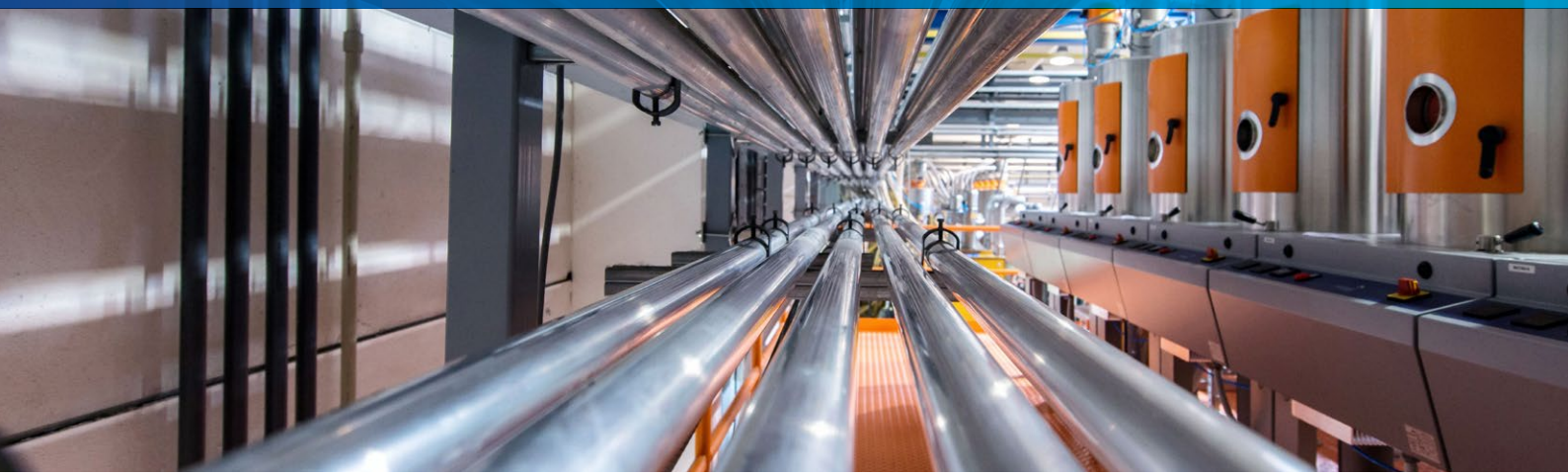
Swiss Re
Corporate Solutions

Risk Engineering Services

Flammable and combustible liquids Mixing operations



The use of flammable and combustible liquids is common in the manufacturing processes of items such as paints, cosmetics, personal care and cleaning products, as well as pharmaceuticals, among others. Due to the fire and explosion hazards associated with these materials, a number of measures should be considered to help prevent or control incidents that could result in extensive property damage and production downtime. Are your plants protected?

The fire hazard involving flammable and combustible liquids arises from vapors emanating from the surface of these substances. When the temperature of a flammable or combustible liquid, whether the liquid is in a natural state (room temperature) or heated, reaches or exceeds its flash point, vapors evolved will have enough concentration to ignite and burn, causing a flash when exposed to an ignition source. If the temperature of the liquid is at or above its fire point, then vapors, if ignited, will sustain combustion.

In addition to fire, flammable and combustible liquids may also create an explosion hazard. For this to occur, all the following conditions must exist: (1) accumulation of flammable liquid vapors within a confined space, (2) presence of an explosive mixture of flammable liquid vapors and air, and (3) an ignition source.

In broad terms, NFPA 30 (flammable and Combustible Liquids Code) defines flammable liquids as those having a flash point below 100° F (37.8° C), and combustible liquids as those with a flash point at or above 100° F (37.8° C).

Due to the fire and explosion hazards, the handling of flammable liquids used in industrial processes requires a high level of care. The same applies to combustible liquids when heated above their flash point, as they behave in the same way as flammable liquids. This is the case with heat transfer fluids*, for example.

