Flammable & Combustible Liquids - Hazards

What are flammable and combustible liquids?

Flammable and combustible liquids are liquids that can burn. They are classified, or grouped, as either flammable or combustible by their flashpoints. Generally speaking, flammable liquids will ignite (catch on fire) and burn easily at normal working temperatures. Combustible liquids have the ability to burn at temperatures that are usually above working temperatures.

There are several specific technical criteria and test methods for identifying flammable and combustible liquids.

- Flammable liquids have a flashpoint below 37.8°C (100°F).
- Combustible liquids have a flashpoint at or above 37.8°C (100°F) and below 93.3°C (200°F).

Flammable and combustible liquids are present in almost every workplace. Fuels and many common products like solvents, thinners, cleaners, adhesives, paints, waxes and polishes may be flammable or combustible liquids. Everyone who works with these liquids must be aware of their hazards and how to work safely with them.

What is a flashpoint?

The flashpoint of a liquid is the lowest temperature at which the liquid gives off enough vapour to be ignited (start burning) at the surface of the liquid. Sometimes more than one flashpoint is reported for a chemical. Since testing methods and purity of the liquid tested may vary, flashpoints are intended to be used as guides only, not as fine lines between safe and unsafe.

Does the liquid itself burn?

Flammable and combustible liquids themselves do not burn. It is the mixture of their vapours and air that burns. Gasoline, with a flashpoint of -40°C (-40°F), is a flammable liquid. Even at temperatures as low as -40°C (-40°F), it gives off enough vapour to form a burnable mixture in air. Phenol is a combustible liquid. It has a flashpoint of 79°C (175°F), so it must be heated above that temperature before it can be ignited in air.

What are flammable or explosive limits?

A material's flammable or explosive limits also relate to its fire and explosion hazards. These limits give the range between the lowest and highest concentrations of vapour in air that will burn or explode.

The lower flammable limit or lower explosive limit (LFL or LEL) of gasoline is 1.4 percent; the upper flammable limit or upper explosive limit (UFL or UEL) is 7.6 percent. This means that gasoline can be ignited when it is in the air at levels between 1.4 and 7.6 percent. A concentration of gasoline vapour in air below 1.4 percent is too "lean" to burn. Gasoline vapour levels above 7.6 percent are too "rich" to burn. Flammable limits, like flashpoints however, are intended as guides not as fine lines between safe and unsafe.

What is an Auto ignition Temperature?

A material's auto ignition or ignition temperature 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). Some have very low auto ignition temperatures. For example, ethyl ether has an auto ignition temperature of 160°C (356°F) and its vapours have been ignited by hot steam pipes. Serious accidents have resulted when solvent-evaporating ovens were heated to temperatures above the auto ignition temperature of the solvents used. Auto ignition temperatures, however, are intended as guides, not as fine lines between safe and unsafe. Use all precautions necessary.
How can flammable and combustible liquids be a fire or explosion hazard?

At normal room temperatures, flammable liquids can give off enough vapour to form burnable mixtures with air. As a result, they can be a serious fire hazard. Flammable liquid fires burn very fast. They also give off a lot of heat and often clouds of thick, black, toxic smoke.

Combustible liquids at temperatures above their flashpoint also release enough vapour to form burnable mixtures with air. Hot combustible liquids can be as serious a fire hazard as flammable liquids.

Spray mists of flammable and combustible liquids in air may burn at any temperature if an ignition source is present. The vapours of flammable and combustible liquids are usually invisible. They can be hard to detect unless special instruments are used.

Most flammable and combustible liquids flow easily. A small spill can cover a large area of workbench or floor. Burning liquids can flow under doors, down stairs and even into neighbouring buildings, spreading fire widely. Materials like wood, cardboard and cloth can easily absorb flammable and combustible liquids. Even after a spill has been cleaned up, a dangerous amount of liquid could still remain in surrounding materials or clothing, giving off hazardous vapours.

What is the danger of flashback?

