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Inflammable Liquids – Hazards and Their Prevention

Otto Ebener*

Abstract: Spillages and fires with inflammable liquids are an enormous challenge for a task force. Only well-equipped and well-trained organisations are in a position to fulfil these tasks. This means firemen should be aware of the dangerous properties of inflammable liquids. The equipment and training must be continually examined and, if necessary, adapted.

Keywords: Earthing · Explosion limits · Inflammable liquids · Phase plan for chemical incidents · Threefold fire protection

1. Introduction

In many instances fire brigades in the chemical industry have to combat fires or chemical spillages of inflammable liquids. It is not always easy for the head of operations to make the correct decision. Besides a good tactical training, an exact knowledge of the dangers involved with inflammable liquids is required. In order that the hazards can be recognised, one must be familiar with certain concepts. This article is designed to assist in recognising and overcoming hazards.

2. Inflammable Liquids and Their Properties

The fire triangle tells us that besides fuel – in this case the inflammable liquid – sufficient oxygen and an ignition source must also be present for a fire to occur.

If one observes a liquid fire closely, it will be noticed that it is not the liquid that burns, but the nascent vapours arising from it.

2.1. *Vapour Pressure and Liquid Vapours*

If during a liquid fire only the vapours burn, the question arises as to how these vapours originate.

If a liquid is heated to its boiling point, a large quantity of vapour is formed. Vapours are formed not only by heating the liquid, but also by the surrounding temperature. This process is known as evaporation.

This evaporation is due to the vapour pressure. The leader of the task force must know that the higher the vapour pressure of a liquid, the more vapour can be formed on the surface of the liquid. If the liquid is heated, the rate of evaporation increases. If the temperature drops, the rate of evaporation automatically falls [1].

This is well illustrated taking gasoline as an example. At 20 °C gasoline is highly flammable, at –30 °C very little vapour is formed and ignition is not possible.

Liquids with higher vapour pressures thus constitute a potentially greater hazard.

2.2. *Flash Point*

The flash point is defined as the temperature at which sufficient vapours are formed at the surface of a liquid for ignition to occur when in contact with a source of ignition. If the ignition source is removed, the flame extinguishes. If liquids with different flash points are mixed, the lower value is decisive. Inflammable liquids are classified according to their flash points.

2.3. *Fire Point*

The fire point is defined as the temperature at which sufficient vapours are formed at the surface of a liquid, so that after ignition with a source of ignition the vapours continue to burn independently.

The fire point usually lies only slightly above the flash point. The higher the boiling point of a liquid, the larger the difference between its flash point and fire point [1].

2.4. *Spontaneous Ignition Temperature*

Another important parameter is the spontaneous ignition temperature of inflammable liquids. If this temperature is reached, the liquid vapours ignite by themselves. No ignition source is necessary [1].

2.5. *Flash Point/Fire Point/Spontaneous Ignition Temperature [2] (Table)*

Table.

Fuel	Flash point	Fire Point	Spontaneous Ignition Temperature
Diesel oil	76 °C	90 °C	350 °C
Paraffin	21 °C	23 °C	400 °C
Gasoline	–30 °C	–25 °C	470 °C
Carbon disulphide	–20 °C	–20 °C	120 °C

*Correspondence: O. Ebener
Lonza AG
Walliserwerke
CH-3930 Visp
Tel.: +41 27 948 5071
Fax: +41 27 947 5071
E-Mail: otto.ebener@lonza.com
www.lonza.com

2.6. *Static Charging*

If inflammable liquids have to be transferred by flowing from one container to another, then this leads to a charge separation. By internal friction in the liquid and by friction on the pipe or tubing walls, a separation of positive and negative charged particles takes place. If this charge cannot flow during its formation, since the liquid or tubing is non-conducting, then a so-called static charging will occur. If an earth connection is in the vicinity, there will be an instantaneous discharge with the formation of a spark. The energy is sufficient to ignite vapours of inflammable liquids [3].