The prevention and protection measures indicated below are a useful tool for companies to deal with the risks associated with processes and operations that involve the use of flammable liquids.

Throughout this document, the term flammable liquid also refers to combustible liquids heated above their flash point. This guide does not apply to processes and operations involving chemical reactions, distillation, solvent extraction, refining or the manufacture of petroleum-based products, in addition to the storage of flammable and combustible liquids.

Examples of flammable liquids

Acetone	Hexane
Isopropyl Alcohol	Methanol
Benzine	Methyl-Ethyl-Ketone
Ethanol	Pentane
Gasoline	Toluene

Examples of combustible liquids

Essences	Insulating mineral oil
Fuel oil	Corn oil
Hydraulic oil	Soybean oil
Lubricants	Organic heat transfer fluids*

Prevention and protection measures

Construction and location

- Operations involving the use of flammable liquids should take place in non-combustible buildings.

- For operations using amounts of flammable liquids which, if released and ignited, could cause a substantial amount of property damage, the following should be considered:
  - Process areas should be provided with automatic sprinklers or water spray systems designed in accordance with NFPA or equivalent standards.
  - If the above is not possible (ex. a facility with no water supply) conduct operations in a reinforced concrete building or protect structural steel supporting the building structure and process equipment with fireproofing. Fireproofing should be rated for the hydrocarbon fire exposure.
  - Regardless of the chosen option, steel building columns or vessel supports exposed to a flammable liquid fire need protection.

- Preferably, operations involving the use of flammable substances should be carried out in a dedicated building, isolated from other areas by a minimum distance separation of 50 ft (15 m).

- If this is not feasible, isolation should be promoted between the operation involving flammable liquids and any other operation or area through fire rated walls.

- An alternative to installing fire walls, would be to enclose these operations in a fire rated vault with masonry walls and a concrete slab.

- In either case, openings to adjacent internal areas should be protected by self-closing fire doors.

- Depending on the type of process and the volumes of flammable liquids used, construction should be robust enough to withstand the pressures anticipated in the event of an explosion. Alternatively, buildings and structures should be fitted with mechanisms to relieve the over-pressures resulting from an explosion.

  In assessing room explosion hazard, the following should be considered:
  - Usually flammable or combustible liquids heated above their flashpoint, but below atmospheric boiling point pose more of a fire risk than an explosion risk.
  - For mixing facilities without atmospheric distillation or vapor phase organic heat transfer systems, a full complement of damage-limiting construction (i.e. a combination of pressure venting and pressure resistant walls) is generally not necessary. Ventilation should still be provided as outlined.

- Buildings may require drainage to direct a flammable liquid spill or pool fire from a process area to a safe location. Drainage systems should be designed to handle the anticipated worst case release of material plus the water needed for firefighting (automatic systems and hose streams). The need for drainage is dependent on a number of factors. Liquids that are fully miscible in water, heavier than water and/or have very high flash points generally do not require large drainage systems.

- Means of containment should be provided to prevent spills from reaching adjacent aboveground/ underground areas. Again, the expected amount of liquids release and their characteristics will determine how much and where containment is required.

Classified electrical equipment

- Electrical equipment in process areas using flammable liquids should be properly classified in order to avoid the possibility that they act as a source of heat / ignition. This includes lighting fixtures, switches, power outlets, electric motors, electrical panels, data processing, automation, instrumentation and telecommunications systems. If required, only classified forklifts should be used. The main concern is with processes in which flammable liquids are used in open or semi-open systems.

- An adequate classification of process areas where flammable liquids are used should be carried out in accordance with the designation of classes, divisions and zones as defined in Chapter 5 of NFPA 70 – National Electrical Code.

- Design, selection and installation of electrical wiring and utilization equipment should meet the requirements of NFPA 30 – Flammable and Combustible Liquids Code, Chapter 7.

