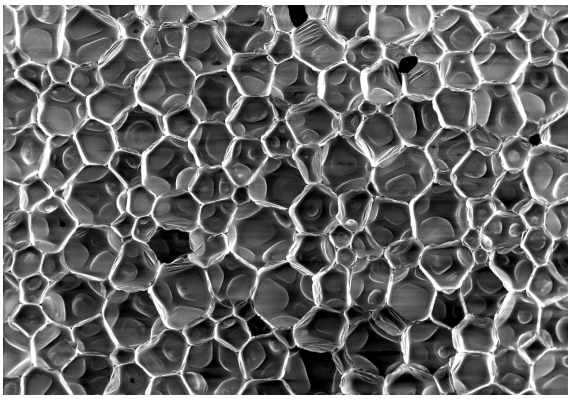
Fire Safety
on
Polyurethane Foam



Japan Urethane Industries Institute

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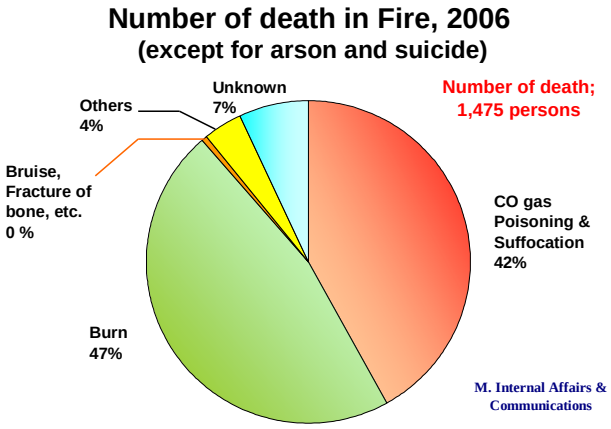
1. Recent trend of fires

According to the recent White paper on fire and disaster management, the number of death in fires increases in the aged people and the infants in recent years. It is estimated that their fate is seriously affected by the physical activities on the refuge behavior after realizing the fire. About 60% of the death number in residence fires is of aged people over 65 years old. It is concerned that the deaths in residence fires will increase following to the ageing of the society. In the process of the death at fires, the delay of the escaping reaches about 60%, in which the cases of delaying to realizing, surrounded with fire and smoke when realizing, no escaping way are counted most. It shows the importance of the countermeasure for the fire extinguish at the initial stage of the fire and the fire prevention.



The cause of death in fires is mostly of the poisoning by carbon monoxide, and suffocation, followed by burn.

Many polymer materials are used in the modern buildings, the harmful gases other than carbon monoxide are reported to generate in the fires. It is estimated that carbon monoxide and other harmful gases generated from various materials interrupt the refuge behavior at the early stage in the fires. The amount of the combustion product generated from the materials depends on the kinds of the materials and the combustion condition.

2. Flammability of polyurethane and polyisocyanurate foams

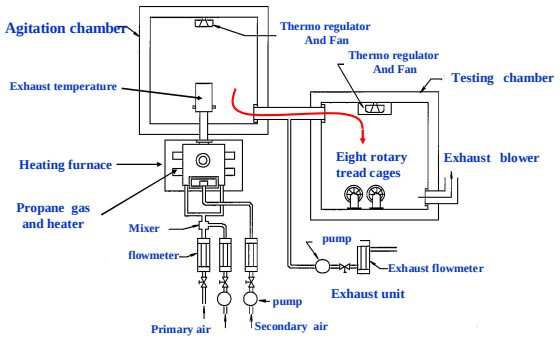
Polyurethane foams are applied to the bedding and furniture as mattress and pillow, sponges and insulation and structural materials in buildings, refrigerators etc.

Recently there appear occasionally news and an article reporting that hydrogen cyanide, a harmful gas, is generated from polyurethane foams in residence fires and as if the deaths were caused by polyurethane foams. However any other various harmful gases are generated in the fires, especially carbon monoxide is widely and mostly generated in case of imperfect combustion of every combustible material as wood, textiles and plastic materials. Polyurethane foams are not denied to generate hydrogen cyanide in case of fires. Hydrogen cyanide has high toxicity in fact, but it is actually not clear what kind of and how much harmful gases are generated in the real fires.

A study is enforced on the influence of hydrogen cyanide contained in the combustion gas from polyurethane foam to the obstruction on the refuge behavior in comparison with other materials existing in the living space in the combustion test under the assumption of the fire.

"Gas hazard assessment" is enforced with fireproof performance test, heat buildup test and others for the fire preventive materials in the Building Standard Law of Japan. "Gas hazard assessment" is to evaluate the requirement to the material "not to generate hazardous smoke and gas in case of evacuation" in article 108 – 2 in the Building Standard Law Enforcement Order , is to judge the influence of the complex combustion gas to guidance on evacuation during fires. Under the assessment arranged by Japan Urethane Industries Institute, polyurethane foam for general use gives longer time to the incapacitation than red lauan, the standard material, and meets the assessment requirement even though it generates hydrogen cyanide. The result confirms that polyurethane foam is not a product to obstruct evacuation action remarkably in comparison with the wood which is a building material used for long time and widely, and other materials existing in the living space.

