

Aspects of compatibility regarding the pre-1990 blasters with new categories of electric detonators

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Abstract. In Romanian mining operations for the initiation of electric detonators are still used blasters manufactured before 1990. These blasters were designed and built for the initiation of electric detonators using the requirements of obsolete standards. For simultaneous initiation of a large number of electric detonators, sufficient electrical power must be supplied to all detonators within milliseconds. The time required to heat up the bridgewire until the fusehead deflagrates is a function of the voltage and the current. In order to be able to use old generation blasters for the initiation of new generation of electric detonators (that are built according to new national and European standards) a comparative analysis must be made between the requirements of the pre-1990 standards and the new standards in use.

1 Introduction

A blasting machine, as defined in the European standard, is a device designed to supply electrical energy to a circuit of electric detonating staples, in order to initiate them [1]. Actually, a blasting machine is a portable source of electric current to reliably fire an electric detonator to trigger a main explosive charge.

A typical "capacitive discharge" blasting machine works by charging a capacitor from a battery, then discharging the capacitor through an external circuit, called the firing line, to fire the electrical detonators.

A detonator (detonating cap) is defined as an object consisting of a small metal or plastic tube containing a primary explosive charge such as lead azide and a secondary explosive charge such as PETN, or other combinations of explosives whose mass usually does not exceed 2 g [2].

A detonator is used to detonate a larger, more powerful but relatively insensitive secondary explosive of an explosive device used in commercial mining, excavation, demolition, etc

There are three popular benefits associated with the electric detonator that makes it one of the most popular accessories for explosives. Due to its accurate delay timing, resistance to water and abrasion-resistant insulation, is considered that the electric detonator can never go wrong in any of the operations.

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But electric detonators are extremely sensitive to shock, radiofrequency energy, heat, static electricity, and electromagnetic radiation.

Successful electrical blasting depends upon four general principles:

- Proper selection and layout of the blasting circuit,
- Adequate energy source compatible with the selected type of blasting circuit,
- Recognition and elimination of all electrical hazards, and
- Circuit balancing, good electrical connections, and careful circuit testing.

Modern, high-energy blasting machines are designed to provide a surplus of firing energy and reduce the possibility of misfires.

Standards that establish the construction and functional requirements to initiate electric detonating caps have evolved over time.

Currently in use in Romania is the standard SR EN 13763-26:2006 - Explosives for civil uses - Detonators and relays - Part 26: Definitions, methods and requirements for devices and accessories for reliable and safe function of detonators and relays.

In order to establish full compliance with this standard for blasting machines built long before its entry into force, a thorough analysis of their functionality and safety in operation is required, subjecting them to multiple laboratory tests, practically a recertification.

This paper is simply a comparative analysis that establishes to some extent whether **the blasting machines of previous generations can initiate the new generations of electric detonators.**

The blasting machines of the older generations were built for the initiation of detonators meeting the requirements of STAS 8136-89:1984 - Electric detonating caps and its predecessors as well as the requirements of Soviet, GDR, etc. standards.

2 Electric detonators

2.1 Electric detonators classification

Standard SR EN 13763-1:2004 - "Explosives for civil uses. Detonating caps and delay relays. Part 1: Requirements" presents a classification of electric detonating caps into four classes according to non-ignition current (Table 1).

Table 1. Classification of electric detonators based on non-ignition current [3].

Detonator class	Class 1	Class 2	Class 3	Class 4
No fire current, I_{nf} (A)	$0,18 < I_{nf} < 0,45$	$0,45 < I_{nf} < 1,20$	$1,20 < I_{nf} < 4,00$	$4,00 < I_{nf}$
No-Firing impulse, W_{nf} (mJ/Ω)	0,5	8	80	500
ESD impulse (mJ/Ω), „pin to pin” configuration	0,3	6	60	300
ESD impulse (mJ/Ω), „pin to case” configuration	0,6	12	120	600

According to PECCS - PAN EUROPEAN COMPETENCY CERTIFICATE FOR SHOT FIRERS / BLAST DESIGNERS to the four classes are added the electrical data as shown in Table 2.

Table 2. Classification of electric detonators based on PECCS [4].

