DIFFERENCES BETWEEN THE ATEX DIRECTIVE, THE IECEX SCHEME AND NORTH AMERICA REGULATIONS

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Abstract – In this globalized world, projects are awarded to international engineering firms and vendors located outside of the end user country. This scenario brings additional challenges to all parties involved and requires a full understanding of the differences between standards and regulations of many different countries. Depending on the end user country, exporters and manufacturers of Ex equipment will be regulated by different standards, codes and regulations that will govern the product approval process and the necessary factory inspections.

This paper addresses some of the most damaging misconceptions about the electric motors certification for North America and the main differences to ATEX Directive and IECEx scheme. It is really important to have a full and clear understanding of these myths and differences in order to make informed decisions, assuring this way compliance with the standards, codes and regulations whilst guaranteeing the safety of people and installations.

Index Terms — ATEX, IECEx, hazardous area, North America regulations

I. INTRODUCTION

The use of electrical equipment in areas that are subjected to presence of flammable substances is regulated through three major schemes: ATEX, IECEx, NEC and CEC.

Even so, there are still major accidents occurring today around the globe taking lives and causing damage and costs. To avoid such incidents, the focus should be in controlling, regulating and leveling the knowledge between the different parties involved in the assurance of protection levels of electrical equipment.

The misunderstandings between the different codes and regulations will not only increase the costs in the certification of products and facilities, but may also jeopardize the security of these facilities associated with the use of erroneous protection levels for hazardous areas.

This paper begins with a brief history of the three major schemes. After which the concept of area classification is detailed for Zones and Divisions. Furthermore, the differences in the protection types for each scheme are analyzed, with special emphasis on the most common protection types.

Finally, the projected future for the different schemes is presented and discussed.

II. THE HISTORY OF HAZARDOUS PROTECTION

The need for protection of electrical equipment in areas with potentially explosive atmospheres was originated by the occurrence of several related accidents around the world. As stated in the work of Munro [1] several authors identify the life cost of accidents in the beginning of 20th century, in the US (1907 – 600 deceased), UK (over 1000 deceased early).

A. European ATEX

The European Economic Community (EEC) was created with the aim to allow the economic communication and integration between the member countries.

In relation to the equipment protection in hazardous areas, the work was initiated to bring the economic operators in the member states under the same guidelines.

The directive 94/9/EC was effectively applied in 2003 in the European Economic Area. In 2016, it was replaced by the new directive 2014/34/EU.

B. North America Regulations

The article 500 of the National Electrical Code represents the foundation for the Division system in the United States.

It supports also the Articles 501 to 504 for this system which addresses both Class I, Class II and Class III hazardous substances.

The Zone system is also associated with NEC and based in Article 505, in an approximation effort to IEC standards.

For Canada the equivalent regulations are the Canadian Electrical Code (CEC).

C. IECEx Scheme

The appearance of the *IECEx* scheme aimed to create an international regulation scheme to provide manufacturers with a single mechanism for certification and safety assessment.

The establishment of IECEx was in 1996 as an initiative of the industry and with support from certification bodies of the United Kingdom, France, Germany and Canada.

The first equipment certificate was issued in 2003 and 33 countries participate in the IECEx to this date. [2]

III. AREA CLASSIFICATION

The risk of explosion is associated with the occurrence of specific conditions that provide what is called the Triangle of Fire for gases or the Pentagon of Fire for dusts.

Focusing in the triangle of fire (Fig. 1) it is possible to identify the three components intervening in the reaction:

- Ignition source;
- Fuel;
- Oxygen.

The simultaneous presence of these three elements in the correct proportions will cause an explosion of the atmosphere.

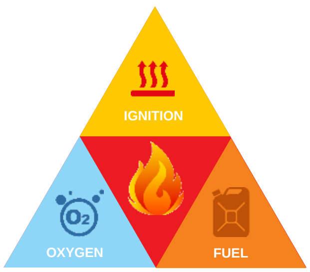

Fig. 1 Triangle of fire

The classification regarding the level of danger in a hazardous area is then dependent on the fuel type and the frequency of occurrence.

