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Reviewing the Risk Acceptance Criteria in ATEX

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The traditional approach for risk acceptance criteria defined by the presence of explosive atmospheres (ATEX), consists in assessing the coincidence likelihood in time and space of both the atmosphere and the potential ignition sources.
For this criterion to work, two fundamental underlying assumptions must be considered. In first place, both the presence of the explosive atmosphere and that for the ignition source must be fully independent in its occurrence. Secondly, it must be possible to prevent the presence of ignition sources in a hazardous location during normal operational conditions.
Both assumptions are easy to apply while considering those ignition sources caused by equipment: engineering design, material specification, sensors and interlocks, etc. are some measures which can be implemented to prevent that a machine generates ignition sources while in operation, but, after all the experience gathered over the years in relation with explosive hazards, it is nowadays clear, that focussing only in equipment generated ignition sources is not enough to ensure safe processes.
It is easy to identify several types of ignition sources which are related either to process conditions or to the properties of the substances handled, not requiring any failure in Ex rated equipment. Moreover, it is also easy to show how, many times, these ignition sources are present under normal process conditions.
This paper will describe with practical examples some cases in which this conflict is clearly present and, afterwards, propose a reviewed criterion for risk acceptance of hazards defined by the presence of explosive atmospheres.

1. Introduction

It is well-known that the risk acceptance criteria in ATEX is based on assessing two likelihoods. In one side the likelihood of presence of a flammable atmosphere and, on the other side, the likelihood of presence of an ignition source. Combining the results of this assessment in terms of coincidence in time and space, the final decision is taken in terms of risk level.
In this first point the two criteria defining the risk acceptance are described and the final traditional approach derived from them is presented.

1.1 Flammable atmosphere

To assess ATEX hazards, it is necessary to define the physical areas where flammable atmospheres may be present, both inside and outside equipment; this is known as defining the ATEX zones. Next, the criteria by which each zone is defined is presented (Directive 1999/92/EC, 1999). Zone definition consider the nature of the substance generating the flammable atmosphere.

In first place, gas and vapour zones are presented:

- Zone 0: A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
- Zone 1: A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

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- Zone 2: A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

In second place, dust zones are presented:

- Zone 20: A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
- Zone 21: A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.
- Zone 22: A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

As can be seen, the fundamental criteria by which zones are defined is by assessing the presence likelihood of an atmosphere in an area.

1.2 Ignition sources

Once the zone definition is set. It is then necessary to consider the presence of ignition sources. For this reason, the assessment of suitable equipment to be installed in a classified area is defined upon the assessment of in which condition equipment do or may generate an ignition source.
Equipment is classified into groups and then into categories within each group (Directive 94/9/EC, 1994). For the purposes of this paper only equipment of Group II is relevant:

- Equipment group I applies to equipment intended for use in underground parts of mines, and to those parts of surface installations of such mines, liable to be endangered by firedamp and/or combustible dust.
- Equipment group II applies to equipment intended for use in other places liable to be endangered by explosive atmospheres.

Concerning equipment categories, they are defined as follows:

- Category 1 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and ensuring a very high level of protection.
  Equipment in this category is intended for use in areas in which explosive atmospheres caused by mixtures of air and gases, vapours or mists or by air/dust mixtures are present continuously, for long periods or frequently.
  Equipment in this category must ensure the requisite level of protection, even in the event of rare incidents relating to equipment, and is characterized by means of protection such that:
  - either, in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection,
  - or the requisite level of protection is assured in the event of two faults occurring independently of each other.

- Category 2 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and of ensuring a high level of protection.
  Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures are likely to occur.
  The means of protection relating to equipment in this category ensure the requisite level of protection, even in the event of frequently occurring disturbances or equipment faults which normally have to be taken into account.

- Category 3 comprises equipment designed to be capable of functioning in conformity with the operating parameters established by the manufacturer and ensuring a normal level of protection.
  Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists, or air/dust mixtures are unlikely to occur or, if they do occur, are likely to do so only infrequently and for a short period only.
  Equipment in this category ensures the requisite level of protection during normal operation.