Static electricity – dissipation through bonding and grounding

- Bonding is used to reduce the electrical potential difference between conductive objects, even where the resulting system is not grounded. Grounding, on the other hand, equalizes the electrical potential difference between the object and the earth.

- To avoid the accumulation of static electricity generated in the handling and transfer of flammable liquids, all equipment should be reduced to the same electrical potential through connection and grounding devices.

- Grounding:
  - All fixed equipment handling flammable liquids should be grounded through suitable conductors, or metallic bond wires. This includes mixing tanks, vessels and containers, piping, pumps and transfer mechanisms, among others.
  - Grounding connections should be provided for movable equipment and containers, such as portable tanks, or temporary IBC type storage and transfer containers.
  - Containers made of non-conductive material or which do not allow for proper grounding, should not be used in operations involving the handling and transfer of flammable liquids.

- Bonding. Any transfer of flammable liquids between equipment and/or containers that are not permanently installed and grounded, should only occur if there are means to promote the electrical grounding of at least one of the pieces of equipment or containers involved and if both have been reduced to the same electrical potential through connectors or cables.

Ignition sources

- Smoking should not be allowed in any area where flammable liquids are present.
- Avoid carrying out hot works in areas involving the processing and handling of flammable substances. If possible, hot works should be carried out in isolated areas. If this is not feasible, hot work should only be allowed if all flammable contents have been removed, and after washing containers and equipment to avoid the presence of any flammable residue. A formal permit to work procedure should be used to authorize and monitor the execution of any hot work.
- Only spark-resistant tools should be used.

Ventilation

- In process areas where flammable liquids are used in open or semi-open systems, a mechanical room exhaust system capable of providing a ventilation rate of 1 ft^3/min per ft^2 (0.3 m^3/min per m^2) of floor area should be provided.
- The room exhaust system intakes should be installed within 12in (0.3m) from the floor, as most vapors emanating from flammable liquids are denser than air and tend to accumulate near the floor.
- It is also necessary to provide spot extraction points in order to remove vapors generated in process equipment containing flammables, such as mixing tanks/vessels, or immersion containers. The points of extraction should be located at the top of such pieces of equipment or near the point from which liquids are transferred. Points of extraction should be installed within a 5ft (1.5m) radius from each potential vapor source.
- Exhaust ventilation discharge should be to a safe location outside the building.
- The exhaust fans should be interlocked with the electrical system in the area to prevent that process equipment or lighting systems be energized without the exhaust system being in operation. If vapors are released during idle periods, the exhaust system should be designed to operate continuously, and monitoring should be provided with visual and audible alarms connected to a constantly attended location.

Equipment, transfer systems and process vessels

- Process equipment and vessels should be built to prevent unintentional leakage of liquids and vapors, or to minimize the amount of liquids or vapors released, should a leak occur. In general, systems and processes containing flammable liquids should be designed so that the liquids are kept as much as possible in fully enclosed systems. This is not always possible with semi-open systems.
- Equipment and piping should be built of materials compatible with the substances being used in the process, but always seeking to use materials resistant to fire and mechanical damage, giving preference to the use of metal. Avoid using containers, permanently or temporarily, made of plastic or any other combustible material.
- Where flexible parts are required, use reinforced rubber hoses or hoses covered in wire mesh.
- For transfer operations, the following should be considered:
  - Whenever possible, transfer of flammable liquids should take place via pressurized systems using positive displacement automatic pumps or by appropriate manual pumps.
  - Transfer systems should have a mechanism that allows the operator to select the volume to be transferred before activation. In this way, the system automatically interrupts the transfer flow as soon as the pre-set volume is reached.
  - Interlocking devices should be available to prevent overpressure during pump transfer operations. The relief mechanism should discharge any excess volume back to the suction tank, pump suction intake or to a safe location.
  - For manual transfer operations (by gravity), dead-man type valves should be provided so that, when released by the operator, the flow is immediately interrupted. When dispensing from a metal drum, a safety vent bung should be provided on the larger of the two drum openings.
- Install pushbuttons to allow operators to command manual shutdown of transfer systems (pumps) in an emergency. In order to provide quick and safe access for operators, the pushbuttons should be installed in an accessible and isolated location. Transfer systems should have interlocking so that the shutdown can also take place whenever a fire protection system is activated, such as sprinklers or hoses.
- Safety shutoff valves should be provided in piping systems to stop the flow of flammable liquids in the event of a fire or explosion. Valves can be actuated automatically via fusible links and/or by means of interlocks with fire protection systems such as sprinklers and hoses. Additionally, means for safe manual actuation of shutoff valves by operators should be provided. The need for and number of safety shutoff valves should be evaluated via a hazard analysis that determines the worst credible case release scenario and the potential consequences. Safety shutoff valves should generally be considered for the following locations:
  - On the discharge of tanks installed internally or externally.
  - On the bottom piping off large mixing tanks, before any pump.
  - At points of flammable liquids use, such as supply pipes to pieces of equipment or at dispensing points.
  - At the entrance point to a building or room where flammable liquids are used.

