

# How to safely handle pyrotechnics

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## Abstract

*The contribution deals with basic information about pyrotechnics, the division of pyrotechnics and the safe handling of pyrotechnics. At the conclusion of the contribution, the results of an evaluation of threats according to a flowchart are evaluated.*

**Keywords:** Pyrotechnics, injuries, risk

## Introduction

According to Regulation of the Government no. 281/2013 Coll., pyrotechnic products are defined as any product containing explosives or mixtures of explosives that are designed for the production of heat, light, gas or smoke or a combination of these effects through individual exothermic chemical reactions.

### Pyrotechnic products are added into:

- display pyrotechnics,
- consumer pyrotechnics,
- other pyrotechnic products.

### According to this government regulation: (Regulation of the Government no. 281/2013)

- consumer pyrotechnics – are pyrotechnic products intended for amusement,
- display pyrotechnics – are pyrotechnic products intended for use on a stage indoors or outdoors, including film and television production or other similar uses,
- a pyrotechnic product is intended for use in vehicles, elements of safety equipment in vehicles that contain pyrotechnic clusters used for activation of these or other equipment,
- a professionally qualified person, who is authorised by a special provision to handle consumer pyrotechnics of category 4, with display pyrotechnics of category T2 or with other pyrotechnic products of category P2 defined in § 3 (classified to categories), or their use.

Before the introduction of pyrotechnic products on the market, the manufacturer is obligated to ensure that pyrotechnic products introduced on the market satisfy the basic safety requirements listed in Annex no. I of Directive of the European Parliament and European Council 2007/23/EC from 23 May 2007 on the introduction of pyrotechnic products on the market.

## **Division of pyrotechnics on the basis of colours**

For fireworks to be visually interesting, certain chemical substances are used (Čuchranová, 2014). Substances that give colour to flames – these substances are made up of a component of oxidation molecules. They are used in lighting elements in consumer pyrotechnics and also the same in elements for night-time signalization.

Chemical elements, which give colour to flames:

- Sodium - yellow colour,
- Strontium - red colour,
- Barium - green colour,
- Copper - blue colour,
- Potassium - light-purple colour.



Figure 1 - Chemical substances influencing the colour of fireworks

Spark-producing substances – to make fireworks that give off a sparkling effect, it is necessary to add coarser-grained substances to the pyrotechnics that upon an explosive force are launched into the wider surrounding, where they burn via atmospheric oxidation – this is perceived as sparking.

Smoke-producing substances – these substances are understood to be those whose effects offer a great amount of smoke, most often white in colour. Obviously, if a sublimating colour were to be added, it is possible to obtain a coloured cloud. The colourful intensity of the cloud is controlled by the amount of colour added and the shade of the mixture of colours used. So in this way any colour can be obtained.

## **Fireworks effects**

In common practice, it is known that concepts like the chrysanthemum evoke flowers in people, but this doesn't always have to be so. The following effects are used in fireworks:

**Peony** – The peony effect is the basic and most commonly used shape in round bombs or compact fireworks of smaller shapes. The resulting effect consists of small lights, which fly from the centre of the effect in the shape of a regular ball.

**Chrysanthemum** – is a denser peony, where the lights leave an equal trace behind them.

**Willow** – this is a chrysanthemum, which is curved downward towards the ground in what is called a willow effect.

**Palm** –strong and moderately curved rays going from the centre. This effect is similar to the willow effect but is more pronounced. If a palm effect is spoken about, there must be at least five rays. The shape is created by a comet, which is going from the ground.

**Rosette** – The basis of a rosette is the flying fluorescence on four sides, which come out of an imaginary centre.

**Whirlpool** – otherwise known as snails. The fluorescence is in the shape of a spiral, at the end of which is a marked termination, a tail.

