A guide for plant management and technical staff on how to conduct an area classification, the process whereby the degree of exposure to explosive atmospheres for a plant area is determined.

Explosive environments: fundamentals of area classification

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Area classification (called "classification of hazardous locations" in our mines) is the process whereby the degree of exposure to explosive atmospheres for a plant area is determined. The information obtained is used to control ignition sources to prevent flammable material explosions. See Table 1 to determine whether explosive atmospheres exist in your plant or factory.

How important is area classification? Consider the following points:

- Without an area classification, or with incorrect classification, the explosion risk becomes unacceptably high.
- It is the first link in the explosion prevention chain and, therefore, the most important part of explosion prevention.
- The information provided by the area classification process will either lead to affordable safety, overly expensive, de-motivating safety or unsafe conditions.

Despite the critical nature of area classification, plant management has the responsibility to obtain the appropriate area classification, but no competence requirements are specified.

Although the area classification process requires technical input on equipment and operations from a range of technical disciplines, a specialist's ability to apply the classification standards is essential to the process. Plant operators are advised to obtain and review external specialists' CVs.

Application of area classification

The basic aim of area classification is to support the correct selection of explosion proof (Ex) equipment. Each explosion protection technique has one or more explosion protection levels (EPLs), as listed in SANS 60079-0.

If equipment selection is done according to the statistical method, the EPL required is directly determined from the zones as shown in Table 2. Alternatively, the EPL may be determined using the risk-based method.

Concepts of classification

Practical area classification for gas explosive atmospheres is simplified if one of the following methods is followed:

- Classification of hazardous locations by direct example, a method applicable to standard installations such as vehicle refuelling stations. Note that care should be taken to ensure that the same products and conditions apply.
- Classification based on dispersion theory.
- If the release rate for secondary sources of release cannot be determined by dispersion theory, a risk-based calculation may be done.

For dust explosive atmospheres, typical

Material state	Ventilation open air	Inside building
Liquefied gas	100 l	5 l
Liquid	200 l	25 l
Gas	1000 l	50 l

Table 1: Do explosive atmospheres exist in your plant?

Zone	Minimum equipment protection level (EPL)
0	Ga
1	Gb
2	Gc
20	Da
21	Db
22	Dc

Table 2: The EPL required is determined from zones.

examples as well as sources of release are considered.

Available standards and application

Approved standards must be used for the classification of hazardous locations, i.e. those listed in or meeting the requirements of SANS 10108 Edition 6:2013.

SANS 10108 requires that preference be given to IEC standards where such a standard is suited to the type of plant to be classified. This means that SANS 60079-10-1 (flammable gases and vapours) and SANS 60079-10-2 (combustible dusts and fibres) are therefore the primary standards. However, SANS 60079-10-1only gives the main principles of area classification.

In conclusion, the logical choices for standards for general classification are IP Code, Part 15, Edition 3 ("IP Part 15" for short) for gases and vapours and SANS 60079-10-2 for dust, as these standards cover all industries, all classification techniques and compliance with SANS 10108.

Area classification for specific installations may be based on other standards included in this list, but be careful not to "mix and match". There must be a main standard forming the classification backbone.

Classification framework

In practice, the following eight steps can be followed:

- List flammable materials.
- Select those present in significant quantities.
- Determine sources of release.
- Determine grades of release.
- Determine zones (0/1/2); i.e. areas where explosive atmospheres occur.
- Size and shape zones.
- Rationalise, i.e. merge overlapping areas with the same zones.
- Determine equipment protection level (EPL).

Sources of information for classification

Ample documented information is usually available for new plant, e.g. a process description, plot plan or site layout, process flow diagrams (PFDs), process and instrumentation diagrams (P&IDs) and material safety data sheets (MSDSs).

For existing plant, this information is often not available. Existing area classification information is out of date and limited to drawings, often a plan view with no cross-sections. Fortunately, a skilled area classification specialist will be able to find this information, even if it means recording information verbally from long-serving staff members.

Fig. 1: Ex equipment must be suitable for the explosive enviroment.

