

GLOBAL COMPLIANCE OF ROOMS IN HAZARDOUS AREAS

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Abstract – This paper reviews the current legislation for certifying rooms in hazardous areas with the following aims: to describe the major aspects of certifying rooms for use in the international marketplace and establish the appropriate body for this assessment. This is achieved by reviewing the current status of the International Electrical Commission, its member states and the progress made towards being incorporated into national legislation. The International Electrical Commission standard is analysed to determine the suitability of the protection concepts and to consider how it reflects current market practices; The harmonised European Standard for Transportable Ventilated Rooms, The North American Fire Protection Association and Det Norske Veritas' standards for off-shore containers are all considered. The discussed differences aim to guide designers in the standards application and how to achieve global compliance.

Index Terms – IEC, Hazardous Area, Explosive Atmospheres, Compliance, Pressurized Room, Pressurization System, Safety Standards, Classification Societies.

I. INTRODUCTION

Equipment located inside hazardous area locations must be protected by suitable methods to limit the risk of an explosion. Protection can be applied to each individual system, but this can lead to complex and expensive equipment specifications for a system. Alternatively, the room in which this equipment is mounted, whether a Remote Instrument Building or a staff rest area, can be positively pressurized ensuring the exclusion of a hazardous environment.

The IEC is becoming a widely accepted body throughout the world with many of the standards already harmonised to local directives. There are however many discrepancies between it and the current legislation. Certain countries, either due to their national skill set or industry, have developed a preference for one style of protection. To illustrate this, consider cable terminal boxes. America tends to favour Explosion Proof concepts (Ex d) while Europeans would use Increased Safety (Ex e); Both are acceptable and safe if installed correctly, yet resistance may be found if the designer applies them in the incorrect market. An explanation may be that industries operating Hazardous Areas are primarily involved in the reduction of risk; Removal of the unknown factor caused by an unfamiliar protection concept goes some way to achieving this. There are, however, also the commercial aspects to consider and these standards serve as powerful barriers to trade. Consider the example above; if the US market demanded the much cheaper and lighter Ex e enclosures for cable termination, an industry worth several million Dollars a year and associated manufactures, would be facing a

significant shift in the product requirements and it may not be one they could accommodate. Designing for the international marketplace requires consideration of these aspects and awareness that more than one protection concept could be applied; the one selected will need to be accepted universally.

The paper outlines the concept of protecting rooms with this in mind by describing the current best practice and highlighting changes that need to be considered. The discrepancies are then examined with respect to safety implications and what is practicable in industry. The safety analysis is drawn from the author's knowledge in the certification field and selected Notified Bodies while the practicalities have been researched with major manufacturers of remote ventilated rooms for use in the on- and off-shore environments. The paper is structured to follow IEC 60079-13 [1] main chapters and will assess whether 60079-13 is sufficient to protect rooms or if other considerations will need to be made.

Protection for internal source of release in safe area pv is dealt with by positive pressurization in IEC while EN uses negative pressure in the Room to contain the hazard. Further variations are made to definitions of containment systems and the assessment of infallible equipment. This will not be covered in this paper but should be read in IEC60079-13 cl 10 & 11 / EN50381 [2] cl 7 & 11 and IEC 60079-16 [3].

II. DEFINITION OF TERMS

The IEC nomenclature is as per the ATEX95 (94/5/C) directive. The terms are described below and where applicable cross referenced to the NFPA equivalent.

1) *Zone 1*: Explosive atmosphere is likely to occur in normal operation occasionally (10>1000 hrs / year). This is similar to NEC Division 1

2) *Zone 2*: Explosive atmosphere is unlikely to occur in normal operation or infrequently (<10 hrs / year). This is similar to NEC Division 2

3) *EPL*: Traditionally zoning only considered the probability of explosion. Equipment Protection Levels were introduced under the IEC standards to take in to account the potential risk of the component creating an explosion. For Group II (above ground) applications the first letter indicates the nature of the hazard being either Gas or Dust and the second letter shown in lower case indicates the risk of. Therefore Ga- is equipment suitable for explosive gas atmosphere having a very high level of protection, Gb-

has a high level of protection and Gc- has an enhanced level of protection.

4) *Pressurization Concepts:* Pressurization protection falls into four categories depending on the application and level of protection required. The equivalent is shown for the current EN standard but is only for indication of the zone and not an indication of the protection concepts employed.

"pv"- maintains adequate dilution to any abnormal internal source of release to reduce the EPL to none. Equivalent to EN50381 type v4

"px"- pressurization and dilution to reduce EPL of Gb to none. Equivalent to EN50381 type v2

"py"- pressurization and dilution to reduce EPL of Gb to Gc. No equivalent to EN50381.

"pz"- pressurization and dilution to reduce EPL of Gc to none. Equivalent to EN50381 type v3

III. REVIEW OF CURRENT PRACTICE

A. *Defining a Standard and its Application*

The following statement has been taken from the IEC website and the relevant sections truncated for clarity:

"An International Standard is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results"... "A normative document, developed according to consensus procedures, which has been approved by the IEC National Committee members of the responsible committee". . . "Any member of the IEC may participate in the preparatory work of an International Standard, and any international, governmental and non-governmental organization liaising with the IEC also participates in this preparation". . . "it can be submitted to public enquiry in any country. Thus, through the democratic tools of consensus and public enquiry, any interested party may speak up and have their say in the development and publication of an international standard"... "Adoption of IEC standards by any country, whether it is a member of the Commission or not, is entirely voluntary."

So, what value does an international standard have if it is recognised by many in the industry, but its application is entirely voluntary? It is not until the standard has been incorporated into the local law that it is of any significant use to manufactures supplying into that area. In the European Community (EC) the central body issues Directives which give guidelines to the EC states who in turn issue regulations in the form of standards which are said to be harmonised to the governing Directive. In the USA the architecture is described by the National Fire Protection Association (NFPA) together with the National Electrical Code (NEC) [4] and, although there is a mutual agreement between the US and Canada allowing all notified bodies to certify to the relevant standard, they too have a set of regulations under the Canadian Electrical Code, (CEC) [5]. This structure is fairly typical worldwide with each economic area needing to be reviewed in accordance with its local laws and practices.

Include the fact that this is a commercial world and the organisations providing the financial backing have a vested interest in how their assets are protected, and yet another layer of

complexity is added. Some economic areas have preferred notified bodies such as Factory Mutual (FM) and Underwriters

Laboratories (UL) in North America or Det Norske Veritas (DNV) operating in Europe and the North Sea; These may also issue additional guidelines in areas where it is felt the risk is not adequately covered by local laws.

In 1995 DNV issued the standard 2.7-2 [6] to provide an engineering standard for the certification of rooms as no European standard existed. When in 2004 the European standard was issued it seems that this was largely ignored, and most major players still work to the DNV code. This is the exception rather than the rule for industry but is an indication of commercial power that is exhibited when product specification changes may negatively impact organisations operating in the market.

B. *Recognising When to Apply the IEC Standard*

The benefit of a single governing standard becomes clear but raises the problem of how to discover if the IEC standard is the best one to adopt for a specific project or product development specification. The IEC publishes a list on its website of the thirty member states, however not all IEC standards have been harmonised under the specific states' directives for hazardous areas.

There is currently no single document outlining the acceptance of 60079-13 at the national level due to its recent issue. Table 1 shows the adoption of 60079-0 General Requirements 5th Edition 2007[7]. Although indicative of the scope of acceptance, the designer must bear in mind that this can vary from one issue of a standard to another as well as across the range of standards included under the 60079 umbrella. [10]

The following key refers to the table below:

- 1- Indicates Adoption without National Difference
- 2- Indicates Adoption with National Difference
- 3- To be Advised
- 4- Not Recognised

TABLE I
ADOPTION OF 60079-0 BY MEMBER STATES

Member States	Adoption Status	Member States	Adoption Status
Australia	1	Slovenia	2
Brazil	1	Sweden	2
Canada	2	United Kingdom	2
China	2	India	4
Croatia	2	Japan	1
Czech Republic	2	S Korea	3
Denmark	2	Malaysia	4
Finland	2	New Zealand	1
France	2	Norway	2
Germany	2	Russia	2
Hungary	2	Singapore	1
Italy	2	South Africa	1
Netherlands	2	Switzerland	2
Poland	2	Turkey	3
Romania	2	USA	3

C: Standards Being Applied in Industry

Review of current practices showed that the North Sea oil fields were complying primarily with DNV standards. Although some manufacturers had done an assessment to EN they were not certifying accordance with this. This aligns with the fact that the selected Notified Body in this region was generally DNV's verification and classification departments. North America is dominated by products that are approved to NFPA 496 [8]. The pressurized room market is well defined in this region. Many competitors supply certified or assessed components that can be added to the pressurized room and simplify the certification process for the room manufacturer.

