

Classification of hazardous areas - natural gas installations

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Received: 11 Jan 2022,

Received in revised form: 03 Mar 2022,

Accepted: 10 Mar 2022,

Available online: 22 Mar 2022

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Keywords—*Hazardous areas, natural
gas networks, IGEN code, IEC code.*

Abstract—*An explosive atmosphere can be created by a gas or vapor, dust or even fibers. Methane-based risks dominate the gas generation and distribution sector. The probability that any hazard exists in fuel concentration is determined by the specifics of the system under consideration. For example, a natural gas vent line is much more likely to contain this hazard than a lube oil line - unless, of course, the oil line flange joint is leaking. In this work we present the global assessment of the risks of explosion that inevitably involves the definition and classification of hazardous areas with natural gas due to the presence of explosive atmospheres.*

I. INTRODUCTION

The ignition of an explosive atmosphere is related to three events necessary for the flame condition to occur: a) existence of oxygen, b) the source of ignition and c) the fuel. A flammable atmosphere thus corresponds to a mixture of oxygen and a combustible gas in a concentration such that it is flammable.

For large industrial installations, oxygen is, of course, the most complicated element to isolate, given the costs involved, so it is not usual to protect the installation in this way. In practice, preventing the formation of a flammable atmosphere is a complicated task. In aerial natural gas infrastructures, exposed to the weather, with many flanged and threaded connections, the probability of small leaks is high. In this way, the biggest control to avoid the flame is the control of the ignition source, being that the main ignition sources correspond to the electric arcs and the heated surfaces. As these sources of ignition are present in any industrial installation, it is also practically impossible to

eliminate them, installing sources of ignition or installing appropriate equipment to operate in these locations.

The equipment area classification service must be performed by experienced teams, since a wrong work in this sense can make projects unfeasible, promote unnecessary changes in existing installations and even bring operational, maintenance and personnel training concerns. .

The present work seeks to exemplify the size and characteristics of classified areas, as well as the costs involved, comparing the results obtained in the area classification in natural gas stations when using a specific standard and a more general standard.

II. CLASSIFICATION OF HAZARDOUS AREAS IN BRAZIL - STANDARDS CONSIDERED

The standard used in Brazil for classifying hazardous areas that operate with combustible gases is ABNT-NBR-IEC-60079-10 - Electrical equipment for explosive atmospheres - Part 10: Area classification. According to this

standard, areas are classified according to the frequency and duration of the presence of a flammable atmosphere, with Zone 0 being an area with continuous presence or for long periods of a flammable atmosphere; Zone 1 an area where a flammable atmosphere may occasionally occur under normal operating conditions; and Zone 2 an area where the presence of a flammable atmosphere is not expected under normal operating conditions, and if it occurs, it will be for short periods. Thus, equipment certified to operate in Zone 0 is more demanding in terms of electrical requirements, limiting circuit power, as is the case with Ex-i (intrinsically safe) or limiting exposure of the electrical circuit, such as Ex-ma (two resin encapsulations). In general, all equipment certified for explosive atmospheres is more expensive than a similar one for industrial use.

But it is not only the cost of acquiring the “Ex” equipment that must be taken into account, those responsible must be aware that the presence of a classified area in the plant involved impacts the cost in other spheres, as follows:

Design: the design of electrical installations in classified areas is normally carried out by specialized companies, thus involving higher costs. Qualified personnel with adequate technical capacity are also needed to analyze and approve the same;

Installation: demand inspection of qualified work to evaluate the materials used and to monitor the assembly and disposal of the equipment, as foreseen in the project;

Operation: hazardous area requires operating personnel to be trained to operate in these locations. In addition, it is necessary to use equipment suitable for that area, making access to them difficult or even limited;

Maintenance: depending on the concept adopted, there may be complications in the context of equipment maintenance itself.

III. IEC 60079 CODE AND IGEM/SR/25 CODE

Within the oil and gas industry, the IEC standard is the reference used. The same, however, was conceived to meet the specific demands of the oil industry, thus presenting a vision totally focused on its own equipment, such as LPG spheres, hydrocarbon storage tanks, vessels, among others. In an attempt to apply the methodology of the IEC standard to classify areas of equipment that operate in the transport and distribution of natural gas, significant distortions occur regarding the size and classification of the region around these equipment.