A. Zones and Divisions

The ATEX directives, the IECEx scheme and NEC 505 classify the hazardous areas in Zones according to the probability of occurrence:

- Zone 0 and Zone 20: continuous presence;
- Zone 1 and Zone 21: in normal operation;
- Zone 2 and Zone 22: in abnormal operation.

Zones associated with gas atmospheres are 0/1/2 and with dust 20/21/21, in the Fig. 2 an example is shown to illustrate a potential zone distribution.

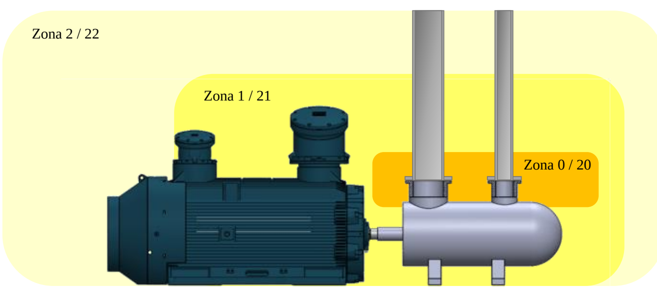

Fig. 2 Typical zone identification

In case of NEC 500 the classification is done using Classes:

- Class I – associated with gas atmospheres;
- Class II – associated with dust atmospheres;
- Class III – associated with ignitable fibers.

And divisions:

- Division I – continuous presence of a hazard;
- Division II – in abnormal operation.

The combination of classes and divisions defines the level and type of hazardous area.

In Fig. 3 the comparison between Zones and Divisions is represented, to be noted that Division 1 encompasses both Zone 0 and Zone 1. This difference implies that the equipment designed for Zone 1 and Division 1 will therefore have different levels of protection to comply with the higher risk level of the Division I.

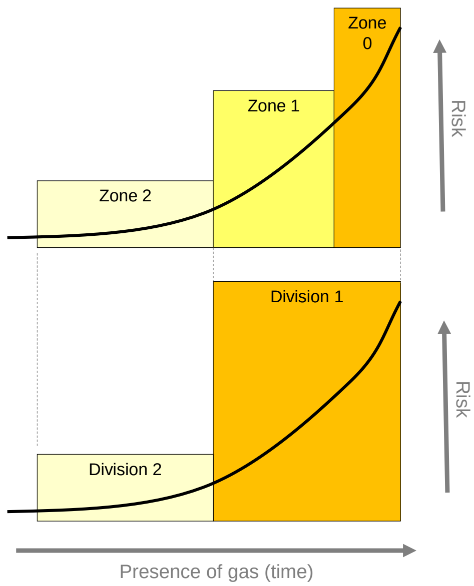

Fig. 3 Equivalence between zones and divisions according to risk level

B. Types of gases and dusts

The classification of gases and dusts in distinct groups is connected to the level of hazard they represent. This concept is associated with two major parameters:

- Minimum ignition energy;
- Maximum Experimental Safe Gap (MESG).

Both of these parameters are connected and as the minimum ignition energy decreases, the MESG also decreases. The most explosive, therefore dangerous gases are associated with the lower levels of both parameters.

In ATEX and IECEx, the gases and dusts are both grouped in three groups [3, 4]. In case of North America division approach gases are divided in four groups [3] and dusts in three groups [4].

A point of attention must be taken related to fiber atmospheres, as they are included in ATEX/IECEx dust group, but in a separate Class for North America [3].

The comparison chart may be seen in Fig. 4.

Explosive atmosphere			ATEX IECEx	NEC 500 CEC		Examples
				Class	Group	
Mines			I	-	-	Methane
Surface	Gases or vapors		IIA	I	Group D	Propane
			IIB		Group C	Ethylene
			IIC		Group B	Hydrogen
					Group A	Acetylene
	Dust	Fibers	IIIA	III	-	Paper fibers
		Non conductive dust	IIIB	II	Group G	Cereal dust
					Group F	Coal dust
		Conductive dust	IIIC		Group E	Aluminum dust

Fig. 4 Different groups of hazardous substances for ATEX/IECEx and NEC/CEC

With reference to Fig. 4 it is important to note that the differences between Zones and Divisions do not allow a clear equivalence between groups.