Fire protection

- Install automatic sprinklers designed and installed in accordance with NFPA 13 – Standard for the Installation of Automatic Sprinklers, for Extra Hazard occupancies.
- For operations where large amounts of flammable solvents are used, such as paint manufacturing, consider installing sprinklers in combination with foam. If flammable liquids are non-water miscible and lighter than water, foam-water protection may be critical if adequate drainage is not or cannot be provided. In other cases, adequate water protection in combination with adequate drainage OR foam-water protection AND adequate containment may be necessary. Foam water systems should be designed and installed in accordance with NFPA 16-Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.
- Sprinklers should be installed to avoid shielding by building or equipment structural elements, or by equipment itself, including vessels and piping.
- Provide adequate manual fire protection through hose connections and fire extinguishers as required by the authority having jurisdiction.

Human element, management programs and emergency response

- Maintain good housekeeping conditions, prohibiting any kind of storage and the accumulation of combustible material in production and processing areas that use flammable liquids. This includes the storage of packaging materials or liquid or solid raw materials that are flammable or combustible.
- Follow manufacturer's guidelines regarding maintenance and testing procedures for process safety and protection systems and devices, including, but not limited to: liquid level sensors, high pressure sensors in pumping systems, automatic shutdown and liquid flow cut-off interlocks, and manual shutdown systems.
- Implement a routine of periodic inspections to check the operating status of liquid transfer systems. Particular attention should be paid to hoses and connections. Any signs of wear or leakage should be corrected immediately.
- Even in the absence of regulatory requirements, elements of Process Safety Management (PSM) should be implemented to a fundamental level. Key programs include:
  - Management of change
  - Hazard analysis/review
  - Process safety information
  - Regular operator training
  - Incident investigation

  The CCPS (Center for Chemical Process Safety) is a good resource for additional information, including publications and training courses.
- Establish specific emergency procedures to address cases involving the release and ignition of flammable liquids. As a minimum, procedures should contemplate, the following points:
  - Immediate notification to the fire department
  - Activation of the plant emergency organization
  - Cut-off the flow of flammable liquids to the processing area
  - Early identification of firefighting methods considering available equipment and building layout
  - Conducting annual drills to address all aspects of emergency response, including operation of firefighting equipment, actuation of shutoff valves, and proper shutting down of equipment, amongst others.

If you would like to find out more about this or other technical matter associated with loss prevention and control, contact our **Risk Engineering Services** team.

Technical references:

NFPA Fire Protection Handbook,
6-12 Flammable and Combustible Liquids
NFPA 30 – Flammable and Combustible Liquids Code
NFPA 13 – Standard for the Installation of Sprinkler Systems
NFPA 70 – National Electrical Code
NFPA 16 – Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems