friction, light, sparks, or other stimuli.

Division 5.2 organic peroxides are divided into seven types: Type A, Type B, Type C, Type D, Type E, Type F, and Type G (see 49 CFR 173.128(b)).

Types are assigned based on:
- The material's physical states (e.g., liquid or solid).
- A determination as to its control temperature and emergency temperature.
- Performance of the material under the test procedures specified in the *UN Manual of Tests and Criteria* and the provisions of 49 CFR 173.128(d).

49 CFR 173.127; 49 CFR 173.128

Class 6: Poisonous Materials and Infectious Substances

Class 6 is split into two divisions: poisonous materials and infectious substances.

Division 6.1: Poisonous materials

Division 6.1 materials are poisonous materials—except for poison gases, which are with the other gases in Hazard Class 2. Division 6.1 materials are presumed toxic to humans based on test results for oral, skin, or inhalation exposure.

Materials that can cause extreme irritation—like tear gas—are also Division 6.1 hazmat.

Packing Groups

Like other hazard classes and divisions, there are three packing groups for poisonous substances. PG I, II, and III are based on oral toxicity, dermal toxicity, and inhalation toxicity.

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	⩽ 50	⩽ 0.2
II	> 5.0, ⩽ 50	> 50, ⩽ 200	> 0.2, ⩽ 2.0
III	> 50, ⩽ 300	> 200, ⩽ 1,000	> 2.0, ⩽ 4.0

Packing Groups for Division 6.1

For *liquids that give off toxic-by-inhalation vapors,* **PG I, II, and III are based on** the concentration and toxicity of the vapor. In this case, PG I is split into two groups: Hazard Zone A and Hazard Zone B. [49 CFR 173.133(a)(2)(i)]

Division 6.2: Infectious substances

Division 6.2 are infectious substances. These are materials known or reasonably expected to contain a pathogen, like a virus, that makes humans or animals sick.

A **pathogen** is a bacteria, virus, parasite, fungus, or other microorganism or agent that can cause disease in humans or animals.

Infectious substances must be assigned to Category A or Category B (see 49 CFR 173.174 (a)(1)).

49 CFR 173.132; 49 CFR 173.133; 49 CFR 173.134

Class 7: Radioactives

Class 7 is for radioactive materials. That includes waste from nuclear power plants as well as materials that contain radionuclides and are used in medical equipment, medical gauges, and even medicines.

The regulations for radioactives found in the Hazardous Materials Regulations (49 CFR 173.401–173.477) act in addition to, not in place of, regulations from the Nuclear Regulatory Commission in 10 CFR Part 71.

Class 8: Corrosives

Corrosive materials are assigned to Hazard Class 8.

Liquid or solid materials get put in Class 8 because they can severely damage and destroy human skin, steel, or aluminum over time. Sulfuric acid, hydrochloric acid, and sodium hydroxide are all Class 8 hazardous materials.

Packing Groups

Packing Group I, II, and III are based on the rate at which the material damages skin or (for PG III) the rate of corrosion on steel or aluminum.

- **Class 8, PG I** materials "cause irreversible damage to intact skin tissue" within 60 minutes after an exposure time of 3 minutes or less.
- **PG II and III** materials may take up to 14 days to cause irreversible damage to skin with longer exposure times.

49 CFR 173.401–173.477; 49 CFR 173.136; 49 CFR 173.137

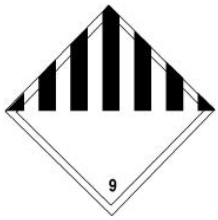
Class 9: Miscellaneous

Last, but not least, Hazard Class 9 is the home for misfit or miscellaneous hazardous materials. Class 9 is for the materials that do not fit into any of the eight classes we already talked about but is nonetheless regulated as hazmat in transportation.

Per 49 CFR 173.140, Class 9 includes:

- "Any material which 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"
- Any material that meets any hazmat definition found at 49 CFR 171.8.

Because US DOT says so



Some materials are Class 9 because they pose a health risk but do not fit into any other hazard class. For example, asbestos does not meet the toxicity criteria to be a Divison 6.1 material. So, it is a Class 9 hazmat because the US DOT "says so."

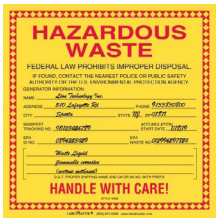
Airplane hazards

Some materials are not hazardous when shipped by ground but could have an anesthetic or noxious effect on a flight crew and pose a serious risk aboard an airplane. Materials like pepper spray or dry ice may be harmless in a truck but can cause an emergency aboard an airplane if released or allowed to sublimate.

49 CFR 173.140

Class 9, Continued...

Hazardous waste



Some hazardous wastes meet the criteria for a hazard class other than Class 9. In that case, they are regulated as that other hazard class. However, a hazardous waste that does not meet any other hazard class criteria but requires the Uniform Hazardous Waste Manifest by the EPA to be shipped off site is a Class 9 hazardous material.

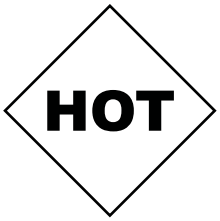
Hazardous substances

Hazardous substances are materials that pose a risk to the environment. US DOT's regulations list hundreds of these substances along with their reportable quantity (RQ) in Appendix A to the §172.101 Hazmat Table. These materials are Class 9 hazardous materials when shipped in a quantity that meets or exceeds their RQ in one package if they do not meet the criteria for any other hazard class.

Marine pollutants

These are materials that threaten aquatic life and are listed in the Hazardous Materials Regulations in Appendix B to the §172.101 Hazmat Table. The rules for marine pollutants come into play when you ship them by vessel or in bulk packages by other modes of transportation.

Elevated-temperature materials



DOT defines elevated-temperature materials as liquids at or above 100°C (212°F), liquids with a flash point at or above 38°C (100°F), and solids at or above 240°C (464°F). For example, asphalt becomes rigid below a certain temperature. To prevent that, it is shipped at about 300°F or hotter. Asphalt's Proper Shipping Name is often "Elevated temperature liquid, N.O.S., at or above 100°C and below its flash point." (UN 3257)

49 CFR 173.140

Ship Hazmat With Confidence

Convenient training for individuals or groups covering what you need to know to ship hazardous materials in compliance with US and international regulations.

Join a live webinar or train online at your own pace.

Hazmat Shipper Training

Hazmat shippers are required by law to train every three years, and IATA requires training every 24 months if you ship hazmat (dangerous goods) by air.

FIND TRAINING

www.Lion.com 888-546-6511 info@lion.com