

## TOXIC GASES AT INDUSTRIAL BLASTING OPERATIONS. NORMATIVE REQUIREMENTS AND RECENT RESULTS

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### SUMMARY

The objective of the present paper is the problem with the emission of toxic gases as a result of blasting operations in the mining, construction and other industries and the affect of their release on the environment. The presented problem has wide implications as extensive blasting operations are performed almost everywhere. Based on the new methodology developed through the contract with the American Agency for International Development for measuring the quantity of the toxic gas emissions, new results have been obtained with the performance of extensive testing as the factor constricted conditions have been eliminated. The obtained results pose very seriously the question for solving the problems associated with toxic gases emissions, which substantially deviate from the approved and circulated in the technical scientific literature. Those problems are to be solved in the future.

The conducted tests and investigation of the industrial blasting agents permitted for use in Bulgaria indicate that their parameters are not compliant with the legal requirements in Bulgaria namely with the Ordinance for labor safety in blasting operations -- 1997:

1. All safety explosives exceed the standard for toxic gases up to 100 litters and are in the range from 93 to 183 l/kg of explosive.
2. All explosives of second degree for underground mines not hazardous for gas and dust as well exceed the norms and are in the range form 165 to 215 l/kg of explosive (excluding Elazit 710)
3. The majority of the explosives used in surface blasting operations as the explosives type ANFO and emulsion explosives emit more toxic gases 222-275 l/kg of the regulatory determined 200 l/kg at usage of the Bulgarian produced ammonium nitrate. Less toxic gases are being emitted when the more expensive porous imported ammonium nitrate is used 165 l/kg.

The current paper deals with the issue of toxic gas emissions resulting form industrial blasting operations in the mining, construction and other industries and their impact on the environment.

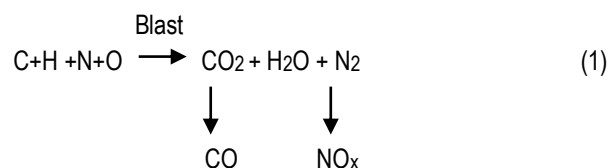
As it is widely known, blasting operations are extensively used in all sectors of the economy. The blasting energy is the cheapest which people use in their activity. Historically blasting operations have been extensively used for excavation of inert materials and mineral exploration. Now days we could hardly imagine production process at underground and in particular surface mining operations at ore mines and quarries and in the construction industry, not involving blasting. This extensive use of explosives and blasting operations, however, inevitably poses some environmental issues as the not completely controlled negative effects of blasting, the seismic effects, extensive fuming among many others.

Here is an example that would demonstrate the importance of the problem. Few years ago at quarry Sheremetia, Veliko Turnovo during detonation of about 18 t explosive (medium size blasting) in perimeter with diameter of about 10m above the pile of blasting agents few hours after the explosion at second explosion seven people die. At a distance of 3-3,5 km from the quarry and the adjacent region 36 people staff and bystanders suffer poisoning of different degree.

According to the municipal authorities of the city of Panagurishte the problem with systematic ecological pollution with gas and dust emitted through the blasting operation in the quarry above Panagurishte is up to 50 t explosives detonated at once.

Similar disturbing signals have being received from many communities surrounding open pit mines and quarries. The impact of such events is visible in the tremendous destruction of flora and fauna in their vicinity and on people living in the area regardless of whether employed in the industry or not. The problem reaches global dimensions taking into account that extensive blasting operations are performed almost everywhere.

The phenomenon explosion represents very rapid transformation of energy. In particular, the commonly used chemical components in Bulgaria that undergo rapid burning are C and H, as the process according to the classical literatures could be represented as follows.



This chemical composition releases from 600 to 1000 liters gases from 1kg explosive at temperature in the range of 2500 to 4500° C and pressure 200-300 MPa. At those parameters part of C is transformed into the toxic CO, whereas N<sub>2</sub> transforms into nitrogen oxides NO<sub>x</sub>. It is a common practice in the blasting technology to convert the nitrogen oxides NO<sub>x</sub> into conditional carbon monoxide as the nitrogen oxides NO<sub>x</sub> are equated to the poisoning action CO as the liters of NO<sub>x</sub> are multiplied with the coefficient 6,5.

$$\text{cond.CO} = 1\text{CO} + 6.5 \text{ NO}_x \text{ l/kg} \quad (2)$$

Of the emitted 600 to 1000 liters gases from 1 kg explosive, 100-120 to 350 liters are toxic gases.

The factors contributing to the emission of toxic gases during blasting operation are varied. However they could be grouped in four major classes:

1. Explosive is said to have an oxygen balance when the burning elements C and H equal the quantity of O<sub>2</sub>. It is well known that an explosive with the so called zero oxygen balance release the least toxic gases, whereas explosive containing slack or excess of oxygen emits more of both CO and NO<sub>x</sub>.
2. The physic-mechanical characteristic of the explosives as homogeneity (density), granular-metric composure, water resistance, packaging and others. Each inconsistency of the explosive's characteristics with the standardized requirements set forth during its development leads to distortion of the detonation process and to the larger release of toxic gases.
3. The chemical composition, strength, and structure of the rock. When detonating rocks with fissures and cracks, whether filled with clay materials or not, the released toxic gases are substantially larger.
4. The technology of the conducted blasting operation and the manner and tools of initiation of the charges. Our investigation suggests that this factor is even more important in regard to toxic gas emissions than the oxygen balance, considered being most significant up till now.

We are able to knowingly influence the listed group of factors through the selection of the blasting agent for conducting blasting operations as well as through development of legal basis preventing the usage of explosives emitting large quantities of toxic gases. We could also influence the problem through the application of new technology through complex mechanization of the blasting operations.