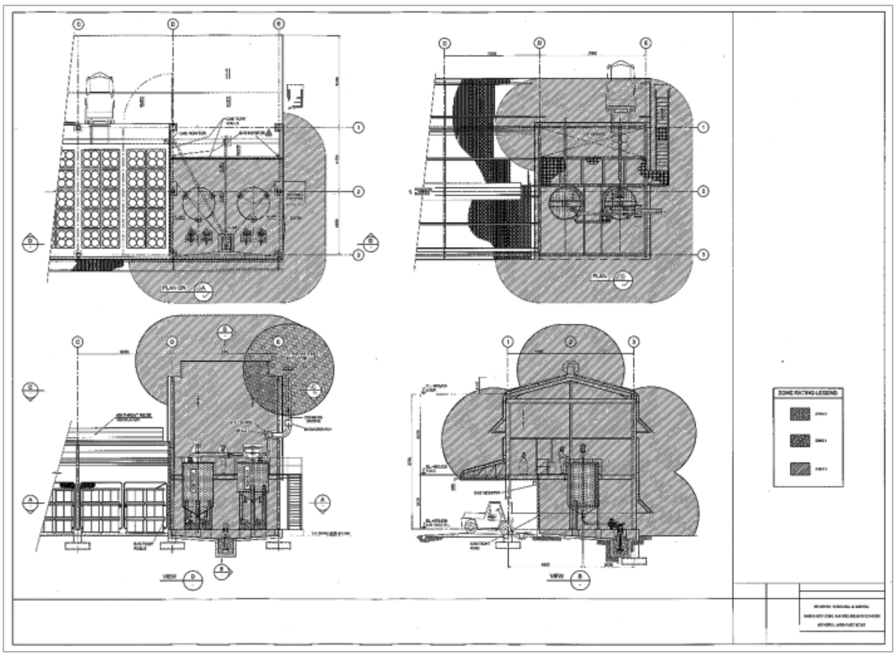

Fig. 2: Typical area classification of a surface plant where explosive vapours are present.

Records

It is strongly recommended that the classification study be documented fully. The documentation should cover all issues considered in deciding on the final classification. All assumptions, approximations and calculations made should be included to ensure full traceability of the process at a later stage. Drawings and reports are the most useful records (see Fig. 2).

Detailed data for flammable gases

For this discussion, we revert to the classification framework steps:

List flammable materials

This is simple. The SHEQ people should already have such a list. When in doubt, look at the MSDSs of the raw materials. If there are no MSDSs for final products, your company is at fault; take action!

Select the flammables present in large quantities

There will typically be fewer than ten substances in this category.

For mixtures containing flammable and non-flammable materials, use a rule of thumb, e.g. that liquid mixtures with less than 30% flammables by mass and gas mixtures with less than 10% flammables by volume, are not flammable. Use the properties of the flammables which make up at least, say, 75% of the mixture.

Use the worst-case values or, if this is too strict, use the weighted average values. SANS 60079-20-1 is an excellent source document for information on pure substances.

Determine source of release

Important to note is that a source of release is a feature of the equipment which exposes flammable material to the atmosphere, where the flammable material forms explosive mixtures in the air either under normal plant conditions (e.g. vents, samples points and oily water sewers) or abnormal conditions (e.g. leaking seals and gaskets or rare events such as a release due to start-up after maintenance shutdown).

For example, an open drum of grease at ambient temperature does not form an explosive atmosphere because the flash point is too high. The grease surface is therefore not a source of release. A drum of petrol, however, will be a source of release.

Substances handled at ambient temperature and with flash points higher than 55°C will generally not form explosive atmospheres, or will form very limited volumes of explosive atmospheres where the substance is a mixture, i.e. where it consists of both more and less volatile materials (high volatility = low flash point and boiling point).

Determine grades of release

Each source of release is associated with at least (and normally only) one grade of release. Three grades of release exist: secondary (typically, up to ten hours in total per year); primary (more than ten and up to 1000 hours in total per year), and continuous (more than 1000 hours in total per year).

Determine zones (0/1/2)

This depends on ventilation. In the case of open air, secondary, primary and continuous grades of release, create zone 2, 1 and 0 areas respectively. The volume of the explosive atmosphere will normally increase where less ventilation occurs than in open air. A more severe zone may even apply, for instance if a uniform ventilation rate of at least twelve air changes per hour is not achieved.

