FIRE SAFETY MANUAL

FOR FLAME EFFECTS
&
FIRE PERFORMERS

THIRD EDITION

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FIRE SAFETY EXPERT

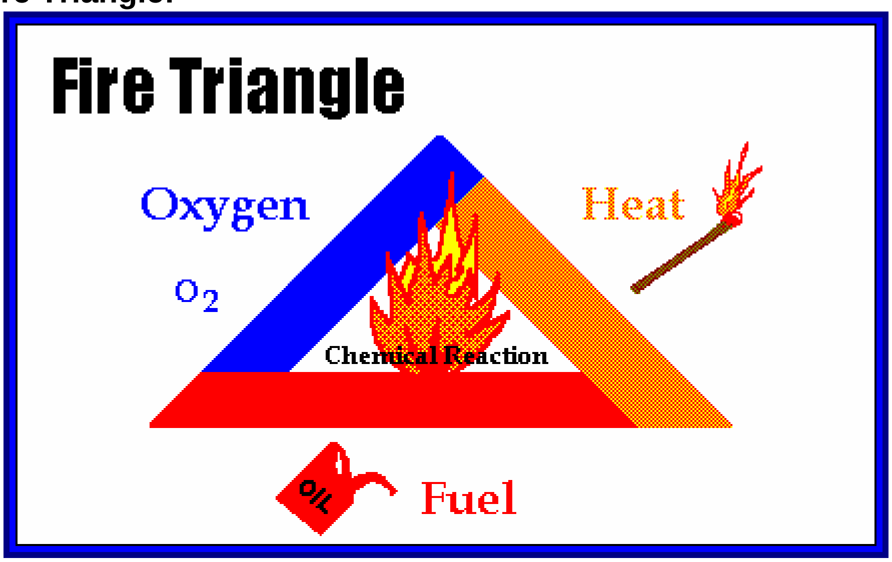
Portions of this manual have been copied from the World Wide Web and compiled specifically for artists and performers that use fire. This manual is for educational purposes only and is

NOT FOR SALE

Key Definitions

1. **Fire** - A rapid, persistent chemical change that releases heat and light and is accompanied by flame, especially the exothermic oxidation of a combustible substance.
2. **Combustion** - A chemical change, especially oxidation, accompanied by the production of heat and light.
3. **Burn** - To cause to undergo combustion.
4. **Explosion** - A release of mechanical, chemical, or nuclear energy in a sudden and often violent manner with the generation of high temperature and usually with the release of gases. A violent bursting as a result of internal pressure.
5. **Flame** - The zone of burning gases and fine suspended matter associated with rapid combustion; a hot, glowing mass of burning gas or vapor
6. **Flash Point** - The lowest temperature at which the vapor of a combustible liquid can be made to ignite momentarily in air.
7. **Ignition Point** - The minimum temperature at which a substance will continue to burn without additional application of external heat. Also called *kindling point* **.**
8. **Pyrophoric** - Spontaneously igniting in air, Producing sparks by friction.
9. **Ignite** - To cause to burn. To set fire to.
10. **Pyromania** -The irresistible urge to start fires.
11. **Auto Ignition Temperature** - A material's auto ignition or ignition is the temperature at which a material self-ignites without any obvious sources of ignition, such as a spark or flame. Most common flammable and combustible liquids have auto ignition temperatures in the range of 300°C (572°F) to 550°C (1022°F).
12. **Exothermic** - Releasing heat: *an exothermic reaction*
13. **Endothermic** - Characterized by or causing the absorption of heat; endoergic.
14. **Flammable (Explosive) Limits**- boundary-line mixtures of vapor with air are known as the lower and upper flammable or explosive limits (**LEL or UEL**). , a vapor/air mixture below the flammable limit is too "lean" to burn or explode, and a mixture above the upper flammable limit is too "rich" to burn or explode

The Fire Triangle:



A fire requires three things; Fuel, Heat & Oxygen. Basically, to put a fire out you remove one or more sides of the “Fire Triangle”. Removing fuel can be as simple as shutting off a valve, removing heat can be done by pouring water on a fire, removing oxygen can be done by tossing playa dust onto the flames or displacing the oxygen with another gas such as CO_2 or halon.

Heat transfer

The movement of heat—is important in a fire. Movement occurs in three ways: conduction, convection, and radiation.

• Conduction

Heat is transferred through a solid surface from a heated to an unheated area (for example, a hand touching a hot solid surface).

• Convection

Heat is transferred by moving particles of liquids or gases, from a heat source to a cooler area (for example, heat from boiling water in a flow of steam).

• Radiation

Heat is transferred by electromagnetic waves (for example, heat from a space heater that can be felt without touching the heater).

Ignition hazard

Many fires occur because people are unaware of what is a hazard, or are careless when working with flammables around potential ignition sources. Examples of ignition sources are:

- cigarettes
- electronic devices-cell phones, two-way radios
- open flames from matches, bunsen burners, pilot lights
- friction or grinding
- static electricity
- sparks generated when lights or motors switch on (especially common fire hazard for domestic refrigerators where flammables are stored)
- hot plates and heating ovens
- exposure of pyrophoric materials to air, or water reactive materials to moisture
- LASER beam

Types of Fires:

The National Fire Protection Association (NFPA) classifies fires into five general categories (U.S.)

- **Class A** fires are ordinary materials like burning paper, lumber, cardboard, plastics etc.
- **Class B** fires involve flammable or combustible liquids such as gasoline, kerosene, and common organic solvents used in the laboratory.
- **Class C** fires involve energized electrical equipment, such as appliances, switches, panel boxes, power tools, hot plates and stirrers. Water is usually a dangerous extinguishing medium for class C fires because of the risk of electrical shock unless a specialized water mist extinguisher is used.
- **Class D** fires involve combustible metals, such as magnesium, titanium, potassium and sodium as well as pyrophoric organometallic reagents such as alkyllithiums, Grignards and diethylzinc. These materials burn at high temperatures and will react violently with water, air, and/or other chemicals. Handle with care!!
- **Class K** fires are kitchen fires. This class was added to the NFPA portable extinguishers Standard 10 in 1998. Kitchen extinguishers installed before June 30, 1998 are "grandfathered" into the standard.

Extinguishing:

1. Remove fuel (shut off)
2. Turn off electric
3. Cool (water, ice, steam)
4. Bind O_2 (Chemicals)
5. Displace O_2 (CO_2)
6. Smother (Dirt, rags, cupping)

Classes of Fire Extinguishers:

A. Ordinary Combustibles
B. Flammable or combustible liquids
C. Electrical fires
D. Combustible Metals
K. Small Kitchen Extinguishers

Types of Fire Extinguishers:

- Water – Class A
- Dry Chemical – Class ABC
- Dry Chemical – Class AB
- Foam – Class B
- CO_2 – Class BC
- Halon – Class BC

Fuels:

The Three States of Matter:

1. Solids
A solid is a substance that retains a definite size and shape under normal conditions. When most solids melt, they change to liquid. The temperature at which this occurs is called the **melting poin**t. When solids change directly to gas, the process is called **sublimation**. Carbon dioxide (dry ice) is a well-known example of a solid that sublimates.

2 Liquids
Liquids are substances that flow easily and have a specific volume but no specific shape. The temperature at which a liquid freezes is called the **freezing point**. The temperature at which a liquid changes to a gas is its **boiling point**. At this temperature, which is unique to each liquid, bubbles of the liquid rise to the surface and enter the surrounding air. The boiling point of a liquid is related to its vapor pressure.

3. Gases
A gas is a substance that expands or compresses readily and has no independent shape or volume. Gases may condense to form liquids; this change occurs when a gas is cooled to or below its boiling point. Substances that occur naturally as gases have low boiling points compared to solids and liquids.

1. **SOLIDS**
    - Wood, Paper, Grass, Wheat, Flour, Cloth
    - Flesh, Hair, Bones, Meat, Food
    - Plastics, Rubber, Tires, Hoses

Material	Ignition Temperature (F)
Non-Fireworks Materials	
Nitrocellulose film	279
Match heads (strike anywhere)	325
Carbon soot (dust)	366
Wood fiberboard (piece)	430
Paper, newsprint (cuts)	446
Cotton sheeting (roll)	464
Douglas fir (shavings)	500
Fireworks Compositions	
Black powder	626
Red flare composition	752
Flash powder	835
Green flare composition	860

2. LIQUIDS

Combustible Liquid

Any liquid having a flash point above 100F and below 200F

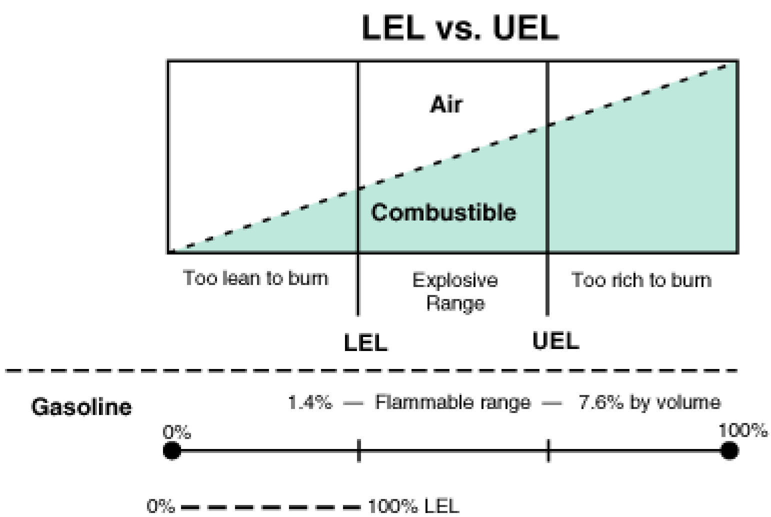
Flammable Liquid

Any liquid having a flash point below 100F

Classification	Term	Flash Point and Boiling Point	Examples
Class IA	Flammable	Below 73F Boils below 100F	ethyl ether, acetaldehdye, methyl formate, pentane
Class IB	Flammable	Below 73F Boils above 100F	acetone, benzene, carbon disulfide, ethanol, toluene
Class IC	Flammable	Above 73F Boils below 100F	xylene, butyl alcohol, amyl acetate
Class II	Combustible	At or above 100F	glacial acetic acid, formaldehyde, hydrazine
Class IIIA	Combustible	At or above 140F	naphthalene, octyl alcohol
Class IIIB	Combustible	At or above 200F	glycerine, propylene glycol

Other Conditions to Consider

1. Situations that produce mists
2. Environments which are oxygen-rich
3. Increasing system pressure



Types of Class B Fuels

1. Fossil Fuels (Hydro-Carbons)
2. Biological Fuels (Hydroxyls & Methyl Esters)

What is the difference between gasoline, kerosene, diesel fuel, etc.?

The "crude oil" pumped out of the ground is a black liquid called **petroleum**. This liquid contains **aliphatic hydrocarbons**, or hydrocarbons composed of nothing but hydrogen and carbon. The carbon atoms link together in chains of different lengths.
It turns out that hydrocarbon molecules of different lengths have different properties and behaviors. For example, a chain with just one carbon atom in it (CH_4) is the lightest chain, known as methane. Methane is a gas so light that it floats like helium. As the chains get longer, they get heavier.
The first four chains -- CH_4 (methane), C_2H_6 (ethane), C_3H_8 (propane) and C_4H_{10} (butane) -- are all gases, and they boil at -161, -88, -46 and -1 degrees F, respectively (-107, -67, -43 and -18 degrees C). The chains up through $C_{18}H_{32}$ or so are all liquids at room temperature, and the chains above C_{19} are all solids at room temperature.
The different chain lengths have progressively higher boiling points, so they can be separated out by **distillation**. This is what happens in an oil refinery -- crude oil is heated and the different chains are pulled out by their vaporization temperatures.

The chains in the C_5, C_6 and C_7 range are all very light, easily vaporized, clear liquids called **naphthas**. They are used as solvents -- dry cleaning fluids can be made from these liquids, as well as paint solvents and other quick-drying products.
The chains from C_7H_{16} through $C_{11}H_{24}$ are blended together and used for **gasoline**. All of them vaporize at temperatures below the boiling point of water. That's why if you spill gasoline on the ground it evaporates very quickly.
Next is **kerosene**, in the C_{12} to C_{15} range, followed by diesel fuel and heavier fuel oils (like heating oil for houses).
Next come the **lubricating oils**. These oils no longer vaporize in any way at normal temperatures. For example, engine oil can run all day at 250 degrees F (121 degrees C) without vaporizing at all. Oils go from very light (like 3-in-1 oil) through various thicknesses of motor oil through very thick gear oils and then semi-solid greases. Vasoline falls in there as well.
Chains above the C_{20} range form solids, starting with paraffin wax, then tar and finally asphaltic bitumen, which used to make asphalt roads.
All of these different substances come from crude oil. The only difference is the length of the carbon chains!

Lost in the mix are the **biofuels**, fuels made from biological ingredients instead of fossil fuels. These starting ingredients can range from corn to soybeans to animal fat, depending on the type of fuel being made and the production method.

So what is biodiesel? Generally speaking, biodiesel is an alternative or additive to standard diesel fuel that is made from biological ingredients instead of petroleum (or crude oil). Biodiesel is usually made from plant **oils** or animal **fat** through a series of chemical reactions. It is both **non-toxic** and **renewable**. Because biodiesel essentially comes from plants and animals, the sources can be replenished through farming and recycling.

Biodiesel is safe and can be used in diesel engines with little or no modification needed. Although biodiesel can be used in its pure form, it usually **blended with standard diesel fuel**. Blends are indicated by the abbreviation Bxx, where xx is the percentage of biodiesel in the mixture. For example, the most common blend is **B20**, or 20% biodiesel to 80% standard. So, **B100** refers to pure biodiesel.

The technical definition of biodiesel is as follows:
a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM D 6751.

Different hydrocarbon chain lengths all have progressively higher boiling points, so they can all be separated by distillation. This is what happens in an oil refinery - in one part of the process, crude oil is heated and the different chains are pulled out by their vaporization temperatures. Each different chain length has a different property that makes it useful in a different way.