Vapours can flow from open liquid containers. The vapours from nearly all flammable and combustible liquids are heavier than air. If ventilation is inadequate, these vapours can settle and collect in low areas like sumps, sewers, pits, trenches, basements and vessel bilges. The vapour trail can spread far from the liquid. If this vapour trail contacts an ignition source, the fire produced can flash back (or travel back) to the liquid. Flashback and fire can happen even if the liquid giving off the vapour and the ignition source are hundreds of metres or several floors apart.

Can flammable or combustible liquids be hazardous to my body?

The most obvious harm would be the danger of a fire or explosion. After the immediate danger of a fire, there are sometimes other properties of these liquids that may be hazardous to the body. Flammable and combustible liquids can also cause health problems depending on the specific material and route of exposure (breathing the vapour/mist, eye or skin contact, or swallowing). Some flammable and combustible liquids are corrosive. Many undergo dangerous chemical reactions if they contact incompatible chemicals such as oxidizing materials, or if they are stored improperly.

The Material Safety Data Sheet and the supplier's labels on the containers should tell you about all the hazards for the flammable and combustible liquids that you work with.

An example is 2-propanol (also known as: dimethylcarbinol, isopropanol, or isopropyl alcohol). It is a colourless liquid with a sharp odour like rubbing alcohol or resembling that of a mixture of ethanol and acetone. It is flammable liquid and vapour. Vapour is heavier than air and may spread long distances. Distant ignition and flashback are possible. It is also considered to be a mild central nervous system depressant. Breathing the vapour may cause headache, nausea, dizziness, drowsiness, unco-ordination and confusion. It may also be irritating to the respiratory tract or eyes.
How Do I Work Safely with Flammable and Combustible Liquids? (General)

Why should I substitute with less hazardous material where possible?

**Substitution can be the best way to avoid or reduce a hazard.** Often, though, it is not easy or even possible to find a non-flammable or less flammable substitute to do the job effectively and safely. Start by obtaining material safety data sheets (MSDS’s) for all possible substitute materials. Find out about all the hazards (fire, health, chemical reactivity) of these materials before making any changes.

Choose the least hazardous materials that can do the job effectively and safely. Learn how to work safely with them also.

What are ignition sources?

For a flammable or combustible liquid fire to start, a mixture of vapour and air must be ignited. There are many possible ignition sources:

- Sparks from electrical tools and equipment.
- Sparks, arcs and hot metal surfaces from welding and cutting.
- Cigarette smoking.
- Open flames from portable torches and heating units, boilers, pilot lights, ovens, and driers.
- Hot surfaces such as boilers, furnaces, steam pipes, electric lamps, hot plates, irons, hot ducts and flues, electric coils and hot bearings.
- Embers and sparks from incinerators, foundry cupolas, fireboxes and furnaces.
- Sparks from grinding and crushing operations.
- Sparks caused by static electricity from rotating belts, mixing operations or improper transfer of flammable or hot combustible liquids.

You can eliminate many of these ignition sources by:

- Removing open flames and spark-producing equipment.
- Not smoking around these liquids.
- Using approved explosion-proof equipment in hazardous areas.

What is spontaneous combustion?

Spontaneous combustion occurs when a material in contact with air can heat up sufficiently (without an outside heat source) to burn. The oils in some wastes and rubbish can slowly react with oxygen in the air. This reaction creates heat that can build up over time if the wastes are left undisturbed. When the heat level in a "self-heating material" is high enough (i.e., when the temperature reaches the autoignition temperature), a fire may start.

For example, rag soaked with vegetable oil in the bottom of a pail could heat up enough to cause spontaneous combustion of the rag. However, the same oil-soaked rag would not be expected to heat up on a clothes line because there would sufficient contact with moving air that would prevent heat from building up. An oil-soaked rag would not heat up if it were in a tight bale because it would not have enough air. Similarly, wet or improperly cured hay stored loose (i.e., not baled) in a barn is susceptible to heating up enough to cause spontaneous combustion. In the cases of spontaneous combustion of hay, grain and oil seeds, the source of heat comes from the action of microorganisms (e.g., bacteria, fungi) on materials having the right moisture and temperature conditions. Damp charcoal, meals (i.e., ground seeds), materials (fabrics, rags, cotton, etc.) soaked with paints containing drying oils are some other examples of materials have a spontaneous combustion hazard.
**Why is good ventilation important?**

Well-designed and maintained ventilation systems remove flammable vapours from the workplace and reduce the risk of fire and health problems.

