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EVALUATION OF SIMPLE CIRCUITS WITH INTRINSIC SAFETY

DĂNUȚ GRECEA[1], SORIN BURIAN[2], MARIUS DARIE[3], TIBERIU CSASZAR[4], COSMIN COLDA[5], ADRIANA ANDRIŞ[6], GABRIELA PUPĂZAN[7], LUCIAN MOLDOVAN[8],

Abstract: In this paper are presented the analysis and characterization of linear sources from within intrinsic safety circuits and issues to be taken into account for the evaluation of these circuits.

For low current electrical equipment (interlocking, command, data communications, signalling) the assessment of explosion protection is often carried out by calculation using the technical data available in the specific standard related to protection to explosion requirements.

Currently, the method of calculation uses simplified but covering models. The major advantage of the outcome's certainty on the confirmation of the explosion protection is balanced by the increased rate of rejection. Complex equipment which cannot be assessed by calculation is tested in explosive atmospheres in compliance with the requirements set out in the relevant standard.

Keywords: explosive atmosphere, explosion protection; electrical equipment, type of protection, intrinsic safety.

[1] *Ph. D.Eng., scientific researcher, INDC-INSEMEX Petroşani*
[2] *Ph. D.Eng., scientific researcher I, INDC-INSEMEX Petroşani*
[3] *Ph. D.Eng., scientific researcher I, INDC-INSEMEX Petroşani*
[4] *Ph. D.Eng., scientific researcher I, INDC-INSEMEX Petroşani*
[5] *Ph. D.Eng., scientific researcher III, INDC-INSEMEX Petroşani*
[6] *Eng., scientific researcher , INDC-INSEMEX Petroşani*
[7] *Eng., scientific researcher, INDC-INSEMEX Petroşani*
[8] *Ph. D.Eng., scientific researcher I, INDC-INSEMEX Petroşani*

1. GENERAL CONDITIONS

In industrial installations in which are processed, used or stored flammable or combustible substances is likely to occur an explosive atmosphere, generating an explosion hazard. In this regard, in order to ensure explosion protection, the electrical equipment used in such installations must be correctly chosen to ensure the level of health and safety at the workplace and to prevent their being built into a source of ignition for explosive atmospheres, [1].

In this paper are presented the analysis and characterization of linear sources from within intrinsic safety circuits and issues to be taken into account for the evaluation of these circuits.

Explosion prevention and explosion protection are of major importance for occupational health and safety in order to minimize losses (both human and material). Explosive atmospheres are defined as a mixture with air, under atmospheric conditions, of flammable substances in the form of flammable gases, mist vapors or combustible dusts, in which, after ignition, combustion is spread throughout the unburned mixture, [7].

The mechanism of an explosion generated by a mixture of flammable gas, vapor or mist with air can be expressed by the well-known explosion triangle shown in Figure 1. Thus, the occurrence of an explosion is conditioned by the simultaneous presence of the following three factors:

1. fuel (flammable gases, vapours, dusts /powders, mists);

2.comburent (oxygen, oxidizing substances);

3. efficient ignition source for ensuring the activation of molecules in order to ignite and propagate the fast combustion reaction, [2].

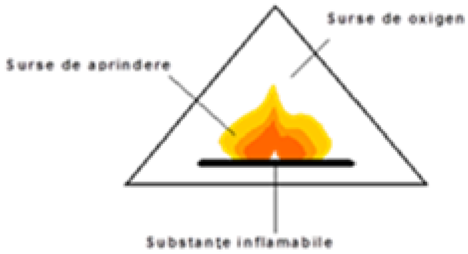

Fig. 1. The explosion triangle

Evaluation and testing of equipment which is part of an explosion protect system in purpose of certification, considers that the risk of explosion has to be minimized in order to ensure security of life and human health, as well as to prevent damage to property and, last but not least, the environment, [3].

All equipment included in a system under construction explosion-protected equipment used in spaces endangered by potentially explosive atmosphere shall meet the following requirements:

• be adequately protected from the explosion;

• to maintain the level of protection for the environmental conditions for which it was built;

• to be able to withstanding all requests (predictable) to which they are subjected during storage, transport, installation and operation of the system, [5].

