Quality assurance issues for normal grade testing protection provided by equipment housings Ex

Niculina Vătavu [1*], *Sorin* Vătavu[2] , and *Mihai* Popa[1]

[1]National Institute of Research and Development for Safety in Mines and Explosion Protection, 32-34 G-ral Vasile Milea, Petroşani, România
[2] University of Petroşani, 20 Universităţii street, Petroşani, 332006, România

Abstract. Potentially explosive atmospheres generated by the raw materials used, intermediate / final products or the resulting waste may form in all industries involving flammable / combustible substances. The creation of these atmospheres must be treated as a major risk, as the fires or explosions that may occur affect human health and safety as well as the environment. Reducing these risks requires the assessment of the risk of explosion and the establishment of measures to reduce it to acceptable levels in accordance with the requirements of European standards and the ATEX Directive.The general standard SR EN 60079-0 requires that only electrical / non-electrical equipment, certified for safe use, be used in hazardous areas Ex, which must ensure an appropriate normal degree of protection through the outer casing, as this protection is a requirement basic explosion protection.The tests for determining the degree of protection were carried out in accordance with harmonized European requirements and in the area of high-performance stands in accordance with SR EN ISO / IEC 17025, and the validity of the test results was demonstrated by successful participation in interlaboratory competitions and test of laboratory competition.

1 Introduction

In technological processes involving flammable or combustible substances, fires may occur, which in the presence of oxygen and a source of ignition may cause explosions. In general, these explosions pose a particular danger to the facilities, equipment and human personnel involved and therefore an attempt is made to reduce the risks as much as possible through the security and protection measures imposed.

To reduce these risks, it is necessary to assess the risk of explosion for the equipment and installations involved and to establish appropriate measures to reduce it to acceptable levels in accordance with the requirements of the harmonized European standards and the ATEX Directive. Protective measures must ensure that the sources of ignition become harmless, or ensure that the likelihood of the occurrence of effective sources of ignition is reduced.

[1] Corresponding author : niculina.vatavu@insemex.ro

As far as possible, technical equipment must be designed, manufactured, installed and maintained in such a way that it cannot generate sources for the initiation of potentially explosive atmospheres in which it is located, or by drawing up and implementing safe operating procedures and using appropriate systems such as are existing safety devices, control devices, adjusting devices and protective devices.

There is no generalized or recognized and recommended method for assessing explosion risks, but regardless of the method applied, it is necessary to determine the probability of a potentially explosive atmosphere, together with the appearance of an effective ignition source and the extent of the foreseeable consequences. In principle, four steps must be taken to assess the risks:

• hazard identification;
• risk estimation;
•risk assessment;
• analysis of risk reduction options.

An essential element in the process of assessing the risk of explosion at workplaces endangered by the occurrence of explosive atmospheres are the technical installations where, in addition to the fact that they must be properly designed, manufactured and assembled, maintenance must be ensured in such a way as to cannot produce ignition sources. Explosion prevention and protection requirements are governed by specific regulations, directives and standards, and the main component in the explosion risk assessment is related to the assessment of the conformity of the equipment / installation with these requirements.

In accordance with the requirements of the European Directives and the general standard SR EN 60079-0 [1] in potentially explosive atmospheric hazard areas, only electrical / non-electrical equipment, Ex components or protective systems certified for safe use shall be used, which in addition to the type of protection required and appropriate to the area, it must ensure an appropriate normal degree of protection through the outer casing, as this protection is a basic requirement for explosion protection.

2 Reducing the safety risks for Ex equipment by using housings with a normal degree of protection appropriate to the explosion

According to the ATEx Directive 2014/34 / EU, taken over in the Romanian legislation by GD 245/2016, the technical equipment intended for use in areas with danger of potentially explosive atmospheres is divided into two groups and three categories. The appropriate procedure for assessing the conformity of the product by an accredited body shall be chosen, after the manufacturer has decided, to which groups and categories the equipment belongs, depending on the level of protection required for the chosen destination [2-4].

The manufacturer must carry out a risk assessment for ignition and must go through the following steps:

• product description in terms of performance, configuration, service life, etc.
• identification of ignition hazards;
• estimation of the ignition risk;
• the actual assessment of the ignition risk.