1.3 Risk acceptance matrix

Considering the zone definition and the equipment categories, and including to them the case where the zone is not classified as Ex or the equipment has no Ex category, the risk acceptance matrix can be easily obtained:

Atmosphere / Ignition Source	No Zone (Never flammable)	Zone 2/22	Zone 1/21	Zone 0/20
Non-Ex (Normally present)	✓	✗	✗	✗
Cat. 3	✓	✓	✗	✗
Cat. 2	✓	✓	✓	✗
Cat. 1	✓	✓	✓	✓

Figure 1: ATEX risk acceptance matrix

As described before, the risk acceptance criterion is clearly based on the assessment of two likelihoods, the likelihood of presence of a flammable atmosphere and the likelihood of presence of an ignition source.

1.4 Risk acceptance principles

Nevertheless, to be able to get to the risk acceptance matrix presented, next principles must be considered:

- The definition the zoning considers all process steps: start-up, shut-down, cleaning, etc. Meaning that the full intended process must be considered while defining the zone that shall be applied to an area.
- Once defined, the classification remains always as defined. This means that the zoning is not a function of process phase or condition in which the facility is at a certain moment. The classification remains as defined even if, for instance, the equipment is not running any process and in an empty and clean condition.
- The generation of ignition sources is independent from the generation of the explosive atmosphere. It can be seen both in the zone, but specially in the category definition, that an underlying assumption is that there is no relation between the process generating the zone definition and the potential generation of an ignition source.
- Risk is acceptable when the combined probability of having an atmosphere and an ignition source in the same place and at the same time is low enough. An example is that the presence of an ignition source in a classified area is accepted if, for instance, in a Zone 2 or 22 the ignition source is not generated during normal process conditions, corresponding to equipment category 3; thus meaning that it is inherently considered that if the ignition source is generated in case of failure it is acceptable due to the fact that in Zone 2 there shall be no flammable atmosphere under normal condition and therefore, the probability of having a simultaneous equipment failures and a normal process deviations, one generating an ignition source and the other generating a flammable atmosphere, is low enough to be considered as an acceptable design condition.

- If the risk is too high, the equipment may still be protected against the consequences of an explosion. Prevention and protection principles against explosions are defined in Directive 1999/92/EC, 1999, in the following order of priority:
  - the prevention of the formation of explosive atmospheres, or where the nature of the activity does not allow that,
  - the avoidance of the ignition of explosive atmospheres, and
  - the mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers.

  Therefore, if the simultaneous coincidence likelihood of an ignition source and an explosive atmosphere is too high according to the criteria defined, then the equipment must be protected since, as the explosion cannot be prevented in a reliable way, the equipment must be prepared to stand it and protect people from its effects.

2. Challenging the risk acceptance criteria

2.1 Scenarios

Processes in industry are complex and many times, the evil is in the details. Let us consider some processes where at some point the presence of a flammable, yet explosive, atmosphere may be present. For instance:

- while filling a flammable liquid in an equipment which will be later inerted, or
- while opening an equipment after a process in which flammable solvents are involved and, therefore, the presence of flammable vapours is feasible, or
- while performing a specific operation in an area designed for such operation, but also frequently used for other tasks.

The situations described could correspond to next specific scenarios:

- Filling by vacuum a flammable solvent into a vessel. As filing by vacuum may lead to air ingress, the potential presence of flammable atmosphere must be considered and, to ensure that no flammable atmosphere is later present during process, the equipment is inerted once charging is finished.
- Top discharge of a centrifuge. A mixture of a solid and a flammable solvent may be dosed under inert conditions into a centrifuge to separate the solvent resulting in a solid cake still wet with flammable solvent. Therefore, if the centrifuge must be opened to discharge it, the presence of a flammable atmosphere inside the centrifuge needs to be clearly considered during normal operation.
- Loading flammable solvents into road tankers. Areas designed to load flammable solvents into road tankers are usually classified due to the potential presence of flammable vapours around the road tanker. Nevertheless, these areas are often placed in facility roads which, when there are no loading operations going on, are used as normal traffic ways within the facility.