Explosion protection for low current installations can be implemented using the intrinsic safety type of protection.

Intrinsic safety type of protection, based on the separation of the circuit is protected from other circuits and limiting the energy that is protected so that it cannot ignite the explosive atmosphere, [4].

The explosion protection evaluation for low current equipment involves a process of analyzing the equipment documentation with respect to compliance with the requirements of the relevant explosion protection standards.

The current trend in assessing explosion protection of low current electrical equipment protected by the type of explosion protection intrinsic safety is to increase the share of assessments by calculation applied to equipment using reference tables and charts presented in the relevant standard SR EN 60079- 0; SR EN 60079-11.

Intrinsic safety equipment and parts with intrinsic safety of the associated equipment are classified after recalled above standard as having levels of protection: ”ia”, ”ib” or ”ic”, [8].

2. EVALUATION CRITERIA FOR SIMPLE CIRCUITS WITH INTRINSIC SECURITY TYPE OF PROTECTION

Explosion protection implemented by intrinsic safety protection type is based on two main guidelines: limiting the transited and stored energy but also the adoption of separations between intrinsically safe circuits and other circuits.

To evaluate the active intrinsic safety circuits, it is necessary to know first the internal resistance and supply voltage.

For the simplest case, the source can be characterized by two electric constant values, either idle voltage U_0 and internal resistance R_i or the idle voltage U_0 and short-circuit current I_0 as shown in Figure 2.

When the circuit to be evaluated, in terms of capacity, is approximated as a simple circuit, for which there are experimentally curves determined in reference accredited laboratories and recognized at international level, the charts in carts A1 ÷ A6 can be used for evaluation.

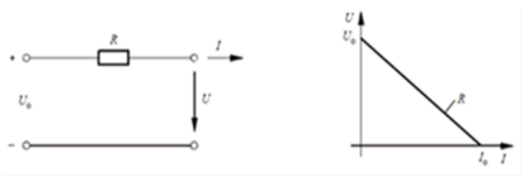

Fig. 2. Resistive circuit with linear characteristic

Specific values of these charts can be processed in tabular form. In both cases, however, the defective conditions and safety coefficients should be considered.

The information given by the following figures relate only to simple circuits and in some cases it can be difficult to apply the information to design practical circuits.

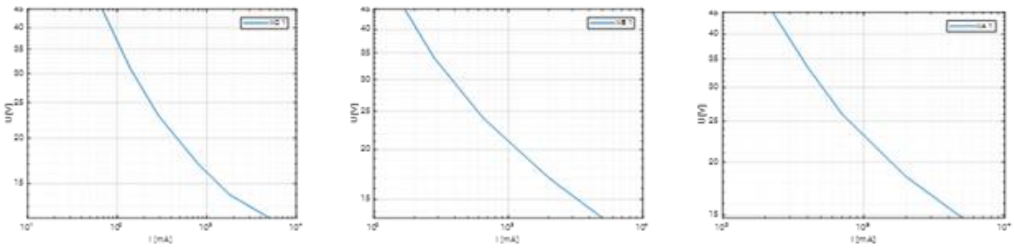

Fig. 3. Curves for evaluation of resistive circuits, group II, safety coefficient 1

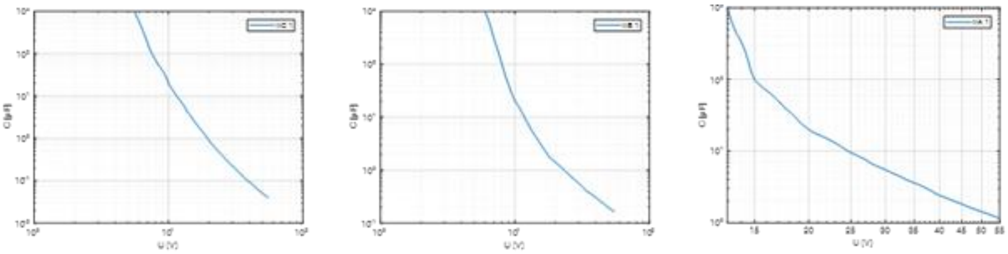

Fig. 4. Curves for evaluation of capacitive circuits, group II, safety coefficient 1