Therefore, by applying the ignition risk assessment procedure when designing equipment or a component, the level of safety (protection) can be defined, which allows classification into categories according to the requirements of European directives (three categories: 3G / 3D, 2G / 2D, 1G / 1D depending on the level of protection required for safe use in the area to be used).

Schematically, Table 1 presents the relationship that must exist between the hazardous atmosphere area and the level of protection required for the equipment (component), so that

sources of initiation can be avoided during normal operation, during foreseeable failures or during rarities unpredictable failures.

Table 1. Level of protection required according to the explosive atmosphere [2, 4, 5].

ZONE	Presence of an explosive atmosphere	Ignition sources avoidance	Level of protection required	Group II category	EPL
2 or 22	Infrequent or only on a short period of time	during normal operation	NORMAL	3G or 3D	Gc or Dc
1 or 21	Likely to occur	also during foreseeable malfunctions (one defect)	HIGH	2G or 2D	Gb or Db
0 or 20	Continuously, for long periods of time or frequently	also during rare malfunctions (two defects independent)	VERY HIGH	1G or 1D	Ga or Da
USERS		**MANUFACTURERS**			
Directive1999/92/EC (HG 1058/2006)		European Directive 2014/34/UE (HG 245/2016)			

Therefore, in order to reduce the risk of an explosion in areas with potentially explosive atmospheres generically called "Ex zones", special construction equipment (with an appropriate type of protection) should be used that does not produce electrical sparks, arcs, mechanical sparks (impact and friction), static electricity, overheated surfaces, or other energy sources that could initiate the atmosphere and generate an explosion.

Another essential requirement that equipment intended for potentially explosive atmospheres must meet is to ensure a normal degree of protection against access to hazardous parts inside the housing, against the ingress of solid foreign bodies and / or against the ingress of water.

3 Ensuring normal degrees of protection through equipment housings

For the proper selection, design and installation of electrical equipment and installations intended for use in areas with a potentially explosive atmosphere, in addition to the protection measures required (choice of type of protection Ex, temperature class, category of equipment), they must be protected by enclosures to ensure [6]:

- protection of persons against access to dangerous parts inside the housing (moving or live parts);
- protection of the equipment inside the housing against the penetration of foreign solid bodies;
- protection of the equipment inside the housing against harmful effects due to water ingress.

The normal degree of protection is symbolized as in fig. 1, (according to the international code we have the group of IP letters, followed by two characteristic digits, and in some cases, we can optionally have - by agreement between the beneficiary and the manufacturer - additional and additional letters, respectively, as follows:

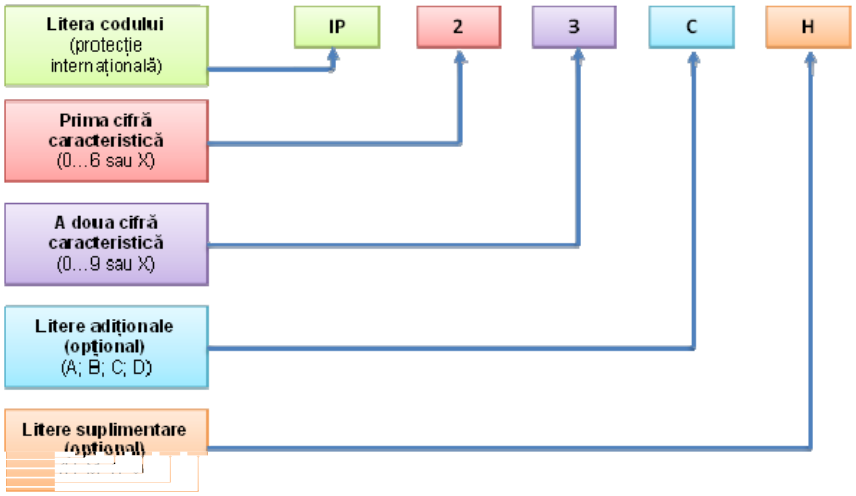

Fig. 1. Normal degree of protection – symbolization.