Petroleum gas - used for heating, cooking, making plastics

- small alkanes (1 to 4 carbon atoms)
- commonly known by the names methane, ethane, propane, butane
- boiling range = less than 104 degrees Fahrenheit / 40 degrees Celsius
- often liquified under pressure to create LPG (liquified petroleum gas)

Naphtha or **Ligroin** - intermediate that will be further processed to make gasoline

- mix of 5 to 9 carbon atom alkanes
- boiling range = 140 to 212 degrees Fahrenheit / 60 to 100 degrees Celsius

Gasoline - motor fuel

- liquid
- mix of alkanes and cycloalkanes (5 to 12 carbon atoms)
- boiling range = 104 to 401 degrees Fahrenheit / 40 to 205 degrees Celsius

Kerosene - fuel for jet engines and tractors; starting material for making other products

- liquid
- mix of alkanes (10 to 18 carbons) and aromatics
- boiling range = 350 to 617 degrees Fahrenheit / 175 to 325 degrees Celsius

Gas oil or **Diesel distillate** - used for diesel fuel and heating oil; starting material for making other products

- liquid
- alkanes containing 12 or more carbon atoms
- boiling range = 482 to 662 degrees Fahrenheit / 250 to 350 degrees Celsius

Lubricating oil - used for motor oil, grease, other lubricants

- liquid
- long chain (20 to 50 carbon atoms) alkanes, cycloalkanes, aromatics
- boiling range = 572 to 700 degrees Fahrenheit / 300 to 370 degrees Celsius

Heavy gas or **Fuel oil** - used for industrial fuel; starting material for making other products

- liquid
- long chain (20 to 70 carbon atoms) alkanes, cycloalkanes, aromatics
- boiling range = 700 to 1112 degrees Fahrenheit / 370 to 600 degrees Celsius

Residuals - coke, asphalt, tar, waxes; starting material for making other products

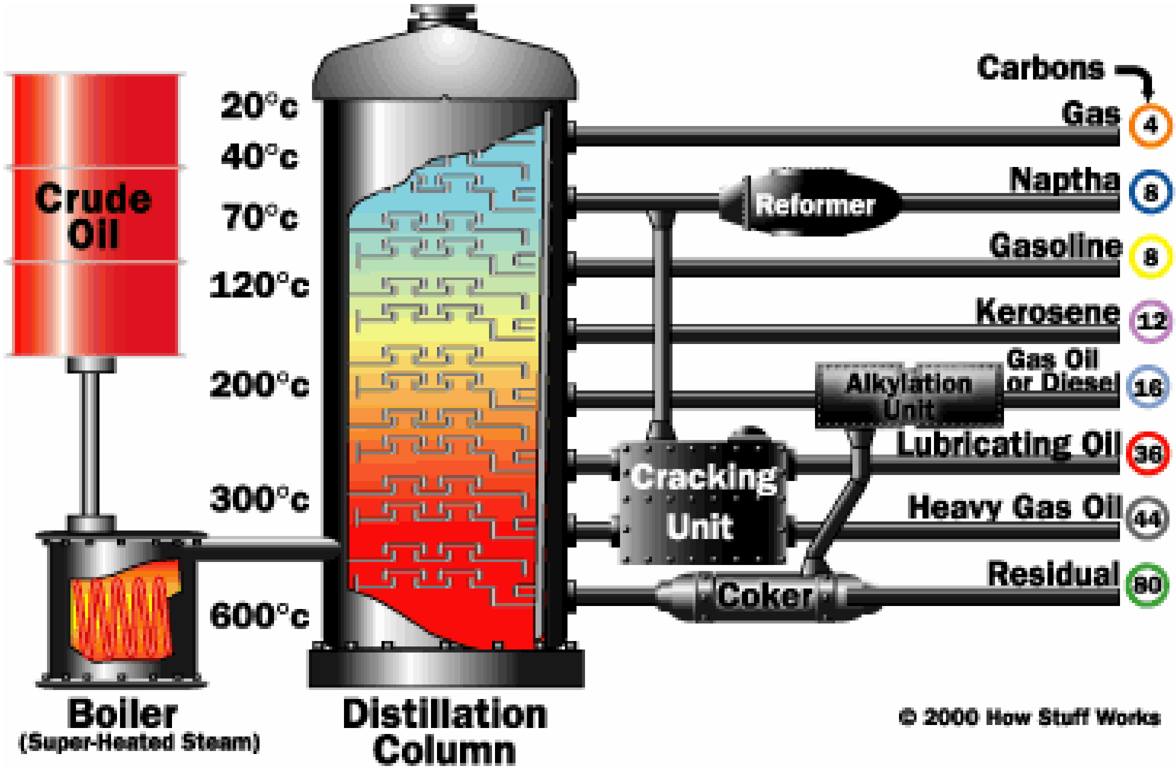
- solid
- multiple-ringed compounds with 70 or more carbon atoms
- boiling range = greater than 1112 degrees Fahrenheit / 600 degrees Celsius

The Refining Process

As mentioned previously, a barrel of crude oil has a mixture of all sorts of hydrocarbons in it. Oil refining separates everything into useful substances. Chemists use the following steps:

1. The oldest and most common way to separate things into various components (called **fractions**), is to do it using the differences in boiling temperature. This process is called **fractional distillation**. You basically heat crude oil up, let it vaporize and then condense the vapor.
2. Newer techniques use **Chemical processing** on some of the fractions to make others, in a process called **conversion**. Chemical processing, for example, can break longer chains into shorter ones. This allows a refinery to turn diesel fuel into gasoline depending on the demand for gasoline.
3. Refineries must **treat** the fractions to remove impurities.

Refineries **combine** the various fractions (processed, unprocessed) into mixtures to make desired products. For example, different mixtures of chains can create gasolines with different octane ratings.


Crude Oil
20°c
40°c
70°c
120°c
200°c
300°c
600°c
Boiler
(Super-Heated Steam)
Distillation Column
Carbons
Gas 4
Reformer
Naptha 6
Gasoline 8
Kerosene 12
Alkylation Unit
Gas Oil or Diesel 16
Lubricating Oil 36
Cracking Unit
Heavy Gas Oil 44
Coker
Residual 80
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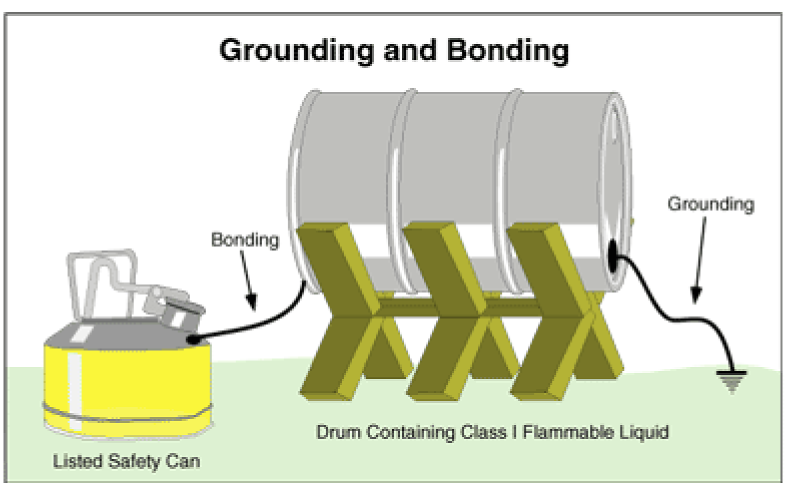
Biodiesel Chemistry

Part of what makes biodiesel so appealing and interesting is that it can be made from numerous natural sources. Although animal fat can be used, **plant oil** is the largest source of biodiesel. You've probably used some of these in the kitchen. Scientists and engineers can use oils from familiar crops such as soybean, rapeseed, canola, palm, cottonseed, sunflower, and peanut to produce biodiesel. Biodiesel can even be made from recycled cooking grease!
The common thread shared by all biodiesel sources is that they all contain **fat** in some form. Oils are just fats that are liquid at room temperature. These fats, or triacylglycerols (sometimes called triglycerides) are made up of carbon, hydrogen, and oxygen atoms bound together and arranged into a specific pattern. These triacylglycerols are pretty prevalent. In addition to household vegetable oils, they're also in common things like butter and lard. You may have seen a triglyceride count listed if you've been to a doctor and had some blood work done.
One way to visualize these triacylglycerols is to think of a capital "E." Forming the vertical backbone of this E is a molecule known as glycerol. Glycerol is a common ingredient used in making such things as soap, pharmaceuticals, and cosmetics. Attached to this glycerol backbone and forming the horizontal elements of the E are three long chains composed of carbon, hydrogen, and oxygen. These are called fatty acids.

So how do these triacylglycerols end up in a car, truck, or boat? Biodiesel is not pure vegetable oil. Although raw vegetable oil has been used to fuel diesel engines in the past, it has usually caused problems. The raw fat or oil must first undergo a series of chemical reactions in order to become fuel. There are a few different ways to make biodiesel, but most manufacturing facilities produce industrial biodiesel through a process called **transesterification**. In this process, the fat or oil is first purified and then reacted with an alcohol, usually methanol (CH3OH) or ethanol (CH3CH2OH) in the presence of a catalyst such as potassium hydroxide (KOH) or sodium hydroxide (NaOH). When this happens, the triacylglycerol is transformed to form esters and glycerol. The esters that remain are what we then called biodiesel.

Grounding of tanks during refueling operations:



Maximum Quantities *Outside* of a Flammable Storage Cabinet or Inside Storage Room

Class IA Liquids in Containers	25 Gallons
Class IB, IC, II or III Liquids in Containers 1	20 Gallons
Class IB, IC, II or III Liquids in a single Portable Tank	120 Gallons

4. FLAMMABLE, EXPLOSIVE AND TOXIC GASES

Flammable Gas

A compressed gas that satisfies the criteria for flame projection, lower flammability limit and flammability range

Hazards

- Leakage or escape of flammable gases can produce a serious explosive hazard in a laboratory. Acetylene, hydrogen, ammonia, hydrogen sulphide, propane and carbon monoxide are especially dangerous.
  Hydrogen flames from leaks can be almost invisible and thus difficult to detect.
- Apart from explosive hazard, gases can be reactive *e.g* oxygen and highly toxic *e.g*. carbon monoxide.
- "Inert" gases such as nitrogen, carbon dioxide and argon can cause asphyxiation if released in quantity

Liquefied Gases

Liquefied gases are gases which can become liquids at normal temperatures when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Initially the cylinder is almost full of liquid, and gas fills the space above the liquid. As gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide are examples of liquefied gases.

Non-Liquefied Gases

Non-liquefied gases are also known as compressed, pressurized or permanent gases. These gases do not become liquid when they are compressed at normal temperatures, even at very high pressures. Common examples of these are oxygen, nitrogen, helium and argon.

Dissolved Gases

Acetylene is the only common dissolved gas. Acetylene is chemically very unstable. Even at atmospheric pressure, acetylene gas can explode. Nevertheless, acetylene is routinely stored and used safely in cylinders at high pressures (up to 250 psig at 21°C).

This is possible because acetylene cylinders are fully packed with an inert, porous filler. The filler is saturated with acetone or other suitable solvent. When acetylene gas is added to the cylinder, the gas dissolves in the acetone. Acetylene in solution is stable.

What are the pressure hazards associated with compressed gas cylinders?

All compressed gases are hazardous because of the high pressures inside the cylinders. Gas can be released deliberately by opening the cylinder valve, or accidentally from a broken or leaking valve or from a safety device. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder.

There have been many cases in which damaged cylinders have become uncontrolled rockets or pinwheels and have caused severe injury and damage. This danger has happened when unsecured, uncapped cylinders were knocked over causing the cylinder valve to break and high pressure gas to escape rapidly. Most cylinder valves are designed to break at a point with an opening of about 0.75 cm (0.3 inches). This design limits the rate of gas release and reduces cylinder velocity. This limit may prevent larger, heavier cylinders from "rocketing" although smaller or lighter cylinders might take off.

Poorly controlled release of compressed gas in chemical reaction systems can cause vessels to burst, create leaks in equipment or hoses, or produce runaway reactions. Valves can also freeze open if gas is allowed to escape too quickly, especially with compressed liquids such as LPG.

What are the fire and explosion hazards associated with compressed gases?

Flammable Gases

Flammable gases, such as acetylene, butane, ethylene, hydrogen, methylamine and vinyl chloride, can burn or explode under certain conditions:

Gas Concentration within the Flammable Range: The concentration of the gas in air (or in contact with an oxidizing gas) must be between its lower flammable limit (LFL) and upper flammable limit (UFL) [sometimes called the lower and upper explosive limits (LEL and UEL)]. For example, the LFL of hydrogen gas in air is 4 percent and its UFL is 75 percent (at atmospheric pressure and temperature). This means that hydrogen can be ignited when its concentration in the air is between 4 and 75 percent. A concentration of hydrogen below 4 percent is too "lean" to burn. Hydrogen gas levels above 75 percent are too "rich" to burn.

The flammable range of a gas includes all of its concentrations in air between the LFL and UFL. The flammable range of any gas is widened in the presence of oxidizing gases such as oxygen or chlorine and by higher temperatures or pressures. For example, the flammable range of hydrogen in oxygen gas is 4 to 85 percent and the flammable range of hydrogen in chlorine gas is 4.1 to 89 percent.

Ignition Source: For a flammable gas within its flammable limits in air (or oxidizing gas) to ignite, an ignition source must be present. There are many possible ignition sources in most workplaces including open flames, sparks and hot surfaces.

The auto-ignition (or ignition) temperature of a gas is the minimum temperature at which the gas self-ignites without any obvious ignition sources. Some gases have very low auto-ignition temperatures. For example, phosphine's auto-ignition temperature of 100°C (212°F) is low enough that it could be ignited by a steam pipe or a lit light bulb. Some compressed gases, such as silane and diborane, are pyrophoric - they can ignite spontaneously in air.

Flash-back can occur with flammable gases. Many flammable compressed gases are heavier than air. If a cylinder leaks in a poorly ventilated area, these gases can settle and collect in sewers, pits, trenches, basements or other low areas. The gas trail can spread far from the cylinder. If the gas trail contacts an ignition source, the fire produced can flash back to the cylinder.