For the industrial chemical fire brigade, 'earthing' is therefore considered to be extremely important. Today it is usual to erect a pipe construction from the earthing point in the forwards direction of the leaking container (Fig. 1).

In factory fire brigades, conducting fire hoses and fittings are generally employed. These are checked at regular intervals, and in particular after deployment.

The earthing system can thus be considerably simplified and made more practical for deployment, since the parallel earthing cables can be omitted.

The potential compensation is also a possibility. Here all points in the system (fireman, reservist, pump, generator) are connected with each other and thus prevent the build-up of different potentials.

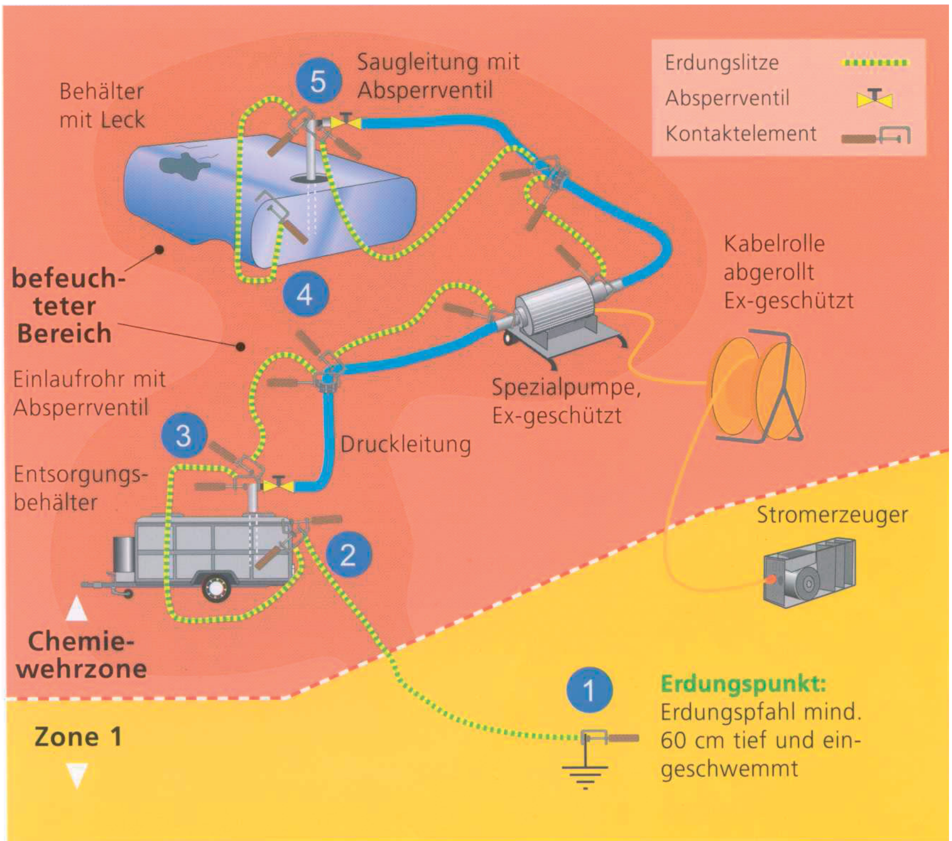

Fig. 1. Earthing to prevent electrostatic charging [4]

2.7. *Classification of Inflammable Liquids*

The flash point is taken as the reference parameter for classifying inflammable liquids. The following classes are differentiated:

F1:	Flash point	under 21 °C
F2:	Flash point	21–55 °C
F3:	Flash point	55–100 °C

2.8. *Explosion Limits*

The explosion limit is an essential concept for the chemical industry fire brigade. If inflammable vapours do not immediately ignite, explosive air/vapour mixtures are formed.

The lower and upper explosion limits are important terms in this connection. The lower explosion limit (LEL) is the lowest concentration of vapour in the air that is still ignitable. If the concentration lies under this level, the mixture is too 'lean' and cannot be ignited.

The upper explosion limit (UEL) is the highest concentration of vapour in air that is still ignitable. If the concentration lies above these limits, the mixture is said to be too 'rich' [2].