Electrical parameter	Class 1 (Type A/S/NT*)	Class 2 (Type U*)	Class 3 (Type VA*)	Class 4 (Type HU/XS*)
Fuse head resistance	0.9 – 1.4 Ω	0.4 – 0.9 Ω	0.15 – 0.25 Ω	0.04 – 0.09 Ω
No fire current	< 0.25 A	< 0.45 A	< 1.2 A	< 4 A
Recommended firing current (single)	≥ 0.6 A	≥ 1.0 A	≥ 2.2 A	≥ 6 A
Recommended firing current (series)	≥ 1.0 A	≥ 1.5 A	≥ 3.5 A	≥ 25 A
Firing impulse	3 – 5 mJ/Ω	8 – 16 mJ/Ω	80 – 140 mJ/Ω	1100 – 2500 mJ/Ω

* Older denomination

2.2 Comparative analysis and observations

It is observed that the old standard STAS 8136-89 has, for some electrical parameters, requirements approaching the requirements of Class 1 in accordance with SR EN 13763-1:2004 and PECCS (Table 3). This standard is still in use in Romania and replaces the 1984 version.

Table 3. Comparison between standard SR EN 13763-1:2004 and standard STAS 8136-89 [3, 5].

Electrical parameter	Class 1	STAS 8136-89
No fire current	< 0.25 A	< 0.180 A
Recommended firing current (single)	≥ 0.6 A	≥ 0.8 A
Recommended firing current (series)	≥ 1.0 A	≥ 0.8 A
Firing impulse	3 – 5 mJ/Ω	≥ 3,2 mJ/ Ω

This means that only Class 1 electrical detonators will be used to check the compatibility of the old blasting machines.

In addition, electric detonators are classified in 4 Groups or 4 Classes depending on their electrical properties.

The classification in Groups is the traditional Nordic conception with the subdivisions 1, 1A, 2 and 3.

The correspondence between Nordic classification, older classification and European classification is shown in Table 4 [6].

Table 4. Correspondence between different classification [6].

Nordic classification	Older classification	European classification
Group 1	(Type A/S/NT)	Class 1
Group 1A	(Type U)	Class 2
Group 2	(Type VA)	Class 3
Group 3	(Type HU/XS)	Class 4

3 Old blasting machines for electric detonators still used in Romania

In Romania we identified 11 types of blasting machines built according to obsolete standards, some built before 1990 but still used in civil applications. Figure 1 shows two of such old blasting machines [7].

The data were collected from evaluation reports issued over several years by the Laboratory of Non-Electrical Ex Equipment, Electrostatics, Materials and EIP within INSEMEX-GLI [8,9].

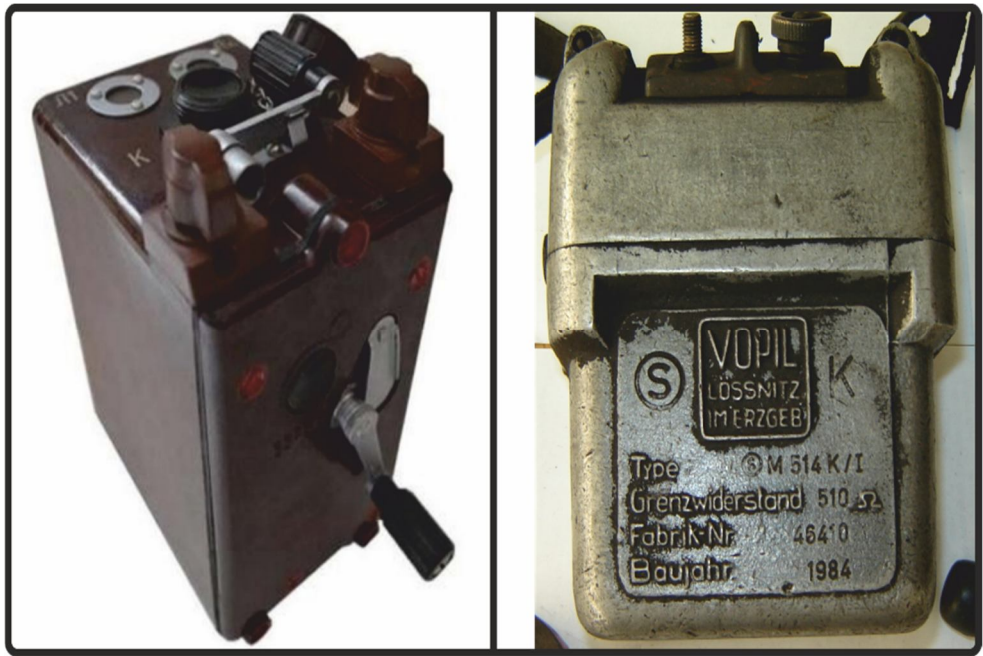


Fig. 1. Two of the old blasting machines – left KPM-3U1 [7] and right Vopil M514k/I

The parameters for these blasting machines are shown in Table 5. These parameters were taken from the nameplates and from the INSEMEX-GLI test reports.