The amount and type of ventilation needed to minimize the hazards of flammable and combustible liquid vapours depend on such things as the kind of job, the kind and amount of materials used, and the size and layout of the work area.

An assessment of the specific ways flammable and combustible liquids are stored, handled, used and disposed of is the best way to find out if existing ventilation controls (and other hazard control methods) are adequate.

Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. If flammable vapours are likely to condense, the ducts should have welded joints. Other workplaces may only require a single, well-placed exhaust fan. Use non-ferrous fan blades and shrouds (housing), and explosion-proof electrical equipment in ventilation systems for these liquids. Regular cleaning of the ducts, filters, plenums, etc. will decrease the severity of any fires and will reduce the likelihood of spontaneous combustion if some self-heating material is present. Ventilation equipment used to handle solvent vapours should meet the relevant fire code requirements.

If the ventilation keeps vapour levels below the occupational exposure limit of a chemical, usually there is little risk of fire or explosion. Vapour levels harmful to people are, in most cases, much below the lowest concentration of vapour in air that can burn. For example, toluene has a workplace exposure limit of 20 ppm [50 parts of toluene per million parts of air or 0.005 percent] (ACGIH 2008 TLVs & BEIs) in many jurisdictions. This is far below the lower flammable limit (LFL) for toluene, which is 12,000 ppm (1.2 percent).

In baking and drying ovens, enclosed air-drying spaces, ventilation duct work or other enclosures where workers are not normally exposed to the vapour, keep vapour levels to 20 percent or less of the LFL.

**How do I store flammable and combustible liquid containers properly?**

Store flammable and combustible liquids according to the laws, including building, fire, and electrical codes, that apply to your particular workplace. These laws specify the kinds of storage areas, such as storage rooms and cabinets, allowed for these liquids. They also specify how to construct these storage areas and the amounts of flammable and combustible liquids in different types of containers that you can store in each kind of storage area. There may also be restrictions about the volume (how much) of product that can be stored. For example: in some jurisdictions, containers used to store flammable or combustible liquids that are smaller than 230 litres, must meet the specifications in following regulations (for construction of the container):

"Transportation of Dangerous Goods Regulations"
"Portable containers for Gasoline and Other Petroleum Fuels"
"Portable Fuel Tanks for Marine Use"
"Safety Containers"
"Portable Tanks for the Transportation of Dangerous Goods"

Your local fire code will specify the quantity of liquid that may be stored at the workplace.

Containers of not more than 1 litre capacity used for flammable liquids (5 litres for combustible liquids) are generally exempt.

Ensure that all containers have safety labels attached, where applicable.

Never use plastic or glass containers for storing flammable liquids unless storage in metal containers would affect the required liquid purity or if the liquid would cause excessive corrosion of the metal container.
In all cases, allow only trained, authorized people into storage areas. Before storing, inspect all incoming containers to ensure that they are not damaged and are properly labelled. Do not accept delivery of defective containers.

In general, store containers of flammable and combustible liquids separately, away from process and production areas, and away from other materials. This separation will reduce the spread of any fire to other materials in storage. It will also protect the stored flammable and combustible liquids from exposure to fires in other areas, and accidental contact with incompatible materials.

Keep containers closed when not in use.

Keep the amount of materials in storage as small as possible. It is a good practice to keep no more than one day's supply of flammable and combustible liquids in the immediate work area. Return any leftover material to the proper storeroom or storage cabinet at the end of the day.