In the particular case of electric motors, they cannot be certified or installed in Class I, Division I, Group A. (not included in the scope of the standards [8])

This subject will be addressed with detail in chapter IV and V.

C. Surface temperature

In addition to the classification of the hazardous atmospheres in groups associated with the energy of the explosion, both regulatory schemes also define the classification of hazardous substances according to their auto-ignition temperature and group them in Temperature Classes.

Fig. 5 shows the temperature classes of both regulations, their correspondence and the maximum surface temperature of the equipment allowed to be installed in the associated explosive area.

ATEX IECEx	NEC 500 CEC	Maximum Surface Temperature
T1	T1	450 ºC
T2	T2	300 ºC
	T2A	280 ºC
	T2B	260 ºC
	T2C	230 ºC
	T2D	215 ºC
T3	T3	200 ºC
	T3A	180 ºC
	T3B	165 ºC
	T3C	160 ºC
T4	T4	135 ºC
	T4A	120 ºC
T5	T5	100 ºC
T6	T6	85 ºC

Fig. 5 Temperature classes for the different regulations

The intermediate temperature classes of the North American Division scheme do not exist in ATEX and IECEx and are not applicable.

IV. TYPES OF PROTECTION OF MOTORS

Electric motors are the main drive in most industry processes, driving a huge variety of machines such as compressors, fans, pumps, which take part in both critical and costly industries where an accident may have a huge impact not only on facility damage costs but also on lives lost.

The protection of motors that are installed in hazardous areas may be done through different approaches. Considering the triangle of fire (Fig. 1), if one of the corners is removed the risk of explosion is excluded, consisting in protection types like: "Increased Safety", "Non-sparking" or "Pressurized".

The other concept, considered the oldest type of explosion protection [1], and also one of the safest, is the containment of the explosion of the atmosphere inside the motor enclosure. This protection is referred as flameproof or explosion-proof.

It is very important to understand that the concept of type of protection is not applicable to the Division Scheme. Nevertheless it is possible to correspond some requirements between this scheme and the type of protection of Zone Scheme.

In the next sections the different protection types for Zone Scheme are detailed and analyzed. The particular cases are addressed in chapter V, including the manufacturer point of view.

A. Flameproof (Ex d)

The flameproof concept in consists of containing the explosion inside an enclosure (Fig. 6). This protection method incorporates two distinct concepts:

- Enclosure integrity;
- Flame transmission.

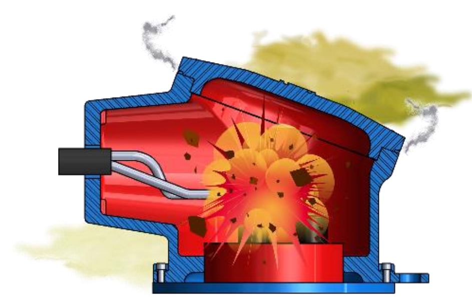

Fig. 6 Explosion-proof or flameproof concept example

The first is achieved by ensuring that the enclosure has enough strength to withstand the explosion of the volume of hazardous substance inside. [8] The intensity of the explosion is highly dependent on the temperature and manufacturers need to select the appropriate materials and calculation procedures, so motors are able to operate and start in these extreme conditions. [1, 8]

The flame transmission to the exterior atmosphere needs to be avoided at all cost. Explosion-proof or flame–proof motor enclosures need to be precisely machined and controlled to achieve critical gaps between parts that quench the explosion flame before it reaches the exterior atmosphere.

Fig. 7 shows a failed test for flame transmission, which caused ignition of the surrounding atmosphere.

Fig. 7 Flame transmission in terminal box test

In the specific case of electric motors there are multiple components where the impact of explosion is sustained and where flame needs to be quenched on its way to the exterior environment. (Fig. 8). All these components need to pass a strict quality control and testing to achieve this kind of protection, as a result, these motors are heavy structures.