The region between the lower and upper explosion limits is called the explosive region (Fig. 2).

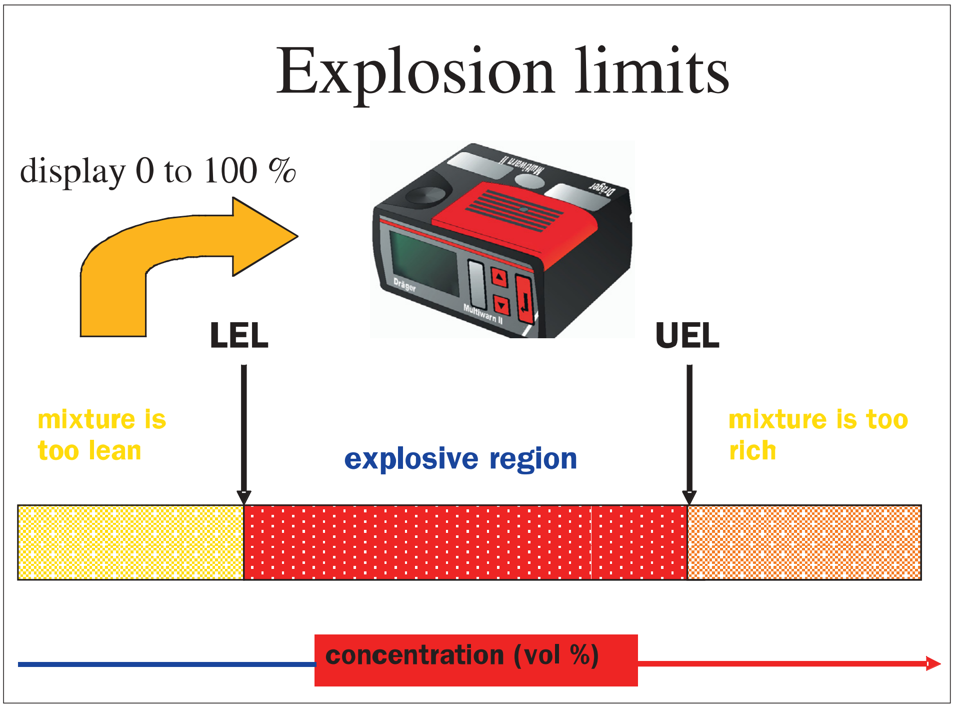

Fig. 2. Explosion limits [5]

In order to be able to safely contain the danger of explosion, permanent explosion measurements are of critical importance. Besides having a thorough knowledge of the equipment, all chemical industry firemen must be schooled in the behaviour of inflammable gases and vapours. All specialists must be able to interpret the measurements and to take the necessary tactical deployment measures. Measurements must be taken during the whole operation.

Results are bound to the place and time. Attention must be paid to employ the most reliable people for measuring explosive hazards.

The explosion measurement is the life insurance for the operating firemen.

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2.9. *Hazards for the Task Force*

In cases of a spillage, liquids spread very fast. The liquid vapours thus formed are all heavier than air and so flow downwards. Cellars, ditches, sewers *etc.* are particularly hazardous places. Various accidents both at home and abroad have shown that these vapours can travel for kilometres. Thus highly dangerous situations can arise both for the task force and for the population. If there is an ignition, flames can spread very rapidly or even explosions are likely.

For the task force the following most important hazards can be deduced

- Fire hazard
- Explosion hazard

All other dangers that can additionally arise from inflammable liquids (burns, acid burns *etc.*) are not considered here.

However in order to meet these dangers safely, the various points must be taken into consideration in the case of an incident.