Test Apparatus
(Construction Ministry Notification No.1231)



3. Flammability test of polyurethane and isocyanurate foams

It is not clear what kind of and how much hazardous gas are generated in the actual fires because every fire is in different situation as quantity of inflammable materials, construction of the building involved etc. and the combustion behavior is too complicated to identify the components in the combustion gas generated in the fires.

Generally there are two evaluation methods for combustion gas toxicity;

1) animal test where animals as rat and mouse are exposed directly to the gas concerned,

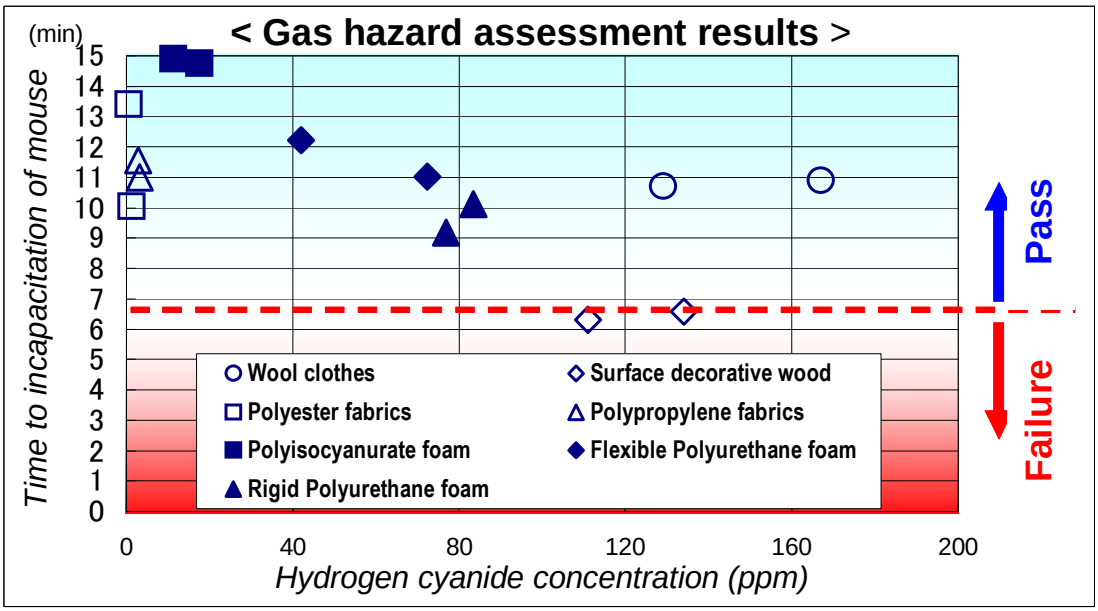
2) the analysis of the amount of decomposed products and combustion products, and then is evaluated in comparison with toxicology data reported in the literatures.

The mouse "Gas hazard assessment", which is introduced in this report, is a method classified in the category 1) above mentioned. The harmful gases generated in the fires are essentially considered most desirable to be evaluated with the information obtained from the organism most close to the human as the complex combustion gas. In Japan "Gas hazard assessment" with using mouse is applied to confirm the hazardous component and to verify the validity of toxicity evaluation with gas analysis result. The materials, which meet the requirements of the heat buildup test others and "Gas hazard assessment" under the fireproof performance test, are regarded to fulfill the requirement of the quality for the fire preventive material by the Building Standard Law of Japan, and hardly generates the products to obstruct the evacuation activities. Many polyurethane products (mainly polyisocyanurate products) are approved as fire preventive materials.

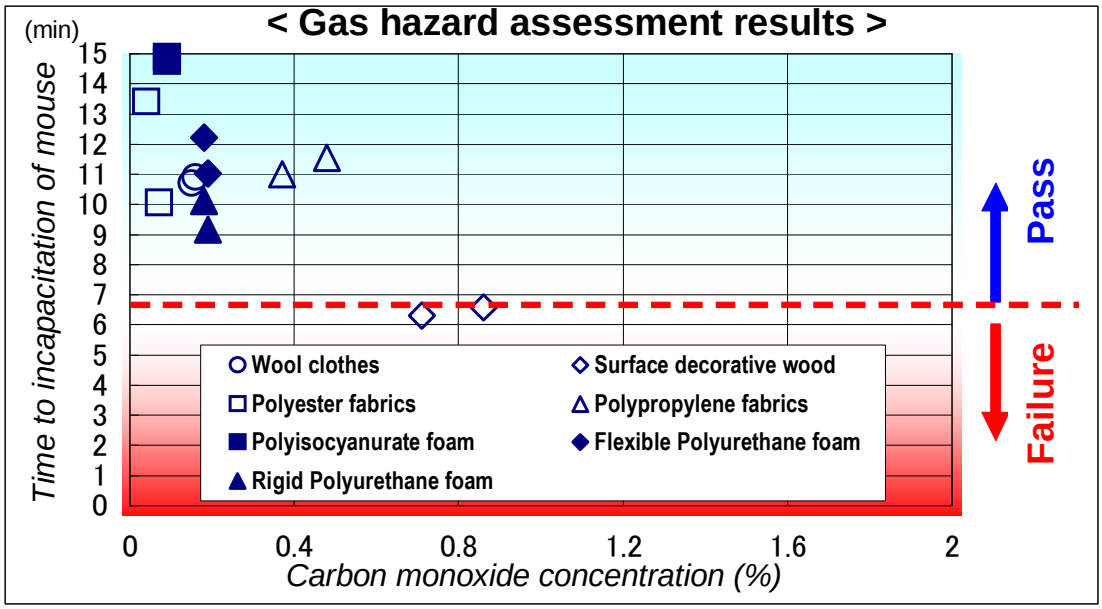
The followings are confirmed of the versatile polyurethane foams and other materials with the "Gas hazard assessment" enforced under Japan Urethane Industries Institute.

