



History of Explosion Protection in Poland

by Michal Górny



Figure 1: Methane burning by flame

Preface

This paper is an overview of the history of explosion protection in Poland. Similar to other industrial countries, the initial scope of explosion protection goes back to the twenties of the 20th century. The first area where explosion protection was established was the mining industry. In the pre-war years, other industrial sectors referred to the experience and expertise of the mining industry. Progress and development of explosion protected equipment were initially based on the flameproof enclosure method.

This paper refers to historical documents (standards, regulations) and information from the laboratory mine ›BARBARA‹ archives – the only available and reliable test stand in Poland, which is described later.

The fast and dynamic industrial expansion in the 18th century lead to the consequential increase in demand of energy (coal). The result being an increase in the number of mines.

One of basic natural hazard in mines (mining industry) is methane release. The risk of firedamp (methane) explosion was always the one of the greater fears of the miners. Initially hazards were reduced by burning the firedamp. Figure 1 shows burning of firedamp by flame.

In 1815 Sir Humphry Davy, an English chemist and inventor, developed a mine lamp, capable of working safely in fire damp. He invented a device which encapsulated the open flame by a special wire mesh enclosure. The mine lamps were protected effectively as there were no risk of ignition of fire damp (methane). Similar constructed safety lamps were utilized for a longer period in the mines.

A comparison of Davy's lamp to the current technical level, shows the similarity of the construction lamp to flame-proof enclosures where the active source of ignition is isolated from the surrounding explosive atmosphere to ensure no flame transmission occurs to the external explosive environment (flameproof enclosure).

Radical changes came about due to the introduction of electrical equipment in the mine shafts, this took place around the time of 1870. After 1882 electrical lighting was installed in the mines and the year also saw the first use of the electrical motor (3 kW, DC) in the Trafalgar Colliery. The three-phase electrical system was invented by Galileo Ferraris in 1885 and the first squirrel cage induction motor was built by Michael Dolivo-Dobrowolski in 1888.

The first research into the essential parameters decisive for firedamp ignition was carried out in Germany by Lehman and Wülner in the period 1884-1885. However, the first tests concerning constructional parameters of flameproof enclosure were carried out by Statham and Wheeler (Sheffield University) and Carl Beyling (Berggewerkschaftliche Versuchsstrecke Dortmund, Germany).

This work led to the issuance of official regulations and standards in Germany and Great Britain. In 1912 the Verband Deutscher Elektrotechniker, VDE (association of electro-engineering Germany) issued a standard

VDE 0170 containing regulations for equipment intended for use in fire damp endangered mines. In 1929 the British Standards Institution issued a flameproof equipment standard BS 229-1929. The first expert evidence (the certificates of today) for flameproof equipment were issued among others by Sheffield University. In the years 1922-1931 approximately 285 reports were issued.

A result of the international standardization development, was the founding of the International Electrotechnical Commission (IEC) in 1906. Within this organisation the Technical Committee TC31 (Equipment for explosive atmospheres) was established in 1948.

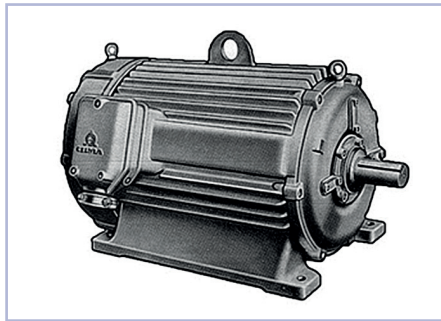


Figure 2: Electrical motor in an improved explosion protected version – approx. 1950 (CELMA INDUKTA, Poland).

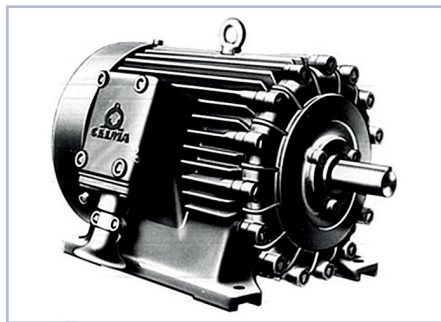


Figure 3: Flameproof electrical motor – about 1950. (CELMA INDUKTA, Poland).

In Poland the first standards for explosion proof equipment were issued in 1929 by the Polish Electricians Association (SEP) : PNE-17:1929. The standards were developed in cooperation with the Czechoslovak Electrotechnicians Association and were issued in 1930 and revised and issued in 1937 and directly after the war in 1946.

When researching into the development of test methods for explosion protected systems and the relevant standards it becomes clear that explosion protection has its origins in mining. The technical solutions for explosion protection applied in mining became the basis for similar solutions developed in the chemical industry. This general assumption is confirmed by the fact that the first Polish standard for the chemical industry in regard to explosion protection was issued in 1963.