What is the danger of an inert gas?

Inert gases, such as argon, helium, neon and nitrogen, are not toxic and do not burn or explode. Yet they can cause injury or death if they are present in sufficiently high concentrations. They can displace enough air to reduce oxygen levels. If oxygen levels are low enough, people entering the area can lose consciousness or die from asphyxiation. Low oxygen levels can particularly be a problem in poorly ventilated, confined spaces.

Flammable Gas Monitors

A variety of sensors are used to detect flammable gases. Each type of flammable condition requires a specific type of sensor to provide an accurate measurement. When selecting a gas monitor for detecting such gases, it is critical to understand the differences and choose an appropriate sensor for the environment.

BLEVE pronounced *blevy*,

An acronym for **Boiling Liquid Expanding Vapor Explosion**. This is a type of explosion that can occur when a vessel containing a pressurized liquid is ruptured. Such explosions can be extremely hazardous. When the liquid is water, the explosion is usually called a steam explosion.
A BLEVE can occur in a vessel that stores a substance that is usually a gas at atmospheric pressure but is a liquid when pressurized (for example, liquefied petroleum gas). The substance will be stored partly in liquid form, with a gaseous vapor above the liquid filling the remainder of the container.
If the vessel is ruptured - for example, due to corrosion, or failure under pressure - the vapor portion may rapidly leak, dropping the pressure inside the container and releasing a wave of overpressure from the point of rupture. This sudden drop in pressure inside the container causes violent boiling of the liquid, which rapidly liberates large amounts of vapor in the process. The pressure of this vapor can be extremely high, causing a second, much more significant wave of overpressure (i.e., an explosion) which may completely destroy the storage vessel and project it as shrapnel over the surrounding area.

A BLEVE does not require a flammable substance to occur, and therefore is not usually considered a type of chemical explosion. However, if the substance involved *is* flammable, it is likely that the resulting cloud of the substance will ignite after the BLEVE proper has occurred, forming a fireball and possibly a fuel-air explosion. BLEVEs can also be caused by an external fire nearby the storage vessel causing heating of the contents and pressure build-up.

1. If there is a leak with no fire present, the **flow of gas should be slowed or stopped**. This action is appropriate when the flow can be controlled, through intact valves or control devices, and by personnel that are trained in the operation of the control devices.

2. Dissipating gas vapors through ventilation or the application of water streams to prevent the vapors from reaching a flammable mixture within the flammable range.

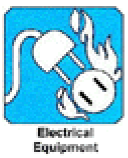
3. Applying water to exposed containers and equipment to cool them and prevent failures and BLEVEs from occurring. The major consideration for this method is the availability of an adequate water source for the constant and long-term application of water to the exposed equipment. The amount of water required is dependent on the size of the leak or fire and its location.

Fire Extinguishers

Fire Extinguisher Ratings

Class A Extinguishers will put out fires in ordinary combustibles, such as wood and paper. The numerical rating for this class of fire extinguisher refers to the amount of water the fire extinguisher holds and the amount of fire it will extinguish.

Class B Extinguishers should be used on fires involving flammable liquids, such as grease, gasoline, oil, etc. The numerical rating for this class of fire extinguisher states the approximate number of square feet of a flammable liquid fire that a non-expert person can expect to extinguish.



Class C Extinguishers are suitable for use on electrically energized fires. This class of fire extinguishers does not have a numerical rating. The presence of the letter "C" indicates that the extinguishing agent is non-conductive.

Class D Extinguishers are designed for use on flammable metals and are often specific for the type of metal in question. There is no picture designator for Class D extinguishers. These extinguishers generally have no rating nor are they given a multi-purpose rating for use on other types of fires.

FIRE SAFETY VEHICLE – 2004

Water, CO_2, Dry Chemical, Trauma Kit, Splints, Stretchers, Jaws of Life, Shovels, Ropes, O_2, Endo-tracheal tubes, Resuscitators, Come-a-long Turn-out gear, SCBA (air tanks), Gas Masks, Pike pole, Axes, Pry bar, Rescue saw w/ carbide blade

Types of Fire Extinguishers

Dry Chemical extinguishers are usually rated for multiple purpose use. They contain an extinguishing agent and use a compressed, non-flammable gas as a propellant.

Water These extinguishers contain water and compressed air and should only be used on Class A (ordinary combustibles) fires.

Carbon Dioxide (CO_2) extinguishers are most effective on Class B and C (liquids and electrical) fires. Since the gas disperses quickly, these extinguishers are only effective from 3 to 8 feet. The carbon dioxide is stored as a compressed liquid in the extinguisher; as it expands, it cools the surrounding air. The cooling will often cause ice to form around the “horn” where the gas is expelled from the extinguisher. Since the fire could re-ignite, continue to apply the agent even after the fire appears to be out.

How to Use a Fire Extinguisher

Even though extinguishers come in a number of shapes and sizes, they all operate in a similar manner. Here's an easy acronym for fire extinguisher use:

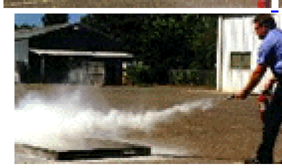
P A S S -- **P**ull, **A**im, **S**queeze, and **S**weep

Pull the pin at the top of the extinguisher that keeps the handle from being accidentally pressed.

Aim the nozzle toward the base of the fire.

Stand approximately 8 feet away from the fire and **squeeze** the handle to discharge the extinguisher. If you release the handle, the discharge will stop.

Sweep the nozzle back and forth at the base of the fire. After the fire appears to be out, watch it carefully since it may re-ignite!



Congratulations -- you did it!!!

ADDITIONAL FIRE EXTINGUISHING MEATHODS

Smothering

- Sand
- Dirt
- Playa Dust
- Wet rags / towels / blankets
- Buckets of water
- Wet Gel Blanket

BURNS

The severity of a burn depends upon its size, depth and location. Burns are most severe when located on the face, neck, hands, feet and genitals. Also, when they are spread over large parts of the body or when they are combined with other injuries.

Burns result in pain, infection and shock. They are most serious when the victims are very young or very old.

- FIRST DEGREE burns are the least severe. They are characterized by redness or discoloration, mild swelling and pain. Overexposure to the sun is a common cause of first degree burns.

- SECOND DEGREE burns are more serious. They are deeper than first degree burns, look red or mottled and have blisters. They may also involve loss of fluids through the damaged skin. Second degree burns are usually the most painful because nerve ending are usually intact, despite severe tissue damage.

- THIRD DEGREE burns are the deepest. They may look white or charred, extend through all skin layers. Victims of third degree burns may have severe pain -- or no pain at all -- if the nerve endings are destroyed.

First Aid for Burns

- FIRST DEGREE: Flush with cool running water, Apply moist dressings and bandage loosely.

- SECOND DEGREE: Apply dry dressings and bandage loosely Do not use water as it may increase risk of shock.

- THIRD DEGREE: Same treatment as second degree.

What are the categories of burns?

The treatment of burns depends on the depth, area and location of the burn. Burn depth is generally categorized as first, second or third degree. A first degree burn is superficial and has similar characteristics to a typical sun burn. The skin is red in color and sensation is intact. In fact, it is usually somewhat painful. Second degree burns look similar to the first degree burns; however, the damage is now severe enough to cause blistering of the skin and the pain is usually somewhat more intense. In third degree burns the damage has progressed to the point of skin death. The skin is white and without sensation.

Regardless of the type of burn, the result is fluid accumulation and inflammation in and around the wound. Moreover, it should be noted that the skin is the body's first defense against infection by microorganisms. Damage to the skin can predispose the burn victim to both infection at the site of the wound as well as internally.

What is the significance of the total body area affected?

In addition to the intensity, the total area of the burn is significant. This is usually measured in terms of percent of total body burnt. The skin acts as a barrier from the environment, and without it, patients are subject to infection and fluid loss. Burns that cover more than 15% of the total body surface can lead to shock and require hospitalization for intravenous fluid resuscitation and skin care.

How important is the location of a burn?

Burn location is even more important than the above factors. Burns of the neck or signs of burns to the nose or mouth require emergent guarding of the patient's airway, as swelling may results in life threatening obstruction. Burned tissue shrinks and can cause damage to underlying structures. Burns that extend circumferentially around body structures require surgical release of the tissue, often referred to as escharotomy. Finally, all eye burns require special attention as soon as possible. Burns to the eye may lead to clouded or lost vision.

BURN FIRST AID TREATMENT

1. First remove any constricting jewelry, such as rings.

2. Do **NOT** use butter or oils on a burn.

3. The effected area should be dowsed with cool water as soon as possible. It can be cleansed gently with chlorhexidine solution. Do NOT apply ice or cool to near-freezing temperatures (this can cause additional tissue injury).

4. A tetanus booster should be obtained if not administered within the previous 5 years.

First degree thermal burns can be treated with local skin care such as aloe vera. Many topical antibiotics and antiseptics are available in the drug store for minor burns.

All second and third degree thermal burns and the complicated locations listed above need immediate physician evaluation. Special topical antiseptic creams are used for more serious burns, including silver sulfdiazine, silver nitrate, and mafenide acetate creams.

Burns can be caused by heat (thermal), as well as by electricity, and chemicals.

What about electrical burns?

Any significant burn resulting from electricity, requires immediate physician evaluation. These burns often result in serious muscle breakdown, electrolyte abnormalities, and occasionally kidney failure. The actual site of damage can be internal and may not be visible on the skin surface.

What about chemical burns?

The treatment for chemical burns is similar to thermal burns except copious amounts of water should be used to irrigate the effected region. Contaminated clothing should be removed. Do NOT attempt to neutralize the burn with a reciprocal chemical. This may cause a chemical reaction that could result in a thermal burn too! Many chemicals have, in addition, specific treatments that can further reduce the resulting skin damage. If in doubt, call your local poison control center or make a quick trip to your local Emergency Room.

What about phosphorous burns or magnesium burns?

These types of burns are especially dangerous. Phosphorous and magnesium are self-oxygenating and burn intensely hot. They will burn through fire coats & leather gloves. The fires are extremely difficult to put out and can cause tremendous amounts of damage. Treatment could very well involve “digging” the material out of a victim’s wound with a spoon or a knife.

		
Water-Jel® Burn Kit	**Dyna Med® Hydrogel Burn Kit**	**Water-Jel Fire Blanket**
$65	**$60**	**$130**
Kit Contents	**Kit Contents**	
1 Face mask (12" x 16") 1 Sterile burn dressing (8" x 18") 2 Sterile burn dressings (4" x 4") 2 Sterile burn dressings (2" x 6") 1 Sterile burn dressing (4" x 16") 1 Burn Jel® dispenser box 25 single dose packets 1 Elastic bandage	1 Sterile gel dressing (2" x 40") 1 Sterile gel dressing (8" x 18") 1 Sterile gel dressing (1" x 20") 1 Hydrogel bottle (4-1/2 oz.) 2 Sterile gel dressings (4" x 4") 2 Sterile gel dressings (8" x 8") 2 Sterile gloves 4 Gauze rolls (1" x 180") 10 Hydrogel packets with attached adhesive bandage (1/8 oz) 1 Nylon bag (5"H x 9"W x 5"D)	Versatile Water-jel Fire Blanket helps stabilize skin temperature, prevent burn progression and relieve pain. Blanket does not require re-wetting, is perfect for stabilizing patients for transportation and protects against airborne contamination. Water-Jel Fire Blanket can also be used to extinguish flames on victim, protect rescuer from intense heat and extinguish small fires. Comes with a hard plastic canister. 6' x 5'.

Minimum Burn Kit for Fire Performances:

1 Large burn sheet
2 Large Sterile dressings
2 Medium Sterile dressings
4 Small Sterile dressings
1 2" Sterile gauze
1 3" Sterile guaze
1 4" Sterile guaze
1 Pair of Sterile gloves
1 Quart of Sterile water (1 Gallon of distilled water for large performances)

Note: These items can be purchased at any large pharmacy for less money than a case of beer.