In all the situations above ATEX zones would usually be defined thus setting a requirement on the limitation of presence of ignition sources. Now, let us consider the following ignition sources:

- In case that solid is introduced in the vessel to be mixed with the solvent or in case that crystallisation operations take place in this vessel, depending on the solvent and vessel properties, the generation of electrostatic charges and a potentially incendive discharge will take place under normal operational conditions. No failure nor deviation are required to cause such an ignition source.
- In the centrifuge case, the generation of electrostatic charges is, again, present under normal operational conditions, no failure nor deviation are required to cause such an ignition source.
- In the case that a normal non-Ex forklift circulates through the loading area when no loading operation is going on, it must be considered that ignition sources are present during normal operational conditions. Also, that would apply to the truck pulling the road tanker as trucks are not Ex rated and to position the road tanker the truck will circulate through the area.

2.2 Risk acceptance

In one hand, considering the scenarios described, the presence, at some point in the process, of a flammable atmosphere will lead to consider the definition of an Ex zone. At this point there is no need to discuss it that would be a zone 0, zone 1 or zone 2 as for the following reasoning the type of zone is not relevant.
On the other hand, in the scenarios described, ignition sources have been identified which will be present under normal process conditions, meaning that no deviation or failure needs to take place so that these ignition sources are generated.

Considering these facts and the risk acceptance matrix presented before, next figure shows the potential results of the risk assessment from a traditional point of view:

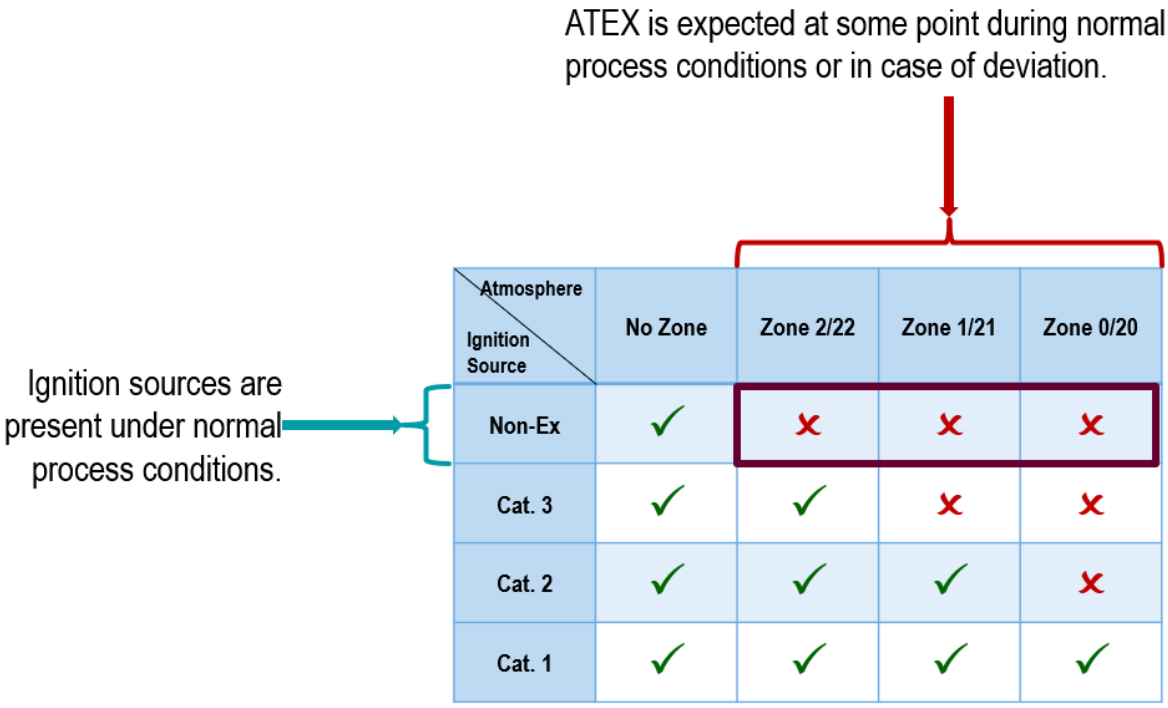

Figure 1: Potential risk acceptance results of frequently found scenarios in process industry

As can be seen, all potential results are non-acceptable from a traditional ATEX criteria point of view; nevertheless, the scenarios described are performed on a normal basis and risk is broadly accepted in industry. This fact, lead to reconsider the risk assessment and acceptance principles and propose the reviewed criteria which is described in the following points.