The electrical motors illustrate clearly the development of explosion protected equipment, albeit other equipment constructed could portray a similar history (e.g. transformers, switchgears and others).

With the introduction in 1963 of the first explosion protection standards for the chemical industry in Poland a lot of further information about explosion protection in this industry became available. Prior to this time there were a number of developments in the chemical industry concerning testing processes and state regulations, however reference was always made to the standards from the mining industry.

In 1934 a statutory regulation for acetylene systems was published as well as the standard for lights ›lighting installation should be made according to standard PNE-17‹.

Test methods

Parallel to the growing awareness of explosion hazards, there was a rise in development of explosion protected equipment test methods. Subsequent to gas mixture property research, processes for testing electrical equipment and at a later point for installation of explosion protected systems were introduced. Initially statutory regulations were published and at a later stage substituted by standards for installation and testing methods.

The first standards did not contain precise requirements. Instead, referred to ›a reliable testing station‹, where all relevant tests and assessments were to be made.

The standard PNE-17:1929 instructed the following; ›all machines, equipment, cable etc. should be constructed, mounted, protected, and maintained in a way that under normal working conditions do not produce sparks in surrounding atmosphere.‹ It is interesting, that there was no reference made to failure analysis, and safety was limited only to normal work conditions. There were no inspection and maintenance methods specified. Today's methods based on ignition probability (e.g.. intrinsically safe circuits Ex i) were only mentioned in connection with workplace design recommendations:

The selection of construction systems listed below, should be done based on following method: Ignition probability of an explosive mixture by electrical spark in a mine is the result of the following 2 factors:

- > formation of such a mixture and
- > the simultaneous formation of an electrical spark at the same time in the same place.



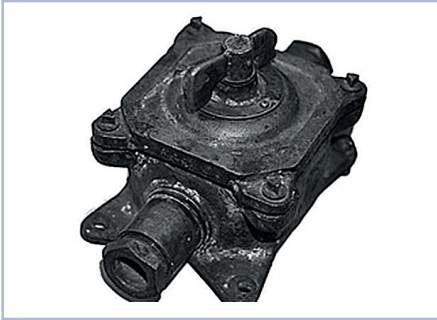


Figure 4: Explosion protected switch with flame proof enclosure Poland (approx. 1930).

For sites with a high probability of factor 1 more reliable electrical constructions should be implemented i.e.. flameproof enclosures. Further-more, to reduce the risk attached to factor 1 electrical equipment should be placed in sites where a fresh air flow.

From the start a flameproof enclosure was considered to be the most reliable method for explosion protection.

A flameproof enclosure was defined as follows: Enclosure which prevents transmission of fire eventually formed inside to the outside.

The first standard was issued in 1930 and revised versions in 1946 and in 1957 were replaced by PN-57/E-08101. The differences in the revised standard were mainly in scope. In over more than 40 pages definitions, constructional requirements, drawings, characteristics and descriptions of documentation for testing all known types of protection (flameproof enclosure, lamellar enclosure, increased safety, oil filling and special construction) were recorded. This standard defined two degrees of equipment tests: type test for new construction and routine tests for each serial produced item.

For the type test of flameproof enclosures a pressure test and a methane explosion test were defined. For the first time a test was defined to cover requirements to ensure there was no external transmission of internal explosion. The pressure test was based on defined standard pressure values (there was no statutory test to measure a maximum explosion pressure) because the non-transmission test was based on applying 6 times the explosion tests in the test rig. The next important standard was the PN-63/E-08102 – the first standard related to the chemical industry (non-mining) equipment. Remarkable was the fact that there was no relevance made to intrinsically safe circuits.

This standard introduced ignition groups (G1 – G5), and divided the equipment into explosion classes (I, II, III, IV) and regulated the ex-marking together with types of protection symbols.

In 1972 common requirements for all Ex-

equipment, mine and non-mine equipment, were collected into one (!) standard. For each type of protection one additional standard was issued. 1972 standards introduce a division in groups: Group I mining and Group II chemical industry. Group II was subdivided in group IIA, IIB and IIC and in temperature classes T1-T6.

The next and the last original Polish standards were the 1983 standards. From this year there were common marking rules, symbols marking types of protection the same like in other countries. The most interesting was introducing a requirement of testing in short circuit condition. A short circuit test was obligatory for some high voltage mining equipment. The tests were made in a methane-air mixture and were similar to the explosion pressure tests and non-transmission tests. Typical short circuit parameters were 1000V and 10kA and 100ms duration.

