Annals of the University of Petrosani, Electrical Engineering, 23 (2021)

ON THE INSPECTION OF ELECTRIC EQUIPMENT WITH TYPE OF PROTECTION FLAMEPROOF ENCLOSURE "d" AND INCREASED SAFETY "e" OPERATING IN POTENTIALLY EXPLOSIVE ATMOSPHERES

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Abstract: Electrical equipment designed for use in potentially explosive atmospheres has some specific properties and characteristics providing explosion protection. These must be preserved on the entire period of their use. Verification of these special properties and characteristics is made by performing specific inspections. This paper underlines specific aspects related to inspections and the importance of performing them.

Keywords: electric equipment, type of protection, inspection

1. GENERALITIES

Installations, operating in hazardous areas endangered by potentially explosive atmospheres, and equipment used in such installations possess specific properties and characteristics in order to provide explosion protection and to avoid the ignition of the surrounding explosive atmosphere. These specific properties and characteristics providing explosion protection have to be preserved on entire period of use for such installations [3, 4], [11]. In the European Union countries, the equipment operating in explosive atmospheres shall be according the ATEX Directive [2].

The correct operation of an equipment does not mean that the integrity of the special features related to explosion protection is preserved [3], [5].

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For older installations, the recommendation is to perform inspections according to the standards that were applicable at the date of the installation erection [8].

The types of protection “d” and “e” were chosen because a lot of equipment in installations operating in explosive atmospheres are designed with these two types of protection.

The type of protection flameproof enclosure “d” consists in placing the parts that could ignite an explosive atmosphere inside of an enclosure that can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the explosion transmission to the explosive atmosphere surrounding the enclosure [6]. In general, it can be applied to electrical equipment which in normal operation produces electrical arcs and sparks.

Increased safety “e” represents a type of protection applied to electrical equipment or Ex components in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and against the occurrence of arcs and sparks [7].

An inspection represents the action comprising careful examination of an item carried out either without dismantling, or with the addition of partial dismantling, supplemented by means such as measurement, in order to arrive at a reliable conclusion regarding the condition of an item [8].

The classification of inspections is made according to the grade and type of inspection [8].

The classification of inspections according their grade is as follows [8]:

- Visual inspection;
- Close inspection;
- Detailed inspection.

The classification of inspections according their type is as follows [8]:

- Initial inspections;
- Periodic inspections;
- Sample inspections.

Another concept for inspection of installations is represented by continuous supervision, using visual or close inspections. In case the installation is not within the continuous supervision capability, it must be subjected to periodic inspection [1].

The results of inspections must be recorded and retained. The results of inspections may indicate some further actions to be taken (maintenance or repair).

2. SPECIFIC CONCEPTS REGARDING INSPECTIONS

Electrical equipment designed for use in explosive atmospheres shall be installed considering the technical documentation supplied by the manufacturer [1, 3, 4, 5, 6, 8, 9]. The initial inspection must be performed after installing of equipment or installation, before the first put into operation and the results shall be recorded and retained [8, 9]. Initial inspection shall be performed with a detailed grade (to verify that all the specific features providing explosion protection are valid). Inspection requirements and other

specific requirements, according the types of protection are specified in SR EN 60079-14 standard [9]. The type of protection is also important regarding the aspects to be verified during inspections. The aspects to be checked in relation to the type of inspection and type of protection (“d”, “e”) are detailed in the Table 1 below.

Table 1. ***Specific inspection features for equipment with type of protection „d” and „e” [8]***

	Check that:	**Ex “d”**			**Ex “e”**		
		D	**C**	**V**	**D**	**C**	**V**
A	**GENERAL (ALL EQUIPMENT)**						
1	Equipment is appropriate to the EPL/zone requirements of the location	X	X	X	X	X	X
2	Equipment group is correct	X	X		X	X	
3	Equipment temperature class is correct (only for gas)	X	X		X	X	
4	Equipment maximum surface temperature is correct						
5	Degree of protection (IP grade) of equipment is appropriate for the EPL/group/conductivity	X	X	X	X	X	X
6	Equipment circuit identification is correct	X			X		
7	Equipment circuit identification is available	X	X	X	X	X	X
8	Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	X	X	X	X	X	X
9	There is no damage or unauthorized modifications	X			X		
10	There is no evidence of unauthorized modification		X	X		X	X
11	Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight						
	– physical check	X			X		
	– visual check		X	X		X	X
12	Threaded covers on enclosures are of the correct type, are tight and secured						
	– physical check	X			X		
	– visual check		X	X		X	X
13	Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	X					
14	Condition of enclosure gaskets is satisfactory	X			X		
15	There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	X			X		
16	Dimensions of flanged joint gaps are: - within the limits in accordance with the manufacturer’s documentation or - within maximum values permitted by the relevant construction standard at time of installation or - within maximum values permitted by site documentation	X					
17	Electrical connections are tight				X		
18	Unused terminals are tightened				X		

