MIE TALK - July 2016

FLASH FIRES AT FILLING STATIONS

EXPLOSIVE GAS ATMOSPHERES

Compiled by

Pieter H. Coetzee

Introduction

Far too many fires and burn injuries result from the careless or inappropriate use of petrol. Because petrol is so common in our environment, we tend to think of it as safe. Petrol gives off highly flammable vapour even at very low temperatures due to its flash point of -45°C. Because of the flammability of petrol vapours, filling stations carry a risk of fire or explosion. Any source of ignition with enough energy like static electrical discharge can ignite petrol vapours. Uncertified equipment like cell phones, smoking or card readers might become a source of ignition. Petrol vapour is heavier than air and will accumulate at the lowest possible level of its surroundings and may gather in tanks, cavities, drains, pits or other low points. The industry experiences currently a lot of flash fires at filling stations due to bad practices like inadequate bonding and earthing.

Legislation

The Electrical Machinery Regulation 9(1) requires the identification of hazardous areas and the classification thereof. In order to prevent the risk of ignition, the service station must be classified on the basis of the probability of an explosive vapour mixture forming.

Hazardous areas, as found around a service station, are classified into three zones as follow:

Table 1: Zone Classification for Vapours

Zone 0	**Present continuously or for long periods 1000hrs + per year**
Zone 1	**Could occur periodically during normal operation 10-1000 hrs per year**
Zone 2	**Present during abnormal operation, short period's 0.1-10hrs per year**

Hazardous Area Classification

The classification of filling stations should be carried out by subject matter expert specializing in the classification of hazardous locations. All zones should be marked clearly on drawings of the filling station which should be available at any time at the station as required by legislation. The zones are in 3 dimensions so the drawings will need to indicate plans and elevations, to show their full extent. The hazardous area must be divided into zones according to the grade of release (determined by the frequency with which a flammable atmosphere occurs and its duration) Ventilation could serve to reduce the extent of a hazardous area as discussed below, or could so affect the duration of the flammable atmosphere that a reduced zone can be allocated. These zoning diagrams should be contained in a document called a Hazardous Area Classification (HAC) Document as per Figure 1.

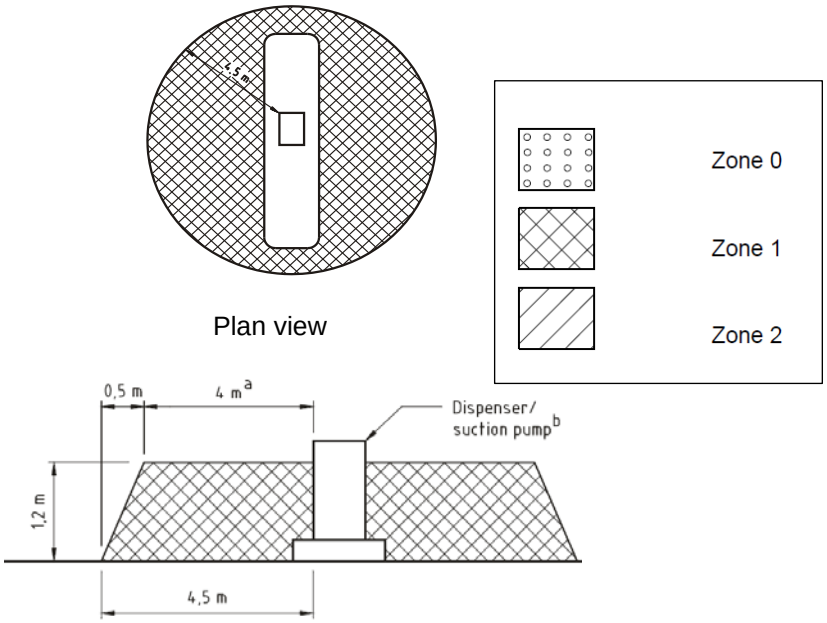


Figure 1: **Typical hazardous location classification**

Any electrical equipment (or mechanical equipment capable of generating enough heat to cause ignition) must be suitably rated and certified by a local accredited ATL like MASC or Explolabs, before it can be installed in a hazardous zone within the station. All Explosion Protected Equipment (EPE) must have an Inspection Authority (IA) certificate before any installation takes place. To ensure the integrity of the electrical installation, all service stations must have their Certificate of Compliances (COC) issued by a registered person who understands the electrical installation requirements for filling stations.