The additional letters are added after the second characteristic figure and signify the protection which the housing provides against access to moving or energized parts inside the housing, as follows:
A - protected against back access;
B - protected against finger access;
C - protected against access with a tool;
D - protected against access with a wire.

The additional letters are added after the additional letters and suggest additional conditions to be observed during the specific tests:
H - high voltage device;
M - the test for verifying the second characteristic figure is performed with the equipment in motion or under voltage;
S - the attempt to verify the second characteristic figure is performed with stationary or non-functional equipment;
F - oil resistance;
W - specific atmospheric conditions (extreme weather conditions) when additional protection measures or procedures are required.

There are situations where it is not required to specify one of the two characteristic figures (the equipment is intended to operate in areas with combustible dust or to operate immersed in liquid). In these situations, one of the characteristic figures must be replaced by the letter "X", the normal degree of protection of a technical equipment can be expressed for example, in the following form: IP 5X, IP X7, IP 6X, IP X6 / X8. By combining the two characteristic digits (the first and the second characteristic digit), in practice, technical equipment with the following normal degrees of protection, shown in Table 2, can be made [2, 3, 6, 7].

In the case of the first characteristic figure, protection against the penetration of dust inside the housing, the upper figures are cover for the lower figures. In the case of the second characteristic figure, the protection against water entering the housing must be taken into account that a housing designated with the normal degree of protection IP X7 or IP X8 is inadequate for IP X5 or IP X6. Also, an IP X9 housing is unsuitable for IP X7, IPX8, IP X6, IP X5, unless it has multiple operating conditions and is tested for each case.

Table 2. Normal degrees of protection existing in practice.

Letters cod	First characteristic numeral: protection against solid particles	Second characteristic numeral: protection against liquid penetration									
		0	1	2	3	4	5	6	7	8	9
IP	0	IP00	-	-	-	-	-	-	-	-	-
	1	IP10	IP11	IP12	-	-	-	-	-	-	-
	2	IP20	IP21	IP22	IP23	-	-	-	-	-	-
	3	IP30	IP31	IP32	IP33	IP34	-	-	-	-	-
	4	IP40	IP41	IP42	IP43	IP44	-	-	-	-	-
	5	IP50	-	-	-	**IP54**	**IP55**	-	-	-	-
	6	IP60	-	-	-	-	**IP65**	**IP66**	IP67	IP68	IP69

In accordance with the provisions of the general standard SR EN 60079-0 [1], electrical or non-electrical technical equipment must provide at least a degree of protection IP XX, for a specific type of protection, the test procedures complying with the requirements of the standard SR EN 60529 [6] for electrical / non-electrical equipment, components or protective systems, respectively complying with the requirements of the standard SR EN 60034-5 [8] in the case of rotary electric machines.

4 Development of laboratory tests and quality assurance of tests to determine the protection against dust and water entering the housings of Ex equipment

For the assessment of the conformity of electrical and non-electrical equipment with the requirements of ATEX Directive 2014/34/EU, transposed in GD 245/2016, as they are established in the harmonized standards under ATEX Directive, the certification body INSEMEX-OEC, RENAR accredited body (Certificate accreditation certificate ON 046 and notified in Brussels with NB No 1809 must carry out evaluations based on the results of tests carried out in competent laboratories.

In addition to the certification body, the INSEMEX GLI Test Laboratory Group operates within INSEMEX, which is the main provider of laboratory testing services for the product certification body, being accredited by RENAR (accreditation certificate no. LI 347) on competence for performing specific tests, based on the requirements of SR ISO/IEC 17025: 2018 [9] and the accreditation criteria established by RENAR - National Accreditation Body of test and testing laboratories.

In order to assess the conformity of the Ex equipment with the requirements of the applicable harmonized standards, for the test to determine the normal degree of protection, within INSEMEX GLI (Testing Laboratories Group), following the analysis of the required technical solutions, state-of-the-art test stands were purchased many attempts to determine protection against the penetration of dust or water into the equipment housing.