**Fish** – if the fluorescence moves irregularly in the sky, it is called a fish effect.

**Pyrotechnic products are assigned into these three categories: (Čuchranová, 2014)**

**a) Consumer pyrotechnics:**

<b>Category 1:</b>	represents a very low danger, has a negligible amount of noise, intended for use indoors at residential buildings.
<b>Category 2:</b>	represents a low danger, has a low level of noise, intended for use outdoors in limited spaces.
<b>Category 3:</b>	represents a moderately large danger, the noise level is not harmful to human health, intended for use outdoors at large open public spaces.
<b>Category 4:</b>	represents a high danger, the noise level is not harmful to human health, which only professionally qualified persons can use.

**b) Display pyrotechnics:**

<b>Category T1:</b>	intended for use on a stage, represents a low danger.
<b>Category T2:</b>	intended for use on a stage, only professionally qualified persons can use them.

**c) Other pyrotechnic products:**

<b>Category P1:</b>	pyrotechnic products other than consumer pyrotechnics and display pyrotechnics represents a low danger.
<b>Category P2:</b>	pyrotechnic products other than consumer pyrotechnics and display pyrotechnics, intended for handling or use only by professionally qualified persons.

**Basic safety requirements with use of pyrotechnic products:**

For safety it is important to consider the correct functioning of the product. For verification of safety a product must be tested under real conditions; if this is impossible, then test must be done in laboratories but also in such conditions under which the given product will actually be used.

Minimizing the risk of damage to the environment can be achieved if every single pyrotechnic product is made and designed such that it can be safely disposed of.

If it is necessary to ensure reliability and safety to the greatest measure possible every single pyrotechnic product must attain the functional characteristics that were set by the manufacturer of the notified person.

**Information, which must be assessed and tested:**

1. Design, construction, sizes and characteristic traits, including detailed chemical composition.
2. Physical and chemical stability of the pyrotechnic product.
3. Sensitivity for common foreseeable handling and shipping.
4. Compatibility of all ingredients with regard to chemical stability.
5. Resistance of the pyrotechnic product to dampness.
6. Resistant to low and high temperatures.
7. Suitable instructions and as needed labelling relating to safe handling, storage, use and disposal.
8. The capability of the pyrotechnic product, its package or other elements to ensure the functional characteristics under standard foreseeable storage conditions.
9. Exact definition of all necessary equipment and accessories and instructions for use for safe functioning of the pyrotechnic product.

## **Requirements for all groups of pyrotechnic products**

### **A. Consumer pyrotechnics (Regulation of the Government no. 281/2013)**

According to the content of the explosives, the manufacturer must assign the given pyrotechnic product to the category of noise or safe distance to which it belongs, which must also be clearly stated on the labels:

#### **1. Conditions of category 1:**

- ✓ 1m = is the minimum safe distance (but in case of need it can be smaller)
- ✓ 120 dB = this level of noise cannot be exceeded at a safe distance.
- ✓ category 1 cannot include in particular firecrackers, batteries of firecrackers, flash firecrackers and batteries of flash firecrackers,
- ✓ with explosive balls of category 1 the limit for the content of explosive silver may not be exceeded, namely more than 2.5 mg.

#### **2. Conditions of category 2:**

- ✓ 8m = is the minimum safe distance (but in case of need it can be smaller)
- ✓ 120 dB = this level of noise cannot be exceeded at a safe distance.

#### **3. Conditions of category 3:**

- ✓ 15m = is the minimum safe distance (but in case of need it can be smaller)
- ✓ 120 dB = this level of noise cannot be exceeded at a safe distance.

The following are among other obligations of the manufacturer:

- ✓ Material used for the production of pyrotechnic products – only those which minimize the risk of damage to the environment, health and property by fragments.
- ✓ The method by which the given pyrotechnic product can be fired off must be labelled either in the instructions for use or must be stated on the labels.
- ✓ Consumer pyrotechnic products cannot move in an unbalanced and irregular way.
- ✓ Products in categories 1, 2 and 3 must be protected from unintentional firing by the package, a cover or the construction of the product. And in relation to category 4, these products must be protected by methods set by the manufacturer.