On-shore Europe is now emerging from a period in which there was no specific cover for fixed installation rooms. Many manufacturers therefore adopted parts of the EN standard, parts of IEC 60079-2 [9] and, if reviewing analyser houses, 60079-16 [3]. Many could then argue that the market did supply a certified pressurization system and so the in-house solution would be considered as part of the entire application certificate. The IEC publication therefore meets the need for room manufacturers to simplify the certification process, much as it is in North America.

To ensure worldwide compliance the pressurization system, installation and the room construction needs to be compliant with all the major regulating standards. The emphasis here is on ensuring the protection concepts employed are robustly reviewed and, as systems are working together, on minimising the risk while ensuring that they do not unnecessarily constrain innovation in the product design or reduce commercial viability.

60079-13 however, is considered to be an installation standard rather than a product standard due to the nature of the fixed installation of the rooms it refers to. However, manufacturers in the field still require their components to be suitable for installation to this code.

IV. ANALYSIS OF STANDARDS

A. Constructional Requirements For Rooms

Many constraints exist for the construction of rooms but those examined below will refer, predominantly, to either enabling pressurization or safety systems required to meet the standards.

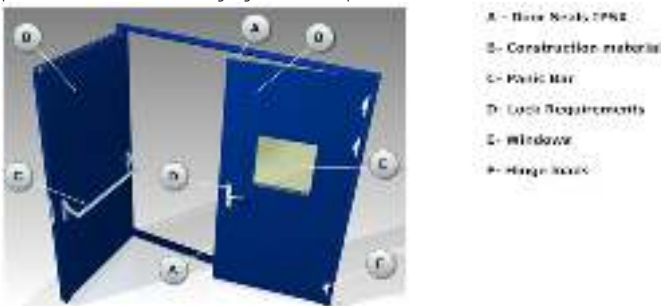


Fig. 1 Typical Door Construction

1) *Doors:* There is no requirement in IEC to provide locks on the doors for normal use to limit access, however, lockable doors still

need to have panic bars inside. Doors not used as primary means of ingress or egress may be omitted from outward velocity calculations if either of the following applies: They are marked as "Restricted Access" and used less than three times per day for no longer than 60s each time, with alarm at constantly manned location on being opened. Or used only for the infrequent movement of equipment, marked again as "Restricted Access" and under management control secured on the closed position. This allows room designers to meet the practicalities of installing large components through double doors without overburdening the requirements of the Room Pressurization system or the additional cost and complexity of large airlocks.

2) *Switches:* Switches are recognised for use with Purge system but not a requirement when using the minimum outward velocity of air concept. However, if an airlock is used it is no longer possible to employ the outward velocity methodology and switches will be required. Switches are useful regardless of specific requirements as means of determining the door status. This is particularly useful in a Zone 1 environment where you may avoid having to restart if it is temporarily halted due to pressure loss and a door switch indicates an open door. The timer must then only be stopped and restarted on return of pressure and flow. This state may persist for 60 seconds before the timer must be reset.

3) *Door Closing:* IEC also has a clause which in practices may be difficult to implement. It states that doors must be capable of closing against the normal operating pressure of the room. This in itself is not impossible although it does require a fairly heavy door spring / gas lift. If the outward velocity concept is employed this becomes less useful due to the nature of fan curves. As the pressurization system goes into the high flow mode and the flow is restricted by the closing of the door the pressure increases along the fan curve and may be several times greater than the normal operating pressure. One solution is to use a two stage closer first closing the door sufficiently to allow the system to return to its normal state and the second then closing against the normal pressure. It is not possible to hinge the doors to allow the pressure to close the doors as all the standards specify that doors must open outwards.

4) *IP Rating:* IEC 60079-13 defines the room as needing to be capable of maintaining a pressurized state where EN requires rooms to be at least IP40. In practice the room should be IP5X in order not to limit the capability of the Pressurization system in overcoming excessive leaks. Another important factor to consider in warmer climates is the additional heat loading that the pressurization system puts on the HVAC of the room. Rooms with high leak rates may struggle to maintain the specified temperature and humidity specifications. In the worst of the case studies excessive room leakage caused the dehumidifier drips trays to flood resulting in water droplets being circulated in a remote instrument building.