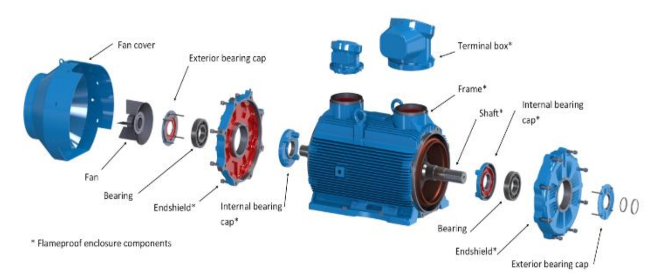

Fig. 8 Exploded view of a motor assembly with identification of flameproof components

Similarly, handling and maintenance of motors with this type of protection needs to be performed by high qualified personnel and following strict rules to avoid damaging the enclosure components that may not only impair the operation of the motor but more importantly invalidate its proper flameproof concept. [9]

B. Increased safety and non-sparking (Ex e, Ex n and NI)

This concept is associated with preventing the occurrence of ignition sources in the electric motor which eliminates one of the corners of the fire triangle. [11]

These motors are similar to safe area motors in their mechanical construction, with the major changes linked with electrical design and limiting the temperature.

However, there is a major difference in this concept between the Zone scheme and Division scheme.

In the Zone scheme, this type of protection may be used in both Zone 1 (Increased Safety) and Zone 2 (Non-Sparking), but in the Division scheme it can only be applied in Division 2 under this type of protection (Non-Incendive).

The protection of this type of motors is then based on reinforcing the insulation of stator which needs to be surrounded by hazardous gases and tested for occurrence of sparks that may ignite the external environment atmosphere.

In addition, the rotor temperature shall also be maintained below the associated temperature rating of the motor, resulting in a control on the locked rotor time and number of starts.

Furthermore, this protection concept is also sensitive to the use of inverters, where the inverter parameters need to be carefully adjusted to avoid both the occurrence of sparks and heating up of the components.

C. Pressurized (Ex p)

Pressurization concept removes the hazardous atmosphere from the vicinity of electrical components inside the enclosure of the motor.

This method can be used in both Zone 1 and Zone 2 or in Division 1 and Division 2.

The disadvantage of this type of protection is requiring several support equipment to pressurize the interior of the motor, and also maintain and control this pressure. (Fig. 9)

Fig. 9 Example of pressurization system installed in electric motor

This protection method is mainly used for higher power motors where the weight of a flameproof or explosion-proof motor would be extremely high in comparison to a pressurized motor.

D. Dust protection

The protection of dust is mainly associated with the ingress protection of the enclosure and its surface temperature. Dust environments may sometimes be wrongly perceived as less dangerous compared to gas environments, however, accumulation of dust when dispersed by air may create a highly dangerous atmosphere that may cause extremely damaging accidents.

In Fig. 10, a motor withstanding an ingress protection test is shown.

Fig. 10 Electric motor covered in dust during ingress protection test

V. MAIN DIFFERENCES BETWEEN REGULATION SCHEMES

Both regulation schemes are intended to improve the safety of people and installations. They both aim to prevent accidents and to regulate the protection degree between manufacturers and end-users across markets.

The two biggest world markets for hazardous areas are also associated with two different schemes. The difference in hazardous areas classification induces major differences that need to be clearly pointed out:

- Divisions scheme allows to place motors in permanent hazardous areas where Zones scheme excludes motors from these areas by limiting them to Zone 1;
- No electric motor can be certified to operate in Class I, Division 1, Group A, thus excluding the application of motors in atmospheres with acetylene in this division;
- Zones scheme permits a more gradual increase in protection, allowing cost reductions for equipment installed in Zone 1.

The difference in cost is more evident with the possibility of using increased safety apparatus in Zone 1.This allows the use of flameproof motors with increased safety terminal boxes, which are usually lightweight and allow easier maintenance and cable installation.

Thus, both schemes have their own specific relaxation compared to the other, where one allows to optimized cost construction and the other allows to have motors operating in any condition using tighter rules and tests.