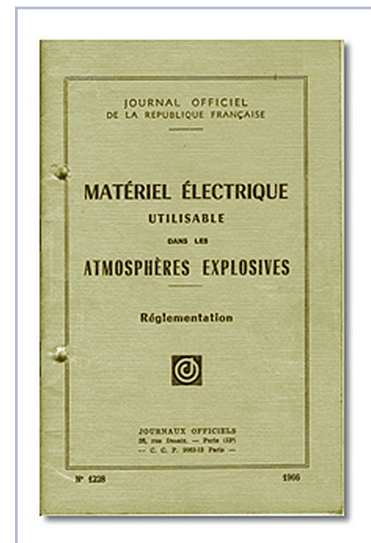
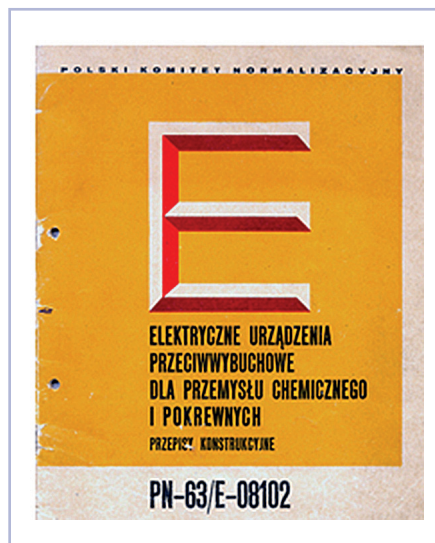


Figure 5: First Polish standard regarding to non-mine industry (group II) and corresponding French regulation.



The requirement of short circuit testing was stopped with introducing EN 50014 series standards in Poland in 1997. But short circuit tests are still important in countries where mining industry is present and developed.

The European standards should be complemented accordingly. These requirements outside the international standards organizations ISO and IEC were seen as national level standards and as suspected from the beginning there was a »dead end«.

In 2006 EN standards were replaced by international IEC standards.

The last 20 years were trouble-some for Polish manufacturers of explosion protected equipment. Standard changes require numerous changes of equipment design. In former times there was one standard change in each 10 years in the average, but from 1993 manufactures need to comply with requirements of:

- > PN-83/E-08110,
- > PN-EN 50014:1997,
- > PN-EN 50014:2002,
- > PN-EN 50014:2004,
- > PN-EN 60079-0:2006,
- > PN-EN 60079-0:2009.

In the same time manufacturers within the European Community countries were »experienced« only with the changes required by introducing new IEC standards.

Typical changes in Polish standardization were collected in Table 1.

Standard	Requirement
PNE-17:1929	First Polish standard. Only mine's equipment. Government regulation and scope of Ex safety frequently relates to it. Re-issued in 1930 and 1946.
PN-57 / E-08101	Mines equipment's only. Defines flameproof and lamellar enclosures (marked BM) and increased safety and oil filling enclosure (marked BW).
PN-63 / E-08102	First standards for non-mine equipment. Introduce ignition groups (G1-G5) and explosion classes regarding to flameproof joint parameters. Ex marking together with symbol of type of protection (national symbol).
PN-72 / E-08110	Common group I (mine) and group II (chemical industry) standard. Group II was subdivided into IIA, IIB and IIC groups. Separate marking of group I and group II equipment. Additional standard for each type of protection.
PN-83 / E-08110	Introduces a common Ex marking for all (mine and chemical) equipment. Introduces international type of protection symbols. For some high voltage group I equipment requirement of short circuit tests (in methane-air mixture).
PN-EN 50014:1997	Introduces an EEx marking, stops short circuit test requirements.
PN-EN 60079-0	Back to Ex marking.

Table 1: Polish Standardization in Ex scope

Development of test methods and of Laboratory Mine »BARBARA«

In Poland the development of test methods was a similar to the development in other countries in which coal production has a significant contribution to economy. Like in Great Britain and Germany an independent testing station was established. The first testing station was only dealing with mine safety.

In 1925 a Laboratory Mine »BARBARA« was constituted. Based on a resolution of the parliament, an Institute of mine safety was established in Mikołów (near Katowice) in an old inoperative coal mine. The main

field of activity of this Institute was scientific research of methane and coal dust explosion and colliery rescue work.

Although there were no standards for the chemical industry in the beginning, equipment for Group II was also tested and assessed (Figure 8).

The development of testing method is interesting and similar to the development in other countries. It is worth to note that the first testing was based on defined explosion pressure (defined in standards). Requirements for the experimental determination of the explosion pressure appeared about 1957.





Figure 6: Laboratory Mine ›BARBARA‹ in 1920 years.