**What should a good storage area be like?**

Store flammable and combustible liquids in areas that are:

- well ventilated to reduce vapour concentrations.
- free of ignition sources.
- cool (temperature controlled) and dry.
- supplied with adequate firefighting and spill clean-up equipment.
- away from elevators, building and room exits, or main aisles leading to exits.
- accessible by firefighters.
- labelled with suitable warning signs. For example: "No Smoking".

Avoid storing flammable and combustible liquids in basements. Ground floor storage is usually preferred as it provides easier access for emergency situations.

Inspect storage areas regularly for any deficiencies such as damaged or leaking containers, poor ventilation or non-approved equipment. Unapproved modifications or damage to approved or explosion-proof equipment or systems could result in unintended hazardous conditions. Correct all deficiencies as soon as possible.

It may be possible to store small amounts of flammable liquids (less than 235 litres) and combustible liquids (less than 470 litres) in approved containers in specially designed storage cabinets near their point of use.

Volatile, flammable liquids are sometimes stored in refrigerators. Use specially designed and approved refrigerators (generally described as "laboratory safe") for this. Standard domestic refrigerators contain many ignition sources and should not be used for storing flammable solvents.

**How do I handle drums safely?**

Many workplaces receive flammable liquids in large metal drums or barrels, then fill smaller containers from them. Moving full drums weighing hundreds of pounds by hand can be difficult and hazardous. Specially designed drum cradles are available for moving drums around and can also be used as individual drum storage racks.

**Why is venting of flammable liquid drums important?**

Drums of flammable liquids should have pressure- and vacuum-relief venting installed. Normally, this is done as soon as the drum is opened for dispensing. If a stored drum will be exposed to heat sources or large temperature changes, relief venting may be needed.

Storing a full drum in direct sunlight or near other heat sources can increase vapour levels in the drum. This leads to an increase in pressure that could, in extreme cases, cause the drum to rupture. A build up in pressure can also result in vapour shooting out into the face or onto the clothing of the person opening the drum. A pressure-relief vent prevents this
Vacuum-relief vents are also useful. If a drum of flammable liquid is subjected to sudden cooling, a partial vacuum can form inside it. This could, in extreme cases, cause the drum to collapse and leak. Also, for proper dispensing of liquids, the space left behind by the liquid in the drum must be replaced with air so that no vacuum forms. There are different kinds of pressure-relief and vacuum-relief devices, including combination types, available from safety equipment retailers.

**What type of containers should I use?**

Whenever possible, use approved, properly labelled safety containers when working with flammable and combustible liquids. "Approved" containers are containers that have been approved by testing laboratories acceptable to government enforcement agencies. These laboratories include Underwriters Laboratories of Canada (ULC), Canadian Standards Association (CSA) and Factory Mutual Research (FM). There are many different kinds of approved containers available from safety equipment retailers.

**Safety Cans**

Portable safety cans for carrying, storing and dispensing flammable and combustible liquids are widely used. They are available in different shapes and in capacities from 0.5 to 25 litres. Approved safety cans are made from metal or very low conductivity plastic. Safety cans have spring-mounted spout caps. These automatically open when the vapour pressure builds up inside, to allow vapours to escape and prevent rupture (or explosion, in the event of fire). The cap-operating mechanisms also cause the spout cap to close automatically when you finish filling or pouring from the safety can, or if the can is dropped.

This safety feature could create a hazard under some conditions. In a warm enclosed space, such as a car trunk, vapours venting from a safety can may reach flammable levels. A spark could cause an explosion. For temporary transport of small amounts (normally less than 25 litres) of flammable liquid, use an approved pressure-resistant and non-venting container. Eliminate ignition sources and ensure good ventilation, too.

Safety cans may also have wire mesh flame arrester screens inside the cap spouts. These prevent flashbacks from reaching the liquid in the cans.

**Other Approved Containers:**

Other types of approved containers include:

- rinse and cleaning tanks for dipping or washing parts in liquid.
- plunger cans for moistening cleaning rags.
- bench cans for dipping and rinsing small parts.
- dispenser or "benzine" cans for dispensing small amounts of liquid directly on work or cloths.
- containers for disposal of flammable and combustible liquids and oily rags and waste.