		
ERT Medical Thigh Pack Kit	**Dyna Med® Pocket Pouch Trauma Kit**	**Dyna Med® Deluxe First Aid Kit**
$50	**$20**	**$25**
Kit Contents	**Kit Contents**	**Kit Contents**
10 Bandages (4" x 4") 2 Bandages (5" x 9") 2 Blood Stoppers 2 Coflex (2") 1 Petroleum Gauze 2 Pair Latex Gloves	10 12-ply gauze pads (4" x 4") 2 ABD combine pad (5" x 9") 2 Bloodstoppers 2 Pairs of large Nitrile Gloves 2 Co-Flex bandages (2"x 5 yards) 1 Vaseline gauze (3" x 9")	1 ABD Combine Pad (5" x 9") 50 Adhesive Bandages (1" x 3") 1 Adhesive Waterproof Tape (1/2" x 5 yds) 2 Ammonia Inhalants 6 Antiseptic Wipes 20 Assorted Woven Bandages 1 Cold pack (5" x 6") 1 Cotton Sterile Roll (1/2 oz) 2 Eye Pads 1 Eye Wash (1 oz) 6 First Aid Cream Packets 4 Gauze Pads (3" x 3") 1 Gauze Roll (2") 5 Non-Adhesive Pads (2" x 3") 1 Scissors (4-1/2") 1 Triangular Bandage (40" x 40" x 56") 1 Tweezers 1 Pair Latex Gloves 1 Small First Aid Instruction Chart

		
Dyna Med® BLS Kit	**Dyna Med® Bandage Kit**	**Dyna Med® Quick Response Kit**
Kit Contents	**Kit Contents**	**Kit Contents**
Airway: 1 Dyna Med CPR Mask 1 Disposable Airway Kit **Burn**: 1 Burn Sheet **Bandages**: 16 Adhesive bandages (1"x 3") 2 Abdominal Pads (5" x 9") 1 Trauma Dressing (12" x 30") 20 Sterile Dressings (4" x 4") 10 Sterile Dressings (3" x 3") 2 Blood Stoppers 2 Gauze Rolls (3" NS) 2 Gauze Rolls (4" NS) 1 Waterproof Tape (1/2") 1 Waterproof Tape (1") 1 Elastic Bandage (3") 1 Elastic Bandage (4") 2 Triangular Bandages 4 Eye Pads 1 Petroleum Gauze (3" x 9") 2 Kerlix (4-1/2") **Equipment & Supplies**: Maxi-Medic Bag 1 BP/Stethoscope Kit 10 Alcohol Prep Pads 1 Antibiotic Ointment 1 Bee Sting Kit 2 Cold Packs 1 Eye Wash 10 PVP Iodine 1 Instrument Pack (shears, Kelly forceps, bandage scissors, splinter forceps, penlight) 1 Space Blanket 1 No Rinse Gel (4 oz) 5 Pair Nitrile Gloves	10 Pair Nitrile Gloves 4 Cold Packs 1 Cloth Tape (1") 1 Cloth Tape (3") 2 Elastic Bandages (3") 2 Trauma Pads (12" x 30") 2 Triangular Bandages 2 Bloodstoppers 2 Non-sterile Coflex (3") 12 Non-sterile Gauze Rolls (4") 12 Non-sterile Gauze Pads (2" x 2") 200 Non-sterile Gauze Pads (4" x 4") 50 Sterile Gauze Pads (4" x 4") 20 Combine Pads 1 Bandage Bag	**Airway**: CPR Microshield **Burn**: 1 Burn Pad (4" x 4") **Dressings & Bandages**: 16 Bandaids (1" x 3") 1 Abdominal Pad (5" x 9") 10 Gauze Pads (4" x 4") 1 Blood Stopper 1 Gauze Roll (3") 1 Gauze Roll (4") 1 Waterproof Tape (1") 1 Waterproof Tape (1/2") 1 Elastic Bandage (3") 2 Triangular Bandages 4 Eye Pads 10 pkg Antibiotic Ointment 10 Alcohol Wipes 10 Antimicrobial Wipes **Equipment & Supplies**: Mini Medic Bag 1 BP/Stethoscope Kit 1 Instrument Pack (shears, bandage scissors, penlight, seatbelt cutter, window punch) 2 Small Cold Packs 1 Space Blanket 2 Pairs Latex Gloves 1 Eye Wash (4 oz) 1 First Aid Book

Note: Large trauma kits can either be purchased fully stocked on E-bay for much less than a medical supplier, or can be made from scratch using the above lists for shopping at a pharmacy. Any bag will do.

		
Dyna Med® BLS XTRA Kit	**Dyna Med® First Responder Kit**	**Dyna Med® ATAC Kit**
Kit Contents **Airway**: 1 Dyna Med CPR Mask 1 Disposable Airway Kit 1 Bag Valve Mask 1 Nasal Airway Kit **Burn**: 1 Burn Sheet 1 Burn Pad (4" x 4") **Bandages**: 16 Adhesive bandages (1" x 3") 2 Abdominal Pads (5" x 9") 1 Trauma Dressing (12" x 30") 20 Sterile Dressings (4" x 4") 10 Sterile Dressings (3" x 3") 2 Blood Stoppers 2 Gauze Rolls (3" NS) 2 Gauze Rolls (4" NS) 1 Waterproof Tape (1/2") 1 Waterproof Tape (1") 1 Elastic Bandage (3") 1 Elastic Bandage (4") 2 Triangular Bandages 4 Eye Pads 1 Petroleum Gauze (3" x 9") 2 Kerlix (4-1/2") **Equipment & Supplies**: Mega-Medic Bag 1 Instrument Pack (shears, Kelly forceps, bandage scissors, splinter forceps, penlight) 1 BP/Stethoscope Kit 1 SAM Splint 1 Ace Collar 1 Obstetrical Kit 1 Personal Protection Kit 1 Ipecac Syrup 1 Charcoal 1 Ammonia Inhalant 1 Insta-Glucose 10 Alcohol Prep Pads 1 Antibiotic Ointment 1 Bee Sting Kit 2 Cold Packs (5" x 9") 1 Eye Wash 10 PVP Iodine 1 Space Blanket 1 No Rinse Gel (4 oz) 5 Pair Nitrile Gloves	**Kit Contents** **Airway**: CPR Microshield **Burn**: 1 Burn Pad (4" x 4") **Dressings & Bandages**: 16 Bandaids (1" x 3") 1 Abdominal Pad (5" x 9") 10 Gauze Pads (4" x 4") 1 Blood Stopper 1 Gauze Roll (3") 1 Gauze Roll (4") 1 Waterproof Tape (1") 1 Waterproof Tape (1/2") 1 Elastic Bandage (3") 2 Triangular Bandages 4 Eye Pads 10 pkg Antibiotic Ointment 10 Alcohol Wipes 10 Antimicrobial Wipes **Equipment & Supplies**: 1 BP/Stethoscope Kit 1 Instrument Pack (shears, bandage scissors, penlight, seatbelt cutter, window punch) 2 Small Cold Packs 1 Space Blanket 2 Pairs Latex Gloves 1 Eye Wash (4 oz) 1 First Aid Book 1 First Responder Bag	**Kit Contents** 1 BP Unit 1 Stethoscope 1 Berman Airway Set 1 EMT Shears 1 Kelly Forceps 1 Penlight 1 Bandage Scissors 1 Tweezer 1 BVM 1 Adjustable Cervical Collar 1 Non-Rebreather Mask 2 Cold Packs 1 Ascherman Chest Seal 1 Sam Splint 4 Trauma Pads (8" x 10") 4 Trauma Pads (5" x 9") 20 Gauze Pads (4" x 4") 3 Kling Sterile Gauze (4") 2 Elastic Bandages (3") 1 Adhesive Tape (1") 2 Triangular Bandages 2 Petroleum Gauze 10 Bandaids (1" x 3") 2 Bandaids (2-1/4" x 3-1/2") 5 Butterfly Bandaids 6 Antiseptic Wipes 2 Water Jel Burn Dressing (4" x 16") 1 Eye Wash (4 oz) 1 Bulb Syringe 1 Space Blanket 4 Pr Nitrile Gloves (L) 2 Pr Nitrile Gloves (XL) 1 Bottle Bio Hand Cleaner

OTHER TYPES OF HAZARDS RELATING TO FIRE PERFORMANCES

Tripping hazards
Moths (people drawn to fire)
Fire dancers & Fire walkers
Drunks
People on drugs

- Hallucinogens
- PCP
- Speed
- Cocaine

People having psychotic episodes
Heat stroke victims
Miscommunication
Confusion
Egoism
Mass panic

FIRE SAFETY EQUIPMENT & WHERE TO BUY

Minimum gear for Flame Effect Assistants within Fire Perimeter

Cover-alls	Thrift store
Shoes or boots	Shoe store
Gloves (in pocket)	Hardware store
Hat or helmet	Hardware store, Thrift store

Minimum gear for Flame Effect Operators within Inner Control Perimeter

Jeans	Thrift store
Boots	Shoe store
Gloves (on hands)	Hardware store
Leather Jacket	Thrift store
Helmet	Hardware store, E-Bay
Safety Glasses	Hardware store

Minimum gear for Fire Safety Back-up within Inner Performance Perimeter

Jeans	Thrift store
Boots	Shoe store
Gloves (on hands)	Hardware store
Leather Jacket	Thrift store
Nomex Hood	E-Bay, Army Surplus

Helmet	Hardware store, E-Bay
Safety Goggles	Hardware store, E-Bay, Army Surplus

Minimum gear for Primary Fire Safety within Inner Performance Perimeter

Bunker Pants	E-Bay, Twin City Surplus (Reno)
Turn Out Coat (Fire Coat)	E-Bay, Twin City Surplus (Reno)
Boots	Shoe store
Gloves (on hands)	Hardware store
Nomex Hood	E-Bay, Army Surplus
Fire Helmet	E-Bay, (or Modified Hard Hat)
Face Shield	Hardware store, E-Bay

Optional gear

Proximity Suit	E-Bay, Twin City Surplus (Reno)
Gas Mask	E-Bay, Army Surplus
Air Tank (SCBA)	E-Bay
Rubber Chemical Gloves	E-Bay, Hardware store
Filter Masks	E-Bay, Hardware store
Latex Gloves (for first aid)	Drug Store
Trauma Kit	E-Bay, Web, Army Surplus
First Aid Kit	Drug store
Sterile Gauze	Drug store
Distilled Water	Grocery store
Safety Vests	Hardware store
Hats, Shirts, Arm Bands, Laminates	Custom Made to Order (silkscreen)
Pike Pole	E-Bay, Custom Made (shop)
Flammable Gas Detector	E-Bay, WEB

Remember:

If your clothing catches on fire, it is a natural response to panic and run to the nearest shower or fire blanket. Don't do it! Running will just fan the flames and increase the potential for serious injury. The correct response is to **Stop, Drop, and Roll** on the ground to extinguish the flames. Cover your face with your hands to protect your face and lungs. If one of your colleagues catches fire, panics, and starts to run, tackle him or her and smother the flames.

Nomex Hood – under $20

Full Turn Out Gear – under $200 used

Aluminized Fire Suit - $170 w/o hood
From Twin City Surplus, Reno

Nomex Racing Suit - $20 used

Full Proximity Suit for Especially Dangerous Fires – Less than $400 used

Aramid Fiber Flight Suit - $20 used

Helmets can range from free to $400 used

Wear whatever you want-UNDER your safety gear!

Factors that Affect Toxicity

1. **Routes of exposure**

Toxicity varies with the route of exposure and the effectiveness at which the material is absorbed. A chemical that enters the body in large quantities but is not easily absorbed is a much lower risk than one that is easily absorbed into the bloodstream.

* **skin contact**

Perhaps the most common route of exposure is through skin contact. Fortunately the skin acts as an effective barrier against entry by most chemicals and thus greatly reduces the possibility of a toxic exposure. This is not true, however, if the skin is not intact, i.e., if there is an open cut. **General rule**: most inorganic chemicals are not easily absorbed through the skin, organic chemicals may or may not be absorbed, depending on numerous conditions. Some chemicals, such as DMSO (dimethyl sulfoxide) greatly enhance absorption of other chemicals through the skin, so particular care should be used with these materials. Once a chemical passes through the skin it enters the bloodstream and is carried to all parts of the body.

*** inhalation**

This is the most dangerous route of entry into body because the lungs are not an effective barrier to entry. The lung membrane allows ready passage of gases necessary to sustain life (a good thing!), but sadly they just as readily allow passage of chemicals that can be fatal (not a good thing!) Chemicals that pass the lung membrane are absorbed into the bloodstream and carried to all parts of the body. Absorption can be extremely rapid. The rate of absorption depends on the concentration of the toxic substance, its solubility in water, the depth of respiration and the rate of blood circulation.

* **ingestion**

Ingestion of toxic materials is an unlikely event in the chemical laboratory as long as good hygiene practices are followed. Materials that are ingested may be absorbed into the bloodstream anywhere along the gastrointestinal tract. If the material cannot be absorbed it will be eliminated from the body.

CODES & LAWS RELATING TO FIRE PERFORMANCES

Organizational Bodies

OSHA
NFPA
DOT
ANSI

BOCA
ICCBO
ASTM
Bureau of Alcohol, Tobacco, Firearms and Explosives (ATFE)

Standards

DOT
NFPA
ANSI

Model Codes

Uniform Building Code (UBC)
International Building Code
NFPA 5000
ISO 3000
Uniform Fire Code (UFC)
International Fire Code (IFC)

Model Codes Are Adopted Into LAW

Uniform Building Code (UBC) + Modifications = California Building Code (CBC)
Uniform Fire Code (UFC) + Modifications = California Fire Code (CFC)
International Fire Code (IFC) = International Fire Code (IFC), Nevada

Enforcement Agencies

Fire Department
Code Officials
State Highway Patrol
Park Rangers
Police

Major Codes Affecting Fire Performances

NFPA 30: Flammable & Combustible Liquids Code, 2000 Edition

NFPA 55: Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks, 2005 Edition

NFPA 58: Liquefied Petroleum Gas Code, 2004 Edition

NFPA 160: Standard for the Flame Effects Before an Audience, 2001 Edition

IFC & CFC
- Establish a perimeter
- Fire Safety Personnel
- ABC Fire Extinguisher

San Francisco Fire Code
- Open Flame Permit (requires a fire marshal at performance)

Department of Transportation (DOT)

Standard Operating Procedure (SOP)

Standard Operating Procedures are previously agreed upon strategies that are initiated in the event of an emergency. Everyone involved automatically initiates the SOP without waiting for instructions or approval from anyone else.

A good example of a SOP would be, if a Flame Effects Device catches on fire during a performance, The show stops temporarily, the fuel is shut off, the fire is put out by the primary fire safety people, the device is checked for damage and the show is not started up again until everyone involved is ready.

Each event, show, crew, device is different. SOP's should be reviewed & agreed upon prior to the performance.

Other examples of situations that could affect a performance are:

- Someone breaking the perimeter
- Fighting or distracting arguments
- Leaking valve
- Fuel Spill
- Sparks from electrical equipment
- Performer or Fire Safety Person turns out to be too drunk, etc.

Classification of Hazardous Materials

The DOT has broad authority to regulate hazardous materials that are in transport, including the discretion to determine which materials shall be classified as "hazardous". These materials are placed in one of nine categories, based on their chemical and physical properties. Based on the classification of the material, the DOT is also responsible for determining the appropriate packaging materials for shipping or transport. Finally, also based on the material classification, strict guidelines are furnished for proper labeling/marking of packages of hazardous materials offered for transport, and for placarding of transport vehicles.

