FLAME RESISTANCE OF PERSONAL PROTECTIVE EQUIPMENT USED IN ENVIRONMENTS ENDANGERED BY POTENTIALLY EXPLOSIVE ATMOSPHERES

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During work process activities the workers might be exposed to various risk factors that could endanger their safety or health. The personnel developing activity in potentially explosive environments might be, at a certain moment, subject to fire and/or explosion hazards. Therefore, the hazard factors should be eliminated or, if this is not possible, diminished at a minimum so as a high level of safety is ensured. Generally, in order to eliminate or minimize the effects of a risk factor over a person, personal protective equipment (or PPE) is employed. As fire and/or explosion hazards are involved, the personal protective equipment, and especially clothing, must show a certain resistance to flame. The flame resistance is a characteristic parameter of the fabric that depends upon a series of other factors as: the ignition source, form, energy, exposure time, environment conditions, shape of the tested sample etc. The flame resistance of a certain fabric can be determined by laboratory tests employing standardized test methods, and the test results allow subsequent assessment of conformity with the essential safety requirements stipulated by PPE Directive. Materials’ behavior under an explosion flame/pressure produced by flammable gas, vapors, mists or dusts differs from the material exposure to a standardized ignition source. In order to perform tests for conformity assessment of PPE employed in environments with explosive atmospheres in present there are no standardized methods that are able to reproduce, in laboratory conditions, the phenomena involved in explosions.

Keywords: explosive atmospheres, explosion protection, flame resistance.

INTRODUCTION

During work process activities the workers might be exposed to various risk factors that could endanger their safety or health. The personnel developing activity in potentially explosive environments might be, at a certain moment, subject to fire and/or explosion hazards.

Explosion prevention and protection have a major importance in providing safety and health of workers, since explosions endanger human life and health due to uncontrolled effects of flames and pressure (hot radiations, flames, pressure waves, projected particles) the presence of toxic reaction by-products and oxygen consumption in the air they have to breathe. Additionally, the material damages in case of an explosion can be particularly important.

Having this aspect in view, there had been developed fundamental concepts for explosion protection and prevention in environments with potentially explosive atmospheres.

The condition that an explosive atmosphere and an ignition source have to occur simultaneously led immediately to the three basic principles in explosion protection and prevention.

Prevention:
- avoiding explosive atmospheres. This can be accomplished mainly by either altering the flammable substance’s concentration up to a certain value that is outside the explosion range or decreasing the oxygen concentration to a value under the limiting oxygen concentration (LOC);
- avoiding all the possible efficient ignition sources;
Protection:
- limiting the explosion effects to an acceptable extent by constructive protective measures. Unlike the other two precautions described above, here the possibility of an explosion occurrence is taken into account.
Within the frame of explosion prevention and protection range of measures, the PPE - personal protective equipment - plays an important role due to the danger that the explosive atmosphere gets ignited by static discharges or by sparks generated by metallic accessories or even due to burning and burning propagation in materials. This is the reason why electro-static properties of the materials employed are essential in explosion prevention and flame resistance is important also in order to minimize the explosion effects on the persons involved in such events.
The test methods and the electrostatic behavior methods regarding resistance to flame are given in the SR EN 1149 standard series.
A series of standardized methods regarding flame resistance are given; they consist basically in exposure of a specific shape and size sample to a specific ignition source (form and energy are given) for a certain period of time, in laboratory conditions.
The materials behavior under flame/pressure of an explosion of gas, vapor, mists or flammable dusts/air mixture differs from the exposure to a standard ignition source. In order to perform tests for conformity assessment of PPE employed in environments with explosive atmospheres in present there are no standardized methods able to reproduce, in laboratory conditions, the explosions specific phenomena.

The Factors Influencing the Textile Materials Test of Flame Resistance

Materials’ resistance to flame depends upon a series of factors, such as: ignition source (flame as a result of a fire or explosion, shape, energy), exposure time, environmental conditions, the shape and size of the tested sample, placement of the tested sample, ventilation degree.
The exposure time of a textile material in contact with an open flame represents a very important factor of influence on what eventually the materials’ resistance to flame depends upon. The greater the exposure time when the material is not thermally affected, the better flame resistance of the textile material is.
The environmental conditions existing at the time of testing the textile material addresses usually temperature and relative humidity, two parameters that should be recorded every time, for whom a certain value of the flame resistance is defined.
Taking into account the fact that sample ignition is very likely to occur from the extremities, its shape and dimensions have a great influence especially in the cases of certain textile materials that, after ignition occurs, the flame continues to propagate, throughout all the material, even if the flame source has been removed. This is lesser important in the case of those materials where the flame burns only locally and in the moment of its removal from the sample, the flame extinguishes.
Oxygen supplements addition attained through ventilation (natural or artificial) in the time of a textile material testing greatly influences also its flame resistance, since is a well known the fact that oxygen presence helps and sustain burning in any combustible material.
Considering this, generally all standardized textile materials ignition tests should specify the ventilation conditions (natural, artificial).
Laboratory Tests to Determine the Explosion Specific Effects on Textile Materials

In order to study the behavior of materials employed in clothing in case of an explosion, there had been performed a series of tests within the LENExMEIP Laboratory in INSEMEX, under non-standardized methods.