These approved safety containers also have different kinds of safety devices, such as self-closing lids or flame arresters. Containers like some rinse or dip tanks, or oily rag and waste cans with lids that are not self-closing are held open by fusible link devices. In the event of a fire in an open container, the fusible link melts, closing the lid and smothering the fire.

In certain cases, flammable and combustible liquids may be stored, handled and used in approved, non-reusable glass or plastic containers (usually the ones they are shipped in), holding no more than 1 gallon (U.S.) or 3.8 L. This may be acceptable if the required liquid purity (such as analytical reagent grade or higher) is affected by storage in metal containers, or if the liquid causes excessive corrosion of metal containers.

**Why should I inspect the container?**

Check all containers used for flammable and combustible liquids regularly to make sure that
they are not damaged, that spring-operated mechanisms are working properly and that flame arresters are not broken. Safety container manufacturers will provide detailed ways to inspect their equipment for safe operation.

**Why should I label containers?**

Properly label all containers used for flammable and combustible liquids. This helps prevent accidentally mixing one chemical with another and reduces the chances of mistaking one liquid for another. Plainly mark the name of the liquid and its hazard on the container. Keep the label clean so that it can be easily seen at all times. Never use a container for any liquid except the one that is marked on the label.

Using unsuitable containers such as jam jars, saucers, open cans, buckets or pails is a dangerous practice. Open containers allow hazardous vapours to escape. Breakable containers increase the chance of serious spills.

**How do I dispense or transfer flammable and combustible liquids carefully?**

Take care when dispensing or transferring flammable and combustible liquids from one container to another. Dispense from only one container at a time. Finish dispensing one material before starting to dispense another. Be sure containers are closed after dispensing to control hazardous vapours and to avoid accidental spills. Approved transfer pumps and drum faucets that cannot be left running accidentally are available. Check these devices periodically to be sure that they work properly and do not leak.

Use an approved safety drip can below each drum faucet to catch spills or drips from worn or damaged faucets.

Never dispense flammable and combustible liquids near ignition sources. Always make sure that metal containers are bonded and grounded when dispensing.

Never transfer liquids by pressurizing their usual shipping containers with air. The pressure may damage ordinary drums and barrels, or create a flammable atmosphere inside the containers. Mark dispensing areas with suitable warning signs.

**How do I dispose of waste material safely?**

Store waste flammable and combustible liquids in the same way as unused flammable and combustible liquids. Clean drums made of compatible material can be used to store waste liquids if they are vented, grounded and bonded similarly to dispensing drums. Approved safety disposal cans are also available for waste liquids.

Place cloth, paper and other solid materials that are soaked with flammable and combustible liquids in approved oily waste disposal cans. These are made of metal and have self-closing lids. Do not overfill them, and empty them at least at the end of every workday to reduce the chance of spontaneous combustion.

Clearly label all waste containers with their contents.

Be careful with "empty" flammable and combustible liquid containers. They may contain enough liquid to create an explosion hazard. Only about 14 ml (0.5 fluid ounce) of liquid are needed to give enough vapour to form an explosive atmosphere in a 182-litre (40-gallon) drum. This amount can easily be trapped in a seam or be present as a very thin film on the inner surface of the drum. Do not perform any work (welding, cutting, drilling, soldering) on an "empty" liquid container until all liquid and vapours have been cleaned out. Contact the chemical manufacturer or supplier for the best way to do this.

Never pour waste flammable liquids down sinks or drains. Dispose of them through hazardous waste collection and disposal companies. Dispose of these wastes according to the environmental laws that apply to your jurisdiction. Contact the appropriate environmental officials for advice.
Why is it important to practice good housekeeping and maintain equipment?