According to the requirements of SR ISO / IEC 17025: 2018, a test laboratory must have control procedures in place to monitor the validity of tests and calibrations performed. This monitoring may include participation in interlaboratory comparisons or competency testing programs [7, 9].

Interlaboratory comparisons are the organization, performance, performance and evaluation of measurements or tests on identical or similar products (equipment) by two or more laboratories in accordance with pre-established conditions.

Thus, in order to ensure the quality of the tests in accordance with the requirements of the SR ISO / IEC 17025: 2018 standard, the INSEMEX GLI Test Laboratories Group participated in a round of non-laboratory comparisons (92 test laboratories were registered). The organizer of the competency testing scheme was Physikalisch - Bechnische Bundesanstalt (PTB), the National Institute of Metrology of the Federal Republic of Germany, a federal scientific and technical authority in the portfolio of the Federal Ministry of Economic Affairs and Energy.

PTB named the program: "Carcass Testing Program - Test Round 2019", and the results were presented online at the PTB Ex PT 2020/2021 workshops. IP tests were performed to determine the normal degree of protection against water ingress (IP X4) and against dust ingress (IP 5X). The regulatory basis for this program was ISO / IEC 17043 - "Conformity assessment - General requirements for proficiency testing" and ISO 13528 - "Statistical methods of use in proficiency testing by interlaboratory comparisons" [10-12].

Within INSEMEX GLI (Testing Laboratories Group), applying the requirements of SR EN 60079-0 and SR EN 60529, tests were performed to determine the normal degree of protection IP X4 and IP 5X on 12 housings, provided by PTB, presented in fig. 2.

Technical Data	
Dimension:	(170 x 170 x 91) mm (W x H x D)
Weight:	0.86 kg
Service temperature (Ts):	-20 ... +100 °C
Material:	Polyester resin, glass-fibre-reinforced, dark grey, similar to RAL 7024
Cover lock:	With captive M6 stainless steel combo head screws according to the specification of the terminal block manufactures
Torque for screws:	4.5 Nm
Enclosure volume:	1.94 l
Type of installation:	Wall mounting

Fig. 2. Test housings.

4.1 Tests to determine protection against spray water on all sides (IP X4 test)

To perform the tests for all 12 housings, follow the steps in the flow chart shown in Fig. 3 [3, 7, 13, 14].

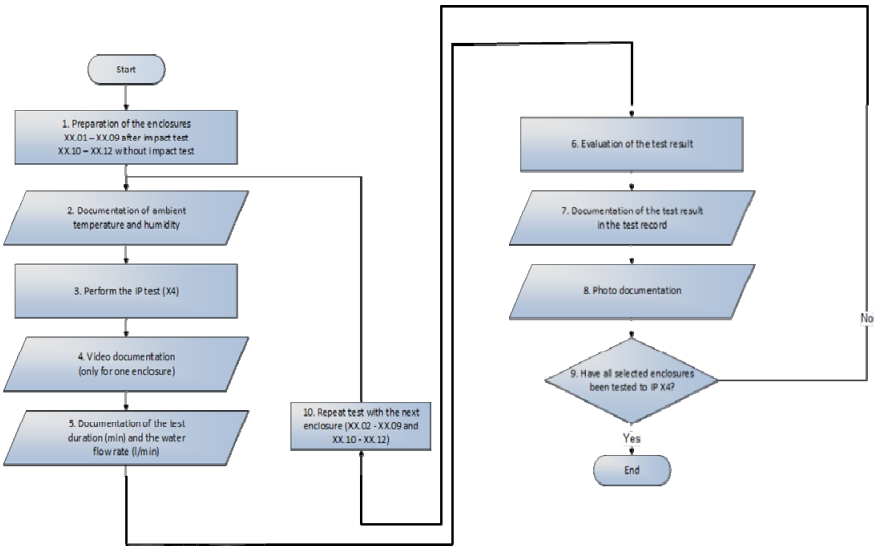

Fig. 3. Flowchart - IP X4 [13].

4.2 Tests for the determination of partial protection against dust ingress (IP 5X test)

To perform the tests for all 12 housings, follow the steps in the flow chart shown in Fig. 4 [3, 7, 13, 14].