As an example, an IECEx certified flameproof motor for Zone 1 group IIC may only be certified without additional explosion tests to a motor for Class I, Division I, Groups B, C and D, but it is not allowed to be installed in an Acetylene environment (Group A in Division scheme).

A. Comparison between Class1, Division 1 and Zone 1 requirements for electric motors.

The following standards/parts were analyzed for this comparison:

- C22.2 No. 145-11 [8];
- IEC 60079-0 ;
- IEC 60079-1 [9];
- IEC 60079-7 [12];

As the type of protection concept is not used in the Division scheme, it is necessary to include the three different parts of IEC 60079 standard

In the rest of this section several requirements from the standards above are compared and analyzed. The tables in this section summarize the differences in the relevant standards.

Requirements to contain the explosion

Firstly, the requirements associated with the containment of explosion are compared, both in terms of structural strength and flame transmission.

In Table 1, the safety factors for overpressure test in both schemes can be found.

It is interesting to note that where IEC includes both routine and type test possibilities, in the Division Scheme there is no reference to routine overpressure tests. Based on safety factor values it is safe to assume that the intent of Division Scheme is overpressure type tests.

Another major difference is the acceptance of mechanical strength calculation for the enclosure in Division Scheme, with a consequent increase in the safety factors.

In Division Scheme, the safety factor for overpressure tests is determined based on types of materials used in part which can bring flexibility to the manufacturers as far as manufacturing methods. On the other hand, not having the routine test option will require an enclosure with more mechanical integrity.

Table 1 – Comparison of safety factors

	CSA C22.2 No. 145-11				IEC 60079-1			
	Type Test		**Calculation**		**Type Test**		**Routine test**	
Cast Metal	*Table 35*	4	*Table 2*	5	*15.2.3.2*	4	*15.2.3.2*	1,5
Fabricated steel		3 (2)		4				
Bolt		3		3				

The surface roughness requirements for the flameproof joints are similar and the major difference is the inclusion of clear criteria for validation methods in the standard for Division Scheme. (Table 2)

Table 2 – Comparison of roughness of flameproof joints

	CSA C22.2 No. 145-11		IEC 60079-1	
Roughness	*11.1*	Ra 6.3	*5.2.2*	Ra 6.3
Verification		Defined feeler gauge dimensions and approval criteria	-	-

To determine the reference pressure of the explosion, both schemes rely on tests with the same explosive gases. (Table 3)

It is important to note that Division Scheme only allows motors to be installed in gas group's equivalent to IEC Group IIB+H.

Also, the gas mixtures are very similar between Schemes but for IEC scheme fewer tests are required to be performed in Groups IIA and IIB.

Table 3 – Comparison of reference pressure tests

		CSA C22.2 No. 145-11		IEC 60079-1	
Reference pressure tests	**Group D / Group IIA**	*Table 31*	20 x Propane at 3 - 7%	*15.2.2.2*	12 x Propane at 4,3 - 4,9%
	Group C / Group IIB		20 x Ethylene at 4 - 9%		12 x Ethylene at 7,5 - 8,5%
	Group B / Group IIB+H		20 x Hydrogen at 15 - 35%		20 x Hydrogen at 30 - 32%
	Group A / Group IIC	-	Not Allowed		20 x Acetylene at 13 - 15%

As far as flame transmission tests which is summarized in Table 4, both schemes are very similar. However, the following differences should be mentioned:

- Division scheme allows the enlarged gaps method even for Group D and C (IEC Group IIA and IIB);
- Without enlarged gaps method, the oxygen enrichment is higher in IEC;
- The enlarged gap for IEC can vary between 1,35 and 1,5 times the construction gap, when in Division Scheme it is only permitted 1,5 times;

- Group A (IEC Group IIC) is not allowed in Division scheme.