- Every polyurethane foam (flexible polyurethane foam, rigid polyurethane foam and polyisocyanurate foam) tested clears "Gas hazard assessment"
- Polyurethane foams release hydrogen cyanide in burning. However hydrogen cyanide is generated from not only polyurethane foams but all polymeric materials containing nitrogen as woolen insulation materials and surface decorative wooden building materials when they burn. The origin of hydrogen cyanide generation is not limited in polyurethane foams.

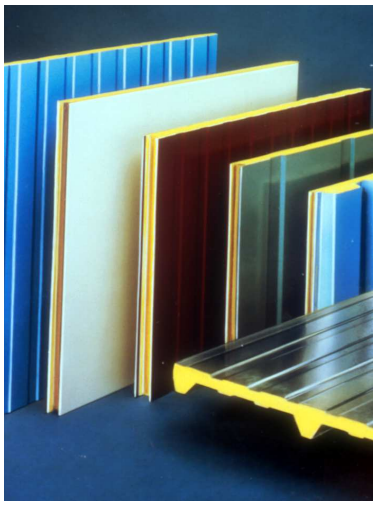
- The concentration of hydrogen cyanide generated in combustion of polyurethane foam is lower than that of surface decorative wooden building materials and wool (clothes etc) which are generally in living space.
- The concentration of hydrogen cyanide is considered to be strongly uncorrelated with the time to the incapacitation.



- The time to the incapacitation is clearly correlated with the concentration of carbon monoxide. It shows low value with high value of carbon monoxide concentration.



- It is necessary to discuss on the risk of the complex combustion gas, dominantly of carbon monoxide, other than hydrogen cyanide, among various combustion products in the fires. It is suggested by the fact that polyester fabrics and polypropylene which release low amount of hydrogen cyanide show similar level of the time to the incapacitation to polyurethane foam.



Not only polyurethane foams but organic materials are flammable. Under combustion they release chemically asphyxiant gases as dominantly carbon monoxide, and irritant gases as aldehydes and hydrogen chloride, further lack of oxygen happens due to raise of carbon dioxide and loss of oxygen. We live in surrounded with flammable materials as wood and fabrics, with taking advantage of their feature well. It may not exaggeration to say that we cannot live under elimination of these flammable materials in daily life. Therefore the fire extinguish in beginning and safe evacuation are important before the fire extends to these flammable materials. Wooden materials are widely used in not only construction and exteriors of houses but interiors, furniture and fixtures in naked condition.

Meanwhile polyurethane foams are rarely used in naked as interior and exterior materials, but used with any surface material as interior material with high fire protection performance. They are considered to be in lower risk of hazard of combustion gas in the actual application. Polyurethane products as other plastics don't ignite by themselves, but catch fire at close origin of fire. After catching fire they may be in danger of expansion of the combustion as other organic materials, so it is important to keep away the fire.

4. Lastly,

Japan Urethane Industries Institute makes every effort to improve technology further, and develop much low combustible products and continuously perform the educational activities to eliminate wrong understanding on combustion safety of polyurethane foams. JUII works on the below educational activities, also.

- Storage of polyurethane raw materials and foam products under appropriate storage circumstance and temperature.
- Observance of processing manuals and handling standards
- Appropriate guard for fire protection, notice on fire prohibition, and arrangement of fire extinguisher
- Thorough observation of fire handling (confirmation and revision of processing manuals)
- Understanding material safety data sheets (MSDS)
- Understanding processing sites of polyurethanes
- Appropriate disposal of waste liquid of raw materials and polyurethane foam waste

For further information, please refer to **Guidance on Fire Safety Assessment of Polyurethane Foams**, edited by Japan Urethane Industries Institute.

Japan Urethane Industries Institute is organized of **Japan Urethane Foam Association** and **Japan Urethane Raw Materials Association** and consults on the programs as to maintain and improve safety and health, to work on environment issues, to spread high quality products, to consult on saving energy and public relations.

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