- Class 1: Explosives
  - Division 1.1 Explosives with a mass explosion hazard
  - Division 1.2 Explosives with a projection hazard
  - Division 1.3 Explosives with predominantly a fire hazard
  - Division 1.4 Explosives with no significant blast hazard
  - Division 1.5 Very insensitive explosives
  - Division 1.6 Extremely insensitive explosive articles
- Class 2: Gases
  - Division 2.1 Flammable gases
  - Division 2.2 Nonflammable gases
  - Division 2.3 Poison gas
  - Division 2.4 Corrosive gases
- Class 3: Flammable liquids.
  - Division 3.1 Flashpoint below -18^{o}C (0^{o}F)
  - Division 3.2 Flashpoint -18^{o}C and above, but less than 23^{o}C (73^{o}F)
  - Division 3.3 Flashpoint 23^{o}C and up to 61^{o}C (141^{o}F)
- Class 4: Flammable solids; spontaneously combustible materials; and materials that are dangerous when wet
  - Division 4.1 Flammable solids
  - Division 4.2 Spontaneously combustible materials
  - Division 4.3 Materials that are dangerous when wet
- Class 5: Oxidizers and organic peroxides
  - Division 5.1 Oxidizers
  - Division 5.2 Organic peroxides
- Class 6: Poisons and etiologic materials
  - Division 6.1 Poisonous materials
  - Division 6.2 Etiologic (infectious) materials
- Class 7: Radioactive materials
  - Any material, or combination of materials, that spontaneously gives off ionizing radiation. It has a specific activity greater than 0.002 microcuries per gram.
- Class 8: Corrosives
  - A material, liquid or solid, that causes visible destruction or irreversible alteration to human skin or a liquid that has a severe corrosion rate on steel or aluminum.
- Class 9: Miscellaneous
  - A material which presents a hazard during transport, but which is not included in any other hazard class (such as a hazardous substance or a hazardous waste).
- ORM-D: Other regulated material

A material which, although otherwise subjected to regulations, presents a limited hazard during transportation due to its form, quantity and packaging.

George W. Bush

Implementation Of the Safe Explosives Act, Applying Stricter Controls on The Purchase of Explosives in The Continuing Fight Against Terrorism

Washington, DC - The Bureau of Alcohol, Tobacco and Firearms (ATF) announces that on November 25, 2002, President Bush signed new legislation that restricts the availability of explosives to felons and other persons prohibited from possessing explosives, strengthens licensing and permitting requirements, and aids in the fight against terrorism. This legislation, the Safe Explosives Act, amends Title XI of the Organized Crime Control Act of 1970.

Previously, a Federal permit to purchase explosive materials was necessary if a person wished to transport, ship, or receive explosives in interstate commerce. A permit, however, was not necessary if a person acquired and used explosives within his or her State of residence. The new legislation now requires that any person who wishes to transport, ship, cause to be transported, or receive explosive materials in either interstate or intrastate commerce must first obtain a Federal permit issued by ATF. This requirement takes effect May 24, 2003.

The new legislation creates a new category of permit -- a "limited permit" -- designed for the intrastate purchaser who buys explosives infrequently and does not intend to transport or use the explosives interstate. This permit will allow the purchaser to receive explosive materials from an in-State explosives licensee or permittee on no more than six (6) occasions during the period of the permit. The permit will allow ATF to better monitor explosives commerce in an effort to enhance homeland security, but is designed to not be overly burdensome to legitimate purchasers. The limited permit is valid for one year and is renewable. ATF intends to set the application fee for the limited permit at $25.

The new legislation requires that all applicants for explosives licenses and permits submit photographs and fingerprints so that ATF can perform thorough background checks. The legislation also requires that all applicants submit the names and identifying information of all employees who will possess explosive materials. In this way, ATF can conduct a thorough background check to ensure that these individuals are not prohibited from receiving or possessing explosives. Under previous law, no background checks were conducted for the employees of businesses that used explosives. The business owners or managers were required to be on record with ATF; employees such as warehousemen and drivers were not. The new legislation enables ATF to systematically identify and conduct background checks on such employees to reduce the risk that prohibited persons will gain access to explosives.

The new legislation also expands the categories of prohibited persons to include: (1) aliens (with limited exceptions); (2) persons dishonorably discharged from the military; and (3) citizens of the United States who have renounced their citizenship. The new prohibitions on possession of explosive materials are effective January 24, 2003.

Finally, the new legislation will require manufacturers and importers of explosive materials, including ammonium nitrate, to furnish samples of these materials to ATF, as well as information on their chemical composition or other information ATF may request. This will assist ATF in the identification of explosives found at crime scenes. This provision will be effective January 24, 2003.

Additionally, on January 24, 2003, ATF will be moved to the Department of Justice and will be known as the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATFE).

The Chemistry of Pyrotechnics

This is serious stuff, and can be really dangerous if you don't treat it seriously. For all you out there who watch too many cartoons, remember that if a part of your body gets blown away in the REAL world, it STAYS blown away. If you can't treat this stuff with respect, don't mess around with it.

Each part will start with a set of safety rules. Don't skip over them. Read 'em and MEMORIZE 'em!! At the beginning, there will be a set of general rules that always apply. Then there will be some things that you HAVE TO KNOW about the materials you will be using and making this time. Read it thoroughly before starting anything.

Pyrotechnic preparations and explosives are, by their very nature, unstable, and subject to ignition by explosion or heat, shock, or friction. A clear understanding of their dangerous properties and due care in the handling of ingredients or finished products is necessary if accidents are to be avoided. Always observe all possible precautions, particularly the following:

1. Mix only small batches at one time. This means a few grams, or at most, an ounce or so. Don't go for big mixes -- they only make for bigger accidents. The power of an explosive cubes itself with every ounce. (9 Ounces is 729 times as powerful as one ounce.)

2. When weighing chemicals, use a clean piece of paper on the scale pan for each item. Then discard the used paper into a bucket of water before weighing the next ingredient.

3. Be a safe worker. Dispose of any chemicals spilled on the workbench or equipment between weighings. Don't keep open containers of chemicals on your table, since accidental spillage or mixing may occur. When finished with a container, close it, and replace it on the storage shelf. Use only clean equipment.

4. Where chemicals are to be ground, grind them separately, NEVER TOGETHER. Thoroughly wash and clean equipment before grinding another ingredient.

5. Mixing of batches should be done outdoors, away from flammable structures, such as buildings, barns, garages, etc. Mixes should also be made in NON METALLIC containers to avoid sparks. Glass also should not be used since it will shatter in case of an accident. Handy small containers can be made by cutting off the top of a plastic bottle three or four inches from the bottom. Some mixes may most conveniently be made by placing the ingredients in a plastic bottle and rolling around until the mixture is uniform. In all cases, point the open end of the container away from yourself. Never hold your body or face over the container. Any stirring should be done with a wooden paddle or stick to avoid sparks or static.

Powdered or ground materials may also be mixed by placing them on a large sheet of paper on a flat surface and then rolling them across the sheet by lifting the sides and corners one at a time.

6. Never ram or tamp mixes into paper or cardboard tubes. Pour the material in and gently tap or shake the tube to settle the contents down.

7. Store ingredients and finished mixes where they will not be a fire hazard away from heat and flame. Finished preparations may be stored in plastic bottles which will not shatter in case of an accident. Since many of the ingredients and mixes are poisonous, they should be stored out of reach of children or pets, preferably locked away.

8. Be sure threads of screw top containers and caps are thoroughly cleaned. This applies also to containers with stoppers of rubber or cork and to all other types of closures. Traces of mixture caught between the container and closure may be ignited by the friction of opening or closing the container. Throughout any procedure, WORK WITH CLEAN CONDITIONS.

9. ALWAYS WEAR A FACE SHIELD OR AT LEAST SHATTERPROOF SAFETY GLASSES. Any careful worker does when handling dangerous materials. Be sure lenses and frames are not flammable.

10. Always wear a dust respirator when handling chemicals in dust form. These small particles gather in your lungs and stay there. They may cause serious illnesses later on in life.

11. Always wear gloves when working with chemicals.

12. Always wear a waterproof lab apron.

13. If you must work indoors, have a good ventilation system.

14. Never smoke anywhere near where you are working.

15. Make sure there are NO open flames present, and NO MOTORS (they produce sparks inside.) No hot water heaters, furnaces, or pilot lights in stoves!! Sparks have been known to very readily explode dust floating in the air.

16. ALWAYS work with someone. Two heads are better than one.

17. Have a source of water READILY available. (Fire extinguisher, hose, etc.)

18. Never, under any circumstances, use any metal to load chemicals or put chemicals in. Fireworks with metal casings are worse to handle than a live hand grenade. Never use any metal container or can. This includes the very dangerous CO_2 cartridges. Many people have been KILLED because of flying fragments from metal casings. Again, please do not use metal in any circumstance.

19. Always be thoroughly familiar with the chemicals you are using. Some information will be included in each bit, but look for whatever extra information you can. Materials that were once thought to be safe can later be found out to be dangerous stuff.

20. Wash your hands and face thoroughly after using chemicals. Don't forget to wash your EARS AND YOUR NOSE.

21. If any device you've built fails to work, leave it alone. After a half hour or so, you may try to bury it, but never try to unload or reuse any dud.

22. If dust particles start to form in the air, stop what you are doing and leave until it settles.

23. Read the entire file before trying to do anything.

24. NEVER strike any mixture containing Chlorates, Nitrates, Perchlorates, Permanganates, Bichromates, or powdered metals don't drop them, or even handle them roughly.

These rules may all look like a lot of silly nonsense, but let's look at one example. When the move "The Wizard of OZ" was made, the actress who played the good witch was severely burned when one of the exploding special effects got out of hand. The actress who played the bad witch got really messed up by the green coloring used on her face, and the original actor who played the Tin Man got his lungs destroyed by the aluminum dust used to color his face.

The actor we know of as the tin man was actually a replacement. The point is, these chemicals were being used under the direction of people a lot more knowledgeable of chemicals than you are, and terrible accidents still happened. Don't take this stuff lightly.

We will be using the following materials this time. Get familiar with them. Some can be highly dangerous.

Aluminum Dust (and powder) Al

An element used for brilliancy in the fine powder form. It can be purchased as a fine silvery or gray powder. All grades from technical to superpure (99.9%) can be used. It is dangerous to inhale the dust. The dust is also flammable, by itself. In coarser forms, like powder, it is less dangerous.

Antimony Sulfide Sb_2S_3

Also known as "Black" Antimony Sulfide. (There is also a "Red" form, which is useless to us.) This is used to sharpen the report of firecrackers, salutes, etc., or to add color to a fire. The technical, black, powder is suitable. Avoid contact with the skin. Dermatitis or worse will be the result.

Barium Chlorate $Ba(ClO_3)_2 * H_2O$

Available as a white powder. It is poisonous, as are all Barium salts. It is used both as an oxidizer and color imparter. It is as powerful as Potassium Chlorate and should be handled with the same care. Melting point is 414 degrees.

Barium Nitrate $Ba(NO_3)_2$

Poisonous. Used as an oxidizer and colorizer. The uses and precautions are the same as with a mixture containing Potassium Nitrate.

Charcoal C

A form of the element carbon. Used in fireworks and explosives as a reducing agent. It can be purchased as a dust on up to a coarse powder. Use dust form, unless otherwise specified. The softwood variety is best, and it should be black, not brown.

Copper Acetoarsenite (CuO) As O Cu(C H O)
3 2 3 2 3 2 2

The popular name for this is Paris Green. It is also called King's Green or Vienna Green. It has been used as an insecticide, and is available as a technical grade, poisonous, emerald green powder. It is used in fireworks to add color. Careful with this stuff. It contains arsenic.

Copper Chloride CuCl
2

A color imparter. As with all copper salts, this is poisonous.

Copper Sulfate CuSO *5H O
4 2

Known as Blue Vitriol, this poisonous compound is available as blue crystals or blue powder. Can be purchased in some drugstores and some agricultural supply stores. Used as a colorizer.

Dextrin

This can be purchased as a white or yellow powder. It is a good cheap glue for binding cases and stars in fireworks.

Lampblack C

This is another form of the element carbon. It is a very finely powdered black dust (soot, actually) resulting from the burning of crude oils. It is used for special effects in fireworks.

Lead Chloride PbCl
3

Available as a white, crystalline, poisonous powder, which melts at 501 degrees. As with all lead salts, it is not only poisonous, but the poison accumulates in the body, so a lot of small, otherwise harmless doses can be as bad as one large dose.

Mercurous Chloride HgCl

Also known as calomel or Mercury Monochloride. This powder will brighten an otherwise dull colored mixture. Sometimes it is replaced by Hexachlorobenzene for the same purpose. This is non poisonous ONLY if it is 100% pure. Never confuse this chemical with Mercuric Chloride, which is poisonous in any purity.

Potassium Chlorate KClO
3

This, perhaps, is the most widely used chemical in fireworks. Before it was known, mixtures were never spectacular in performance. It opened the door to what fireworks are today. It is a poisonous, white powder that is used as an oxidizer. Never ram or strike a mixture containing Potassium

Chlorate. Do not store mixtures containing this chemical for any length of time, as they may explode spontaneously.

Potassium Dichromate $K_2Cr_2O_7$

Also known as Potassium Bichromate. The commercial grade is used in fireworks and matches. The bright orange crystals are poisonous.

Potassium Nitrate KNO_3

Commonly called Saltpeter. This chemical is an oxidizer which decomposes at 400 degrees. It is well known as a component of gunpowder and is also used in other firework pieces. Available as a white powder.

Potassium Perchlorate $KClO_4$

Much more stable than its chlorate brother, this chemical is a white or slightly pink powder. It can often substitute for Potassium Chlorate to make the mixture safer. It will not yield its oxygen as easily, but to make up for this, it gives off more oxygen. It is also poisonous.

Red Gum

Rosin similar to shellac and can often replace it in many fireworks formulas. Red Gum is obtained from barks of trees.

Shellac Powder

An organic rosin made from the secretions of insects which live in India. The exact effect it produces in fireworks is not obtainable from other gums. The common mixture of shellac and alcohol sold in hardware stores should be avoided. Purchase the powdered variety, which is orange in color.

Sodium Oxalate $Na_2C_2O_4$

Used in making yellow fires. Available as a fine dust, which you should avoid breathing.

Strontium Carbonate $SrCO_3$

Known in the natural state as Strontianite, this chemical is used for adding a red color to fires. It comes as a white powder, in a pure, technical, or natural state.

Strontium Nitrate $Sr(NO_3)_2$

By far the most common chemical used to produce red in flares, stars and fires. Available in the technical grade as a white powder. It does double duty as an oxidizer, but has a disadvantage in that it will absorb some water from the air.