Good housekeeping and equipment maintenance are important wherever any chemicals, including flammable and combustible liquids, are used:

- Keep all areas where these liquids are stored, handled or used clear of burnable materials.
- Provide drip trays and empty them often wherever recurring leakages occur.
- Consider using splash guards to enclose machines or processes that eject flammable or combustible liquids.
- Clean up liquid spills immediately.
- Remove any obstructions that prevent containers with lids held open by fusible links from closing fully.
- Make sure that flammable and combustible liquids are not left where they could block or otherwise prevent people from escaping in case of a fire.

Regular equipment inspection and maintenance are important for controlling the hazards of flammable and combustible liquids.

- Ensure maintenance personnel know the hazards of the materials to which they might be exposed.
- Carry out repairs to equipment properly, including special equipment like explosion-proof fittings. Fires and explosions have resulted from the addition of non-approved parts or equipment to approved systems.
- Do not use safety containers that are damaged in any way. If repairs using approved parts cannot restore safety containers to a safe condition, discard the containers once they have been properly cleaned.

When should I wear proper Personal Protective Equipment (PPE)?

You must wear the PPE necessary for the job you are doing.

If other methods, such as engineering controls, are not available or effective in controlling exposure to toxic materials, wear suitable personal protective equipment (PPE).

Choosing the right PPE to wear when doing a particular job is essential. The other hazards of the flammable and combustible liquid may need to be addressed such health toxicity and reactivity. MSDS’s should provide general guidance. Selecting PPE for a specific job is best done with the help of someone who knows how to evaluate the hazards of the job and how to select the proper PPE such as the plant safety officer or in consultation with the Health and Safety Committee.

Know and be familiar with the right PPE for emergencies, as well as for normal operations.

What should I do in an emergency?

Be ready to handle emergencies safely. In emergencies like chemical fires and spills, act fast.

- Leave the area at once if you are not trained to handle the problem or if it is clearly beyond your control.
- Alert other people in the area to the emergency. (Raise the alarm)
- Call the fire department immediately.
- Report the problem to the people responsible for handling emergencies where you work.
- Obtain first aid if you have been exposed to harmful chemicals and remove all contaminated clothes. Emergency eyewash stations and safety showers should be present wherever accidental exposure to materials that can damage skin or eyes might occur.

Only specially trained people, equipped with the proper tools and protective equipment, should handle the emergency. Nobody else should go near the area until it is declared safe. Planning, training and practicing for emergencies are important so that everyone knows
what they must do.

The MSDSs for the materials you are using are a good starting point for drawing up an emergency plan. MSDSs have specific sections on fire and explosion hazards including suitable fire extinguishing equipment and methods (using the wrong fire extinguisher or using it incorrectly is dangerous), spill clean-up procedures, and first aid instructions. If the directions in each MSDS section are not clear or seem incomplete, contact the material’s manufacturer or supplier for help.

You can obtain help in developing emergency plans from many other sources too. Local fire departments can assist with fire emergency plans and training. Occupational health and safety and environmental enforcement agencies, provincial safety associations, St. John Ambulance, insurance carriers, professional societies in occupational health and safety, labour unions, trade associations, some local colleges and universities, and CCOHS can supply useful information at little or no cost. Specialized private consultants are also available.

What are basic safety practices for flammable and combustible liquids?

Following these basic safe practices will help protect you from the hazards of flammable and combustible liquids:

- Obtain and read the Material Safety Data Sheets (MSDSs) for all of the materials you work with.
- Be aware of all of the hazards (fire/explosion, health, chemical reactivity) of the materials you work with.
- Know which of the materials that you work with are flammable or combustible liquids.
- Eliminate ignition sources (sparks, smoking, flames, hot surfaces) when working with flammable and combustible liquids.
- Use the smallest amount of flammable liquid necessary in the work area.
- Keep storage areas cool and dry.
- Store flammable and combustible liquids away from incompatible materials (e.g., oxidizers).
- Use approved containers for disposal of rags and other work.
- Store, handle and use flammable and combustible liquids in well-ventilated areas.
- Use approved equipment, including labelled safety containers, for flammable and combustible liquids.
- Keep containers closed when not in use.
- Bond and ground metal containers when transferring flammable and combustible liquids.
- Practice good housekeeping and equipment maintenance. Keep area clear of burnable materials.
- Wear the proper personal protective equipment for each of the jobs you do.
- Know how to handle emergencies (fires, spills, personal injury) involving the flammable and combustible liquids you work with.