Table 5. Parameters for blasting machines.

Crt no.	Type of blasting machine	Nominal Voltage [V]	Capacitor capacity [μF]	Maximum number of detonators	Maximum circuit resistance [Ω]
1	MD-76	800	20	100	510
2	ECI-100	1000	10	100	510
3	ETZ-100	1000	15	100	510
4	RKC	1000	20	150	760
5	modified EI-200 D	1000	10	100	510
6	VEB(S) M 20-359	1400	20	200	1110
7	EI-200 D	1400	14	200	1010
8	KPM-3U1	1600	4	150	760
9	ETP 200AS	1600	8	200	1010
10	VOPIL M514 k/I	1800	2	100	510
11	AICmI-1	1800	20	220	1110

For a successful simultaneous initiation of a high number of detonators, sufficient electrical power must be delivered to all detonators within a few milliseconds. The time required to heat up the bridgewire until the fusehead deflagrates is a function of the voltage and the current [6].

It is important that all detonators in a firing circuit are initiated instantaneously. If one detonator in the circuit fires before any other the circuit breaks and one or several detonators will not get the firing impulse and misfires will occur [6].

4 Compatibility check between old blasting machines and current Class 1 electric detonators

Two very important parameters, namely firing current and firing impulse, are taken into account for the compatibility check.

For the 11 types of blasting machines, firing current and maximum output energy were calculated using the blasting machine parameters given in Table 6.

At the same time, the data from the test reports drawn up by the Laboratory of Non-Electrical Ex Equipment, Electrostatics, Materials and EIP of INSEMEX-GLI during the periodic tests on the blasting machines.

The results are shown in Table 6.

Table 6. Blasting machines - firing current and maximum output energy.

Crt no.	Type of blasting machine	Initial current (calculated) [A]	Maximum energy (calculated) [J]	Firing Impulse (calculated) [mJ/Ω]	Measured Firing impulse * [mJ/Ω]	
					[mJ/Ω]	(with security factor 1.5) [mJ/Ω]
1	MD-76	1,57	6,4	12,55	10,74	7,16
2	ECI-100	1,96	5	9,80	9,26	6,17
3	ETZ-100	1,96	7,5	14,71	14,40	9,60
4	RKC	1,32	10	13,16	13,00	8,66
5	EI-200 D modified	1,96	5	9,80	10,78	7,18
6	VEB(S) M 20-359	1,26	19,6	17,66	21,38	14,25
7	EI-200 D	1,39	13,72	13,58	15,90	10,6
8	KPM-3U1	2,11	5,12	6,74	6,40	4,26
9	ETP 200AS	1,58	10,24	10,14	7,58	5,05
10	VOPIL M514 k/I	3,53	3,24	6,35	7,15	4,76
11	AICmI-1	1,62	32,4	29,19	30,86	20,57

*These values are taken from the test reports of the INSEMEX-GLI test laboratory.

The requirements for Class 1 electrical detonators present a recommended firing current (series) of minimum 1A and firing pulses of 3...5 mJ/Ω.

The data in Table 6 shows the potential incompatibilities of the KPM-3U1 (USSR) and VOPIL M514 k/I (GDR) type blasting machines. These two types of blasting machines if used to initiate the maximum number of electric detonators are requiring a firing impulse greater than 4.26 and 4.76 mJ/Ω respectively. The attempt to use the maximum number of detonators specified by the manufacturer may lead to misfires.

These two types of blasting machines are designed with electrical parameters that should be able of initiating detonators from Class 1, having a sufficient calculated firing impulse but the measured firing impulse was less than required (Table 6).

The decrease in the value of the impulse delivered by the blasting machine can occur during time due to ageing of the energy storage capacitor, decrease in the voltage generated by the inductor and/or change in the surge voltage of the gas discharge tube.

5 Conclusions

Although in Romania blasting machines produced 30-40 years ago are still used for the initiation of electric detonators with modern design, it is found that under certain conditions they partially meet the current requirements. They have not been removed from use although they are no longer produced, manufacturers no longer exist and original spare parts can no longer be found.

For the two types of blasting machines identified as having issues with the delivered firing impulse it is recommended to check the delivered impulse more frequently and to reduce the maximum number of electrical detonators (reduce the maximum resistance of the firing circuit).

For all types of blasting machines in this category, they must be checked frequently in specialised workshops and at least once a year in an accredited laboratory.

The data used to prepare this evaluation were collected from assessment reports and test reports prepared by Laboratory of Non-Electrical Ex Equipment, Electrostatics, Materials and EIP over 22 years.

References

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