To facilitate and standardize the process of classifying the area of natural gas installations, the standard IGEM/SR/25 - Hazardous area classification of natural gas

installations is suggested, which should be used to complement the IEC standard. The IGEM/SR/25 standard is based on an objective methodology to dimension the size of the classified area, making the classification of the area less subjective, and thus, bringing more confidence to those responsible for these classifications. For dimensioning the size of hazardous areas, the IGEM/SR/25 - Edition 2 standard used the RR630 research report from the HSE (Health and Safety Executive), which is based on the same mathematical modeling used by the IEC standard.

In many aspects, the IGEM/SR/25 and IEC 60079 standard bring equivalent concepts, such as:

3.1 – Differentiation between normal operating releases (fugitive leaks in connections, releases in relief valves, etc.) and catastrophic leaks (breakage in equipment or piping, etc.). For area classification purposes, only normal operating leaks are considered, considering concepts of probability, duration and conditions surrounding the facilities. On the contrary, catastrophic spills are emergencies and part of a contingency approach. This difference is important in order not to overestimate the size or type of the classified area.

3.2 - Are based on the same mathematical models for computational simulation of leaks and on the explosive cloud dispersion behavior.

3.3  They present a distinction between primary and secondary releases: the standards distinguish the type of release according to the equipment installed in the field. An equipment has a primary release if releases are expected to occur during its normal operation. An example of equipment classified in this category is a relief valve. Otherwise, an equipment is classified as being of the secondary type.

In natural gas distribution companies, the topic of area classification was normally discussed in a superficial way. However, in recent years, with the expansion of natural gas distribution networks and service to regions increasingly distant from the operational bases, there was a need for these companies to install field automation to monitor the network and enable more efficient management. As a result, for example, the difficulties of moving personnel to carry out consumption readings and regular on-site inspections to verify the operation of the equipment installed on the network were avoided.

Automation brings many gains in several spheres, having presented a great leap in the operational management of natural gas distribution companies; however, automation brought with it an unavoidable problem, electricity.

From then on, the topic of area classification became a concern and an obstacle to projects of this type, due to the

initial lack of knowledge on the topic and, in part, because the IEC 60079-10 standard is not clear for applications in distribution companies. To reduce these problems, many of these companies have switched to contracting outsourced services in the area classification of their equipment. The biggest problem is that such specialized companies use the IEC 60079-10 standard as a reference to carry out their studies, resulting in dangerous areas of great extension, thus causing all the problems mentioned above.

IV. PRESSURE REDUCTION STATION – NATURAL GAS

Among the equipment used by natural gas distribution companies, the most common and which deserve special attention are the non-buried gas stations.

These stations, when not buried, can be of the ERP type (Pressure Reduction Station) or of the EMRP type (Measuring and Pressure Reduction Station). The main difference between these devices is that the EMRP is installed at the end customers, having a consumption meter, while the ERP only reduces the operating pressure of a certain line.

Before starting a station's area classification, two assumptions need to be considered:

- the stations discussed in the present work do not operate in adverse situations. The IGEM/SR/25 standard considers as an adverse situation: a) gas with a lot of particulates or wet gas; b) operation with excessive vibration; and c) corrosive atmosphere, such as the marine atmosphere.
- secondary releases are caused by fugitive leaks, with maximum dimensions of 0.25 mm².

The process of classifying the area of non-buried stations according to the IGEM/SR/25 standard begins with the identification of 3 points basic:

- kind of equipment
- work pressure.
- availability of ventilation

For each piece of equipment in a gas station, the IGEM standard classifies the type of release, which can be primary or secondary. As a rule, all equipment in a gas station is of the secondary release type, with the exception of the relief valve. The equipment of a station that has secondary release type are: pair of flanges, threaded unions, threaded fittings and block valves.

The equipment with secondary release promotes a classified area of the zone 2 type. The equipment with

primary release, on the other hand, generates a classified area of the zone 1 type, with an associated zone 2 classified area. Figure 1 illustrates the equipment with secondary release and the dimension of the Zone 2 classified area generated by them.

The size of the hazardous area of equipment that falls into the secondary release type depends on the operating pressure and degree of ventilation. Tables 1 and 2 present the size of the hazardous area of equipment with secondary release, and must be used in conjunction with figure 1. Table 1 establishes the dimensions of a freely ventilated station and Table 2 of one with ventilation restriction.

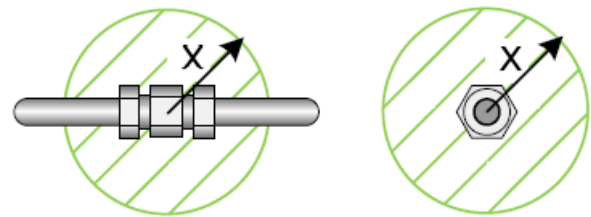


Fig. 1(a): Accessories or threaded unions

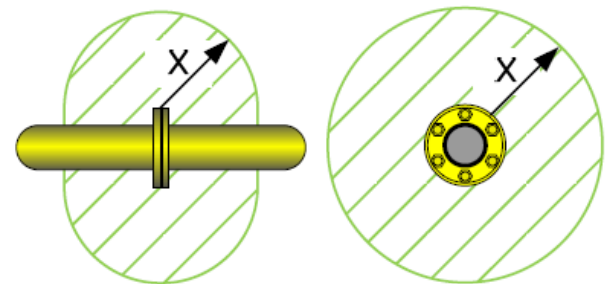


Fig. 1(b): Pair of flanges

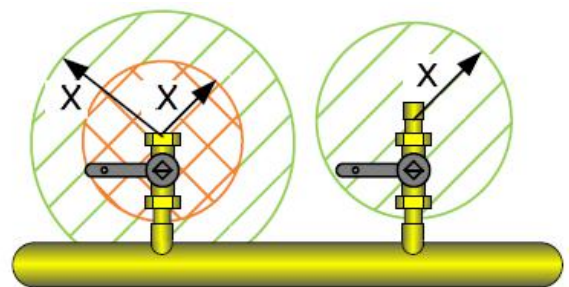


Fig. 1(c): Threaded stop valve, without and with plug

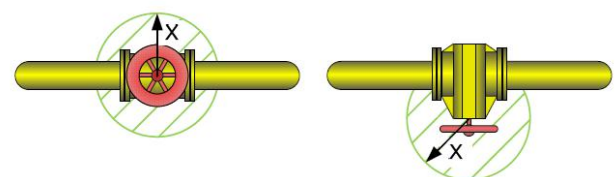


Fig. 1(d): Flanged block valve

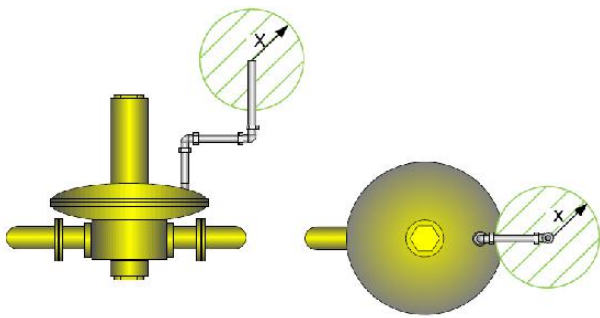


Fig. 1(e): Pressure regulator

Fig. 1: Identification of the location of the classified area in equipment with secondary release (adapted from the IGEM/SR/25 Edition2 standard)

Table.1: Dimension of the classified area of Stations Unrestricted Ventilated (IGEM/SR/25 Edition2)

Operating pressure (bar)	Dimension (X) of Zone 2 under normal operating conditions (m)
> 75 < 100	1.5
> 50 < 75	1.5
> 30 < 50	1.0
> 20 < 30	1.0
> 10 < 20	0.75
> 7 < 10	negligible
> 5 < 7	negligible
> 2 < 5	negligible
> 0.1 < 2	negligible
< 0.1	negligible

Table.2: Dimension of the classified area of Stations hundred ventilation restrictions (IGEM/SR/25 Edition2)

Operating pressure (bar)	Dimension (X) of Zone 2 under normal operating conditions (m)
> 75 < 100	2.0
> 50 < 75	2.0
> 30 < 50	1.5
> 20 < 30	1.5
> 10 < 20	1.0
> 7 < 10	0.75

> 5 < 7	0.75
> 2 < 5	0.50
> 0.1 < 2	0.50
< 0.1	0.50

4.1 – Area Classification around Relief Valve type equipment

Relief valve type equipment is present in the vast majority of pressure reducing gas stations. This device discharges any rises in the pressure of the gas network to the environment, causing this equipment to have the primary release type. The standard suggests the area classification as shown in Figure 2.