	Check that:	Ex "d"			Ex "e"		
		D	C	V	D	C	V
19	Enclosed-break and hermetically sealed devices are undamaged						
20	Encapsulated components are undamaged				X		
21	Flameproof components are undamaged				X		
23	Breathing operation is satisfactory (type "nR" only)	X			X		
24	Breathing and draining devices are satisfactory	X	X		X	X	
	EQUIPMENT SPECIFIC (LIGHTING)						
25	Fluorescent lamps are not indicating EOL effects				X	X	X
26	HID lamps are not indicating EOL effects	X	X	X	X	X	X
27	Lamp type, rating, pin configuration and position are correct	X			X		
	EQUIPMENT SPECIFIC (MOTORS)						
28	Motor fans have sufficient clearance to the enclosure and/or covers, cooling systems are undamaged, motor foundations have no indentations or cracks	X	X	X	X	X	X
29	The ventilation airflow is not impeded	X	X	X	X	X	X
30	Insulation resistance (IR) of the motor windings is satisfactory	X			X		
B	**INSTALLATION − GENERAL**						
1	Type of cable is appropriate	X			X		
2	There is no obvious damage to cables	X	X	X	X	X	X
3	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	X	X	X	X	X	X
4	Stopping boxes and cable boxes are correctly filled	X					
5	Integrity of conduit system and interface with mixed system maintained	X			X		
6	Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)						
	– physical check	X			X		
	– visual check		X	X		X	X
7	Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	X			X		
8	Automatic electrical protective devices are set correctly (auto-reset not possible)	X			X		
9	Automatic electrical protective devices operate within permitted limits	X			X		
10	Specific conditions of use (if applicable) are complied	X			X		
11	Cables not in use are correctly terminated	X			X		
12	Obstructions adjacent to flameproof flanged joints are in accordance with SR EN 60079-14	X	X	X			
13	Variable voltage/frequency installation complies with documentation	X	X		X	X	

	Check that:	Ex “d”			Ex “e”		
		D	C	V	D	C	V
	INSTALLATION – HEATING SYSTEMS						
14	Temperature sensors function according to manufacturer’s documents	X			X		
15	Safety cut off devices function according to manufacturer’s documents	X			X		
16	The setting of the safety cut off is sealed	X	X		X	X	
17	Reset of a heating system safety cut off possible with tool only	X	X		X	X	
18	Auto-reset is not possible	X	X		X	X	
19	Reset of a safety cut off under fault conditions is prevented	X			X		
20	Safety cut off independent from control system	X			X		
21	Level switch is installed and correctly set, if required	X			X		
22	Flow switch is installed and correctly set, if required	X			X		
	INSTALLATION – MOTORS						
23	Motor protection devices operate within the permitted t_E or t_A time limits.				X		
C	**ENVIRONMENT**						
1	Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	X	X	X	X	X	X
2	No undue accumulation of dust and dirt	X	X	X	X	X	X
3	Electrical insulation is clean and dry				X		

In the technical standards [8, 9], are also presented the aspects to be verified for other types of protection applied for electrical equipment (intrinsic safety “i”, pressurization “p” etc.).

An inspection program, comprising the periodical inspections shall be established after installing the equipment / installation [3].

Additional interim sample inspections should be performed to verify if the inspection schedule is adequate or needs adjustments. Sample inspection can be used when many similar items, having the same manufacturer, type, type of protection (electric motors, luminaires, junction boxes, etc.) are installed in the same period, work in the same environment and conditions. But still, each item should be subjected to at least a visual inspection [8].

The factors to be considered when establishing an inspection schedule (program) are: the manufacturer's instructions, type of equipment, deterioration factors, area classification and/or the EPL requirements, results of previous inspections; also, the experience of the personnel on similar installations and equipment can be used in determining the inspection strategy). The time interval between periodic inspections shall not exceed three years without consulting of an expert. Intervals between periodic

inspections exceeding three years should be based on an assessment including relevant information [3, 8].

In case of hand-held (portable) equipment the interval between periodic inspections needs to be reduced (because they are more prone to damage than fixed equipment) according to SR EN 60079-17 [8].

It is possible to change the inspection period, if necessary, based for example, on the results of previous inspections.

An inspection shall be performed (on the relevant parts of equipment) after any adjustment, maintenance, repair, reclamation, modification or replacement [8].

The personnel performing specific inspections must be competent personnel (it shall possess knowledge, skills and specific competencies) [3, 8]. In Romania, the personnel performing specific inspection activities must be authorized by INSEMEX according normative NEx 01-06/2007 (considering also the provisions of applicable standards) [2].

In case of equipment having multiple types of protection (there are many equipment with type of protection “d” and “e”) the applicable inspection operations, specific for each type of protection shall be performed. Care shall be taken, in this case, in order to correctly identify the specific compartments and elements for each type of protection. It is very important to verify only what is applicable for each type of protection.