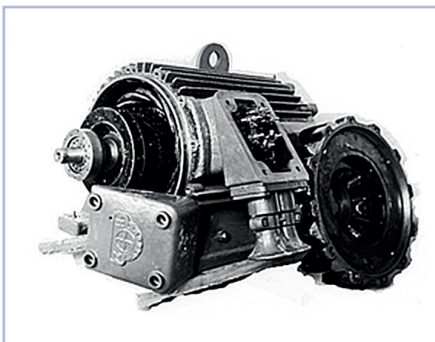


Figure 7: Ex d motor 65kW, 500V) testing in Experimental Mine ›BARBARA‹ (1951, CELMA INDUKTA, Poland)

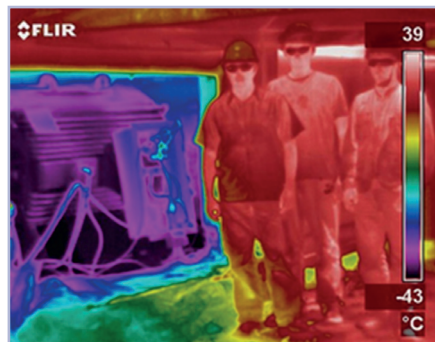


Figure 8: Low temperature group IIC Exd motor testing, weight about 6000 kg (ZME ›EMIT‹).

Also the first testing was without safety margins – non-transmission tests were made in the mixture of the same flammable gas in which equipment should operate. Detailed development of test methods for flameproof enclosures – see table 2.

Summary

In Poland the development of explosion protection and the awareness for safety in explosive areas, as well as the development of the legal and technical requirements were similar to those in other industrialized countries. Also in Poland the origin of explosion protection was the mining industry.

The development of tests methods, standards changes and new regulations is closely connected with the Laboratory Mine ›BARBARA‹, which up to 1997 was defined in the Polish standard as ›the one reliable testing station‹.

A big achievement in 2010 of KDB staff (KDB stands for Laboratory Mine ›BARBARA‹) was the joining to the IECEx scheme and testing a large number of Ex d equipment for the use in low temperatures.

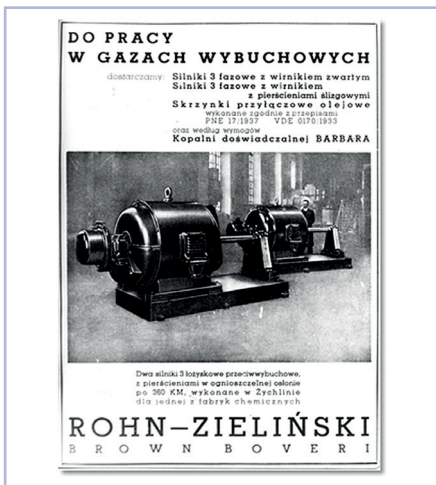


Figure 9: Advertising folder of explosion protected induction motors of a Polish company (for chemical industry) (ZME ›EMIT‹).

Standard	Requirement
PNE-17:1929	A 8 bar overpressure test for over 1 litre enclosures and 3 bar for smaller ones. Flameproof gaps checking, but requirements only for flanged joints and for shaft joints. Minimum length of shaft joint is 50 mm
PN-57 / E-08101	Static overpressure test. 6 bars for enclosures 0,05 – 0,1 dm ³ and 8 bars for over 0,1 dcm ³ enclosures. Explosion test: non-transmission test using methane air mixture (about 9% CH ₄). Test makes 6 times.
PN-63 / E-08102	Determination of explosion pressure required. Test is made by using a proper gas mixture (different for each explosion class I, II, III, IVa, IVb, IVc, IVn). Test makes 5 times. Pressure test using maximum explosion pressure. 10 times non-transmission test, using the same gas mixtures.
PN-72 / E-08110	Common standard for group I and group II equipment. Determination of explosion pressure for equipment's of each safety class (I, IIA, IIB, IICa, IICb). Determination (except class IICa and IICb) by using 3 components mixtures (methane + hydrogen + air). Test made 3 times. In case of scattering results – 2 additional tests. Overpressure test using 1,5 times maximum explosion pressure. Non-transmission test – using the same mixtures. For electrical motors tests in running and stalled motor. Test makes 10 times.
PN-83 / E-08110	Determination of maximum explosion pressure using characteristic gas mixtures for each group (and subgroup): group I 9.8% methane + air group IIA 4.6% propane + air group IIB 8,0% ethylene + air and in case of pressure pilling 20.4% hydrogen + 3.6% methane + air group IIC 31,0% hydrogen + air and 8% acetylene + air. Test made 3 times. For some group I equipment additional short circuit tests (in methane air mixture). Non transmission tests using gas mixtures with safety margins. Test makes 5 times. For some group I equipment additional short circuit tests (in methane air mixture).
PN-EN 50018:2000	Short circuit test waved.
PN-EN 60079-1	Additional requirements for tests in low (below -20°C) and high (above +60°C) temperatures.

Table 2: Development of test methods for Ex d