5) *Mechanical Strength:* IEC 60079 and EN 50381 require over pressure tests of either: 1.5 times maximum operating pressure or, as per IEC, only the maximum pressure achievable by the system. The

latter reduction in test criteria is reasonable considering the defined characteristics that fan driven

pressurization systems will have. IEC also lists the requirements of an impact test using a 25mm diameter sphere striking any part of the room with 10 Joules of energy. The test requirement is for the part not to sustain any damage that may cause the differential pressure to drop below 25Pa. This has particular implications for structures such as windows. The construction requirements in DNV are more onerous, covered under 2.7.1, and are based on the in-service expectations of mobile rooms being hoisted on to platforms.

6) *Inlets & Ducting:* IEC recommends the location of inlets and outlets are arranged so as to aid the distribution of the purge gas while having considered the density of the hazardous gases being dispersed. Normal practice is to locate the inlet and outlet at diagonally opposite ends of the room. Dispersion of lighter than air gases require a high outlet location while the denser than air gases would have it at floor level. If there are false floors or cable runs these must be considered for their ability to trap gases. Where a mixture of light and heavy gases may be present it is good practice to place the exit at low level as the lighter gases such as H₂ are more dispersive. The methodology employed in EN is similar but goes further to recommend the use of internal fans to aid distribution. DNV gives limited guidance with regards to location but insists on a purge test, EN and IEC recommend minimum air changes.

B. Air Supply & Purging

EN 50381 specifies that the protective gas shall come from a non-hazardous area. IEC 60079-13 supports this but allows for Zone 2 inlets when using type pz protection if it is fitted with gas detectors. These must be located in the air inlet and also in the room and the system must be programmed to shut down upon detecting 40% of the limiting value. The final condition is slightly more onerous and requires that all other equipment used for alarming or emergency action now carry an Equipment Protection Level (EPL) of Gb or better which is the equivalent of zone 1.

DNV states the source should be at least 3m from a zoned area and that gas detectors are required at the inlet to the room if the ducting is under negative pressure and not of fully welded construction or at the actual inlet and this applies to all

installations. The minimum ventilation flow rate is 5 volume changes per hour in both IEC & EN but DNV specifies this as function of the number of persons in the room requiring 12 l/s per person. Let us consider a small container of 10'x8'x8'6" and assume that it is a densely placed office space housing three workers. IEC would require 96 m³/hr while DNV requires 130 m³/hr. In this instance the IEC standard would fall short of the minimum air change requirement for human habitation at 10 l/s. per [12] Of course if a large enclosure were to be considered at the same occupancy the IEC would be significantly more than required. The designer needs to bear both constraints in mind and ensure that the greater requirement is met.

All standards recognise the need for purging rooms but only IEC makes allowance to not purge the room if the atmosphere is checked with a portable gas detector. IEC describes a change in normal purge testing methodology as it allows for the use of chemical smoke to determine the purge time for the room. EN requires verification of gases emulating both heavier than air Carbon Dioxide and lighter than air Helium. Chemical smoke has approximately the same density as air and so would be a good representative for the lighter and therefore more dispersive gases. Heavier than air gasses may be more difficult to disperse and in areas where the flow is not turbulent enough to cause diffusion, therefore there may be some difference between the two test methodologies. Having said this however, the process of filling rooms with Argon or Carbon Dioxide is not only costly but can itself represent a hazard and bring some complexity to the verification process. Plants with heavier than air gases should conduct research into the similarities of these tests and determine a correction factor for when smoke is used.

EN prohibits the location of pressurization fans internal to the room and for v2 or any internal source of release requires two fans (Dual Redundant) . IEC makes no reference to the location of the fans; neither does it require dual redundancy for any of its protection concepts. EN specifies the ventilation flow must be achieved with 50% of the flaps closed and that for v2 and v3 flow will be monitored at inlet and for v4 at the outlet. IEC requires that if an outlet valve is fitted then flow shall be verified there and places the constraint that if a dedicated outlet valve is not used then verification shall be by gas detection. This clause effectively defines the requirement for a dedicated outlet for any system that employs purging.