Follow the health and safety rules that apply to your job.

How Do I Work Safely with Flammable and Combustible Liquids?
(Static Electricity)

What is static electricity and how is it generated?

Static electricity is the electric charge generated when there is friction between two things made of different materials or substances, like clothes tumbling in your dryer. Static electricity is what causes the sparks when you comb your hair or touch a metal object, like a doorknob, after walking across a carpet on a cold, dry day (especially during Canadian winters). It can also be generated by repeated contact and separation between unlike
materials, like a flat belt on a rotating pulley.

Electric charges can build up on an object or liquid when certain liquids (e.g., petroleum solvents, fuels) move in contact with other materials. This can occur when liquids are poured, pumped, filtered, agitated, stirred or flow through pipes. This build up of electrical charge is called static electricity. Even when liquids are transported or handled in non-conductive containers, something rubbing the outside surface of the container may cause a static charge to build up in the liquid. The amount of charge that develops depends, in part, on how much liquid is involved and how fast is it flowing or is being agitated or stirred.

Is static electricity hazardous?

Depending on circumstances it can be a nuisance or a hazard. Static cling in your clothes can be a nuisance but a spark that has enough energy to cause a fire or explosion is a definite hazard. To decide if static electricity is likely to be a hazard, you must consider several factors:

- Can a static electric charge be generated under the operating conditions?
- Can the charge accumulate?
- If it discharges, will it cause a spark?
- Is there an ignitable mixture (e.g., solvent vapour or dust in the air) in the area where a static electricity discharge can occur?
- Will the discharge generate an incendive spark, i.e., a spark that has enough energy to ignite the mixture in air?

If the answer to the above five questions is yes where a solvent or fuel is used, then static electricity can be a fire / explosion hazard. It means that the spark can ignite a vapour/air mixture that is in its flammable range, the concentration range between the upper and the lower flammable limits.

What kind of solvents are likely to be a static electricity hazard?

Flammable and combustible liquids can present a static electricity hazard depending on their ability to generate static electricity, how well they conduct electricity (conductivity), and their flash point.

Solvents and fuels produced from petroleum (e.g., benzene, toluene, mineral spirits, gasoline, jet fuel) can build up a charge when they are poured or flow through hoses. They tend to hold a charge because they cannot conduct electricity well enough to discharge when in contact with a conducting material, like a metal pipe or container that is grounded. When enough of a charge is built up, a spark may result. If the vapour concentration of the liquid in air is in the "flammable range" and the spark has enough energy, a fire or explosion can result.

According to the NFPA (Code 77), solvents that are soluble in water (or can dissolve some water themselves) do not build up static electricity. Examples of such liquids include alcohols and ketones like acetone. However, when liquids are transferred into non-conductive containers (e.g., plastic, glass), even conductive solvents may build up a charge because the plastic or glass containers decrease the rate at which the charge in the solvent dissipates.

The flash point and vapour pressure of the liquid and the temperature are other factors to consider. The vapour levels will be higher in the air around the container if you are working outside on a hot summer day than in the winter when the temperature is below 0°C (32°F) or colder.

At higher elevations in the mountains, the air pressure is significantly lower and solvents boil at lower temperatures. Under these conditions, the flash point and the temperature for the optimal vapour/air ratio are lower and some "combustible" liquids can become "flammable".

A liquid like hexane has a low flash point and it is flammable when its temperature is in the range -33°C to -3°C (-28°F to +26°F) at sea level. At normal room temperatures, the vapour/air ratio at the surface of the solvent will be well above its upper flammability limit and would be "too rich" to burn. However, at some distance away from the solvent surface,
there is a concentration of hexane vapour in the air that is in the flammable range.