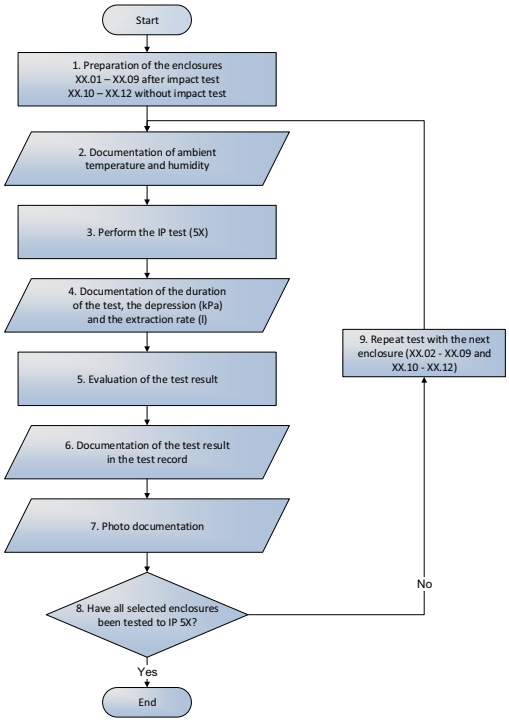

Fig. 4. Flowchart - IP 5X [13].

Following these flow charts, all participating laboratories performed the tests and sent the results to the Organizer of the Competency Testing Scheme, Physikalisch - Bechnische Bundesanstalt (PTB).

The expected value corresponds directly to the test result in terms of passed / failed assessments, performed after each test, the difference being the estimation of the absolute differences between the assigned value and the participant's result.

The results obtained at the interlaboratory tests by the 84 laboratories participating in the scheme, for the determination of IP 5X are presented in fig. 5 and for the determination of IP X4 are presented in figure 6. The results of the test laboratory within INSEMEX GLI are highlighted in yellow (LC0026).

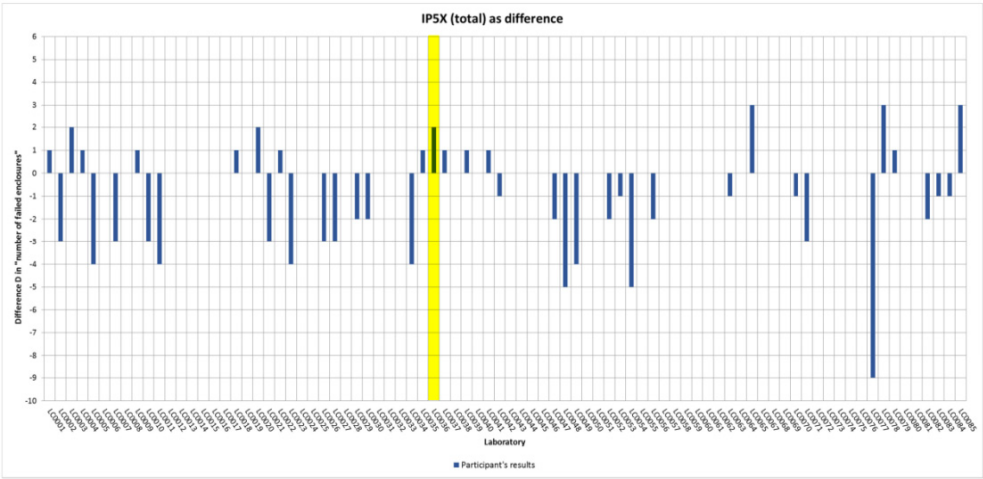

Fig. 5. Results (as difference) for IP 5X. INSEMEX GLI laboratory at position LC0026 [7].