Fig. 2 Inlet Options



Fig. 3 Typical Outlet Cowl

Detection of failure of the pressurization system is allowed by either monitoring the discharge end of the fan or the room pressure under the IEC. NFPA only recognises the detection at the discharge end of the fan and DNV requires that two pressure switches monitor the pressure in the room. This disparity of monitoring makes a single solution more difficult. Room pressure should be the governing measure as it is, after all, the sole priority of the system. The dual redundancy of the DNV requirements seems arduous considering the fault tolerances specified according to the protection type. Precedence, however, is set by the requirement in IEC 60079-2 for two pressure sensors when dealing with static pressurization of enclosures.

IEC employs a protection concept borrowed from NFPA regarding the need to achieve an outward velocity across a door of 0.3 m/s when all openings capable of being opened are open, except for doors that are specified as an exception and covers that can only be removed with the use of a tool. This is a more stringent specification concerning the fan's capabilities and requires the system to have adjustable fan speeds to meet both ends of the system curve.

The protection concept of maintaining a safe internal environment by generating the specified outward velocity brings some advantages. Power does not need to be isolated as long as the system verifies that the fan is running and delivering the required flow rate for type pz, py and pv. Door switches are still required for protection type px and the outward velocity concept may only be used for up to 60 seconds. DNV does not accept the IEC recommendation of 0.3m/s and cites 2m/s as an example of the flow that may be required to be effective in the offshore environment. It goes on to suggest that this is not a suitable method of protection due to the high wind velocities experienced offshore and recommends the use of an air lock. Some exceptions are cited when the area is zone 2 or non-hazardous, the door is facing away from the prevailing wind and any hot or sparking equipment is away from the door and in a suitable enclosure. So, does 0.3m/s represent safe practice? Consider that IEC 60079-10-1 ,5.4. 5 a) states that wind speeds below 2-3m/s are generally insufficient to cause turbulent

diffusion of the gas cloud. Also, IEC 60079-13 has a note which states that the value 0.3m/s is for low wind environments and this needs to be increased for local conditions. In some instances where winds of 1.5 – 2 m/s occur the gas cloud can be blown into the room. Designers should bear this in mind and work as per DNV recommendations so that risks can be reduced. The additional benefits described above in terms of the functionality of the pressurization system make this a worthwhile consideration.

C. Safety Provisions, Devices and Disconnects

Consistent across all the standards is the requirement for the protection devices, including the pressurization system to be suitable for use in the zoned area. This includes components that are installed internal to the room or within the clean air stream. This is a typical philosophy in hazardous areas and is born of the idea that the systems may be required to operate before the safe state of the area is known or that they may have to take action upon an unsafe state being identified.

NFPA and DNV don't make specific reference to the integrity of the safety devices while IEC lays out the requirement for zone 1 installation (px, py, pv) to be single fault tolerant and for zone 2 (pz) as normal operation. This means that the safety devices in case of the zone 1 systems must return a safe state if any one of the components fails while zone 2 appliances should always return to a safe state during normal operation. This is generally accepted good practice and the other standards refer to similar constraints.

In the case of failure of the pressurization system power must be isolated from the room in all conditions. An exception is made if the immediate isolation of power would lead to potentially more dangerous state and, in this instance, power may be maintained for short period. This period and applicability of this clause would be down to the plant operators risk assessment. The system should be designed to facilitate automatic isolation for type px and manual isolation for pz and py. IEC recommends the location of isolation equipment being in the safe area however if the contactors are suitably housed and have the required Ex rating it may be more practicable to have these locally at the power inlet feeds. In all instances a local alarm is required which must also be transmitted to a constantly manned location. For a more detailed description of the installation of this equipment the paper, Directives for offshore containers [13] describes the required equipment and installation methods.

V. CONCLUSIONS

The IEC standard makes a start between the NFPA standard which appears to be its basis and the current requirements under the EN and DNV standards. Some variations are easily explained by the difference in operating environments and the subsequent restriction on equipment; some however are based on the culture differences in the application of protection concepts. The concept of outward velocity across an open door is the most notable of these exceptions and further work is needed to understand the mechanics of gas cloud migration under the specified condition.

The research focused exclusively on European manufacturers and a North American perspective would help clarify the application of NFPA. The IEC standard has only just been released and the true limitations and implications for industry are yet to be identified. There are some areas of resistance but whether these are founded on sound engineering judgement or simply economic factors associated with changes to product specification are yet to be seen.

The primary goal must be the reduction of risk in all its forms to the greatest practicable extent. This includes but is not limited to technical, environmental, economic and cultural risks. Understanding this will allow the designer to account for a truly global design taking into to consideration not only the legal implications but also the preferred concept employed at specific locations.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

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