3. FINDINGS FROM THE INSPECTION – EXAMPLES

Inspections are performed to provide evidence that equipment and installations are maintained in good condition regarding the use in explosive atmospheres. To this, it is important to verify all aspects of the specific equipment as presented in the columns of inspection tables (considering the type(s) of protection, the grade and type of inspection) [3].

Some aspects related to the findings that can be revealed when performing inspections (influencing explosion protection of equipment) are included in the following examples:

Fig.1 Equipment in normal construction installed in hazardous area classified as zone 2

Fig. 2 Ex equipment installed in zone 2 but with its label plate being painted

Fig. 3 Bolts missing to an Ex d equipment

Fig. 4 Damaged cable and cable gland of an Ex d equipment

Fig. 5 Ex e blanking element installed to an Ex d equipment

Fig. 6 Damage of rubber elements leading to invalidation of explosion protection for an “Ex de “ equipment

4. CONCLUSIONS

The paper presented some relevant information regarding the inspection of electrical equipment used in explosive atmospheres. The paper was focused on electrical equipment with two types of protection, flameproof enclosure “d” and increased safety “e”. The definitions regarding inspections are also common to other specific types of protection.

In the first two parts of the paper were exposed important features regarding the inspection activity: importance and classification of inspections, verifications needed to be made on inspections according the type of protection, type and grade of inspection; factors that influence the inspection program and competence of personnel.

The third part consisted in some specific examples of non-conformities related to explosion protection that can be found on equipment with type of protection “d” and “e (frequent damages).

These aspects are very important to the personnel performing inspection (and maintenance) activities in installations operating in explosive atmospheres.

REFERENCES

[1]. Grecea D., Darie M., Csaszar T., *The test method used to determine surface temperature for Ex equipment certification,* 9th International Symposium on Occupational Health and Safety, SESAM 2019, MATEC Web of Conferences, Vol. 305, Art. no. 00083, 2020, eISSN: 2261-236X.

[2]. Moldovan L., Magyari M., Andris A., Pupazan G., Moldovan C., *Importance of training the personnel performing specific activities related to equipment / installations operating in areas classified as with potentially explosive atmospheres*, 9th International Symposium on Occupational Health and Safety, SESAM 2019, MATEC Web of Conferences, Vol. 305, Art. no. 00037, 2020, eISSN: 2261-236X.

[3]. Moldovan L., Magyari M., Rad M., Moldovan C., Zsido S., *Considerations regarding the inspection of equipment designed for use in potentially explosive atmospheres*, International Multidisciplinary Symposium Universitaria Simpro, 2021, Petrosani, MATEC Web of Conferences, Vol. 342, Art. no. 04002, eISSN 2261-236X.

[4]. Moldovan L., Burian S., Gaman G.A., Paraian M., Magyari M., *Aspects regarding the assessment of technical installations operating in environments with hazard of explosive atmospheres, in Romania*, Proceedings of the 17th International Multidisciplinary Scientific Geoconference SGEM 2017, vol. 17, pg. 531-538, ISBN 978-619-7408-00-3 / ISSN 1314-2704.

[5]. Niculescu T., V. Arad, M. Marcu, S. Arad, F.G. Popescu, *Safety barrier of electrical equipment for environments with a potential explosion in underground coal mines*. MINING OF MINERAL DEPOSITS. Volume: 14 Issue: 3 Pages: 78-86, DOI: 10.33271/mining14.03.078, 2020.

[6]. Niculescu T., Pasculescu D., Pana L., *Study of the operating states of intrinsic safety barriers of the electric equipment intended for use in atmospheres with explosion hazard*, WSEAS Transactions on Circuits and Systems, Volume 9, pp.430-439, 2010.

[7]. Pasculescu D., Niculescu T., Pana L., *Uses of Matlab Software to size intrinsic safety barriers of the electric equipment intended for use in atmospheres with explosion hazard*, Proceedings of the International Conference on Energy and Environment Technologies and Equipment (EEETE '10), Bucharest, Romania, Aprilie 20-22, 2010, pag. 17-21.

[8]. Rad M. D., Magyari M., Moldovan L., Fotau D., Salasan D., *Aspects concerning the importance of inspection and maintenance of electrical equipment with type of protection flameproof enclosure and increased safety used in liquefied petroleum gas car filling station*, Proceedings of the 20th International Multidisciplinary Scientific Geoconference SGEM 2020, Vol. 20, pg. 657-664, ISBN 978-619-7408-00-3 / ISSN 1314-2704.

[9]. ***, Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast), Official Journal of the European Union, no.96, 2014.

[10]. *** Normative of 2 May 2007 on explosion prevention for design, installation, commissioning, use, repair and maintenance of technical installations operating in atmospheres potentially explosive, indicative NEx 01-06, Official monitor of Romania 411/19.06.2007.

[11]. ***, SR EN 60079-17:2014, Explosive atmospheres - Part 17: Electrical installations inspection and maintenance.

[12]. ***, SR EN 60079-14:2014, Explosive atmospheres - Part 14: Electrical installations design, selection and erection.