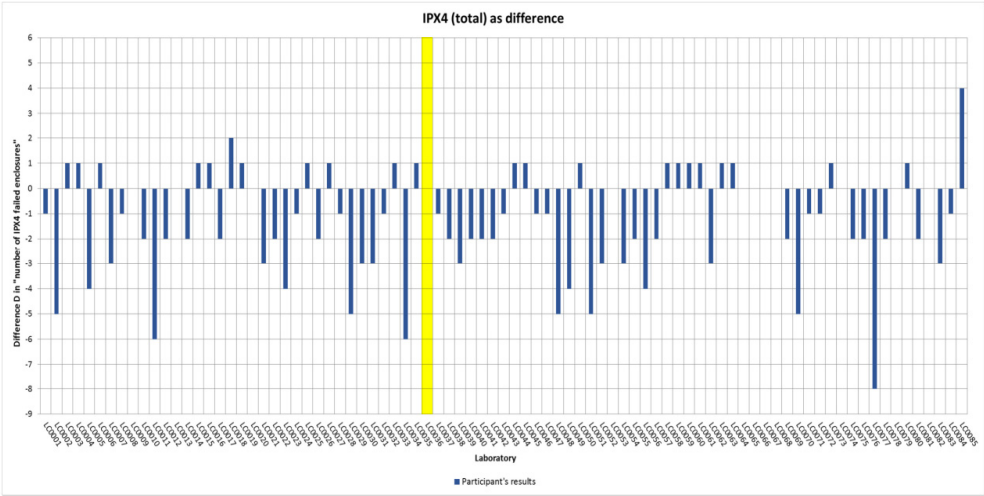

Fig. 6. Results (as difference) for IP X4. INSEMEX GLI laboratory at position LC0026 [7].

From the two graphs shown in fig. 5 and fig. 6, it is highlighted that after evaluating the results obtained in the interlaboratory tests between the 84 participating test laboratories, there are 14 laboratories with warning signal and 3 laboratories that are outside the allowed limits. The results obtained by the GLI laboratory within INCD INSEMEX Petroșani are very good.

5 Conclusions

The development of specific test and testing methods for electrical and non-electrical equipment intended for potentially explosive atmospheres in accredited test laboratories is a key requirement given the dynamic development of European standards in the field.

Given that the assessment of the conformity of Ex equipment with the requirements of the applicable harmonized standards provides for the determination of the normal degree of protection IP XX, within the INSEMEX GLI Testing Laboratories Group modern test stands were purchased, used to determine protection or against dust penetration equipment and water protection, equipped with automated systems for achieving the planned test parameters and specialized software for recording values in order to draw the test diagrams.

To ensure the quality of the tests, the INSEMEX GLI Test Laboratories Group successfully participated in a round of non-laboratory comparisons, the results being considered very good.

References

1. Standard SR EN **60079**-0:2018 + AC:2020
2. N. Vătavu, E. Ghicioi, S. Vătavu, M. Părăian, A. Jurca, F. Păun, D. Gabor, M. Popa Research on the identification of the dangers of dust and water entering equipment for potentially explosive atmospheres, *Universitaria SIMPRO, Conference Procedings, Petroșani*, 409-415, (2018)
3. N. Vătavu, M. Părăian, S. Vătavu, M. Popa, Considerations regarding test methods against dust and water ingress protection for Ex equipment, *10 th International Symposium on Occupational Health and Safety SESAM*, (2021)
4. Directive **2014/34/EU** (2014) of the European Parliament and the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres, Official Journal of the European Union. L 96/314, 29.3.2014
5. N. Vătavu, A. Jurca, S. Vătavu, and D. Gabor, Research on the improvement of test methods for the determination of dust penetration in enclosures of equipment intended for explosive atmospheres*, 9th International Symposium on Occupational Health and Safety SESAM* (2019)
6. Standard SR EN **60529** (1995) + A1(2003) + A2 (2015) + AC (2017)
7. L. Ostermann, Interim Report for the program "Tests of Enclosures - Test Round 2019" of the PTB Ex Proficiency Testing Scheme (2020)
8. Standard SR EN **60034-5**+A1:2007
9. Standard SR EN ISO / IEC **17025**:2018
10. M. Thedens, PTB Workshops 2020 presentation, (2020)
11. M. Detlev, PTB Workshops 2020 presentation, (2020)
12. L. Ostermann, PTB Workshops 2020 presentation, (2020)
13. T. Krause, PTB Workshops 2020 presentation, (2020)
14. PTB Working Group 3.54, Roll-out for Test Round 2021, (2021)