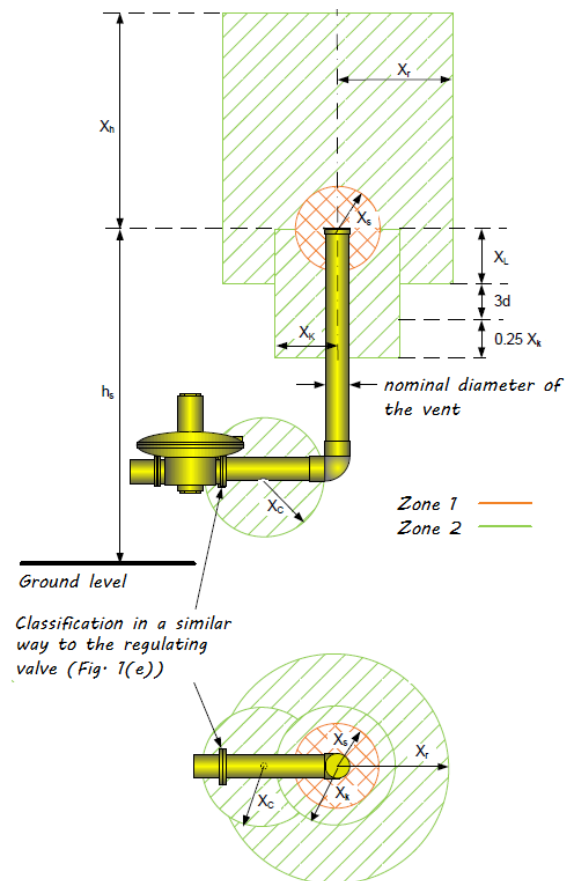


Fig. 2: Relief valve hazardous area (primary release). IGEM/SR/25 Edition2

The IGEM standard uses tables to obtain the values of X_r , X_h and X_k , and the input variables to obtain these values are: the vent diameter and the maximum flow of the relief valve (given in kg/s).

The value of the maximum flow rate of the relief valve can be obtained from the manufacturer's technical data. If

this value is not available, the standard suggests equations to obtain the flow, as follows:

For operating pressure ≥ 0.85 bar:

$$g = 675 (C_d)A(M^{0.5})T^{-0.5}(P + 1.013)^{1.05} \quad (1)$$

For operating pressure < 0.85 bar:

$$g = 1500 (C_d)A(M^{0.5})T^{-0.5}(P)^{0.5} \quad (2)$$

given: g = mass released [kg.s⁻¹];

M = molecular weight [kg.kmol⁻¹]. Consider GN = 17.367 kg.kmol⁻¹;

p = gas pressure [bar]. Assuming 110% of the opening pressure of the relief valve;

T = gas temperature at the discharge [K];

C_d = orifice discharge coefficient (according to manufacturer's data or adopt = 1;

A = cross-sectional area of the vent [m²].

Table.3: X_r , X_h and X_k values for vent diameter 25.4 mm. (IGEM/SR/25 Edition2)

Maximum flow from the relief valve (kg/s)	X_r (m)	X_h (m)	X_k (m)
> 0.01 <			
0.01 0.02	3.0	3.0	3.0
0.02 0.05	3.0	5.0	3.0
0.05 0.10	3.0	7.0	3.0

V. CASE STUDY - TYPICAL PRESSURE REDUCTION STATION AREA - NATURAL GAS

Considering a large station (Figure 3), with a regulating valve capable of regulating a flow of 20.000 m³/h, inlet pressure = 35 bar, outlet pressure = 7 bar, maximum flow of the relief valve regulated with 1.2% of the maximum flow of the regulating valve (resulting in 240 m³/h or 0.0433 kg/s).

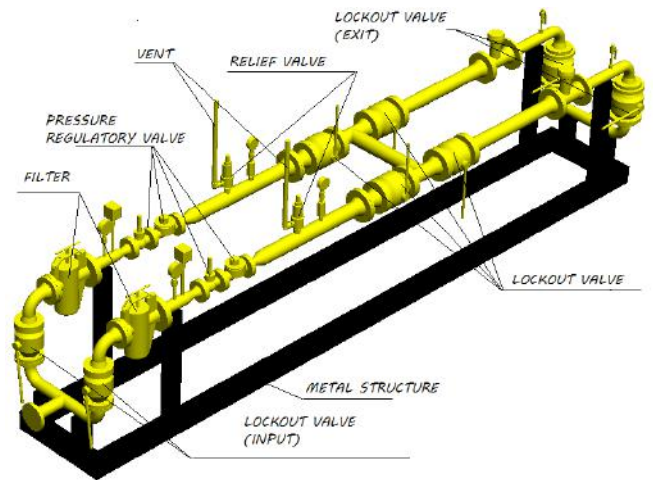


Fig. 3: Typical pressure reduction station

Figure 4 shows the size of the classified area (in a side view) around equipment of a 20.000 m³/h gas station, considering two types of ventilation: (a) free ventilation and; (b) obstructed ventilation.

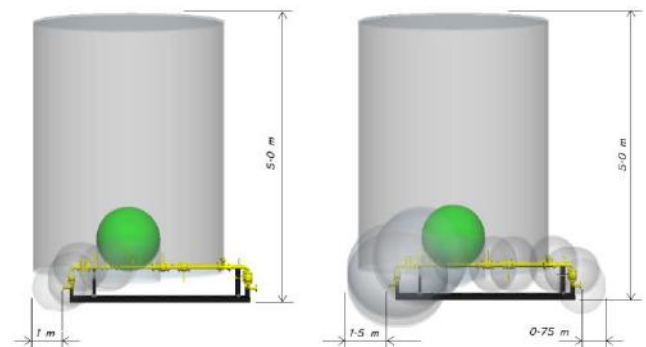


Fig. 4: Area classification considering: (a) free ventilation and; (b) obstructed ventilation.

Through Figure 4, it is noted that the free ventilation condition is more convenient, as it generates a smaller Zone 2 classified area, in addition, after the pressure adjustment to 7 bar, the size of the Zone 2 classified area is null, or according to the designation of Standard IGEM/SR/25, Zone 2 NE.

Next, Figure 5 presents the result of the classification of the fully ventilated station area, according to the IGEM (a) and IEC (b) standards. It can be clearly seen that the condition presented by the IGEM standard is more favorable in every way, since the Zone 1 classified area is relatively smaller.

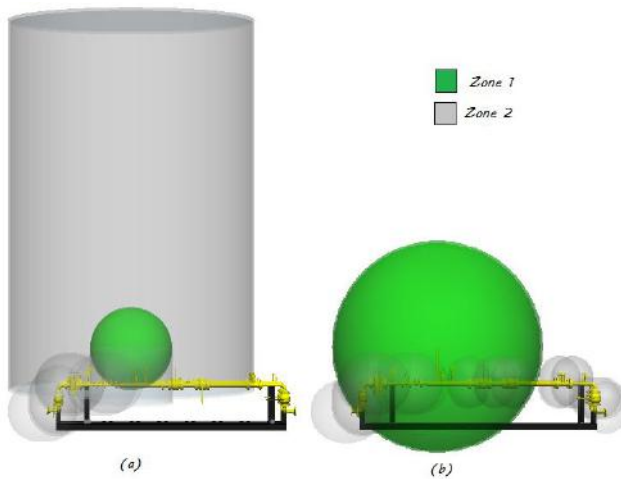


Fig. 5: Area classification according to IGM code (a) and IEC code (b).

VI. CONCLUDING REMARKS

The second edition of the IGM/SR/25 standard complements the ABNT-NBR-IEC-60079-10 standard, helping mainly in the natural gas distribution sector, since this fluid has different properties from other flammable fluids. Piped gas distributors are responsible for the joint and continuous implementation and discussion of such concepts for their validation, as well as the discussion of notable points, including the classification of small sheltered stations (residential/commercial segment). The benefits of applying the IGM standard are diverse, including greater safety in the installations; better documentation of classified areas; and good possibilities for reducing the costs of installing and operating the infrastructure. With automation, and as a consequence of the need for electric energy present in the stations, the area classification in gas stations has become a matter of responsibility, security, network integrity and cost reduction.

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