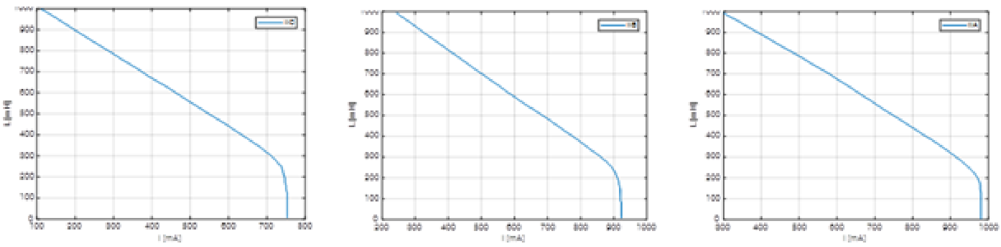

Fig. 5. Curves for evaluation of inductive circuits, group II

A circuit intended for use in potentially explosive environments, with the protection type intrinsic safety "i" must satisfy three basic criteria:

a) does not result in any electrical spark ignition owed when the circuit is rated or tried in accordance with the specified protection level and specified electrical equipment group. This requirement may be satisfied through evaluation, information, current and voltage information on circuit parameters such as inductance and capacity.

b) the temperature class of the equipment with the intrinsic safety is established so as to ensure that the ignition is not caused by hot surfaces. This requirement can be satisfied by estimating the maximum surface temperatures of the components, from the knowledge of their behavior and thermal maximum power to which they may be subjected in operation/fault conditions. The temperature classes of flammable substances (Table 1) are as follows:

Table 1. ***Temperature classes of flammable substances***

Temperature class	Auto-ignition temperature range (AIT) (°C)
T1	≥ 450
T2	$300 \leq AIT \leq 450$
T3	$200 \leq AIT \leq 300$
T4	$135 \leq AIT \leq 200$
T5	$100 \leq AIT \leq 135$
T6	$85 \leq AIT \leq 100$

c) the circuit should be separated by the other circuits. This can be satisfied by providing isolation distances on the surface and in air insulation distance, electro insulating material, compound or galvanic separation elements.

The following diagram is presented for the evaluation of a circuit intended for use in potentially explosive atmospheres having that type of protection intrinsic safety "i", Figure 6. The steps that you must follow are:

-faling the circuit in one of the levels of protection imposed: "ia", "ib" or "ic";

-identify the values for the U_m respective U_i;

- is determined by the coefficient shall be applied to the security parameters of the electrical circuit rated you as well as for evaluation of surface temperature;

-shall be determined points of application defects in circuit rated depending on the level of protection circuit is employed;

-calculate the maximum values for parameters U_i, I_i, respectively P_i, taking into account the tolerance values of components depends on the type of protection;

-compare the values obtained with the diagrams of acceptability standard.

Based on circuit analysis, a MATLAB computing application was developed to evaluate simple linear circuits using curves and reference tables. Specific values of these diagrams were processed and tabular form. In both cases, however, defective conditions and safety coefficients should be considered, [6].

In Figure 7 is represented the capture of the user interface. This interface allows you to choose the type of simple circuit, the coefficient of safety and gas subgroup required in the evaluation process, based on the charts values, in tabular form inserted and processed in MATLAB in the form of .mat file, graphically indicating validation or invalidation of the protection taking into account the input data (voltage U, resistance R, capacitance C, inductance L).