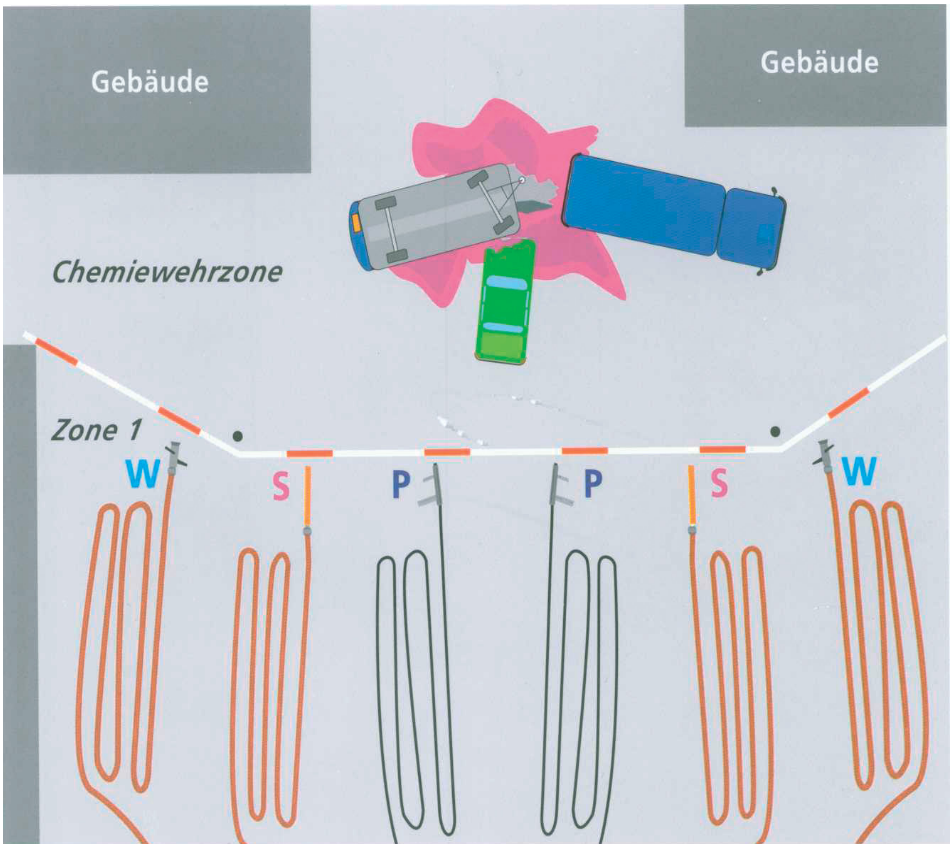

Fig. 3. Threefold fire protection with heavyweight means [4]

3. Measures for Fighting Spillages of Inflammable Liquids

In order to deal with all types of chemical accidents, a general phased plan has been worked out by the chemical fire brigade. This plan covers six phases and practically every large chemical industry fire brigade employs it today.

3.1. *Phase Plan*

Phase 1

- Approach
  - Wind direction
  - Distance
- Self Protection
  - Breathing apparatus
  - Operational equipment
- Reconnoitring/identification of substances involved
  - Warning signs/danger notices
  - Transport papers
  - Condition of the apparatus to be utilised

Phase 2

- Rescue
  - Rescue of endangered/injured people from zone 1
  - Initial decontamination of patients
- Containment
  - Precipitation of gases and vapours
  - Construction of the threefold fire protection/extinguishing attack
- Fencing off
  - Formation of zones 1 + 2
  - Chemical fire defence zone with entry and exit
  - Set-up decontamination site

Phase 3

- Restrain/collect/temporary storage
  - Full protection, light chemical protection, breathing apparatus
  - Chemically resistant containers

Basic principle: collection before sealing

Phase 4

- Sealing
  - Full protection, light chemical protection, breathing apparatus
  - Suitable sealants

Phase 5

- Pumping/absorbing
  - Full protection, light chemical protection, breathing apparatus
  - Chemically suitable pumps
  - Binding material

Phase 6

- Decontamination/clean-up
  - Decontamination of personnel and material with suitable means

All incidents can be handled according to this phase plan. Each phase must be intensively trained with the task force. Spillages with inflammable liquids are additionally classified into two categories:

- Spillages without fire
- Spillages with fire

Accordingly one speaks of the threefold fire protection or the threefold extinguishing attack. The threefold fire protection or extinguishing attack has today become generally accepted in Switzerland.

