Classification of hazardous locations

By Z Jooma, e-Hazard

Although the subject of 'hazardous locations' classification' has been covered on numerous occasions, it should be revisited to accommodate the fresh recruits in industry and as a refresher to practising professionals.

The principles pertaining to the requirements for achieving safety in hazardous locations is fairly simple theoretically, but the implementation of a legally compliant programme can be a challenge to experienced professionals. This is not due to a lack of knowledge regarding what is required but rather the management of the sheer volume of documentation, due diligence, verification and the challenges of leading a multidisciplinary team that in most cases does not share the level of expertise of the team leader. Understanding the principles of what is required is the stepping stone of a successful programme. Like any sky scraper building - attaining structural stability lies in the design of the foundation and vertical support structures. Basic education in hazardous locations and explosive atmospheres is considered the foundation and the identification and classification of hazardous locations are considered the vertical support structures. These form the groundwork for a successful programme.

Definitions

Hazardous locations

Location is determined by national regulations or by the risk assessment of the plant or mine, where there may be significant risk of the ignition of gas, dust or vapour - SANS 10108 Ed 5 [1].

Explosive atmosphere

An explosive atmosphere is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, dust, fibres or 'flyings' which, after ignition, permits self-sustaining propagation – SANS 60079-10-1: 2010 Ed 1 [2].

LEL– Lower Explosive Limit
OSHA – Occupational Safety and Health Administration
SHE – Safety, Health and Environment
UEL – Upper Explosive Limit

Abbreviations

Zoning in on the classification of a hazard

A hazard is anything (condition, behaviour, system etc) which has the possibility to cause harm (physical, financial etc). In order to understand when a hazard is present, it is necessary to understand the combustion and propagation methods.

Fire Triangle

In order to achieve combustion three essential ingredients, as shown in *Figure 1*, are required – namely oxidising agent, fuel and energy source.

1. The most common oxidising agent which is freely available in air is oxygen. It is for this reason that combustion is easily achievable in the presence of air. Other oxidising agents are available in certain industrial applications or explosive materials. If in doubt, request the expertise of a chemist or chemical engineer before ruling out the presence of an oxidising agent which supports combustion.
2. Fuel is generally available as vapours released from a solid, fine dust mixtures or gas. Some battery systems, when charging, release hydrogen into the surroundings. Natural gas, chemical gas production systems and industrial waste gas recovery processes are all examples of the presence of gas in an environment. Examples of vapours are the handling and storage of petrol or diesel which may create vapours (or fumes). Another example is certain pockets of fossil which release combustible vapours from solids. Dust concentrations are typically found in coal plants, flour mills and crushing plants.
3. The third constituent of the combustion triangle is energy. An electrical arc which is a result of static discharge, a millisecond phenomenon, has been responsible for combustion. Energy should not only be perceived as a naked flame. Energy can also be in the form of a temperature excursion on a conductive surface.

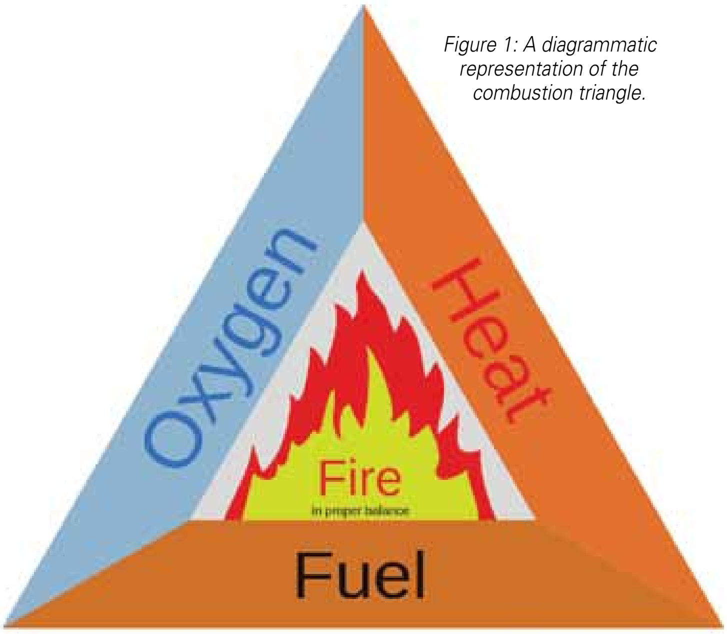

Figure 1: A diagrammatic representation of the combustion triangle.

A good example of this is seen on instrumentation. A low voltage and current dissipated over prolonged periods of time can produce surface temperatures of a few hundred degrees Celsius, enough to spontaneously ignite certain fuels [3].

Explosive limits

The presence of the constituents of the combustion triangle must occur within certain limits for combustion to occur. Imagine a wick of a candle which is lit using a match. Once combustion is initiated, the burning tip ignites the lower portion of the wick and the candle continues burning. The oxygen is present from air and the fuel is the fumes given off the surface of the wick and wax. If a glass is placed over the candle the flame goes out. This occurs due to the starvation of oxygen ie oxygen will be used up until it reaches a lower threshold at which stage combustion will cease. Another example is a sealed container filled with methane with a 100% volume concentration. A static electrical discharge in the container will theoretically not result in combustion. Such a situation would only suffice as a theoretical example, as in practice micro-environments could be created which could produce a runaway effect.