3. Reviewed risk acceptance criteria

3.1 Act upon the zoning

In first place, one could consider that it would still be possible keeping the traditional approach by acting upon the zone definition, but, in this case, the only possible solution would be to reduce the zone classification to “No Zone” and that presents the following difficulties:

- In first place, to consider that a zone as not classified at all, it is necessary to discard the presence of a flammable atmosphere even in the case of a process deviation and for a short period of time, which corresponds to the definition of Zone 2 and Zone 22. This requirement cannot be fulfilled in many occasions as deviations are hard to exclude with absolute reliability and, sometimes it is also acknowledged that Zones 2 and 22 are defined on a conservative principle to signal that presence of hazards needs to be considered in an area where operations are performed.
- Secondly, if the “No zone” consideration could be achieved, then it would mean that non-Ex rated equipment generating ignition sources under normal process conditions should be acceptable to be installed in such area. In this sense, it is considered that this situation would clearly lead to a risk level increase since, as already presented, a totally exclusion of flammable atmospheres might be very difficult to achieve and even if formally classified as No Zone, the potential presence in some areas should be considered.

3.2 Act upon the ignition source criteria

Reviewing the way that risks are accepted in the scenarios described above, it has been noticed that, regardless the zoning definition, a principle is broadly applied leading to accepting the presence of ignition sources generated under normal conditions in an area which is formally classified as Ex Zone. This principle is the exclusion principle, meaning that, even if the zone is classified regardless of process condition, the

operations generating ignition sources under normal conditions are well known and, when they are carried out, it is ensured that no flammable atmosphere is present in the area of concern.
Reviewing the scenarios considered in this paper, it can be easily understood why inert conditions are ensured during crystallisation, centrifugation and other processes generating electrostatic discharges under normal operation and, in the same sense, traffic of non-Ex forklifts is prohibited around road tankers during loading operation.
It is also frequent the exclusion principle is managed by using work permits, leading to accepting the introduction of ignition sources in formally classified Ex zones after following a procedure ensuring that ATEX is excluded when ignition sources are introduced.
The exclusion principle is already broadly applied and is based on fact that if the coincidence of the flammable atmosphere and that of the ignition source are excluded, thus leading to an acceptable risk. The problem is that the principle is not well described when deriving the criteria from the definitions of the zoning and equipment categories.
For this reason, the assessment of ignition sources is proposed as follows in the ignition source column of the risk acceptance matrix:

- A: Non-Ex equipment OR the ignition source present under normal conditions
- B: Category 3 equipment OR the ignition source is not present during normal operation but may be generated in case of foreseeable failure OR present under normal conditions, but coincidence excluded in a reliable way.
- C: Category 2 equipment OR the ignition source is not present during normal operation but may be generated in case of rare failure OR present under normal conditions, but coincidence excluded in a highly reliable way.
- D: Category 1 equipment OR the ignition source must be reliably excluded; it will not appear even in the case of rare failure OR potential ignition sources are never incendive.

The risk acceptance matrix remains unchanged in all other columns and criteria.

4. Conclusions

Many operations are performed in industry for which the traditional risk acceptance criteria derived from the Ex zones definition and the equipment category requirements is not suitable.
In order to well describe the risk acceptance criteria in these operations, the exclusion principle is introduced directly at the same level of ignition source assessment, meaning that not only the way ignition sources are generated will be taken into account, but also, for those which is known that will be present, it must be ensured that when it is so, safety measures are in place to ensure that the presence of an ATEX is sufficiently excluded.
Exclusion of ATEX, as generation of ignition sources, needs to be ensured in several degrees in relation with the formal zone definition of an area, which as is current practice, once defined remains unchanged and is not a function of process conditions.

References

Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

DIRECTIVE 94/9/EC OF THE EUROPEAN PARLIAMENT AND THE COUNCIL of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres