Area Classification for Explosive Atmospheres: Comparison Between European and North American Approaches

AREA CLASSIFICATION FOR EXPLOSIVE ATMOSPHERES: COMPARISON BETWEEN EUROPEAN AND NORTH AMERICAN APPROACHES

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Abstract – The object of this paper is to review various methods of determining the extent of hazardous areas in industrial facilities where explosive gas or vapor atmospheres may be present. Three different approaches are analyzed and compared. The first one is recommended in North American Standards, such as API500 [1], API505 [2] and NFPA 497 [3]. The second is one of the proposals for the second edition of the International Standard IEC 60079-10-1 [4] (adopted as European standard EN 60079-10-1). The third approach had been previously worked out with the authors' contribution and had been adopted by the Italian Guide CEI 31-35 since 2001 [5]. The last two approaches are analytical, meanwhile the first one is prescriptive. In the second part of the paper both analytical approaches are applied to the releases which are analyzed in NFPA 497 [3] as practical examples. Resulting hazardous area extents are compared and the differences among the three methods are discussed.

Index Terms — Hazardous area classification, Gas atmospheres, International standards, Risk analysis, Explosions.

I. INTRODUCTION

For many years the risk of explosion and the consequent requirement for the classification of areas has been a concern worldwide [6] and in the beginning industry codes were mainly used [7]. In 1994 and 1999 two ATEX directives were published by the European Parliament, respectively Directive 94/9/EC [8] and Directive 99/92/EC [9]. The first deals with equipment and protective systems intended for use in potentially explosive atmospheres; the latter with the safety and health protection of workers potentially at risk from explosive atmospheres. In particular, Directive 99/92/EC [9] requires that the employer adopts adequate measures in order to prevent the formation of explosive atmospheres, avoid their ignition and mitigate the detrimental effects of an explosion. Among these measures is the classification of the places where explosive atmospheres may occur.

The regulations provided by the second ATEX Directive have been adopted in the International Standard IEC 60079-10-1 [4]; in Italy, moreover, since 2001 the Guide CEI 31-35 has been published. Recently a new version of CEI 31-35 [5] has been issued, incorporating some novelties in the hazardous areas evaluation. Also, a new version has been proposed and is in draft (its publication is forecasted for December 2013) for the International Standard IEC 60079-10-1[10]. One of the proposals for the new IEC Standard incorporates a new approach for the evaluation of the extent of hazardous areas, which was initially presented by researchers of the Health and Safety Laboratory (UK) [11].

In the United States other Standards, with similar methods, are used for the classification of hazardous locations [12], while in South American Countries sometimes IEC Standards are applied [13]. In the United States API [1],[2], and NFPA [3] Recommended Practices are used. Particularly, API standards [1],[2] are the most commonly used ones in North America for the Oil and Gas industry.

The two main sets of Standards, North American and European, have been compared for what concerns the protection methodologies [14] but the Standard variety is vast and for this reason we think there is the need for some exchange of knowledge between the experiences of different Countries in this field.

This paper compares the area classification approaches adopted by the API [1],[2], and the NFPA Recommended Practice [3], to the future Standard IEC 60079-10-1 [10] and to the Italian Guide CEI 31-35 [5]. It analyzes the procedure for the area extent assessment and then it illustrates some examples of classification carried out following the prescriptions of the three different methodologies.

II. DIFFERENT APPROACHES IN AREA CLASSIFICATION

Nowadays two different approaches deal with the classification of hazardous areas, whenever flammable concentrations of gas may arise.

The first approach, used to classify hazardous locations, is the one proposed by both NFPA 497 [3] and by API 500 [1], which are published in the United States respectively by the National Fire Protection Association and by the American

Petroleum Institute (API). According to these Standards, the hazardous locations are to be classified Class I Division 1 or Division 2. In Division 1 ignitable concentrations of flammable gases or vapors can exist under normal conditions. In Class I Division 2 ignitable concentrations of flammable substances escape and are present only under abnormal conditions, when accidental rupture or unusual faulty operation occurs and the flammable material is no longer confined within a closed system. Class I Division 2 is also applied to a location adjacent to a Division 1 location, to which ignitable concentrations of gases might occasionally be communicated.

The second approach is proposed by the Standard IEC 60079-10-1[4]. According to this approach, hazardous locations (in which an explosive gas atmosphere is present, or may be expected to be present) shall be classified in Zones on the basis of the frequency of occurrence and persistence of the dangerous atmosphere, as reported in Table I.

TABLE I

ZONE TYPES (IEC 60079-10-1)

ZONE 0	An explosive atmosphere is present continuously or for long periods or frequently
ZONE 1	An explosive atmosphere is likely to occur in normal operation occasionally
ZONE 2	An explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only

In accordance with Table B.1 of Standard IEC EN 60079-10-1 [5] (Table II below) the type of zone can be evaluated, knowing three parameters: the grade of release, the degree and availability of the ventilation.

TABLE II

INFLUENCE OF VENTILATION AND GRADE OF RELEASE ON TYPE OF ZONE (IEC 60079-10-1)

Grade of release	Ventilation						
	Degree						
	High			Medium			Low
	Availability						
	Good	Fair	Poor	Good	Fair	Poor	Good, fair or poor
Continuous	(Zone 0 NE) Non-hazardous[a]	(Zone 0 NE) Zone 2[a]	(Zone 0 NE) Zone 1[a]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
Primary	(Zone 1 NE) Non-hazardous[a]	(Zone 1 NE) Zone 2[a]	(Zone 1 NE) Zone 2[a]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or Zone 0[c]
Secondary[b]	(Zone 2 NE) Non-hazardous[a]	(Zone 2 NE) Non-hazardous[a]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0[c]

NOTE 1 '+' signifies 'surrounded by'.

NOTE 2 Particular care should be taken to avoid situations where enclosed areas containing sources that give only secondary grades of release might be classified as zone 0. This applies also to small non- purged and non-pressurized enclosed areas, e.g. instrument panels or instrument weather protection enclosures, thermally insulated heated enclosures or enclosed spaces between pipe installations and envelope of thermal insulation.

Such enclosures should preferably be provided with at least some kind of appropriately located apertures that will enable unimpeded movement of air through the interior. Where that is not possible, practicable or desirable, effort should be made to keep major potential sources of release out of enclosures, e.g. pipe connections should normally be kept out of insulation enclosures as well as any other equipment that may be considered a potential source of release.

NOTE 3 Continuous and primary sources of release should preferably not be located in areas with a low degree of ventilation. Either sources of release should be relocated, ventilation should be improved or the grade of release should be reduced.

NOTE 4 The summation of sources of release with regular (i.e. well predictable) activity should be based on detailed analysis of operating procedures. For example, *N* sources of release with common mode of release should be normally considered as a single source of release with *N* different discharge points.

[a] Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions.

[b] The zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in this case, the greater distance should be taken.

[c] Will be zone 0 if the ventilation is so weak and the release is such that in practice an explosive gas atmosphere exists virtually continuously (i.e. approaching a 'no ventilation' condition).

Sources of release are classified in the following three grades of release:

- **continuous grade** of release when the release is continuous or is expected to occur frequently or for long periods;
- **primary grade** of release when the release can be expected to occur periodically or occasionally during normal operation;
- **secondary grade** of release when the release is not expected to occur in normal operation and, if it does occur, is likely to do so infrequently and for short periods.

Two aspects of ventilation are considered in controlling dispersion and persistence of the explosive atmosphere: the degree of ventilation and its availability.

Three degrees of ventilation are identified:

- **high ventilation (HV)** can reduce the concentration at the source of release virtually instantaneously, resulting in a concentration below the lower explosive limit. A zone of negligible extent may result (depending on the availability of the ventilation);
- **medium ventilation (MV)** can control the concentration, resulting in a stable zone boundary while the release is in progress and in the elimination of the explosive atmosphere after the release has stopped;
- **low ventilation (LV)** cannot control the concentration while release is in progress and/or cannot prevent the persistence of an explosive atmosphere after release has stopped.

The concept of degree of ventilation is related to the flow rate of the ventilation itself and obviously it is not an absolute concept, but it is related with the flow rate of the source of release.

Three levels of ventilation availability are considered:

- **good** if ventilation is present virtually continuously;
- **fair** if ventilation is expected to be present during normal operation. Discontinuities are permitted provided they occur infrequently and for short periods;
- **poor** if ventilation does not meet the standards of fair or good, but discontinuities are not expected to occur for long periods.

The philosophy behind the IEC standard is that an installation in a hazardous area is safe if there are, at least, three safety barriers against explosion. These three safety barriers can be provided partly by the type of Zone itself (likelihood of presence of an explosive atmosphere), partly by the installed equipment (likelihood of ignition). The safety barriers provided by the type of Zone are related to the likelihood of presence of an explosive atmosphere in this way: Zone 0 has zero safety barriers, Zone 1 has itself one safety barrier, Zone 2 has itself two safety barriers. Table III shows the levels of protection for the equipment (EPLs) [8][9], in order to achieve the three safety barriers required for each kind of Zone. In particular:

- Zone 0 (0 intrinsic safety barriers) requires equipment with 3 safety barriers;
- Zone 1 (1 intrinsic safety barrier) requires equipment with 2 safety barriers
- Zone 2 (2 intrinsic safety barriers) requires equipment with 1 safety barrier.

The IEC Standard [4] seems to be more refined in comparison to the North American Standards [1][2][3]. The three Zones established by IEC are in fact based on how often the hazard is present and the difference between continuous and primary grade of release is taken into account; in the Division approach instead, Division 1 covers both Continuous (IEC Zone 0) and Primary (IEC Zone 1). Thus, by splitting Division 1 into Zone 0 and Zone 1, it is possible to limit the most stringent methods of protection to Zone 0 areas and to have more methods of protection in Zone 1 areas. Zone 2 and Division 2 areas are similar in description and methods of protection allowed.

Nowadays however, North American Standards also describe the Zones approach, and this approach is often used for new facilities classification, applying in particular API 505 [2].

TABLE III
EPLS AND ZONES

likelihood of presence of explosive atmosphere	likelihood of ignition		
Zone	**Equipment**	**Protection**	**Group/Category/ EPL**
Zone 0 An explosive atmosphere is present continuously or for long periods or frequently (zero safety barrier)	Equipment for explosive gas atmospheres, having a 'very high' level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected or when subject to rare faults.	Two independent means of protection or safe even when two faults occur independently of each other. (three safety barriers)	Group II Category 1G EPL Ga
Zone 1 An explosive atmosphere is likely to occur in normal operation occasionally (one safety barrier)	Equipment for explosive gas atmospheres, having a 'high' level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.	II /2 G Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account (two safety barriers)	Group II Category 2G EPL Gb
Zone 2 An explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only (two safety barriers)	Equipment for explosive gas atmospheres, having a 'enhanced' level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences.	Suitable for normal operation (one safety barrier)	Group II Category 3G EPL Gc

For what concerns the influence of ventilation in the classification, API 505 [2] and NFPA 497 [3] distinguish between 'adequate' and 'not adequate' ventilation: an 'adequate ventilation' is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentration above 25 percent of their lower flammable limit (LEL). Moreover API 505 [2] indicates how to estimate if ventilation is adequate or not and explains that if adequate ventilation is provided, many enclosed locations may be classified Zone 2 instead of Zone 1 and some locations may be classified Zone 1 instead of Zone 0.

On the other hand, IEC Standard [4] takes ventilation into account in a more sophisticated way, considering both the degree and the availability of the ventilation, and analyzing its impact on the hazardous location. This implies that, for example, a theoretical Zone 1 produced by a primary grade of release and classified by North American Standards as Zone 1, according to the IEC Standard [4], in the presence of a good availability of high ventilation, becomes a non hazardous location. On the contrary, for example, areas characterized by a secondary grade of release and classified by North American Standards as Zone 2, in the presence of a low degree of ventilation can be classified by IEC as Zone 1 or even as Zone 0.

III. THE EVALUATION OF THE EXTENT OF HAZARDOUS AREAS

IEC 60079-10-1 [3] introduces the 'Hypothetical volume' ('V_z') concept. V_z is defined as the volume in which the average concentration of the gas in air is equal to a critical threshold which is fixed by the LEL of the gas. IEC introduces equation (1) to calculate V_z.

$$V_z = \frac{f(Q_g)_{max}}{C} \frac{1}{k \cdot LEL_m} \frac{T}{293} \tag{1}$$

where

- f is the efficiency of the ventilation in terms of its effectiveness in diluting the explosive gas atmosphere
- C is the number of fresh air changes per unit time [s^{-1}]
- k is a safety factor
- LEL_m is the lower explosive limit [kg/m^3]
- T is the ambient temperature [K]
- $(Q_g)_{max}$ is the maximum release rate of gas from a container [kg/s]; if the gas velocity is choked, Q_g may be estimated by means of equation (2) [15]

$$Q_g = S \cdot p \cdot C_d \sqrt{\gamma \frac{M}{R \cdot T} \left(\frac{2}{\gamma + 1} \right)^{(\gamma+1)/2(\gamma-1)}} \tag{2}$$

where:

- S is the cross section of the opening, through which gas is released [m^2]
- p is the pressure inside the container [Pa]
- C_d is the coefficient of discharge [15]
- γ is the polytropic index of adiabatic expansion
- M is the molecular mass of gas [kg/kmol]
- R is the universal gas constant [J $kmol^{-1}$ K^{-1}]
- T is the absolute temperature inside the container [K].

The volume V_z can be used to assess the degree of ventilation [16]. In fact IEC suggests evaluating a high degree of

ventilation when the calculated value of V_z is less than 1% of the room volume. On the other hand, according to IEC, ventilation should be regarded as low if V_z exceeds the room volume.
At the moment in IEC 60079-10-1[3] there are no formulas to estimate the extent of the hazardous zones. The given formulas are used only to perform the ventilation study of the location.

Another approach, summarized in [11], has been proposed to be considered in the new version of IEC 60079-10 [10].This approach had been studied by the HSL ('Health and Safety Laboratory') which is an in-house agency of the UK 'Health and Safety Executive. HSL developed an integral model of gas dispersion and from this model an analytic formula for the hypothetical volume V_z, had been derived and validated against CFD ('Computational Fluid Dynamics') simulations.

As it is shown in [11], in the case of outdoor releases, V_z is calculated by means of equation (3) .

$$V_z = \frac{9\pi r_s^3}{16\alpha}\left(\frac{\rho_a}{\rho_s}\right)^{3/2}\left(\frac{1}{X_{crit}}\right)^3 \tag{3}$$

where
X_{crit} is the critical concentration of interest [vol/vol]
ρ_a is the density of ambient air [kg/m^3]
ρ_s is the gas density [kg/m^3]
α is the entrainment coefficient
r_s [m] is the actual hole radius in the case of subsonic jets.
Gas jets are expected to be sonic in releases from pressures of 0.89 bar above atmospheric or higher. In these cases, outside the release source, as the gas pressure drops to ambient pressure, then the gas density drops also and the jet cross-sectional area must grow to balance the density drop. Thus, in the case of sonic jets, r_s is the radius of a pseudo-source and it is estimated by equation (4).

$$r_s = r_0\sqrt{1 + 0{,}5\left(\frac{p}{p_a} - 1{,}89\right)} \tag{4}$$

where
r_0 is the actual hole radius
p/pa is the ratio of storage pressure to ambient pressure.
It is important to note that, according to this approach, the hypothetical volume is strongly dependent to the jet source size, because V_z is proportional to the cube of the source radius.

On the other hand, the Italian Guide CEI 31-35 [5] introduces an equation for the evaluation of the hazardous distance (d_z), which is the distance from the source, along the central axis of the jet, at which the flammable gas concentration is reduced to the LEL of the gas. This formula, shown in equation (5), was worked out by the authors in previous works [17],[18],[19] and it is used to calculate the hazardous distance d_z for jet gas releases, when release velocity $u_0 \geq 10$ m/s.

$$d_z = 5{,}2 \cdot (P \cdot S)^{0{,}5}\,\frac{k_z}{k_{dz}\cdot LEL_v}\cdot M^{-0{,}4} \tag{5}$$

where:
- S is the cross section of the source of release [m^2];
- P is the absolute pressure inside the containment system [Pa];
- M is the flammable substance molar mass [Kg/Kmol];
- LELv is the substance lower explosive limit, expressed in volume per cent;
- k_z is a correction coefficient to account for the gas or vapour concentration in the far field (far away from the source of release, where the gas or vapour is completely mixed with air); in the case of open space release $k_z = 1$;
- k_{dz} is the safety coefficient applied to the LEL for the calculation of d_z; it assumes values between 0.25 and 0.5 for releases of continuous and primary grade and values between 0.5 and 0.75 for secondary grade releases.

Experimental measures have been carried out in the case of a natural gas release [20] and have been compared with the calculations suggested by the Italian Guide CEI 31-35 [5].The experimental data of the gas release fit quite well the theoretical model suggested by the Italian Guide for the calculation of the hazardous distance.

IV. CASE STUDY I

The first example considered is a leakage located outdoor, at grade. The material is a compressed flammable gas.
NFPA 497 [3], in figure 5.9.2 (a), indicates the classification, using Divisions, showed in Fig. 1.

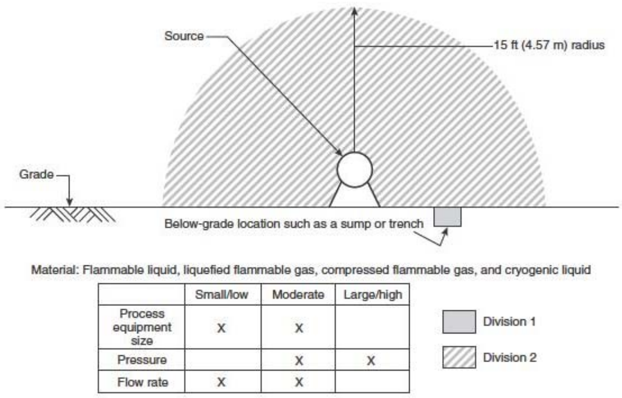

Fig. 1. Leakage of compressed flammable gas located outdoor

The same classification, using zones, is reported in fig. 5.10.2 (a) of NFPA 497 [3], where the figure is identical but Division 1 and 2 are replaced respectively by Zone 1 and 2. This evaluation considers a process equipment size and a flow rate from "Small" to "Moderate" and a pressure from "Moderate" to "High". It means a pressure range from 100 psi to more than 500 psi (in this example we assume 1000 psi) and a flow rate from less than 100 gpm (in this example we assume 50 gpm) to 500 gpm. The extent of Zone 2 (or Division 2) is, in all cases, 4.57 m.

Converting inches and gallons to international units and considering methane as flammable gas (density 0.65 kg·m^{-3}) it means a pressure in the range of 6.9 to 69 bar and a flow rate from 2.07 to 20.7 g/s.

Basing on equation (2) it is possible to analytically find out the dimension of the leakage corresponding to a flow rate of 2.07 g/s at 6.9 bar (or a 20.7 g/s at 69 bar): the cross section of

the opening, through which gas is released is approximately 2 mm^2.
The calculation made with relation (5), assuming the chemical parameters of methane and a safety coefficient k_{dz}=0.5 (i.e. considering a zone boundary with concentration 0.5 LEL), gives an extension of the hazardous zone (d_z) from approximately 1 m to 3 m as showed in fig. 2.

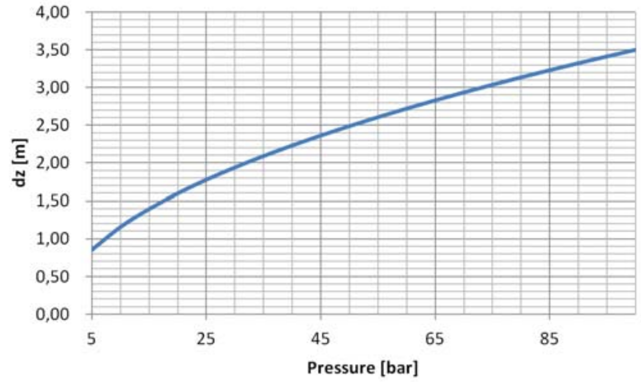

Fig. 2. Extent of the zone with formula (5)

It is clear from this example that the classification provided by the NFPA Standard is much more conservative, especially for low pressures of the gas in the containment system. The Italian guide instead requires a more complicated study, involving some calculations, but gives a smaller hazardous area (with a size depending on the characteristics of the source of emission).

A smaller hazardous area may mean smaller expenses for electrical components, as more components can be installed outside of the hazardous area.

V. CASE STUDY II

The second example is a leakage of flammable liquid located indoor, at floor level.

NFPA 497 [3], in figures 5.9.1 (e) and 5.10.1 (e), indicates the classification, using respectively Divisions and Zones, where is assumed that an adequate ventilation is provided.

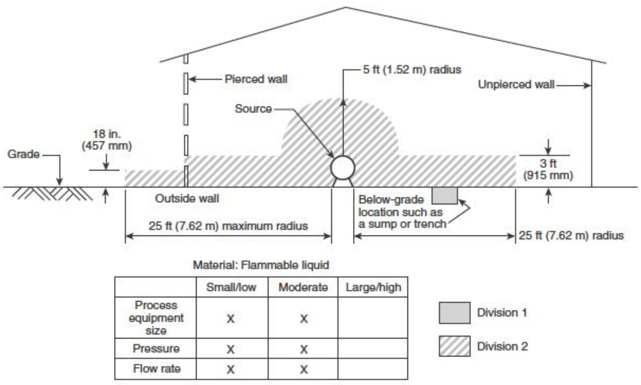

Fig. 3. Leakage of flammable liquid located indoor, ventilation adequate

Figure 5.9.1 (e) is reported in Fig. 3. Figure 5.10.1 (e) is identical to Fig. 3, but Division 1 and 2 are replaced respectively by Zone 1 and 2.

The same leakage is analyzed in NFPA 497 [3], figures 5.9.1 (f) – divisions - and 5.10.1 (f) - zones - when adequate ventilation is not provided, Fig. 4.

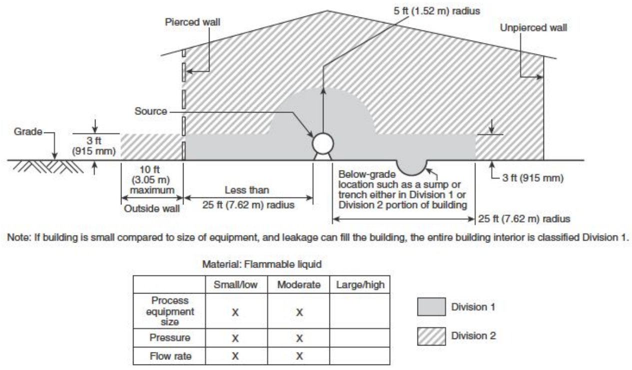

Fig. 4. Leakage of flammable liquid located indoor, ventilation not adequate

As shown in Fig. 3, when an adequate ventilation is provided and prevents communication of ignitable concentrations of gases, Zone 2 is confined to a limited part of the building, around the source of emission. If not, as shown in Fig. 4, Zone 2 fills the entire building and a Zone 1 appears close to the source of release. The calculation in the far field is determined assuming the concentration to be homogenous, regardless the small "pockets" of higher concentration near source of release [2].

This approach is very similar to the concept of degree of ventilation of IEC 6007910-1 [4] where medium ventilation (MV) *"can control the concentration, resulting in a stable zone boundary, while the release is in progress"*. In other words, with MV, the hazardous location is present only near the source of release and the concentration of explosive atmosphere outside this boundary is far less than the LEL.

Guide CEI 31-35 [5] fixes the concentration in the field which is far away from the source of release, where the vapor is completely mixed with air: $X_{m\%}$, above which the MV is achieved, as follows:

$$X_m\% \le \frac{k \cdot LEL_v}{f_a} \tag{6}$$

where k is a safety factor (k=0.25 to 0.5) and f_a is a coefficient depending on the effectiveness of the ventilation (i.e. the interaction between source of release and ventilation). The coefficient f_a is to be chosen in the range 1 to 5.

If the condition on X_m% not fulfilled, the degree of ventilation is **low** (LV) and the hazardous location fills the entire building.

Note that LV is very similar to the assumption of "ventilation not adequate" of NFPA.

In the case of medium ventilation the extent of hazardous zone (Zone 2 in this case) depends on the flow rate of the leakage (i.e. the area of the pool formed at the ground).
The calculation of d_z (assuming a pool of gasoline and 0.5 m/s as the air speed near the pool) can be carried out with the equation (7) [15]. Equation (7) is introduced (as equation (5),

mentioned above) in the Italian Guide CEI 31-35 [5]; particularly, equation (5) regards gas jet release, meanwhile equation (7) regards a vapor release from a pool of flammable liquid.

$$d_z = \mathbf{3.5} \cdot \left(\frac{P_v \cdot 10^{-5}}{\mathbf{M}} \right)^{\mathbf{0.1}} \cdot (k_{dz} \cdot LEL_v)^{\mathbf{-0.26}} \cdot A^{0.7} \qquad (7)$$

where:

- A is the size of the pool [m^2];
- P_v is the vapor pressure [Pa];
- M is the flammable substance molar mass [Kg/Kmol];
- LELv is the substance lower explosive limit, expressed in volume per cent;
- k_{dz} is the safety coefficient applied to the LEL for the calculation of d_z; it assumes values between 0.25 and 0.5 for releases of continuous and primary grade and values between 0.5 and 0.75 for secondary grade releases.

Fig. 5 shows the extent of the hazardous zone for different sizes of the pool.

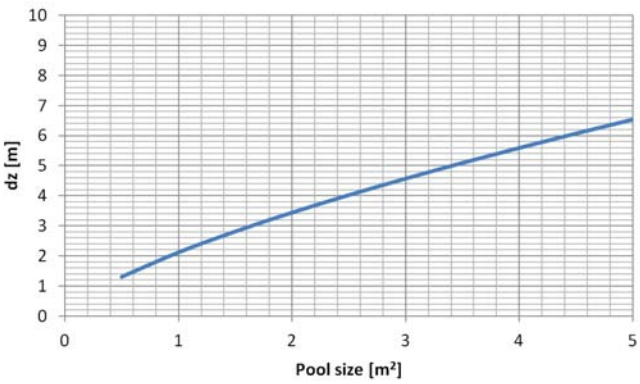

Fig. 5. Extent of the zone calculated with equation (7)

The NFPA Standard[3] leads to more conservative results in the size of the hazardous location as it only considers the influence of ventilation, whereas Guide CEI 31-35 [5] considers both the influence of ventilation and the leak flow rate.

VI. CONCLUSIONS

In this paper the approaches to the classification of hazardous areas proposed by the North American Standards API 500 [1], API 505 [2] and NFPA 497 [3], by the European Standard IEC 60079-10-1 and by the Italian guide CEI 31-35 [5] are compared. The different types of Zones-Divisions, the ventilation influence and the evaluation of the hazardous zone size are analyzed and compared.

In the case study examples it is showed that the North American approach involves less calculations and is easier to be used; however, if compared with the IEC and Italian CEI guide approach, it leads to a bigger estimation of the Zone/Division extent, especially for low pressures in the containment system (gas releases) and for low flow rates of the source of release (liquid releases).

A bigger estimation of the Zone/Division extent often means higher expenses in the installation of the electrical equipment: in fact special equipment may need to be be used instead of normal one. Also permits-to-work and work procedures are affected. For sure, instead, a bigger estimation leads to a safer classification. However it is showed in literature [16],[20] that the results obtained through calculation using the Italian method lead to conservative results with respect to Computational Fluid Dynamics (CFD) simulations and experimental measures.

The differentiation between Zone 0 and Zone 1 in the European approach (both included in Division 1 in the NFPA approach) allows for a higher safety of installation as it is possible to restrict methods of protection in Zone 0 and to have more methods of protection in Zone 1.

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VIII. VITA

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