Lower Explosive Limit (LEL) is the lowest percentage concentration of a fuel in air capable of combusting if an ignition source with sufficient energy is introduced. At a concentration in air below the LEL there is not enough fuel to support combustion [4].

Upper Explosive Limit (UEL) is the highest percentage concentration of a fuel in air capable of combusting if an ignition source with sufficient energy is introduced. At a concentration in air above the UEL, the mixture is considered too rich to combust.

The LEL for methane is 4% while the UEL is 15%. At 8% percentage volume in air, only 0,2 mJ is required for ignition.

Please see E+C Spot On (www.eandcspoton.co.za) for the table on 'Examples of Lower Explosive Limits and Upper Explosive Limits of a few gases.'

Propagation

Although concentrations of a potential explosive mixture may exist in a lower or upper explosive limit, the possibility of combustion should not be ruled out. This is simply due to a phenomenon known as deflagration. Deflagration is the propagation of a mixture at a velocity less than the speed of sound without combusting. This has an effect of propagating an explosion or creating a hazardous location in a previously unclassified location. Care should be taken to ensure proper isolation or segregation between areas. Where this is not possible, the adjoining areas should be classified.

Hazardous areas classification

South Africa governs safety in a hazardous location by the Occupational Health and Safety Act, the sub regulations and the relevant government gazettes. The standard which stands out in this instance would be SANS 10108:2007 Ed 5 [1]. The standard must be read in conjunction with the associated ARP 0108:2007 Ed 1.1 [5]. What some professionals sometimes bypass, especially those new to the field and with a good theoretical understanding, is that SANS 10108:2005 section 4.4 [1] prohibits the exclusive use of SANS 10108 [1] for the classification of hazardous locations. In addition to the various references, the most commonly used in a factories or mines environment would be SANS 60079-10 [2] (parts 1 and 2 respectively) in addition to SANS 10108 [1]. After reading the relevant standards in detail, the custodian should elect a working group or hazardous locations committee.

Hazardous locations committee

The standards once again prohibit the identification or classification of a hazardous location by a single person. It is recommended that a group consisting of the following individuals be elected to offer insight into the various plant installations, plant or process operation, equipment used and finally a person knowledgeable in the requirements of local and international statute. It is recommended that the following persons be nominated into the working committee:

- Legal appointee in terms of the OSHA
- Electrical engineer
- Mechanical engineer

- Chemical engineer
- Master installation electrician
- Instrumentation, electrical and mechanical representatives co-opted for specific meetings
- Representative of training
- SHE Practitioner

Understanding the zones

Once the concepts (as discussed) are firmly understood and a committee has been elected, the actual processes of identification and classification may begin. However, in order to differentiate between the different levels of risks posed, the exposure to the hazard should be defined. International standards define the exposure probability. SANS 10108 [1], goes a step further by defining times and not merely using the terms long, normal, short etc. The definition of zones as stated in SANS 10108 [1] are shown in *Table 1*.

ZONE	DEFINITION AND EXPLANATION
Zone 0	Any area in which an explosive atmosphere is present for more than 1 000 hours per annum
Zone 1	Any area in which an explosive atmosphere is present for between 10 hours to 1 000 hours per annum
Zone 2	Any area in which an explosive atmosphere is present for less than 10 hours per annum
Zone 20	Any area in which dust or fibrous materials can form explosive mixtures frequently or for long periods of times
Zone 21	Any area in the immediate vicinity of a Zone 20 area or where explosive mixtures are likely to occur during normal operations
Zone 22	Any area which may contain residual dust or fibres which: • May escape from leaks and forms deposits • May not be sufficiently removed by a cleaning or removal process • May arise during abnormal operating conditions and give rise to an explosive environment

Table 1: Definitions of Hazardous Locations into Zones by SANS 1010 8[1].

Identification

Plant personnel, even if unqualified in the principles of hazardous area classification at the time, should be involved as these individuals are less likely to omit or bypass a plant or process. Every single area, no matter its application or process, must be identified. It is the responsibility of the committee and not an individual to decide on the classification of an area. Areas which can be omitted may be those deemed as domestic premises as SANS 60079-10 [2] does not cover domestic areas. It is recommended that the following steps be undertaken:

- List all plant, work, process, equipment and storage areas
- Ensure that no areas are omitted by verification with plant responsible or accountable persons and double check against civil drawings
- For each plant provide detailed drawings in plan and elevation. This may be the difficult task since detailed drawings are not always available in older and sometimes smaller plants. It is recommended that detailed photographs be taken to ensure that the committee has a good three dimensional appreciation for the area. A post classification site visit by the committee may be required as a due diligence measure.
- List all substances which are processed, handled, stored, manufactured and transferred. These can be solids, liquids or gases. If possible identify the pressure, volume and temperature of these items and locate the relevant material safety data sheet. Where mixtures occur, the chemical engineer or chemical specialist should determine the mass balance of the mixture and provide details on the formulated substance. At this stage the grades of release (continuous, primary or secondary) may be defined.
- List all energy sources. These will include electrical apparatus such as extractions fans, lighting, socket outlets, motors, distribution boards and instrumentation. Chemical reactions which can generate heat should also be identified. Mechanical installations such as pressure relief devices on steam lines or frictional items which can generate heat are also important ignition sources and should be considered.