3.2. *Threefold Fire Protection*

The three extinguishing materials powder, foam, and water are deployed in this order in fire protection (Fig. 3).

Powder: rapidly available and a very good initial extinguisher.

Foam: leaking liquids are covered with foam. The foam cover must be continually kept under surveillance, if necessary renewed.

Water: cools the surroundings and protects the task force.

The threefold fire protection is set up for every spillage involving inflammable liquids without fire. The most acute attention is required from the fire-hose leaders, because they must be able to intervene immediately during the whole operation.

3.3. *Threefold Extinguishing Attack*

In the case of the threefold extinguishing attack the three extinguishing agents powder, foam, and water are utilised in this order (Fig. 4):

Water: to cool and maintain the surroundings. By removal of heat the extinguishing action is also directly supported.

Foam: extinguishes the burning liquid and provides a closed blanket of foam to prevent back ignition.

Fig. 4. Threefold extinguishing attack; the state of the art in fire-fighting. Picture by the Works Fire Brigade Lonza Ltd.

Fig. 5. Solvent fire. Picture by the Works Fire Brigade Lonza Ltd.

Powder: supports the extinguishing attack in the extinguishing phase and as a safeguarding extinguisher.

The threefold extinguishing attack is considered to be the state of the art in fire fighting. In order that the threefold extinguishing attack can be effectively implemented, a good basic training and repeated exercises are necessary. In exercises and courses frightening deficiencies are repeatedly brought to light; on the one hand in the tactical implementation of an attack, and on the other hand in the practical implementation by the hose-leaders.

3.4. *Personal Equipment*

In operations involving inflammable liquids great attention must be paid to the personal equipment of the task force.

The fire-protection equipment utilised today offers excellent heat protection on account of the various extremely resistant outer materials. This protection is however only ensured if the equipment is worn and deployed according to regulations. Today it must be clear that coats are completely buttoned up and collars turned up. This situation requires a continuous sensitisation and a regular exercising, so that these requirements also become generally accepted.

Particular attention must be paid to looking after one's personal equipment. Only intact and well looked-after protective equipment fulfils the task.

When working with toxic or corrosive substances, full protective suits or light chemical protective suits are used. These suits must be evaluated against the set requirements. Utilisation of such suits requires additional training. On this topic alone it would be possible to write a report of several pages.

4. Lonza's Fire Brigade and Its Training Opportunities

4.1. *Organisation and Tasks*

Lonza's fire brigade is a private emergency organisation founded in 1925.

From 1967 onwards the present chemical industrial fire brigade was formed under the leadership of the then commandant of the fire brigade, Rudolf Sandmeier. Lonza's fire brigade was responsible for the tactical and material development of fire fighting for the whole of the Swiss chemical industry. We are still proud of this.

Today we are a nationally recognised industrial fire brigade, consisting of six full-time professionals and 84 militia firemen.

Lonza's fire-brigade equipment is specially tailored to the requirements of the individual plants. It includes all necessary vehicles and equipment for fire- and spillage fighting. Since no similar fire brigade is present in the immediate vicinity, the equipment is very extensive. By order of the Canton of Valais, the works fire brigade is also the chemical defence base for the German-speaking part of the canton.

4.2. *Training Opportunities*

A suitable training area is necessary in order for an industrial fire brigade to be comprehensively trained.

Thanks to the far-sightedness and skill of the responsible persons, it is today still possible for the works fire brigade to train all sections of the chemical fire defence on its own exercise ground.

Particularly important are the facilities for exercising the threefold extinguishing attack. Fire exercises in a production plant, in a tank farm and in a lorry can be carried out with all extinguishing agents at the exercise area.

Every two years the fire brigade carries out a further education course on the topic 'threefold fire protection and extinguishing attack in chemical fire defence'. Firemen from all over Switzerland and the neighbouring countries participate in these courses.

The exchange of experience with other organisations and a targeted training has contributed to a well-organised works fire brigade that can fulfil its duties (Fig. 5).

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