### **B. Other pyrotechnic products**

1. With these pyrotechnic products, it is important that they are designed so that their use and handling minimizes the risk of damage to property, the environment and health.

2. The method of firing off the given pyrotechnic product must be clearly and visibly stated on the package, or there must be instructions for use.

3. With the unintentional firing of the product, the given pyrotechnic product must be made such that it minimizes the risk of damage to property, health and the environment by possible fragments.

4. The given pyrotechnic product, on the basis of a determined use-by date, must function properly up to the given date.

Each year the number of injuries that occur during the handling of pyrotechnics increases; incorrect handling of pyrotechnics can even cause injuries that are life threatening. The most common injuries with the handling of pyrotechnics are burns and dismemberment injuries. Burns are localized mainly on the upper limbs, namely from first up to serious third-degree burns. The most affected areas are the hands and face and often. However, serious injuries occur to the eyes, which can end in permanent blindness. Among the most serious injuries, which in the majority of cases lead to invalidity are burns on the face and hands and dismemberments. Most injuries of this type occur around New Year's Eve, rarely also in the pre-Christmas period when some people want to try out pyrotechnics, or make them at home. The best prevention against such injuries is to avoid using pyrotechnics completely.

Since, however, this is a part of end of the year celebrations and children, like adults, don't want to stop using them, it is recommended that several pieces of advice be followed:

- Purchase consumer pyrotechnics only from certified makers and sellers.
- Read the instructions for their use and handling thoroughly and follow them.
- Consumer pyrotechnics belongs in the hands of adults who are not under the influence of alcohol or any other stupefying substance.
- Use pyrotechnics in an open space at sufficient distance from houses, trees as well as the presence of people.
- If despite observing all safety regulations some injuries occur, the proper first aid is important.

## **Conclusion**

In conclusion, it can be stated that the consequences on health occur in the form of the following: 1) third-degree burns, eyes damaged by launched particles causing blindness, 2) explosions causing dysfunctional torn off limbs or serious psychic trauma, and 3) explosions that damage hearing and respiratory passages. All of these injuries can have a consequence impairment of quality of life and in critical cases, even death.

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of methods of implementation and verification of integrated systems for safe machines, machine systems and industrial technologies”

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## Biography

Marianna Tomašková has been working as docent at the Technical University of Kosice, Faculty of Mechanical Engineering, Department of Safety and Quality Production since 2001. He is a graduate of the Faculty of Mechanical Engineering in the field of technical safety systems and safety. It specializes in the area of fires, risks, dangerous substances and fire protection. Cooperation with practice, is a member of three projects financed by the Structural Funds and 2 domestic projects. He has published 60 articles in domestic and international conferences and in professional journals.

### APPENDIX A

Results of risk assessment using a flow chart on the basis of standard ISO/TR 14121-2 Safety of machines. Risk assessment. Part 2: Practical instructions and examples of methods.