All end users (owners of filling stations) shall be in possession of a certificate in a form acceptable to the chief inspector like:

- Certificate of Compliances (COC).
- IA certificates for all Explosion Protected Equipment (EPE).
- Auditable inspection report for the 2 yearly inspections as required by EMR 9(8).
- Periodic inspection and test report for earthing and bonding systems.
- Electrical drawings as per installation

Classification of fuel dispensers

The dispenser must also comply with the area classification. Figure 2 shows hazardous locations associated with typical dispensers. Petrol dispensers should use apparatus and systems suitable for gas group IIA and temperature class T3 as defined in SANS 10089-2.

- The volume within a dispenser housing up to 1 200 mm vertically above the base is zone 1 except where the extent of the zone 1 location is limited by a vapour barrier or an air gap.
- Any area within a nozzle boot is zone 1.
- Zone 2 locations include the volume within a dispenser housing above the zone 1 area, the volume surrounding the dispenser housing within 450 mm horizontally in all directions from the zone 1 area located within the housing, and the volume within 450 mm horizontally in all directions from the opening of a nozzle boot not isolated by a vapour-tight partition, except that the area is not required to be extended around a corner of 90°.

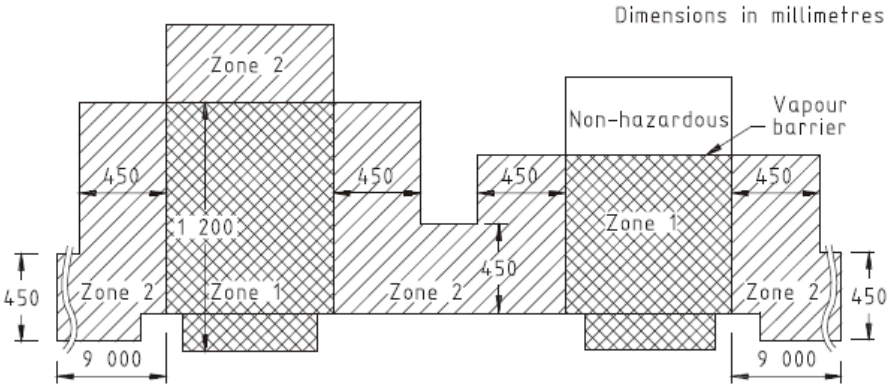


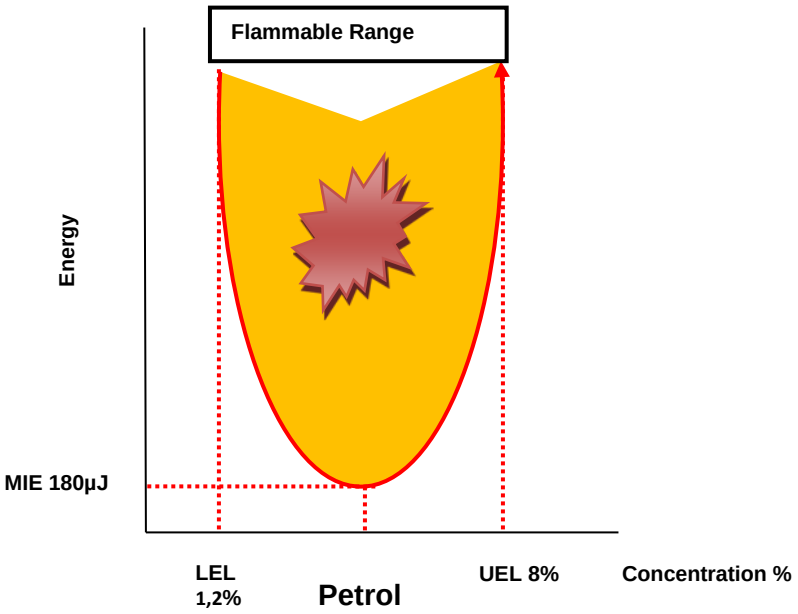
Figure 2: Hazardous locations associated with typical dispensers

Flammable properties

It shall be noted that SANS 1020 does not distinguish in its design and constructional features between dispensing units for class 1 (petrol) and class 2 (diesel and kerosene) products. We need to understand the properties of the flammable substance present at filling stations for the area classification as well as for the selection of equipment.