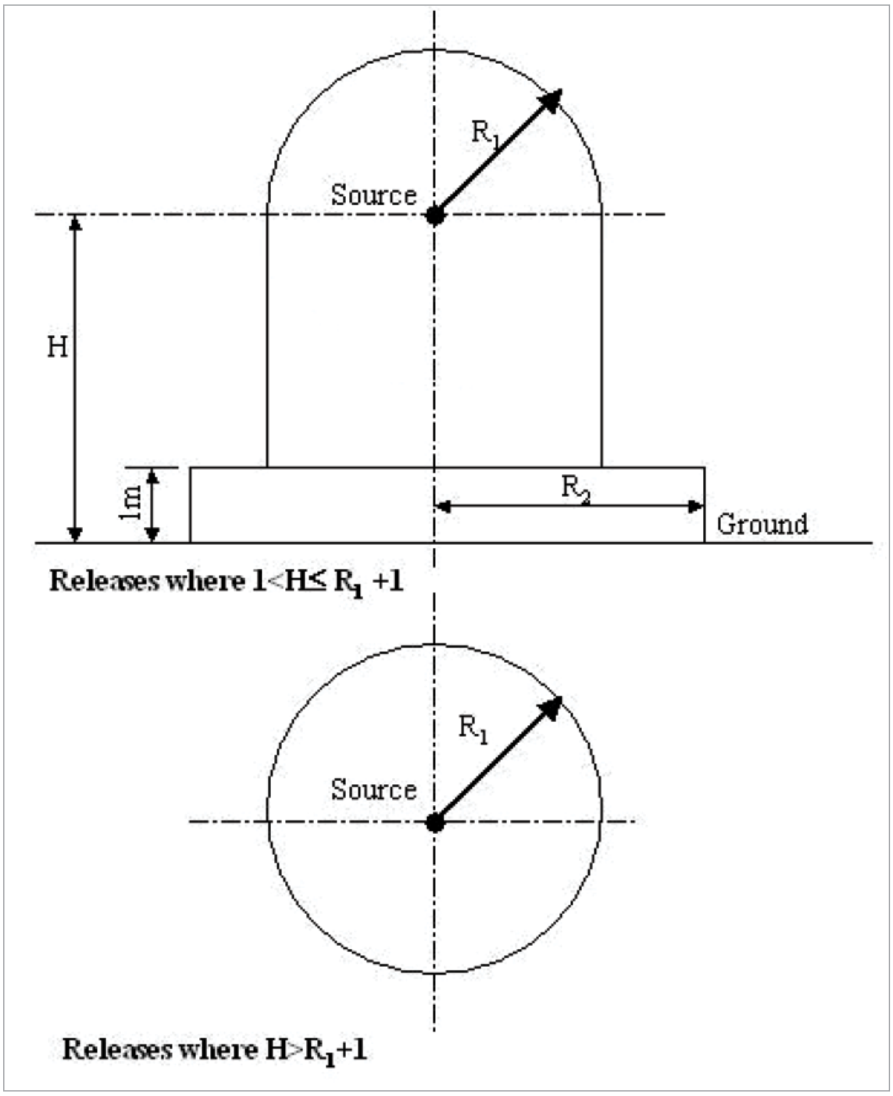

Fig. 3: In free space, the explosive atmosphere takes the form of a sphere; this sphere becomes flattened where solids are interecepted.

Size and shape of zones

In terms of shape, a simplified model is proposed these days, as follows: in the case of pressurised releases, gravity effects are overridden by the pressure driving force. In free space, the explosive atmosphere takes the form of a ball or sphere; the sphere becomes flattened where solid obstacles such walls and the ground are intercepted (see Fig. 3).

In the case of atmospheric-pressure releases, lighter-than-air gases/vapours normally dilute quickly (unless there is a solid ceiling); heavier-than-air releases collect in below-grade structures such as sumps, sewers, pits, bunds or enclosed spaces such as sewer systems and therefore take on the size and shape of the containing structure.

Of the common gases, only a few such as hydrogen, methane and ammonia are lighter than air, with carbon monoxide being almost neutral.

In terms of size or the volume of the explosive atmosphere: for atmospheric releases, this size is a balance between rate of vaporisation (dependent on volatility, i.e. flash point and boiling point of liquids) and rate of dilution (ventilation). Where the gas/vapour is heavier than air, we have established that the explosive atmosphere may collect in hollows and enclosures and take on the size and shape of the containing structure.