Table 4 - Comparison of flame transmission tests

		CSA C22.2 No. 145-11		IEC 60079-1	
Flame transmission without enlarged gaps	**Group D / Group IIA**	*Table 33*	10 x Hydrogen at 54 - 56%	*15.3.2*	10 x Hydrogen at 54,5 - 55,5%
	Group C / Group IIB		10 x Hydrogen at 36 - 37%		10 x Hydrogen at 36,5 - 37,5%
	Group B / Group IIB+H		10 x Hydrogen at 39 - 40% and Oxygen 8,5 - 10,5%	*15.3.3.4*	10 x Hydrogen at 39 - 40% and Oxygen 19 - 21%
Flame transmission with enlarged gaps	**Enlarged gap**	*Table 32*	1,5	*15.3.3.2*	From 1,35 up to 1,5
	Group D / Group IIA		10 x Propane at 4,1 - 4,3%		-
	Group C / Group IIB		10 x Ethylene at 6 - 7%		-
	Group B / Group IIB+H		10 x Hydrogen at 26 - 28%		10 x Hydrogen at 26 - 29%
Condition to larger gaps than standard	**Without enlarged gaps**	*36.4*	Use 1,2 times construction gap	**-**	-
	With enlarged gaps		Use 1,8 times construction gap instead of 1,5 times		

According to Table 4, additional conditions for larger gaps identified in CSA C22.2 No. 145-11 need to be met.

With the comparison above, and if an electric motor is certified using the “First Method” of IEC 60079-1, the following particular situation can be considered:

A motor prototype, tested with enlarged gaps for IIC and the same prototype tested for IIB:

- Tested with 27,5% hydrogen;
- Tested in the same prototype with 37% hydrogen;

Can comply with the following condition for Division if constructed with the gaps for IEC Group IIC:

- $CSA\colon i_E = 1{,}2 \times i_C$, tested with 37% hydrogen.

Thus, an IEC certified motor for gas group IIC would only be able to be recertified for Class I, Division 1, Groups C and D, and only in this particular situation.

<u>Requirements to limit surface temperatures</u>

One of the main differences between schemes is the concept of “type of protection”.

As the Division Scheme does not recognize the type of protection for motors, the requirements extend to other IEC types of protection, demanding compliance and additional tests.

As shown in Table 5, the Division Scheme requires several operational tests with overload conditions which are not required for flameproof motors in IEC, where thermal tests are limited to normal operation.

Due to the requirement of motors to withstand overload conditions without reaching the temperature class, it is normally mandatory to fit and install a device for limiting the motor temperature.

Table 5 – Comparison of thermal tests

	CSA C22.2 No. 145-11		IEC 60079-1	
Thermal tests	*31 to 33*	- Normal temperature test (until stabilization) - Running overload test (until trip) - Single-phasing test (until trip) - Locked-rotor test (until trip)	*Table 6*	- Normal temperature test (until stabilization) - No overload

For VFD operation the requirements of both Schemes are similar, as IEC allows to use a temperature limiting device to guarantee the surface temperature.

Table 6 – Comparison of VFD operation

	CSA C22.2 No. 145-11		IEC 60079-1	
VFD Motors	*30*	Marked frequency range, tested with representative type of inverter	*Annex H*	Test with specific inverter or use of temperature limiting device in windings

<u>Requirements for external fan</u>

Regarding fans and fan covers, the Schemes differ and Division Scheme requires a fan made from aluminum or brass with limited hardness.

On the contrary, IEC Scheme only imposes requirements regarding non-metallic materials.

Table 7 – Comparison of fan and fan cover

		CSA C22.2 No. 145-11		IEC 60079-0	
Fan and fan cover	**External fan material**	*22.1*	Brass or aluminium with hardness not over Rockwell B66	*17.2.2*	Any material, restrictions if non-metallic
	Non-metallic fan	*22.1.2*	Pass in conductivity test and accumulation of static electricity test	*7.4.2*	Multiple methods including testing
	Ventilation openings	*22.2.3*	Block entry of rod of 19,1mm Do not allow touching moving parts of rod of 12,7mm and 101,6mm	*17.2.1*	IP20 in inlet (≤ 12mm) IP10 in outlet (≤ 50mm)

<u>Requirements for air distances</u>

As mentioned in the previous sections, due to the non-existence of the type of protection concept in the Division Scheme, some requirements extend the scope of IEC 60079-1 part of the standard.