- **Ignition temperature:** The temperature class of the equipment must be lower than 257°C as it is not allowed to exceed the ignition temperature class of diesel in this case. The temperature class (T-Rating) of all equipment must be limited to a T3 rating.
- Before a fire or explosion can occur, three conditions must be met simultaneously. A fuel (i.e combustible gas) and oxygen (air) must exist in certain proportions, along with an ignition source, such as a spark or flame. The ratio of fuel and oxygen that is required varies with each combustible gas or vapour.
- The minimum concentration of a particular combustible gas or vapour necessary to support its combustion in air is defined as the Lower Explosive Limit (**LEL**- Petrol 1,2%) for that gas. Below this level, the mixture is too “lean” to burn. The maximum concentration of a gas or vapour that will burn in air is defined as the Upper Explosive Limit (**UEL**- Petrol 8%). Above this level, the mixture is too “rich” to burn.
- The range between the LEL and UEL is known as the flammable range for that gas or vapour as per graph below.

- **Minimum ignition energy (MIE)** is the minimum amount of energy required to ignite a combustible vapor, gas or dust cloud, for example by means of an **electrostatic discharge**.
- MIE is measured in joules (J).



Flash point: Petrol has the dangerous combination of a low flash point combined with a high vapour density. The flash point of a liquid is defined as the temperature above which the liquid produces vapours which can ignite or explode. The flash point of petrol is - 45°C. In practical terms, this means that at all temperatures above minus 45 degrees, petrol is producing vapour which can ignite or explode.

Relative Density: The vapour density is defined as the ratio of density of the vapour of a substance to the density of air. Air has a density of one. Substances with a vapour density of less than one are lighter than air and tend to dissipate easily. Substances with a vapour density greater than one are heavier than air and tend to accumulate in low places. Petrol has a vapour density of 2,8. At normal temperatures, petrol is producing vapours that can catch fire, and which accumulate in low places. These vapours can travel considerable distances from the spill point.

Table 2: Flammable properties of petrol and diesel

Gas (substance)	Ignition temperature	Explosive limit in air % (volume fraction)		Typical flash point	Relative density
	°C	Upper	Lower	°C	(air = 1)
	Subgroup IIA				
Petrol	560	8,0	1,2	−45	2,8
Diesel	257	7,5	0,6	> 55	> 1

Selection of equipment for filling stations

All electrical and electronic installation shall comply with the requirements of the safety legislation, Electrical Installation Regulations or Electrical Machinery Regulations, together with SANS 1020, SANS 10086-1, SANS 10089-2, SANS 10108 and SANS 10142-1. Uncertified electrical equipment or

systems shall not be installed or used in hazardous locations. Selection of EPE must always follow the hazardous area classification of the specific area. The designer and installer needs to take the following into account during selection of EPE for the hazardous location as it must be appropriated to the area classification:

- Type of protection
- Gas Group
- Temperature classification

All EPE shall be installed in accordance with SANS 10142-1 and SANS 60079-14: Electrical installations design, selection and erection.

Table 3: Classification of equipment for use in hazardous locations

1	2
Hazardous zone	**Equipment classification**
0	Intrinsically safe apparatus of category "ia" (Ex ia) with overvoltage surge protection compliant with an approved standard (note 1).
1	Intrinsically safe equipment of category "ia" or “ib” (Ex ia or Ex ib) (note 1) Flameproof (Ex d) equipment Specially protected (Ex s) equipment Increased safety (Ex e) equipment (note 2) Encapsulated (Ex m) equipment
2	Any type of equipment suitable for zone 0 or zone1 Intrinsically safe apparatus of category "ic" (Ex ic) Non-sparking (Ex n) or (ec) equipment
NOTE 1 All intrinsically safe circuits (Ex i circuits) should have system certification from an approved testing/certification body to ensure that the various devices in the circuit, with the interconnecting wiring and cabling, are compatible and suitable for the application. The following information should be submitted for certification of Ex i circuits: a) a loop diagram showing all equipment and cabling or wiring; b) information about the equipment characteristics indicated on the loop diagram and in the form of a certificate by an approved testing/certification body; and c) cabling and wiring information indicating cable types and lengths as well as resistance, capacitance and inductance characteristics. **NOTE 2** Ex e motors should not be used in hazardous locations unless approved overload protective devices are used with such equipment and precautions taken to ensure that such protection cannot be rendered ineffective during use. **NOTE 3** Equipment ratings should be taken into account so as not to cause overheating that leads to excessive surface temperatures.	