Strontium Sulfate $SrSO_4$

Since this chemical does not absorb water as readily as the nitrate, it is often used when the powder is to be stored. In its natural state it is known as Celestine, which is comparable to the technical grade used in fireworks.

Sulfur S

A yellow element that acts as a reducing agent. It burns at 250 degrees, giving off choking fumes. Purchase the yellow, finely powdered form only. Other forms are useless without a lot of extra and otherwise unnecessary effort to powder it.

Zinc Dust Zn

Of all the forms of zinc available, only the dust form is in any way suitable. As a dust, it has the fineness of flour. Should be either of the technical or high purity grade. Avoid breathing the dust, which can cause lung damage. Used in certain star mixtures, and with sulfur, as a rocket fuel.

Most pyrotechnic mixtures follow a very simple set of chemical rules. We'll go over those now. Most mixtures contain an oxidizing agent, which usually produces oxygen used to burn the mixture, and a reducing agent, which burns to produce hot gasses. In addition, there can be coloring agents to impart a color to the fire, binders, which hold the mixture in a solid lump, and regulators that speed up or slow down the speed at which the mixture burns. These are not all the possibilities, but they cover most all cases.

Oxidizing agents, such as nitrates, chlorates, and perchlorates provide the oxygen. They usually consist of a metal ion and the actual oxidizing radical. For example, Potassium Nitrate contains a metal ion (Potassium) and the oxidizing radical (the Nitrate). Instead of potassium, we could instead substitute other metals, like sodium, barium, or strontium, and the chemical would still supply oxygen to the burning mixture. But some are less desirable. Sodium Nitrate, for example, will absorb moisture out of the air, and this will make it harder to control the speed at which the mixture will burn.

In the following examples, we'll use the letter "X" to show the presence of a generic metal ion.

Note that Nitrates are stingy with the oxygen that they give up. They only give one third of what they have.

Some Some
Nitrate Nitrite Oxygen

$2XNO_3$ ---> $2XN0_2$ + O_2

Chlorates are very generous, on the other hand. They give up all the oxygen they have. Furthermore, they give it up more easily. It takes less heat, or less shock to get that oxygen loose. Mixtures using chlorates burn more spectacularly, because a smaller volume of the mix needs to be wasted on the oxidizer, and the ease with which the oxygen is supplied makes it burn faster. But the mixture is also MUCH more sensitive to shock.

Some Some
Chlorate Chloride Oxygen

2XClO ---> 2XCl + 3O
3 2

Perchlorates round out our usual set of oxidizing tools. Perchlorates contain even more oxygen than Chlorates, and also give it all up. However, they are not as sensitive as the Chlorates, so they make mixtures that are "safer". That is, they're less likely to explode if you drop or strike them.

Some Some
Perchlorate Chloride Oxygen

XClO ---> XCl + 2O
4 2

Reducing agents, like sulfur and charcoal (carbon) simply burn the oxygen to produce sulfur dioxide and carbon dioxide. It's usually best to include a mixture of the two in a pyrotechnic mixture, as they burn at different speeds and temperatures, and the proper combination will help control the speed of combustion.

Also, when extra fast burning speed is needed, like in rockets and firecrackers, metal powder is often added. The finer the powder, the faster the burning rate. The proportions change the speed, as well. Magnesium powder or dust is often used for speed. Aluminum dust works, but not as well. Zinc dust is used in some cases. Powdered metal, (not dust) particularly aluminum or iron, are often used to produce a mixture that shoots out sparks as it burns. In rare cases, it is desirable to slow down the burning speed. In this case, corn meal is often used. It burns, so acts as a reducing agent, but it doesn't burn very well.

Coloring agents are very interesting. It's long been known that various metals produce different colored flames when burned in a fire. The reasons are buried in the realm of quantum physics, but the results are what matters, and we can present them here. Note that if we use an oxidizing agent that contains a colorizing metal, it can do a double job. It can produce oxygen and color.

Barium -Barium salts give a pleasant green color. Barium Nitrate is most often used.

Strontium -Strontium salts give a strong red color. Strontium Nitrate is a very convenient material for red.

Sodium -Sodium salts give an intense yellow color. So intense in fact that any sodium compounds in a mixture will usually wash out other colorizers. As has been said, Sodium Nitrate absorbs moisture from the air, and so is not really suitable to impart color. Instead, Sodium Oxalate is usually used. This does not absorb lots of water, but has the disadvantage of being very poisonous.

Copper -Copper salts are used to give a blue color. Blue is the most difficult color to produce, and it's usually not too spectacular. Usually Copper Acetoarsenite (Paris Green) is used. This compound contains arsenic, and is very poisonous. Since it still doesn't

produce a very memorable blue, it's often used with mercurous
chloride, which enhances the color, but is also poisonous, and
expensive, to boot.
Potassium -Potassium salts will give a delicate purple color, if they're very pure. The cheaper lab grades of potassium nitrate often contain traces of sodium, which completely obscure the purple color. In order to get the purple coloring, very pure grades must be used, and you must be very careful to mix it in very clean vessels, and scoop it from the supply jar with a very clean scoop. The color is certainly worth the effort, if you can get it.

Some mixtures that burn in colors also contain binders, that hold the mixture together in a solid lump. These lumps are usually referred to as stars. The balls fired from a roman candle or the colorful showers sprayed from aerial bombs are examples of stars. Depending on the mixture, the binder is either a starch called dextrin or finely powdered orange shellac. A shellac-like material called red gum is also used on occasion. In some mixtures, the shellac powder also helps produce a nice color. Shellac mixtures are moistened with alcohol to get them to stick together. Dextrin mixtures are moistened with water.

If the colored mixture is to be used as a flare, it's just packed into a thin paper tube. If it's to be fired from a roman candle, it's usually extruded from a heavy tube by pushing it out with a dowel, and the pieces are cut off as the proper length pops out. Stars fired from an aerial bomb are usually made by rolling the moist mixture flat, and cutting it with a knife into small cubes. Stars that are extruded are often called "pumped stars" those that are rolled out are "cut stars".

The following are formulas for mixtures that burn with various colors.
Parts are by weight.

Red

Potassium Chlorate 9
Sulfur 2
Lampblack 1
Strontium Nitrate 9
bind with shellac
dissolved in alcohol

Blue

Potassium Chlorate 9 This one is inferior
Copper Acetoarsenite 2 Potassium Chlorate 12
Mercurous Chloride 1 Copper Sulfate 6
Sulfur 2 Lead Chloride 1
bind with dextrin Sulfur 4
in water bind with dextrin in water

Green

Barium Chlorate 8 Barium Nitrate 3
Lampblack 1 Potassium Chlorate 4
Shellac Powder 1 Shellac Powder 1
bind with alcohol Dextrin 1/4
Bind with alcohol

Yellow

Potassium Chlorate 8 Potassium Chlorate 8
Sodium Oxalate 3 Sodium Oxalate 4
Lampblack 2 Shellac Powder 2
Bind with shellac in Dextrin 1
alcohol or dextrin Bind with alcohol
in water

White

Potassium Nitrate 6
Sulfur 1
Antimony Sulfide 2
bind with dextrin in
water

Orange

Strontium Nitrate 36
Sodium Oxalate 8
Potassium Chlorate 5
Shellac Powder 5
Sulfur 3
Bind with alcohol

Purple (ingredients must be very pure)

Potassium Chlorate 36 This one has more of a lilac color
Strontium Sulfate 10 Potassium Chlorate 38
Copper Sulfate 5 Strontium Carbonate 18
Lead Chloride 2 Copper Chloride 4
Charcoal 2 Lead Chloride 2
Sulfur 12 Sulfur 14
Bind with dextrin in Bind with dextrin in water
water

Brilliant White

Potassium Perchlorate 12
Aluminum Dust 4
Dextrin 1
Bind with water

Golden Twinkler Stars - Falls through the air and burns in an on and off manner. The effect is spectacular. A pumped or cut star.

Potassium Nitrate 18
Sulfur 3
Lampblack 3
Aluminum Powder 3
Antimony Sulfide 3
Sodium Oxalate 4
Dextrin 2
Bind with water

Zinc Spreader Stars - Shoot out pieces of burning zinc and charcoal. These stars are much heavier than usual, and require larger charges if they're to be fired from a tube.

Zinc Dust 72
Potassium Chlorate 15
Potassium Dichromate 12
Granular Charcoal 12
Dextrin 2
bind with water

Electric Stars - Stars that contain aluminum powder

Potassium Nitrate 15 Potassium Chlorate 60
Aluminum, fine 2 Barium Nitrate 5
Aluminum, medium 1 Aluminum, fine 9
Black Powder 2 Aluminum, medium 4
Antimony Sulfide 3 Aluminum, coarse 3
Sulfur 4 Charcoal 2
bind with dextrin in Dextrin 5
water bind with red gum in
water

Potassium Perchlorate 6
Barium Nitrate 1 Potassium Perchlorate 4
Aluminum 20 Aluminum, medium 2
Dextrin 1 Dextrin 1
bind with shellac in bind with shellac in alcohol
alcohol

Simpler Zinc Spreaders

Potassium Nitrate 14 Potassium Chlorate 5
Zinc Dust 40 Potassium Dichromate 4
Charcoal 7 Charcoal, medium 4
Sulfur 4 Zinc Dust 24
bind with dextrin in bind with dextrin in water
water

Willow Tree Stars - Use large amounts of lampblack -- too much to burn fully. Gives a willow tree effect.

Potassium Chlorate 10
Potassium Nitrate 5
Sulfur 1
Lampblack 18
bind with dextrin in water

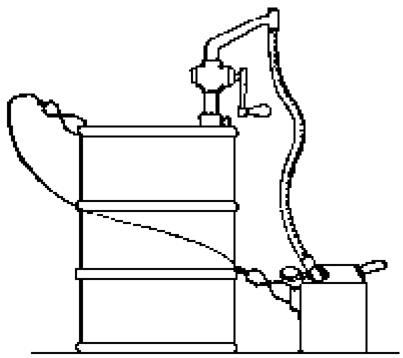
COLOR	MATERIAL	USED IN
red	strontium (strontium nitrate)	road flares, salts,red sparklers,
green	barium salts (barium nitrate)	green sparklers
yellow	sodium salts (sodium nitrate)	gold sparklers
blue	powdered copper old pennies	blue sparklers,
white	powdered magnesium or aluminum	firestarters, aluminum foil
purple	potassium permanganate	purple fountains, treating sewage

Chemical Equivalency List

Acacia.........	Gum Arabic
Acetic Acid..............	Vinegar
Aluminum Oxide.....................	Alumia
Aluminum Potassium Sulphate......	Alum
Aluminum Sulfate....................	Alum
Ammonium Carbonate.............	Hartshorn
Ammonium Hydroxide............	Ammonia
Ammonium Nitrate...................	Salt Peter
Ammonium Oleate	Ammonia Soap
Amylacetate.............	Banana Oil
Barium Sulfide	Black Ash
Carbon Carbinate....	Chalk
Carbontetrachloride	Cleaning Fluid
Calcium Hypochloride	Bleaching Powder
Calcium Oxide	Lime
Calcium Sulfate	Plaster of Paris
Carbonic Acid	Seltzer
Cetyltrimethylammoniumbromide	Ammonium Salt
Ethylinedichloride.........	Dutch Fluid
Ferric Oxide	Iron Rust
Furfuraldehyde.........................	Bran Oil
Glucose.................	Corn Syrup
Graphite.....................	Pencil Lead
Hydrochloric Acid	Muriatic Acid
Hydrogen Peroxide	Peroxide
Lead Acetate	Sugar of Lead
Lead Tero-oxide	Red Lead
Magnesium Silicate	Talc
Magnesium Sulfate..	Epsom Salt
Methylsalicylate...........	Winter Green Oil
Naphthalene	Mothballs
Phenol	Carbolic Acid
Potassium Bicarbonate	Cream of Tarter
Potassium Chromium Sulfate	Chromealum
Potassium Nitrate	Salt Peter
Sodium Oxide.....	Sand
Sodium Bicarbonate	Baking Soda
Sodium Borate	Borax
Sodium Carbonate	Washing Soda
Sodium Chloride.........	Salt
Sodium Hydroxide	Lye
Sodium Silicate	Glass
Sodium Sulfate	Glauber's Salt
Sodium Thiosulfate	Photographer's Hypo
Sulfuric Acid	Battery Acid
Sucrose	Cane Sugar
Zinc Chloride	Tinner's Fluid
Zinc Sulfate	White Vitriol

OSHA:Flammable and Combustible Liquids

FLAMMABLE AND COMBUSTIBLE LIQUIDS - 1910.106



Introduction

The primary basis of this standard is the National Fire Protection Association's publication NFPA 30, Flammable and Combustible Liquids Code. This standard applies to the handling, storage, and use of flammable and combustible liquids with a flash point below 200°F. There are two primary hazards associated with flammable and combustible liquids: explosion and fire. In order to prevent these hazards, this standard addresses the primary concerns of: design and construction, ventilation, ignition sources, and storage.

Definitions

There are a number of definitions included in 1910.106. These definitions were derived from consensus standards, and were not uniquely developed for OSHA regulations. Some of the more important definitions are discussed below.

Aerosol shall mean a material which is dispensed from its container as a mist, spray, or foam by a propellant under pressure.

Approved shall mean approved or listed by a nationally recognized testing laboratory.

Boiling point shall mean the boiling point of a liquid at a pressure of 14.7 pounds per square inch absolute (psia). This pressure is equivalent to 760 millimeters of mercury (760 mm Hg).

At temperatures above the boiling point, the pressure of the atmosphere can no longer hold the liquid in the liquid state and bubbles begin to form. The lower the boiling point, the greater the vapor pressure at normal ambient temperatures and consequently the greater the fire risk.

Container shall mean any can, barrel, or drum.

Closed container shall mean a container so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures.

Fire area shall mean an area of a building separated from the remainder of the building by construction having a fire resistance of at least 1 hour and having all communicating openings properly protected by an assembly having a fire resistance rating of at least 1 hour.

Flash point means the minimum temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid. The flash point is normally an indication of susceptibility to ignition.