One of the other relevant points is the air distances between conductive parts. In IEC 60079-1, there is no requirement since the flameproof concept guarantees the containment of a potential explosion.

In Table 8, the air distances between the CSA C22.2 No. 145-11 standard and the IEC 60079-7 are compared and it is verified that the distances in the Division Scheme are even greater than those for Zone Scheme Increased Safety protection method.

Table 8 - Comparison of air distances

		CSA C22.2 No. 145-11		IEC 60079-0		IEC 60079-7	
Air insulation	Creepage	*Table 26*	For 7200 V - 125mm	*14.3*	According to Type of Protection requirements	*Table 2*	For 6300V and IIIa - 100mm For 8000V and IIIa - 125mm
	Clearance		For 7200 V - 100mm				For 6300V and IIIa - 63mm For 8000V and IIIa - 80mm

B. Motor manufacturer point of view

Having the two different regulation schemes has both benefits and disadvantages for motor manufacturers

The standards associated with the Division scheme for motors have a high degree of details which clearly define not only the minimum requirements for structure and dimensions but also the acceptance criteria for a multitude of industrial cases such as porosities, etc. Measurement methods for flameproof gaps are also clearly identified.

On the other hand, IEC and EN standards and their equivalent for North American markets only represents major guidelines of compliance, allowing the manufacturer a broader range of options but at the same time leave some specific design points out.

The inherent differences between products are indicated in this chapter, conducing to products that may be radically different, both in performance and in its application.

The correct understanding of both Schemes is mandatory for all those involved in the development and certification of these machines, nevertheless it is an enormous challenge to design a product that may comply with both Schemes as the concepts are clearly distinct.

C. End user and maintenance team

If the end users have the same type of classification throughout their facilities, the maintenance challenges are reduced compared to when multiple classification and schemes are used, which is common when a single maintenance party is responsible for multiple plants.

End users and maintenance team need to be clearly trained that using “zone marked” equipment in a division area is not allowed and vice versa. Even though some maintenance aspects can be equivalent between the regulation schemes, they should never be assumed as interchangeable.

Sourcing equipment, principally for replacement needs to be done with due diligence to avoid any mistakes as these may trigger additional certification testing and even in some cases create a new product, therefore new certification

The next chapter demonstrates an example where a motor already dispatched was converted from Zone to Division Classification.

VI. CONVERSION OF FLAMEPROOF MOTOR FROM ZONE TO DIVISION

In some cases, the type of equipment purchased may be of a classification not suitable for the installation. In this example, a flameproof electric motor was dispatched for United States, which was certified and marked as:

- Class I, Zone 1, AEx db IIC T4

The motor was certified for Class I, Zone 1 using the type tests and documentation for obtaining the ATEX and IECEx certificate.

After the motor was dispatched, it was identified that an error has occurred in the order, and it was asked if the motor could be installed in a Division classified Area as followed:

- Class 1, Division 1, Groups C and D, T4.

In a joint analysis with the certification body, it was confirmed that the tests for reference pressure, overpressure and non-transmission performed for type certification for Group IIC motors also comply with the requirements of Division 1, Groups C and D.

It is also worth mentioning that manufacturers need to prove the equipment performance and its characteristics as an electric motor, in addition to meeting the Division classified area compliance requirements.

To comply with the major differences enunciated in Chapter V there is the need to perform product modifications and witnessed tests are mandatory for the approval for U.S. (UL-674) or Canada (CSA 22.2 No. 145).

To comply with the referred standards above, it was identified that the motor needed to be modified in the areas below:

- Internal volume of terminal boxes;
- Certified equipment installed in the motor;
- Temperature control devices;

In addition to these changes, tests below were mandatory to be performed at the manufacturer facilities which were witnessed by a certification body representative:

- Normal temperature test
- Running overload test;
- Dielectric Voltage-Withstand Test.

Fig. 11 – Motor subjected to modifications to comply with UL-674 and CSA 22.2 No. 145

Following the indicated changes and tests, the motor was set to return to the manufacturer facility where the terminal box was changed for an increased size, a thermostat was installed in the windings and some equipment were needed to be replaced such as space heaters and thermal sensors.