The tests consisted in feeding explosive mixtures into a test room with a given volume of one cubic meter, and ignite them electrically. There had been performed two tests, in explosive mixture of methane and of hydrogen.

Four textile types had been used as samples with the 680 mm length and 70 mm width. Three textiles were composed of 100% cotton - symbolized as M1, M2 and M3 and one sample included synthetic fibers - symbolized as M4.

The explosive concentration of the mixture in the moment when explosion occurred was 10% vol.CH\textsubscript{4} and 15% H\textsubscript{2}. Both in cases of employing hydrogen and methane, the four samples were placed vertically next to the test room, so that they would come in contact with the explosion flame right in the moment when the explosion occurs.

After explosion, as consequence of igniting the explosive methane mixture, the following effects on the material samples had been noticed.
- sample #1, material code M1 - ignited at contact with the flame, burnt fully;
- sample #2, material code M2 - did not ignite at contact with the flame, only light thermal effects on the edges of the sample were detected;
- sample #3, material code M3 - did not ignite at contact with the flame, only light thermal effects on the edges of the sample were detected;
- sample #4, material code M4 - did not ignite at contact with the flame, but was melted at contact with it on approx. 40% of that surface area.

After explosion, as consequence of igniting the explosive hydrogen mixture, the following effects on the material samples had been noticed.
- sample #1, material code M1 - did not ignite at contact with the flame, only light thermal effects on the edges of the sample were detected;
- sample #2, material code M2 - did not ignite at contact with the flame, only light thermal effects on the edges of the sample were detected;
- sample #3, material code M3 - did not ignite at contact with the flame, only light thermal effects on the edges of the sample were detected;
- sample #4, material code M4 - did not ignite at contact with the flame, but was melted at contact with it on approx. 60% of that surface area.

From the tests performed, it can be concluded that some materials do not ignite under the effect of an explosion flame. This is due to the relatively short exposure time while the textile material time was exposed to the flame. The exposure time, or in other words the persistence of the flame resulted as a consequence of an explosion depends upon the substance that forms the explosive mixture, respectively the velocity at what the burning propagates.

The laboratory tests had been performed with methane and hydrogen. The flame maximum velocity in case of methane with a stoechiometric composition of 9.5 vol. CH\textsubscript{4} is 43 cm/s; in case of hydrogen having a stoechiometric composition of 29.58 vol. H\textsubscript{2} is 346 cm/s.

It can be easily noticed that the flame maximum velocity for hydrogen is approx. 8 times higher than the methane one, respectively the exposure time is 8 times shorter than the methane exposure time, what explains the fact that the sample M1 was ignited in the methane test and not ignited in the hydrogen test.
The Thermal Effects Generated by Burning of Clothes, in Victims Involved in Explosions

Over the years there had been recorded series of events caused by explosions of gas, vapor, mists and combustible dusts mixtures with air, both in underground mines or those parts of surface plants that are endangered by firedamp and/or coal dust, and in surface plants, other than mines.

The majority of these events involved persons that were developing their activities in those places. The expertise surveys performed subsequent those events (explosions) pointed out various thermal effects over human body according to the clothing kind worn. So, there had been noticed major thermal effects in case when the protective clothing worn by the victims had burnt or had molten. In some cases, had been notices only minor thermal effects or even lack of thermal effects on the natural fiber textiles clothing (100% cotton).

The chances of surviving for the persons involved in explosions are given by the degree of toxic poisoning, extending of burns inside the respiratory system, and also by the extend of the external burns. This is the reason why the behavior to combustion of the textile materials employed in personal protective clothing represents an important factor for health and safety of workers that develop activities in environments with substances that can generate an explosive atmosphere.

CONCLUSIONS

The materials used to manufacture clothing articles intended for use in environments with potentially explosive atmospheres have a great importance from the point of view of the properties these must have, in order to ensure workers health and safety at workplaces.

The safety characteristics imposed for these materials have in view the antistatic properties and behavior to combustion. If, in order to prevent explosion ignition from electrostatic discharges, the norms and standards in force clearly stipulate the safety requirements, for the resistance to burning the requirements are not clearly defined. Certainly, the ideal way would be to be used only fireproofed materials, but for certain circumstances this requirement is considered as too exigent.

REFERENCES


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