At this stage it is imperative that the committee chair decides on the suitability of the skills sets of the team members to determine the level of responsibility given to an individual. It may be decided that the process is handled by the entire committee or certain individuals of a group. It is found that most gaps in the programme stem from a poor identification process. This results in frustration, programme delays, loss of interest, feelings of incapability to complete the tasks, over expenditure later in the programme and poor maintenance due to a lack of understanding.

Although this may vary from site to site, it is recommended that the greatest allocation of the committee's time be spent on the critical steps discussed in this section. If the identification process is extremely well synthesised, it is rare that the remaining process will be as time consuming.

Classification of hazardous locations

Once the requirements of section are firmly in place and the engineering team has performed a due diligence study on the validity of the data, the actual classification process may begin. It is a twofold consideration - with the fire triangle in mind: Place all the process items of relevance to each other and try to complete the triangle. The committee will have to make use of the material safety data sheets to determine the LEL and UEL based on the data collected. Determine the availability of the oxidising agent and the energy source. In addition, refer to the definition of the zones and assign each hazardous location appropriately.

The next aim is to quantify the extent of the zone so as to maintain safety within the area of focus and prevent unnecessary capital and maintenance costs on areas outside the hazardous area. This is not always that simple and the standards have provided some guidelines via equations and definitions of grades of release. Generally the immediate vicinity around a hazardous location will default to a lower level depending on the type of segregation between such areas.

Classification by example

A similar approach to the classification of areas exists. These are classification by example and are allowed by both SANS 10108:2005 [1] and SANS 60079-10:2010 [2].

However, take note of two important recommendations. Firstly, examples do not exonerate the committee from undertaking a detailed identification process as described in the standards. Secondly, each committee should undertake a simple application to understand the principles of a hazardous location identification and classification process before resorting to the use of examples. After classifying an area, the committee should check the classification against two verification tools. Firstly, the examples in Annexure C of SANS 60079-10-1:2010 [2] and secondly by the use of a specialist consultant in the area.

Conclusion

Hazardous areas are well regulated via local and international legislation and standards. The most pertinent standards are SANS 10108:2005 [1] and SANS 60079-10-1/2 [2] for gas and dust explosive atmospheres. Even with the presence of these standards, establishing and maintaining a programme is not well understood by a large contingent of industries. Many outsource this responsibility and any risk-averse consultant would rather be cautious in the classification. This will no doubt increase the cost of compliance and maintenance. It is thus imperative that industry accepts responsibility in educating, training and exposing personnel to the basic processes of hazardous locations.

Although the programme is extremely extensive incorporating legislative maintenance requirements and highly specialised equipment installations, these were not encompassed in the scope of this article – which is not intended as a substitute to reading and understanding the relevant standards nor does it serve as an example of a hazardous location classification. It has reaffirmed the importance of developing a solid foundation which is the establishment of a hazardous locations committee and the identification process. The classification process is somewhat more technical; however, following the guidelines discussed will assist the end user in getting a programme initiated.

References

[1] SANS 10108:2007: The classification of hazardous locations and the selection of apparatus for use in such locations.

[2] SANS 60079-10-1:2010. Explosive Gas Atmospheres. Explosive Atmospheres and Explosive Dust Atmospheres.

[3] Thermal Considerations for Surface Mount Layouts, Charles Mauney, Texas Instruments. Link: http://focus.ti.com/download/trng/docs/seminar/Topic%2010%20-%20Thermal%20Design%20Consideration%20for%20Surface%20Mount%20Layouts%20.p.df

[4] Flammability Limit. Wikipedia. Link:http://en.wikipedia.org/wiki/Flammability_limit.

[5] ARP 0108:2007: Regulatory requirements for explosion protected equipment.

Zarheer Jooma is a professionally registered electrical engineer with the Engineering Council of South Africa and a senior member of the South Institute of Electrical Engineers. He is the director of the South African branch of the US based company e-Hazard. The company specialises in achieving safety via training, developing systems, engineering interventions and auditing. In addition to their core function of electrical arc flash safety, the company also focuses on hazardous locations as required by the NFPA 70E standard. Hugh Hoagland operates and manages the US based companies e-Hazard and Arc Wear. The company Mission sums up their international commitment. 'We help people who work around electricity go home safely to their families'.

Enquiries: Tel. 016 889 8159 or email zarheer@e-hazard.com.

About the author