Kiosks or other types of occupied structures should not be within any hazardous location. Further care shall be taken not to introduce sources of ignition into hazardous locations, for example, cold drink dispensers and fridges, electrical signage, sound systems or uncertified portable credit card readers (as per SANS 10089-3).

The majority of filling stations use uncertified card readers that can be a hazard to the public as well as to the filling station as it can be a source of ignition. The result of fires and explosions includes:

- Loss of life
- Loss of business
- Damage to filling stations

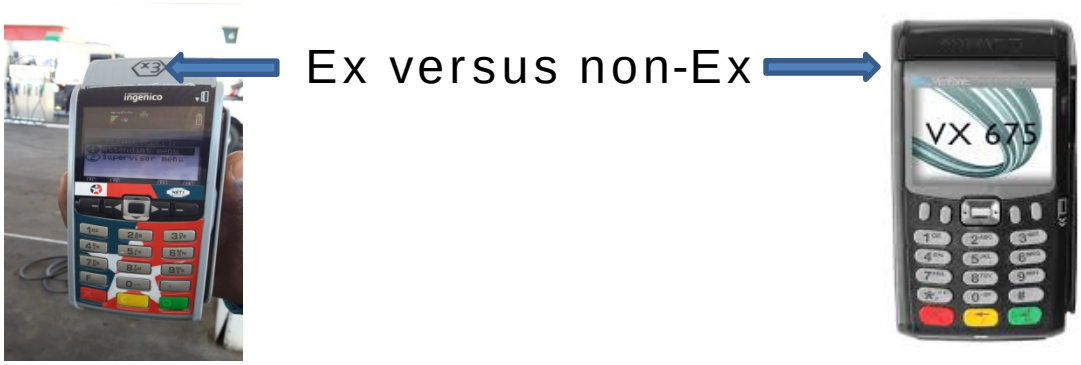


Figure 3: Portable card readers

Precautions to Avoid Inadvertent Ignition of Petrol Vapours from Electrostatic Discharges

Static electricity in one form or another is a phenomenon of nature and often results in electrostatic discharges that can cause fires and explosions. All storage tanks and delivery pipework must be adequately earthed and bonded to prevent flash fires. This is particularly important at sites provided with non-metallic off-set fill pipework.

Earthing requirements as per SANS 10089-2

In addition to the electrical safety earth provided to comply with SANS 10142-1 (for example the "spare core" earth), a second earth connection should be provided to each item of electrical equipment to prevent the potential to earth of such equipment rising above spark potential. It is always safe to have a parallel return earth path for any fault current in a hazardous location. The external earth is also easier to inspect during the 2 yearly inspection of all EPE as required by the Electrical Machinery Regulation 9(8), as it will be impractical and time consuming to open all enclosures, in order to verify if they are internally earthed.

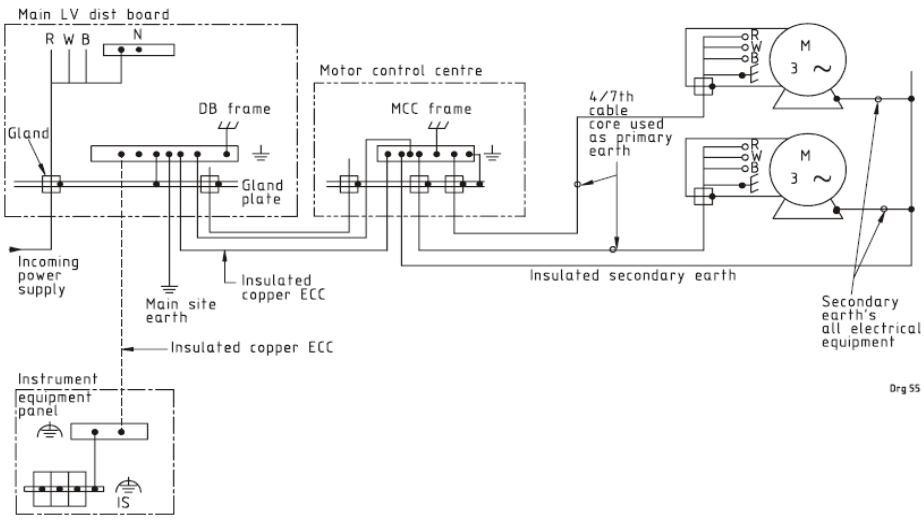


Figure 4: Earthing and bonding of electrical circuits

Note: The use of composite materials at filling stations

Some composite materials are non-conductive and should not be used where static discharge could be a problem. Graphite filament reinforced plastic (GFRP) or composite materials that contain metal particles are usually conductive enough to drain off static charges if given a conductive path from the material to the metallic structure. Special attention must be given to bonding across joints in composite materials. Composite materials must comply with static test as required by SANS 60079-0 clause 7.4 and 26.13