The flash point is determined by heating the liquid in test equipment and measuring the temperature at which a flash will be obtained when a small flame is introduced in the vapor zone above the surface of the liquid.

A standard closed container is used to determine the closed-cup flash point and a standard open-surface dish for the open-cup flash point temperature, as specified by the American Society for Testing and Materials (ASTM). These methods are referenced in OSHA's 1910.106 standard.

Combustible liquid means any liquid having a flash point at or above 100^{o}F (37.8^{o}C). Combustible liquids shall be divided into two classes as follows:

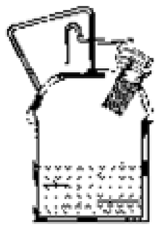
> **Class II liquids** shall include those with flash points at or above 100^{o}F (37.8^{o}C) and below 140^{o}F (60^{o}C), except any mixture having components with flash points of 200^{o}F (93.3^{o}C) or higher, the volume of which make up 99 percent or more of the total volume of the mixture.
>
> **Class III liquids** shall include those with flash points at or above 140^{o}F (60^{o}C). Class III liquids are subdivided into two subclasses:
>
>> **Class IIIA** liquids shall include those with flash points at or above 140^{o}F (60^{o}C) and below 200^{o}F (93.3^{o}C), except any mixture having components with flash points of 200^{o}F (93.3^{o}C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.
>>
>> **Class IIIB** liquids shall include those with flash points at or above 200^{o}F (93.3^{o}C). This section does not regulate Class IIIB liquids. Where the term "Class III liquids" is used in this section, it shall mean only Class IIIA liquids.

When a combustible liquid is heated to within 30^{o}F (16.7^{o}C) of its flash point, it shall be handled in accordance with the requirements for the next lower class of liquids.

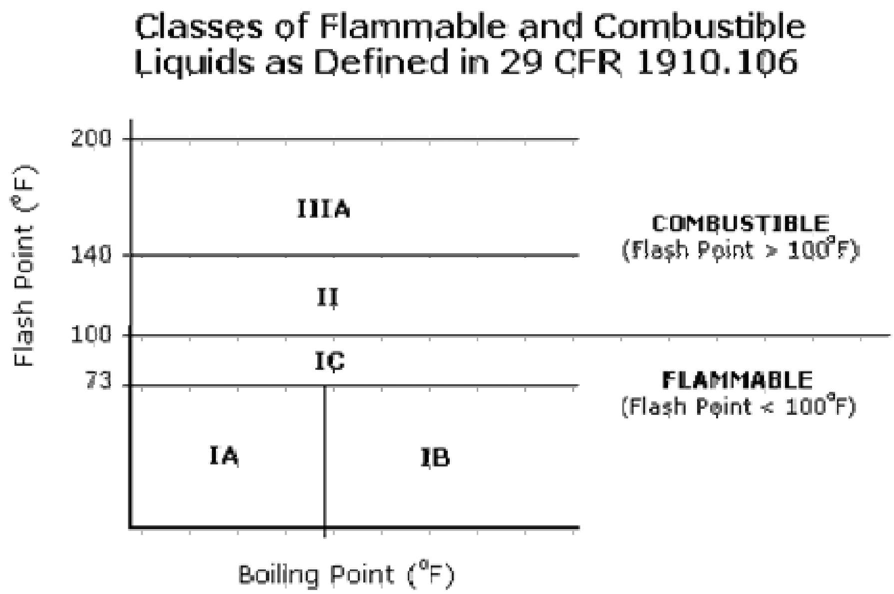
Flammable liquid means any liquid having a flash point below 100^{o}F (37.8^{o}C) or higher, the total of which make up 99 percent or more of the total volume of the mixture. Flammable liquids shall be known as Class I liquids. Class I liquids are divided into three classes as follows:

> **Class IA** shall include liquids having flash points below 73^{o}F (22.8^{o}C) and having a boiling point below 100^{o}F (37.8^{o}C).
>
> **Class IB** shall include liquids having flash points below 73^{o}F (22.8^{o}C) and having a boiling point at or above 100^{o}F (37.8^{o}C).
>
> **Class IC** shall include liquids having flash points at or above 73^{o}F (22.8^{o}C) and below 100^{o}F (37.8^{o}C).

It should be mentioned that flash point was selected as the basis for classification of flammable and combustible liquids because it is directly related to a liquid's ability to generate vapor, i.e., its volatility. Since it is the vapor of the liquid, not the liquid itself, that burns, vapor generation becomes the primary factor in determining the fire hazard. The expression "low flash - high hazard" applies. Liquids having flash points below ambient storage temperatures generally display a rapid rate of flame spread over the surface of the liquid, since it is not necessary for the heat of the fire to expend its energy in heating the liquid to generate more vapor.



The above definitions for classification of flammable and combustible liquids are quite complex. The diagram below should aid in their understanding.



Portable tank shall mean a closed container having a liquid capacity over 60 U.S. gallons and not intended for fixed installation.

Safety can shall mean an approved container, of not more than 5 gallons capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

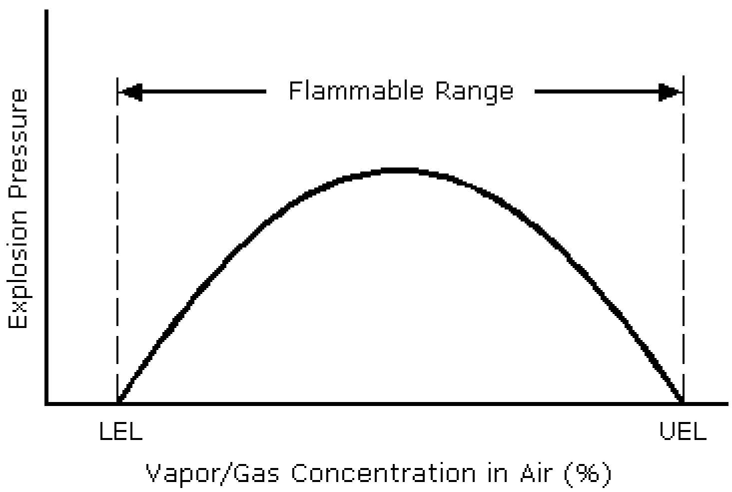
Vapor pressure shall mean the pressure, measured in pounds per square inch (absolute) exerted by a volatile liquid as determined by the Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method), American Society for Testing and Materials ASTM D323-68.

Vapor pressure is a measure of a liquid's propensity to evaporate. The higher the vapor pressure, the more volatile the liquid and, thus, the more readily the liquid gives off vapors.

Ventilation as specified in this section is for the prevention of fire and explosion. It is considered adequate if it is sufficient to prevent accumulation of significant quantities of vapor-air mixtures in concentration over one-fourth of the lower flammable limit.

Flammable (Explosive) Limits

When vapors of a flammable or combustible liquid are mixed with air in the proper proportions in the presence of a source of ignition, rapid combustion or an explosion can occur. The proper proportion is called the flammable range and is also often referred to as the explosive range. The flammable range includes all concentrations of flammable vapor or gas in air, in which a flash will occur or a flame will travel if the mixture is ignited. There is a minimum concentration of vapor or gas in air below which propagation of flame does not occur on contact with a source of ignition. There is also a maximum proportion of vapor in air above which propagation of flame does not occur. These boundary-line mixtures of vapor with air are known as the lower and upper flammable or explosive limits (LEL or UEL) respectively, and they are usually expressed in terms of percentage by volume of vapor in air. See figure below.



In popular jargon, a vapor/air mixture below the flammable limit is too "lean" to burn or explode, and a mixture above the upper flammable limit is too "rich" to burn or explode. No attempt is made to differentiate between the terms flammable and explosive as applied to the lower and upper limits of flammability.

Container and Portable Tank Storage

Scope

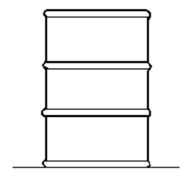
This section applies only to the storage of flammable or combustible liquids in drums or other containers (including flammable aerosols) not exceeding 60 gallons individual capacity and portable tanks of less than 660 gallon individual capacity. A portable tank is a closed container which has a liquid capacity of over 60 gallons and is not intended for fixed installations.

This section does not apply to the following:

- Storage of containers in bulk plants, service stations, refineries, chemical plants, and distilleries;
- Class I or Class II liquids in the fuel tanks of a motor vehicle, aircraft, boat, or portable or stationary engine;
- Flammable or combustible paints, oils, varnishes, and similar mixtures used for painting or maintenance when not kept for a period in excess of 30 days;
- Beverages when packed in individual containers not exceeding 1 gallon in size.

Design, Construction, and Capacity of Containers

Only approved containers and portable tanks may be used to store flammable and combustible liquids. Metal containers and portable tanks meeting the requirements of the Department of Transportation (DOT) (49 CFR 178) are deemed acceptable when containing products authorized by the DOT (49 CFR 173).



The latest version of NFPA 30, Flammable and Combustible Liquids Code, indicates that certain petroleum products may be safely stored within plastic containers if the terms and conditions of the following specifications are met:

(a) ANSI/ASTM D 3435-80, Plastic Containers (Jerry Cans) for Petroleum Products.

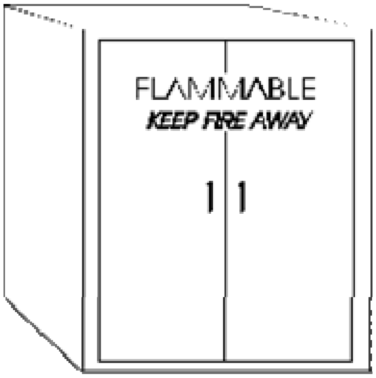
(b) ASTM F 852-86, Standard for Portable Gasoline Containers for Consumer Use.

(c) ASTM F 976-86, Standard for Portable Kerosine Containers for Consumer Use.

(d) ANSI/UL 1313-83, Nonmetallic Safety Cans for Petroleum Products.

This standard also requires portable tanks to have provision for emergency venting. Top-mounted emergency vents must be capable of limiting internal pressure under fire exposure conditions to 10 psig or 30 percent of the bursting pressure of the tank, whichever is greater. Portable tanks are also required to have at least one pressure-activated vent with a minimum capacity of 6,000 cubic feet of free air at 14.7 psia and 60^{o}F. These vents must be set to open at not less than 5 psig. If fusible vents are used, they shall be actuated by elements that operate at a temperature not exceeding 300^{o}F.

Maximum allowable sizes of various types of containers and portable tanks are specified based on the class of flammable and combustible liquid they contain.



Design, Construction and Capacity of Storage Cabinets

Not more than 60 gallons of Class I and/or Class II liquids, or not more than 120 gallons of Class III liquids may be stored in an individual cabinet.

This standard permits both metal and wooden storage cabinets. Storage cabinets shall be designed and constructed to limit the internal temperature to not more than 325^{o}F when subjected to a standardized 10-minute fire test. All joints and seams shall remain tight and the door shall remain securely closed during the fire test. Storage cabinets shall be conspicuously labeled, "Flammable - Keep Fire Away."

The bottom, top, door, and sides of metal cabinets shall be at least No. 18 gage sheet metal and double walled with 1½-inch air space. The door shall be provided with a three-point lock, and the door sill shall be raised at least 2 inches above the bottom of the cabinet.

Design and Construction of Inside Storage Rooms

Construction

Construction is to comply with the test specifications included in NFPA 251-1969, Standard Methods of Fire Tests of Building Construction and Materials.

Openings to other rooms or buildings shall be provided with non-combustible liquid-tight raised sills or ramps at least 4 inches in height, or the floor in the storage area shall be at least 4 inches below the surrounding floor. Openings shall be provided with approved self-closing fire doors. The room shall be liquid-tight where the walls join the floor. A permissible alternate to the sill or ramp is an open-grated trench inside of the room which drains to a safe location. This method may be preferred if there is an extensive need to transfer flammable liquids into and out of the room by means of hand trucks.

Rating and Capacity
Storage in inside storage rooms shall comply with the following:

STORAGE IN INSIDE ROOMS			
Fire Protection Provided[1]	Fire Resistance	Maximum Floor Area (ft^2)	Total Allowable Quantities (gal/ft^2 floor area)
Yes	2 hr.	500	10
No	2 hr.	500	4*
Yes	1 hr.	150	5*
No	1 hr.	150	2

* NOTE: These numbers are incorrectly shown in 29 CFR 1910.106.

FOOTNOTE(1) Fire protection system shall be sprinkler, water spray, carbon dioxide, or other system.

Wiring
Electrical wiring and equipment located in inside storage rooms used for Class I liquids shall be approved under Subpart S, Electrical, for Class I, Division 2 Hazardous Locations; for Class II and Class III liquids, shall be approved for general use.

Ventilation
Every inside storage room shall be provided with either a gravity or a mechanical exhaust ventilation system designed to provide for a complete change of air within the room at least six times per hour. Ventilation is vital to the prevention of flammable liquid fires and explosions. It is important to ensure that air flow through the system is constant and prevents the accumulation of any flammable vapors.

Storage
In every inside storage room, there shall be maintained an aisle at least 3 feet wide. Easy movement within the room is necessary in order to reduce the potential for spilling or damaging the containers and to provide both access for fire fighting and a ready escape path for occupants of the room, should a fire occur.

Containers over 30 gallons capacity shall not be stacked one upon the other. Such containers are built to DOT specifications and are not required to withstand a drop test greater than 3 feet when full.

Dispensing shall be only by approved pump or self-closing faucet.

Storage Inside Buildings

Egress
Flammable or combustible liquids, including stock for sale, shall not be stored so as to limit use of exits, stairways, or areas normally used for the safe egress of people.

Office Occupancies
Storage shall be prohibited except that which is required for maintenance and operation of equipment. Such storage shall be kept in closed metal containers stored in a storage cabinet or in safety cans or in an inside storage room not having a door that opens into that portion of the building used by the public.

General Purpose Public Warehouses
There are tables in the standard summarizing the storage requirements applicable to "General Purpose Public Warehouses." These tables refer to indoor storage of flammable and combustible liquids which are confined in containers and portable tanks. Storage of incompatible materials that create a fire exposure (e.g., oxidizers, water-reactive chemicals, certain acids and other chemicals) is not permitted.