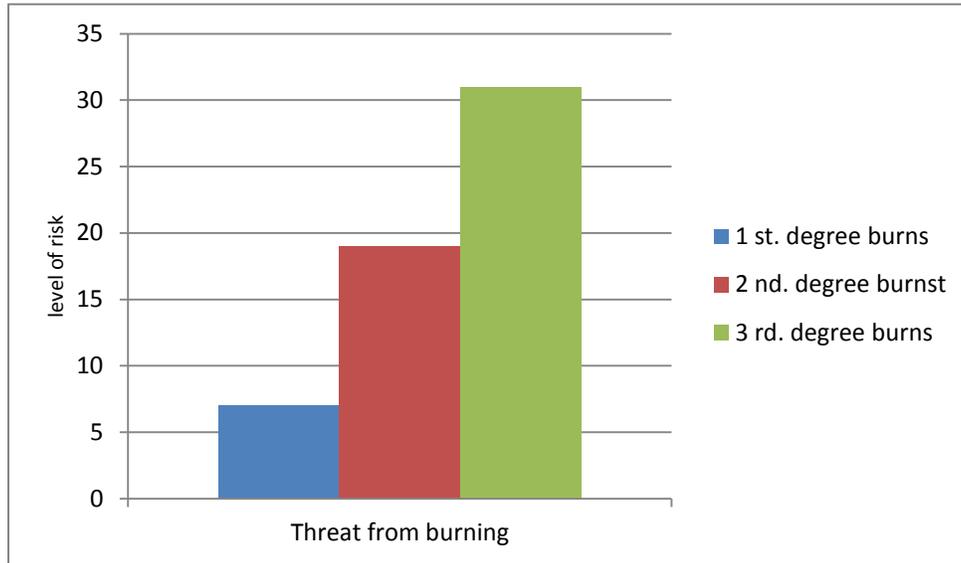


Figure 2 - Threat from burning

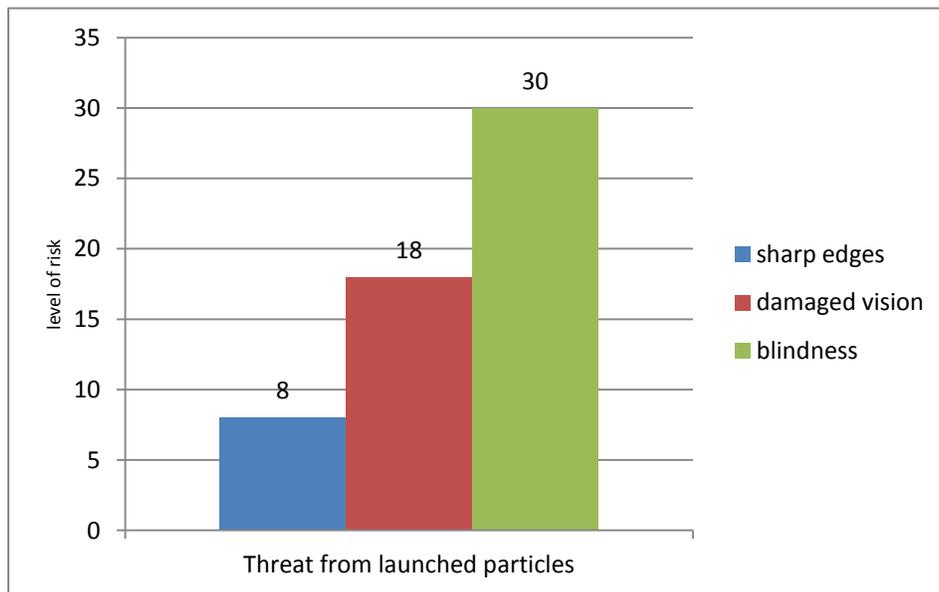


Figure 3 - Threat from launched particles

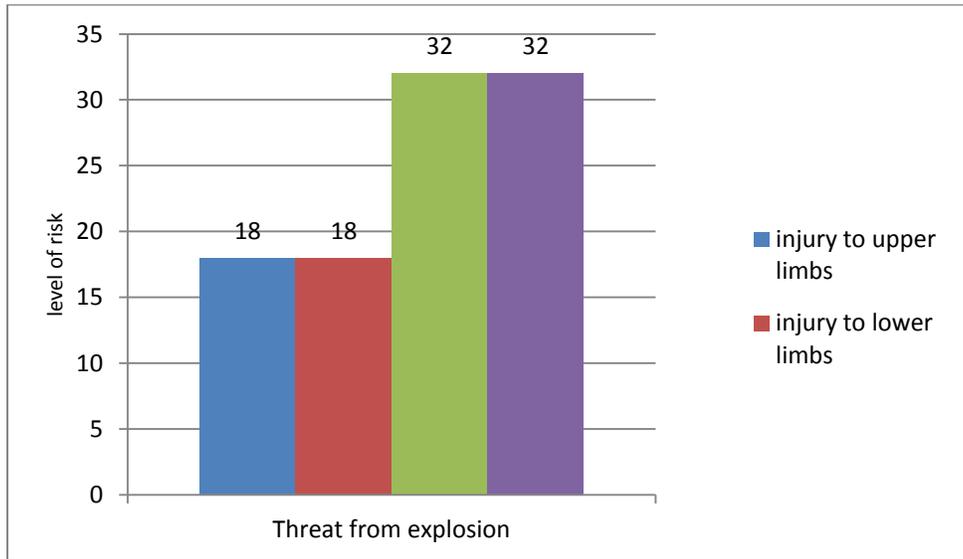