On rare, windless days, explosive atmospheres can form "trails" and migrate over considerable distances. As a rule of thumb, a wind speed of 3 m/s is needed to provide effective mixing and dilution. Open air is considered rarely to provide less than 0,5 m/s and frequently more than 2 m/s.

For pressurised releases, rate of release (pressure dependant) must also be considered, and the size of the explosive atmosphere is a balance between these three factors (assuming a long term, constant release, of course).

But what size can be expected for pressurised releases in practice? A few examples of "typical" radii are shown in Table 3.

Equipment	Flammable substance	Hazard radius in meters (assuming spherical HA)
Small centrifugal pump with single mechanical seal and throttle bush	Liquid (petrol)	≤5
Small pump with single seal	LPG	≤5
Flanged joint	Liquid (petrol)	1,5
Flanged joint	Gas	1
Sampling point, drain into sample bottle	Liquid (petrol)	2,5
Sampling point, drain into sample bomb, open purge	Liquid (petrol)	2
Sampling point, drain into sample bomb, closed-loop purge	Liquid (petrol)	~0
Tank vent	Liquid (petrol)	2 – 3
Process vent	Gas/vapour	5 – 9

Table 3: Examples of "typical" radii for pressurised releases.

Rationalise

This simply means that a typical classification meets the "raisin cake" model: isolated zone 1 (outside vessels) and zone 0 (mostly inside vessels) pockets in a zone 2 matrix (justified by the combination of releases from hundreds of secondary sources of release).

Combustible dust: gathering, processing info

The six basic steps to follow are as follows:

List of flammable materials

The material safety data sheets (MSDS) normally offer little information on flammability and explosivity. It is worthwhile to remember that most organic and metallic solid fines are flammable and a potential explosion hazard. The condition of the particles (size, shape, oxidation, moisture content etc.) plays an important role. Samples of the material often need to be tested to get an accurate indication of explosivity.

Select flammables in significant quantities

Typically, solid materials with particle sizes under 0,5 mm can participate in an explosion. Frequent and effective cleaning and dust extraction will minimise fines formed as byproducts during handling.

Determine sources of release

A source of release is a feature of the equipment which releases fines into the air and creates explosive atmospheres. This can happen either inside (the containment system) or outside equipment. Dust must be in suspension (i.e. form dust clouds) to explode.

Examples are mill interiors, pneumatic transport systems (internal), dust extraction systems (internal) or bag filling operations (external).

The lower explosive limit/concentration for dust-air mixtures is generally between 30 and 40 g/m^3. A useful rule of thumb is that a dust cloud is explosive if a 40 W incandescent lamp is invisible to the eye at a range of 3 m. Loosely translated, this means that the dust cloud is dense enough to prevent normal human operation in the area.

Determine grades of release

In terms of gases, distinction is made between secondary, primary and continuous grade releases, defined as follows:

- Continuous grade of release: a dust cloud may exist continuously, or may be expected to continue for long or short periods which occur frequently.
- Primary grade of release: a source can be expected to occasionally release combustible dust during normal operation.
- Secondary grade of release: a source which is not expected to release combustible dust during normal operation: should it release, it is likely to do so only infrequently and for short periods only.

These formal definitions fail to point out clearly that an explosive dust cloud must result.

Determine zones (20/21/22)

Unlike gases, the zones for dusts are best determined following the "Cremora" rule: if the dust clouds are *inside*, we have a zone 20. If they are *outside*, we are dealing with zone 21. If there are dust layers which may be suspened due to known disturbances *on top* of equipment, it is zone 22. Note that this is a broad approach and not a hard-and-fast rule.

Size and shape of zones

Internal explosive atmospheres take the form of the enclosure. External explosive atmospheres are normally shaped according to the shape of the source of release, varying from a true point (such as a bag filling point) creating a spherical explosive cloud, to a cloud which fills a smallish room.

Practical experience has shown that the hazard radius is often 1 m.

Conclusion

Everybody with a technical background can determine whether they have the potential for explosive atmospheres in their plant. More insight and detailed information is required to conduct a complete area classification and the input of specialists may be required to assist in determining aspects such as:

- Properties of flammable mixtures.
- Selection of classification standards.
- Establishing the type of zone.
- Establishing the size of zone (especially where ventilation is restricted).

Once a proper, reliable and accurate area classification is in place, the next challenge can be taken on with confidence, namely to control ignition sources.

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