Warehouses or Storage Buildings
The last type of inside storage covered by this paragraph addresses storage in "warehouses or storage buildings." These structures are sometimes referred to as outside storage rooms. Practically any quantity of flammable and combustible liquid can be stored in these buildings provided that they are stored in a configuration consistent with the tables in this paragraph.

Containers in piles shall be separated by pallets or dunnage where necessary to provide stability and to prevent excessive stress on container walls.

Stored material shall not be piled within 3 feet of beams or girders and shall be at least 3 feet below sprinkler deflectors or discharge orifices of water spray, or other fire protection equipment.

Aisles of at least 3 feet in width shall be maintained to access doors, windows or standpipe connections.

Storage Outside Buildings
Requirements covering "storage outside buildings" are summarized in tables in this paragraph. Associated requirements are given for storage adjacent to buildings. Also included are requirements involving controls for diversion of spills away from buildings and security measures for protection against trespassing and tampering. Certain housekeeping requirements are given which relate to control of weeds, debris and accumulation of unnecessary combustibles.

Fire Control

Suitable fire control devices, such as small hose or portable fire extinguishers, shall be available at locations where flammable or combustible liquids are stored.

At least one portable fire extinguisher having a rating of not less than 12-B units shall be located:

- outside of, but not more than 10 feet from, the door opening into any room used for storage; and
- not less than 10 feet, nor more than 25 feet, from any Class I or Class II liquid storage area located outside of a storage room but inside a building.

The reason for requiring that portable fire extinguishers be located a distance away from the storage room is that fires involving Class I and Class II flammable liquids are likely to escalate rapidly. If the fire is too close to the storage area, it may be impossible to get to it once the fire has started.

Open flames and smoking shall not be permitted in flammable or combustible liquid storage areas.

Materials which react with water shall not be stored in the same room with flammable or combustible liquids. Many flammable and combustible liquid storage areas are protected by automatic sprinkler or water spray systems and hose lines. Consequently, any storage of water-reactive material in the storage area creates an unreasonable risk.

Industrial Plants

Scope

This paragraph applies to those industrial plants where:

- the use of flammable or combustible liquids is incidental to the principal business; or
- where flammable or combustible liquids are handled or used only in unit physical operations such as mixing, drying, evaporating, filtering, distillation, and similar operations which do not involve chemical reaction.

This paragraph shall not apply to chemical plants, refineries or distilleries.

Incidental Storage or Use of Flammable or Combustible Liquids

Application
This subparagraph is applicable to those portions of an industrial plant where the use and handling of flammable or combustible liquids is only incidental to the principal business, such as paint thinner storage in an automobile assembly plant, solvents used in the construction of electronic equipment, and flammable finishing materials used in furniture manufacturing.

Containers

Flammable or combustible liquids shall be stored in tanks or closed containers.

The quantity of liquid that may be located outside of an inside storage room or storage cabinet in a building or in any one fire area of a building shall not exceed:

- 25 gallons of Class IA liquids in containers
- 120 gallons of Class IB, IC, II, or III liquids in containers
- 660 gallons of Class 1B, 1C, II, or III liquids in a single portable tank.

Handling Liquids at Point of Final Use

Flammable liquids shall be kept in covered containers when not actually in use.

Where flammable or combustible liquids are used or handled, except in closed containers, means shall be provided to dispose promptly and safely of leakage or spills.

Flammable or combustible liquids shall be drawn from or transferred into vessels, containers, or portable tanks within a building only in the following manner:

(1) Through a closed piping system,

(2) From safety cans,

(3) By means of a device drawing through the top, or

(4) From containers or portable tanks by gravity through an approved self-closing valve.

Transfer operations must be provided with adequate ventilation. Sources of ignition are not permitted in areas where flammable vapors may travel.

Transferring liquids by means of air pressure on the container or portable tanks is prohibited. This may result in an overpressure which could exceed what the container or tank could withstand. In addition, a flammable atmosphere could be created within the container or tank. This atmosphere would be particularly sensitive to ignition because of the increased pressure.

(18) Combustible liquid means any liquid having a flashpoint at or above 100°F (37.8°C). Combustible liquids shall be divided into two classes as follows:

(i) Class II liquids shall include those with flashpoints at or above 100°F (37.8°C) and below 140°F (60°C), except any mixture having components with flashpoints of 200°F (93.3°C) or higher, the volume of which make up 99 percent or more of the total volume of the mixture.

(ii) Class III liquids shall include those with flashpoints at or above 140°F (60°C). Class III liquids are subdivided into two subclasses:

> (a) Class IIIA liquids shall include those with flashpoints at or above 140°F (60°C) and below 200°F (93.3°C), except any mixture having components with flashpoints of 200°F (93.3°C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.
>
> (b) Class IIIB liquids shall include those with flashpoints at or above 200°F (93.3°C). This section does not cover Class IIIB liquids. Where the term "Class III liquids" is used in this section, it shall mean only Class IIIA liquids.

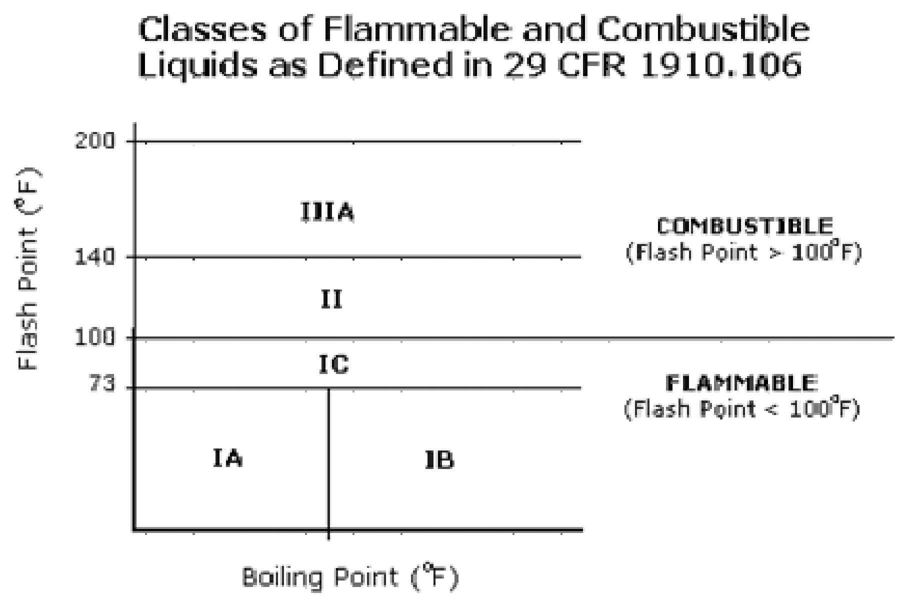
(iii) When a combustible liquid is heated for use to within 300°F (16.7°C) of its flashpoint, it shall be handled in accordance with the requirements for the next lower class of liquids.

(19) Flammable liquid means any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°C) or higher, the total of which make up 99 percent or more of the total volume of the mixture. Flammable liquids shall be known as Class I liquids. Class I liquids are divided into three classes as follows:

(i) Class IA shall include liquids having flashpoints below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C).

(ii) Class IB shall include liquids having flashpoints below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C).

(iii) Class IC shall include liquids having flashpoints at or above 73°F (22.8°C) and below 100°F (37.8°C).



FLASH POINT -- the lowest temperature at which a flammable liquid will give off enough vapors to form an ignitable mixture with the air above the surface of the liquid or within its container.

LOWER FLAMMABLE LIMIT -- the percentage of vapor in the air below which a fire can't occur because there isn't enough fuel: the mixture is said to be too lean.

UPPER FLAMMABLE LIMIT -- the percentage of vapor in the air above which there isn't enough air for a fire: the mixture is said to be too rich.

VAPOR DENSITY -- the weight of a flammable vapor compared to air. (Air = 1). Vapors with a high density are more dangerous and require better ventilation because thay tend to flow along the floor and collect in low spots.

PEL -- the Permissible Exposure Limit of the vapor according to OSHA standards, expressed in parts of vapor per million parts of contaminated air. The PEL is listed because many of these substances present inhalation as well as fire hazards.

Classes of Some Flammable Liquids
Class IA

Liquid		Flash Point (°F)	Boiling Point (°F)	Flammable Limits		Vapor Density Air = 1	PEL (ppm)
Common Name	Other Names			LEL	UEL		
1-1 Dichloroethylene	Vinylidene chloride	0	99	7.3	10.0	3.4	-
Ethylamine		<0	63	3.5	14.0	1.6	10
Ethyl Chloride	Chloroethane	-58	54	3.8	15.4	2.2	1000
Ethyl Ether	Ether	-49	95	1.9	36.0	2.6	400
Isopentane		<-60	82	1.4	7.6	2.5	-
Isopropyl Chloride	2-Chloropropane	-26	97	2.8	10.7	2.7	-
Methyl Formate		-2	90	5.0	23.0	2.1	100
Pentane		<-40	97	1.5	7.8	2.5	1000
Propylene Oxide		-35	93	2.8	37.0	2.0	100

Class IB

Liquid		Flash Point (°F)	Boiling Point (°F)	Flammable Limits		Vapor Density Air = 1	PEL (ppm)
Common Name	Other Names			LEL	UEL		
Acetone		0	134	2.6	12.8	2.0	1000
Benzene	Benzol	12	176	1.3	7.1	2.8	1
Carbon Disulfide	Carbon bisulfide	-22	115	1.3	50.0	2.6	20
1,2-Dichloroethylene	Acetylene dichloride	43	140	9.7	12.8	3.4	200
Ethyl Acetate		24	171	2.2	11.0	3.0	400
Ethyl Alcohol	Ethanol, Grain alcohol	55	173	3.3	19	1.6	1000
Ethyl Benzene		59	277	1.0	6.7	3.7	100
Gasoline		-45	100-399	1.4	7.6	3-4	-
Hexane		-7	156	1.1	7.5	3.0	500
Methyl Acetate		14	135	3.1	16	2.6	200
Methyl Alcohol	Wood alcohol, Methanol	52	147	6.7	3.6	1.1	200
Methyl Ethyl Ketone	MEK, 2-Butanone	21	176	1.8	10	2.5	200
Methyl Propyl Ketone	2-Pentanone	45	216	1.5	8.2	2.9	200
VM&P Naphtha	76 Naphtha	20-45	212-320	0.9	6.0	4.2	-
Octane		56	257	1.0	6.5	3.9	500
Propyl Acetate		58	215	2.0	8.0	3.5	200
Isopropyl Acetate		40	192	1.8	8.0	3.5	250
Isopropyl Alcohol	IPA, 2-propanol	53	180	2.0	12	2.1	400
Toluene	Toluol	40	232	1.2	7.1	3.1	200
Butyl Acetate		72	260	1.7	7.6	4.0	150

Class IC

Liquid		Flash Point (°F)	Boiling Point (°F)	Flammable Limits		Vapor Density Air = 1	PEL (ppm)
Common Name	Other Names			LEL	UEL		
Isoamyyyl Acetate	Banana Oil	77	288	1.0	7.5	4.5	100
Amyl Alcohol	Pentanol	91	281	1.2	10	3.0	
Butyl	Butanol	84	243	1.4	11.2	2.6	100
Methyl Isobutyl Ketone	MIBK, Hexone	73	246	1.4	7.5	3.5	100
Naphtha (Petroleum)	Mineral Spirits, Petroleum Ether	85-110	302-399	0.8	6.0	4.2	-
Propyl Alcohol	Propanol	77	208	2.1	13.5	2.1	200
Styrene (Monomer)	Vinyl Benzene	90	295	1.1	6.1	3.6	100
Turpentine		95	307-347	0.8	-	-	100
Xylene	Xylol	81-115	281-291	1.1	7.0	3.7	100

Class II

Liquid		Flash Point (°F)	Boiling Point (°F)	Flammable Limits		Vapor Density Air = 1	PEL (ppm)
Common Name	Other Names			LEL	UEL		
Isoamyl		109	268	1.2	-	3.0	100
Cellosolve Acetate	2-Ethoxyethyl acetate	117	313	1.7	-	4.7	100
Cyclohexanone		111	313	-	-	3.4	50
Fuel Oil #1 & #2		100+	-	-	-	-	-
Fuel Oil #4		110+	-	-	-	-	-
Fuel Oil #5		130+	-	-	-	-	-
Kerosene		110-150	180-300	0.7	5.0	4.5	-
Naphtha (coal tar)		100-110	300-400	-	-	4.3	100
Naphtha (High Flash)	100 Naptha Safety Solvent, Stoddard Solvent	100-110	300-400	0.8	6.0	>4.2	500
Methyl Cellosolve	2-Methoxyethanol	115	255	2.5	14.0	-	25

Class III

Liquid		Flash Point (°F)	Boiling Point (°F)	Flammable Limits		Vapor Density Air = 1	PEL (ppm)
Common Name	Other Names			LEL	UEL		
Aniline		158	363	1.3	-	3.2	5
Butyl Cellosolve	2-Butoxyethanol	160	340	1.1	10.6	4.1	50
Cellosolve Solvent	2-Ethozyethanol Cellosolve Solvent	202	275	1.8	14.0	3.1	200
Cyclohexanol		162	322	-	-	2.5	50
Ethylene Glycol	Glycol	232	387	3.2	-	-	-
Furfural		140	324	2.1	19.3	3.3	5
Glycerine	Glycerol	320	554	-	-	3.2	-
Isophorone		184	419	0.8	3.8	-	25
Nitrobenzene		190	412	-	-	4.3	1

Non-Flammable Liquids(*)

Liquid		Boiling Point (°F)	PEL (ppm)
Common Name	Other Names		
Carbon Tetrachloride		171	10
Chloroform	Trichloromethane	142	50
Ethylene Dibromide	1,2-Dibromoethane	270	20
Methyl Chloroform	1,1,1-Trichloroethane	165	350
Methylene Chloride	Dichloromethane	104	500
Perchloroethylene	Tetrachloroethylene	248	100
Trichloroethylene	TCE, Trichlor	190	100