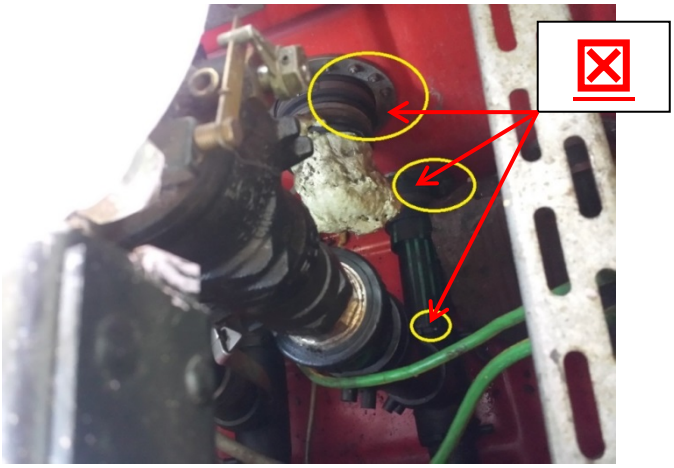


Figure 5: No bonding across composite piping of fuel dispenser

Avoidance of a build-up of electrostatic charge on Group I or Group II electrical Equipment:

Electrical equipment shall be so designed that under normal conditions of use, maintenance and cleaning, danger of ignition due to electrostatic charges shall be avoided. This requirement shall be satisfied by one of the following:

a)by suitable selection of the material so that surface resistance complies with either of the limits given below when measured in accordance with 26.13 of SANS 60079-0

109 Ω measured at (50 ± 5) % relative humidity; or
1011Ω measured at (30 ± 5) % relative humidity

Note: Non-metallic surfaces may be covered with a bonded durable conductive coating to minimize static.

Earthing requirements of Filler boxes

Metal filler box

Each metal filler box shall have a frame bolt that can be used as an earth connection point, filler box shall be connected to the electrical earth continuity conductor of the installation. A metal tag shall be provided onto which the operator can connect the bonding cable from the bulk vehicle while delivering the product.

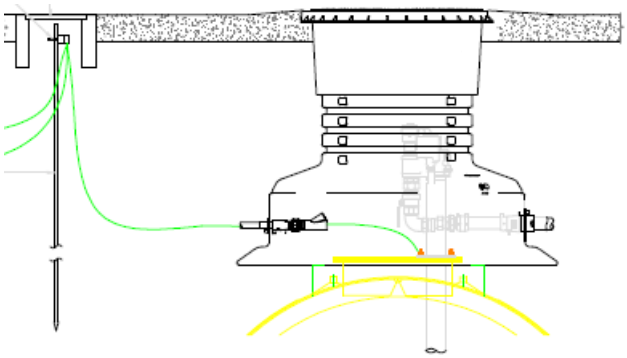


Figure 6: Earthing and bonding of a metal filler box

Non-conductive filler boxes

In a non-conductive filler box, the conductive parts inside the box shall be connected to the electrical earth continuity conductor, connection point shall be provided onto which the operator can connect the bonding cable of the bulk vehicle.

Figure 7: Earthing of composite filler box

Conclusion

The 2 yearly inspections as per Electrical Machinery Regulation (EMR 9(8) must be done on all Explosion Protected Equipment at all filling stations by a person who is declared competent to express an opinion, to ensure that all installations as well as equipment complies with the relevant regulations and standards.

Yearly earth continuity test as well as bonding tests must be conducted on all electrical installations at filling station to maintain the integrity of the earthing system.

Scheduled inspection and maintenance will prevent flash fires that are a safety risk to the public and employees working at filling stations.

The OHS Act- section 8 stipulates that it is the employer's duty to ensure a safe work environment without any risk.