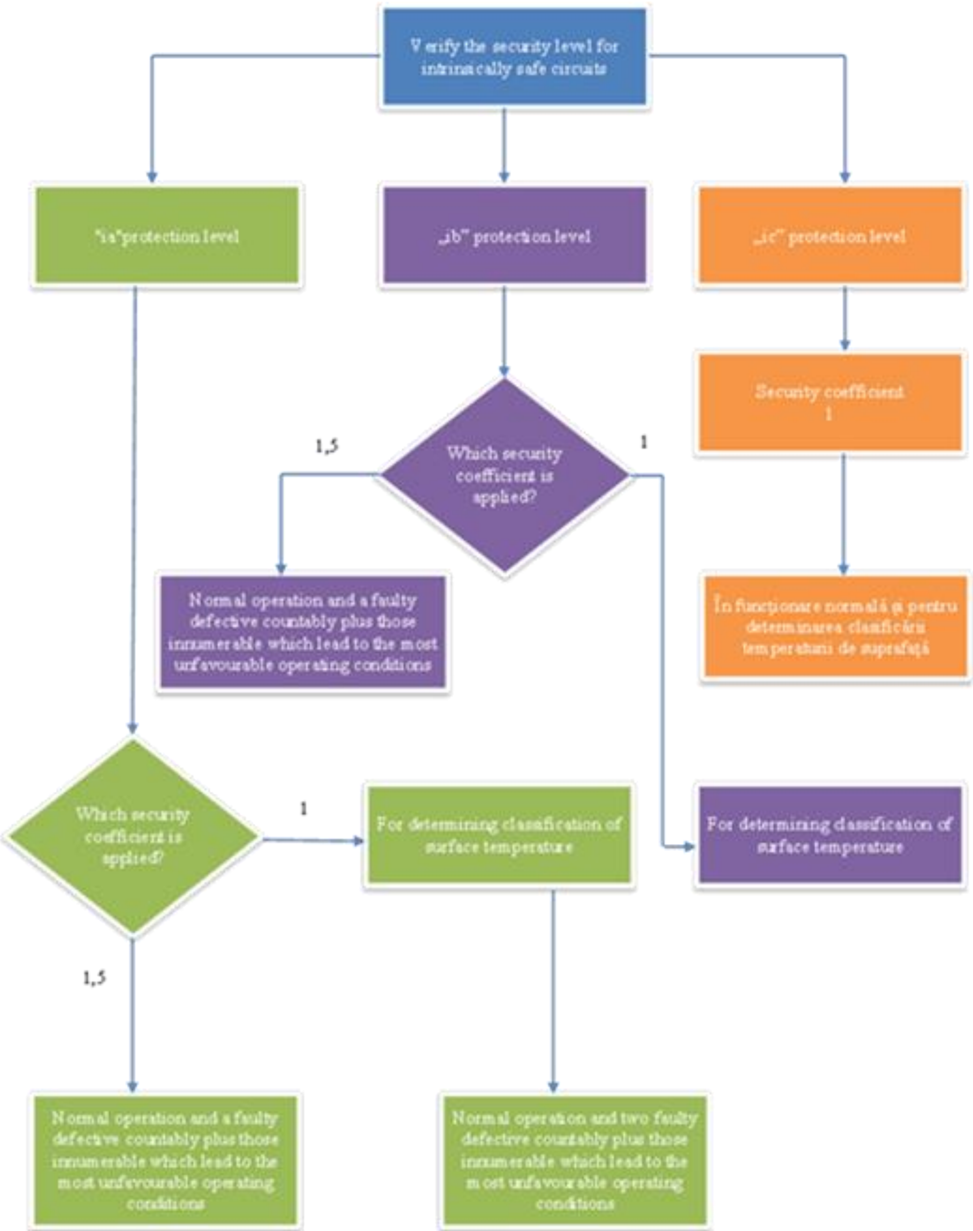

Fig. 6. Diagram of evaluation circuit with intrinsic safety "i"