Figure 4 - Threat from explosion

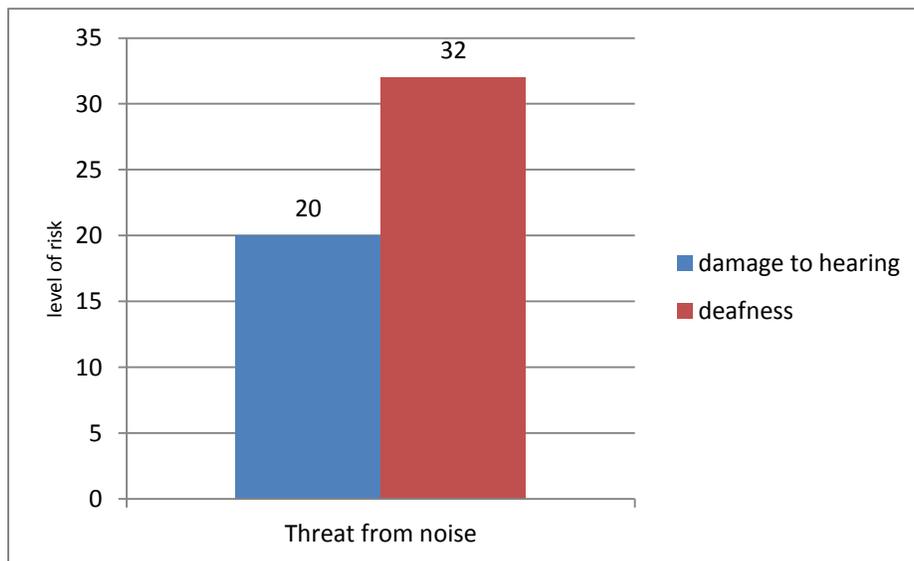


Figure 5 - Threat from noise

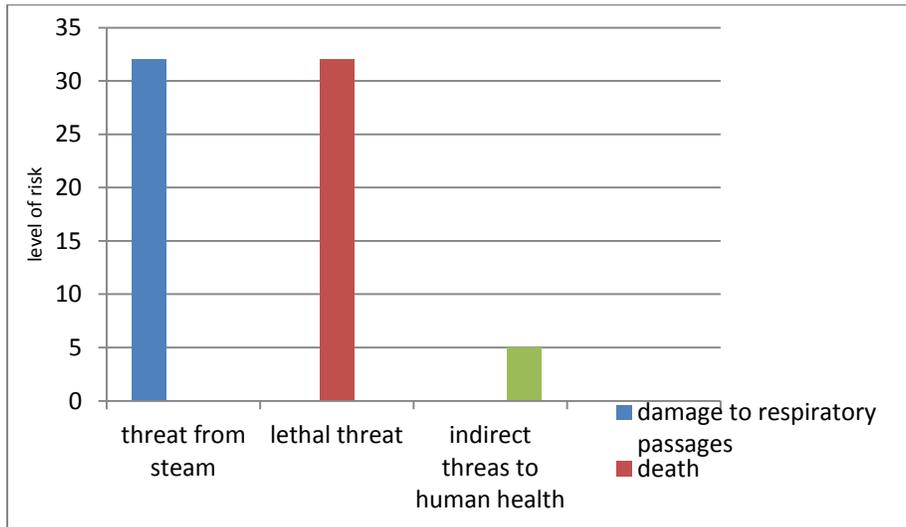


Figure 6 - Threats