#### Let us have a look at the current state of affairs.

1. The ordinance for work safety prohibits the usage of blasting agents with oxygen balance different from the standard zero, as the regulatory allowable quantity toxic gases to be emitted from 1 kg explosive is 100l. While this standard seeks to achieve very desirable level of gas emissions it is highly unattainable and unrealistic. In Bulgaria, in all sectors of the economy, we continue to use outdated technology and hand set cartridges, able to achieve density of 0,6 g/cm<sup>3</sup> at ammonium nitrate explosive materials to 0,8 g/cm<sup>3</sup> at TNT explosives. This small density cannot achieve

the necessary velocity of detonation, which results in larger quantities of toxic gases emissions. It is imperative that all facilities, where possible, switch to bulk emulsions and mechanization of the blasting preparation and process.

II. The situation in surface mining is catastrophic due to the lack of normative base until recently. Numerous open-pit mines and quarries still employ explosive materials with highly negative balance e.g. explosive type "Granutolol", which emits 360 CO/kg. Moreover at single mass detonation of 50 tons, in the environment are released at once approximately 18 million liters CO. According to the newest industrial testing, the predominantly used blasting agent in Bulgaria type coarse ammonite emits from 103-to 201-l/kg conditional CO.

Of most significant importance at surface mining is the extensive application of the technology for demolition of over sized rocky pieces with open charges. The relative expense of explosive materials is over twice larger and the blasting ineffective leading to large-scale pollution of the environment.

Through the contract with the American Agency of International Development – EcoLinks we have developed a new technology for environmentally friendly blasting operations designed for demolition of large size rocky pieces. The technology uses classical cartridge explosives types Amonit and Lazarit and new charge construction with cumulative action build up at place of application. Its implementation has achieved double reduction of the toxic gases emissions resulting from the blasting as the effectiveness of demolition of the oversized rock has been considerably improved. The technology is currently available at quarry Skakavtisa, part of the Bulgarian State Railway Company ( Kamburova, G. & Lazarov S.,2001).

Currently, in Bulgaria for industrial applications are used over 20,000 tons explosive materials at which detonation are emitted about 3 billions liters toxic gases. By solving some of the existing technological and regulatory problems we would be able to reduce this toxic emission over 2-3 times up 1,5 billion liters.

The minimization of these toxic emissions could be achieved through:

1. New explosive material recommended for wet applications. The basis for this technical solution is the experience of developed countries, namely Switzerland, USA, and Germany in their use of explosives types Emuliti, consisting of water oil emulsion of ammonium nitrate (dense water solution with oil). Those blasting agents are water resistant and do not contain any materials classified as explosives (TNT, nitroglycerin) in clean form. They are very safe and emit 70-275 l/kg toxic gases of one kg explosive, could be loaded with equipment or manually when necessary, and are designed for both surface and underground mining. At present Bulgaria is capable of producing those blasting agents at Elazite and Asarel Medet.
2. In dry environmental conditions transition to explosives type ANFO in surface as well in underground mining with complex or partial mechanization of the blasting operations.
3. Reconsidered should be the data for toxic gases and the applicable regulatory norms. Or Through the contract with AAID-Ecolinks developed was new methodology for

determination of toxic gases. As a result of extensive testing obtained were new data as the factor narrowed conditions, compared to the normative documents, was eliminated. The charges of the utilized blasting agents weighted 400-1000g, instead of the 10 to 40 grams as prescribed in the normative methods used in Bulgaria. The tested probes of explosives were placed in the mortar in metal tube and for comparison in free hanging condition in plastic folio. This methodology enables us to conduct testing in condition very close to reality.

The preliminary results of the conducted tests emphasize the necessity of finding solution for toxic gases, the emission of which greatly diverge from the currently accepted and circulated in the technical literature. Those problems are yet to be solved. Based on the conducted testing, however, we could state with certainty that the majority of the admitted for use industrial explosives in Bulgaria do not comply with the requirements of the Ordinance for Labor Safety in blasting operations (1997), namely:

1. All Powder Safety Explosives emission of toxic gases exceed the regulatory norms up to 100 l and are from 93 to 183 l/kg explosive.
2. The toxic gases release of all explosives of class II, for use in underground mines not dangerous for gas and dust exceed the regulatory determined ones and are from 165 to 215 l/kg. (excluding Elazit 710).
3. The majority of the explosives used in surface mining as explosives type ANFO and emulsion explosives emit more toxic gases– 222-275 l/kg than the regulatory allowed -200 l/kg when mixed with ammonium nitrate production of Neohim, Dimitrovgrad. The quantity of the toxic gases is much less (165 l/kg) when the blasting agents are prepared with the significantly more expensive imported porous ammonium nitrate.

The conducted investigation suggests the need for improvement and modification of the regulatory requirements for monitoring the production of explosives in regard to toxic gases. Specifically we advise that the calculations are based on the assumption that toxic gas emission is over 150 l/kg, and not less than 100 l/kg, as it was considered till now.

As the results obtained by the new methodology for measurement of toxic gas emissions for industrial purposes suggest, new regulatory requirements are necessary for the allowable emission of toxic gases for all industrial explosives whether they are used for surface or underground conditions.

Through the application of alternative technological solutions we would be able to perform extensive blasting operations that are acceptable from environmental standpoint.

## REFERENCES

- Lazarov, Sl., 1988. "Blasting Operations", publishing house Tehnica.
- Kamburova, G. & Lazarov, S., 2001. "Technological Project for the new technology for primary blasting operations at quarry Skakavitsa with the applications of millisecond demolition of the rocky mass". Ecolinks.
- Kamburova, G. & Lazarov, S., 2001. "Technological Project for blasting demolition of excess demetion rocky pieces with charges with cumulative effect for the conditions of quarry Skakavitsa. Ecolinks.