The motor was then tested at full load condition up to thermal stabilization, shut down and checked for maximum surface temperature. After this test the motor was subjected to overload test until the thermostat actuated to confirm the effectiveness of thermal protection.

The motor was finally approved to be shipped to final destination marked for Division I, Groups C and D.

VII. THE FUTURE OF HAZARDOUS AREA PROTECTION

The important question for the future of hazardous area protection is if the two regulation schemes will be converged into a single scheme and if the new single scheme can use the benefits of these two separate schemes. Can a single classification scheme for hazardous areas that would allow the flexibility of protections of Zones but at the same time the availability of Explosion-Proof motors in Divisions with a permanent hazardous atmosphere exist?

This convergence appears to be difficult in the near future, as obstacles to globalization still exist and are growing in some cases. These tendencies might push industries and political representatives to drive away from uniform market policies and increase the internal market protection by means of economic policies.

VIII. CONCLUSIONS

The arising of electricity drove the world to developments never before thought possible. It also created the dangers associated with these new equipment to a level that caused the death of many people over the years.

The need for protection and regulation of electrical equipment installed in these hazardous areas drove several countries to find means of prevention and control over these industries.

The pursuit of new means of protection and new concepts brought to light technologies, testing and calculation methods that evolved and to this day are still used to validate the compliance of electrical products.

The industrial growth and globalization has moved the world markets closer and harmonized their own rules to decrease costs and increase safety and efficiency. This gave birth to the major guidelines that, today, rule and control the manufacturers and end-users of hazardous area electrical equipment.

Nevertheless, even today the world clings in two major blocks of area classification – Zones and Divisions – that, despite aiming for the same goals, still maintain their distance due to conceptual and technical differences. There are markets faithful to one of the concepts and other that allow both, but the misconception and doubts persist in which is safer . On the other hand, there are many existing facilities that are designed and stablished based on a particular regulation scheme which needs to be considered as well and developing a harmonized scheme is gradual and will take time. For instance, U.S. and Canada debated the reasons of classifying hazardous areas as zones instead of divisions for over 20 years. As a result of these discussions, NEC allowed zone scheme to be used in 1996 and CEC quickly followed in 1998.

This paper summarizes a broad vision of the concepts behind both Zones and Division regulation schemes and the advantages and disadvantages of each. If used correctly and within their scope of application they are safe and valid.

Finally, the big question is: will these two schemes be able to converge and allow a global market for hazardous areas in the future or will they maintain their individuality?

IX. REFERENCES

[1] J. Munro, “Are the IEC requirements for overpressure testing of flameproof equipment appropriate?,” em *PCIC Europe* , Berlin, 2016.

[2] IEC, Module 21 - unit 05: IECEx a short history, IEC, 2015.

[3] *IEC 60079-10-1 - Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres,* 2015.

[4] *IEC 60079-10-2 - Explosive atmospheres - Part 10-2: Classification of areas - Explosive dust atmospheres,* 2015.

[5] *ANSI/NFPA 70 National Electrical Code Article 501: Class I—Flammable or Combustible Liquid-Produced Vapors or Flammable Gases.*

[6] *ANSI/NFPA 70 National Electrical Code Article 502: Class II—Combustible Dust.*

[7] *ANSI/NFPA 70 National Electrical Code Article 506: Class III—Easily Ignitible Fibers/Flyings.*

[8] CSA, “C22.2 No. 145-11 - Electric motors and generators for use in hazardous (classified) locations,” CSA, 2015.

[9] *IEC 60079-1 - Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d",* 2014.

[10] R. Barata, P. Maia e J. Cardante, “Flameproof motors operating in the arctic circle without the need for pre-heating,” em *PCIC Europe*, Berlim, 2016.

[11] F. Carvalho e P. Maia, “Best Practices in Maintenance, Repair and Overhaul of Flameproof Motors,” em *PCIC Middle East 2017*, Abu Dhabi, 2017.

[12] *IEC 60079-7 - Explosive atmospheres - Part 7: Equipment protection by increased safety "e",* 2015.

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