A fuel like kerosene is a combustible liquid with a flash point above 38°C (100°F). Under hot weather conditions or if high flash point liquids are heated to temperatures around or above their flash points, a flammable vapour/air mixture will form.

Generally, the conditions for igniting a liquid are optimal when the liquid is used at a temperature that produces a vapour in air concentration (at the surface of the liquid) that is halfway between the upper and lower flammability limits. Recognizing that these conditions represent an "optimal" fire hazard, one has to take appropriate precautions.

**Why is it important to bond and ground containers?**

Transferring a liquid from one metal container to another may result in static electrical sparks. To prevent the build up of static electricity and prevent sparks from causing a fire, it is important to bond metal dispensing and receiving containers together before pouring. Bonding is done by making an electrical connection from one metal container to the other. This ensures that there will be no difference in electrical potential between the two containers and, therefore, no sparks will be formed.

The best way to bond containers is to securely attach a special metal bonding strap or wire to both containers. Some liquid transfer pumps have self-bonding hoses. Bonding can also be done by keeping a solid metal-to-metal contact between the containers themselves or between a metal container and a conducting nozzle. These latter two methods are usually not reliable because a good electrical contact is often hard to make and maintain during the entire transfer.

In the flammable liquid storage and dispensing area, ground dispensing drums. Grounding is done by connecting the container to an already grounded object that will conduct electricity. This could be a buried metal plate, a metallic underground gas piping system, metal water pipes or a grounded, metal building framework. Bonding both containers and grounding one of them "drains off" static charges and prevents the discharge of sparks. All grounding and bonding connections must be bare metal to bare metal. Remove all dirt, paint, rust or corrosion from points of contact. Specially designed and approved bonding and grounding wire assemblies are available from safety equipment retailers.
Do all kinds of containers have to be bonded or grounded?

You only need to bond those containers that conduct electricity, such as those made from metal or special, conductive plastics. If a container is made from a material that does not conduct electricity, such as polyethylene plastic or glass, bonding or grounding is not necessary: in fact grounding the container will not have any effect.

Are there special precautions to take when filling non-conductive containers?

Even if a liquid is conductive, filling or handling plastic or other non-conducting containers can be hazardous. The splashing and turbulence of the liquid in the container can cause a static electric charge to build up in the liquid or on conductive parts on the container that are not grounded. A spark with enough energy to ignite a vapour/air mixture in its flammable range (an incendive discharge) can originate from the liquid or from the container.

For medium-sized containers (5 - 60 U.S. gallons or about 19 - 227 L) it is advisable to ground any metal parts on the container (and nearby conductive surfaces that the container may come in contact) and fill the container from the bottom through a long, grounded metal pipe. This procedure will reduce the amount of static charge produced and will enable the generated charge to relax (dissipate) through the metal pipe.

When filling non-conducting portable containers, the NFPA recommends that a grounded dip pipe or grounded wire be in the liquid in the container while it is being filled. The filling rate should be minimized, especially if there is filter in the line. Any metal parts of the container and metal funnel, if one is used, should also be grounded. When filling containers with low-conductivity liquids (i.e., ones with a conductivity less than 50 picoSiemens, pS), one should keep the grounded dip rod in the liquid for around 30 seconds after the filling is completed.

Similarly, filling an ungrounded portable fuel tank on a plastic-lined truck bed can cause spark-induced gasoline fires. For that reason, portable fuel tanks should be removed a safe distance from the vehicle (which, of course, is turned off) and be filled on the ground. The nozzle should be held in contact with the container while it is being filled.

When do I need to bond and ground containers?

Bonding and grounding are needed when dispensing flammable or hot combustible liquids from storage drums to smaller electrically conductive containers. Similarly, whenever you transfer these liquids between conductive containers in any work areas, for example, when filling or draining dip tanks, mixers, rinse tanks or other equipment, bond both containers together and ground one of them. Check bonding and grounding connections regularly to ensure they are in good condition.