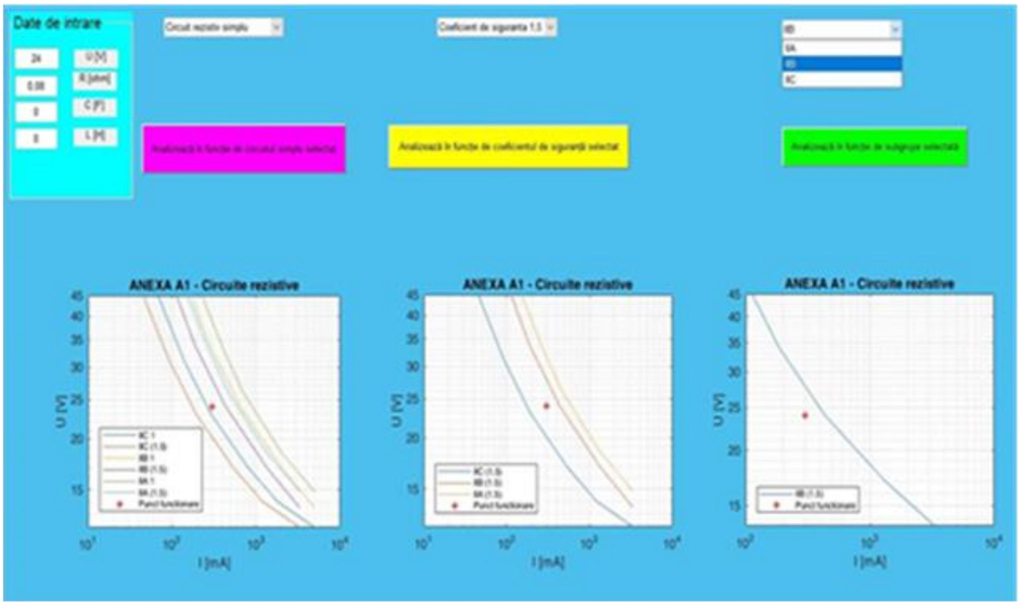

Fig. 7. The user interface of the application

3. CONCLUSIONS

1) This paper aims to increase the ability to evaluate intrinsically safe protection equipment by using the standardized means and the simulation based on the ignition diagrams within the equipment certification body to perform tests on low current equipment protected by the type of protection intrinsic safety intended for use in explosive atmospheres by implementing specific requirements

2) For simple circuits, especially those with a linear characteristic, it is possible to assess the non-ignition capability using the standardized means and the simulation based on the ignition diagrams.

3) The increased complexity for the circuits of the equipment involves in the evaluation process, the use of simplified models of circuits that are comprehensive in terms of explosion protection.

4) Joining the IECEx scheme for products certification has imposed the implementation of appropriate methods for assessing the low current circuits in testing laboratory infrastructure. This position involves maintaining a process of updating the procedures for conformity assessment and testing and suitability for carrying out the necessary tests required by the process.

5) Explosion prevention and explosion protection are of major importance for occupational health and safety in order to minimize losses (both human and material).

4. ACKNOWLEDGMENTS

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REFERENCES

[1]. Burian S., Ionescu J., Darie M., Csaszar T., Andriş A., *Requirements for Installations in Areas with Explosive Atmosphere, Other than Mines, (in Romanian),* INSEMEX – Petrosani Publishing House, Romania, (2007).

[2]. Burian S., Ionescu J., Ghicioi E., Darie M., Moldovan L., Csaszar T.. *Influence of environmental conditions on test mixtures used for testing of equipment with type of protection intrinsic safety*, Proc. Science and technologies in geology, exploration and mining - SGEM 2014, Albena, Bulgaria, 16-22, June, 2014. 719-726, (2014)

[3]. Csaszar T., Pasculescu D., Darie M., Ionescu J., Burian S., *Method for assessing energy limited supply sources, designed for use in potentially explosive atmospheres*, Environmental Engineering and Management Journal, 11, 1281-1285, (2012).

[4]. Darie M., Ionescu J., Burian S., Csaszar T., Moldovan L, *Ignition probability assessment of low current circuits designed for use in explosive atmospheres*, Environmental Engineering and Management Journal, volume 11/2012, No.5, (2012).

[5]. EN Directive, *Directive 2014/34/EU 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, No L96/309, 29.03.2014, Brussels, (2014).

[6]. Grecea D., Burian S., Darie M., Csaszar T., Colda C., Andriş A., Pupăzan G., Moldovan L., *Issues concerning the requirements for the achievement of a spark test apparatus simulator for linear circuits*, 8th International Multidisciplinary Scientific Symposium SIMPRO 2018, 11-13 October 2018, Petroșani

[7]. Prodan M., Ghicioi E., Oancea D, *Correlation of explosion parameters and explosion-type events for preventing environmental pollution*, Environmental Engineering and Management Journal, 13, 1409-1414., (2014).

[8]. SR EN (IEC) 60079-11:2012. *Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"*, ASRO, (2012). [7] R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.