PlasticsEurope
Association of Plastics Manufacturers

FACTSHEET ***January 12th 2015***

Toxicity of Combustion Gases from PS foams

Background

In public discussion often the toxicity of gases from combustion of plastics is mentioned, stating that building materials made from plastics increase the risks caused by toxic combustion gases compared to traditional building products.

Most fatalities caused by fires in buildings, are caused by inhalation of combustion gases. Many people killed by smoke are sleeping or not able to escape. Building experts and regulators agree, that in the field of construction, the risks for occupants will be limited by preventing initiation and limiting growth of fire and ensuring adequate means of escape for occupants with appropriate building design (e.g. exit routes, compartmentation). Further measures, like smoke detection and alarms, are also important to manage the risk.

Nevertheless the question is brought up again and again, whether gases from combustion of plastics are more toxic than those from other construction products. Even if this has been taken out of context, Plastics Europe raw material producers for polystyrene foam wanted to get a better understanding of this issue and initiated a project for comparative measurement of combustion gases from different insulation products, in order to be able to respond to this question in a scientifically supported way.

Project Scope

Comparative data on smoke gas toxicity of EPS and XPS products are available from the 80s. The results show, that combustion gases from PS foams are no more toxic than those from natural products, like wood, cork etc. [1].

New methods for testing and for analysis of fire gases have been developed since then. In addition new products (like grey PS foams with improved lambda value) have been developed and the replacement of the flame retardant HBCD by the Polymeric Flame Retardant (Polymeric FR) in PS foams is in progress.

So a test program for comparing construction products including PS foams and various non-plastic insulation products was conducted at the fire laboratories of SP[1] in Sweden.

Test method

For construction no dedicated methods for assessment of toxicity of combustion gases of materials and products are in place in regulations. A number of methods are currently being discussed in ISO (International Standardisation Organisation), but for regulatory purposes standardised mandatory test methods for assessment of toxicity of combustion gases of materials and products, have only been developed in the area of transportation. This is because in vehicles and other means of transportation escape may be delayed or not even possible. Therefore for this program the test was selected, which is defined in EN 45545-2 for products used in railway applications. A similar method is also used for marine applications, defined by IMO (International Maritime Organisation).

As described in EN 45545-2:2013, the test specimens were irradiated by a heating cone inside the EN ISO 5659-2 test chamber. The specimens were subjected to three test conditions; 25 kW/m² with pilot flame, 25 kW/m² without pilot flame (additional test - not mandatory in EN 45545-2) and 50 kW/m² without pilot flame.

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The concentrations of the following toxic combustion gases were analysed at 240 s and 480 s after start of the test by FTIR technique as specified in EN 45545-2:2013:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Hydrogen cyanide (HCN)
- Nitrogen oxides (NOX)
- Sulphur dioxide (SO_2)
- Hydrogen chloride (HCl)
- Hydrogen fluoride (HF)
- Hydrogen bromide (HBr).

As used for railway applications, the Conventional Index of Toxicity, CIT was calculated from the measured concentrations of these gases. This is a value, which adds up the results of the comparison of each measured gas to a reference value. The reference values used in the calculation of CIT are IDLH-values (Immediately Dangerous to Life and Health) which are limiting values for personal exposure (30 min) from NIOSH (National Institute for Occupational Safety and Health, US).

In addition to the analysis and evaluation of the gases specified in EN 45545-2, isocyanates were also analysed for some selected products. The selection criterion was that the product should contain nitrogen, which is a fundamental condition for isocyanate production.
Measurement of isocyanates is not included in EN 45545-2:2013, and quantitative assessment of toxicity was not possible, as there are only IDLH-values published for a very limited number of specific isocyanates.

Products tested

All products were tested at densities typical for application. Table 1 gives details for the products tested.

Product designation	**Measured density* (kg/m³)**
EPS white without FR	18.9 – 21.9
EPS white with HBCD	17.7 – 19.2
EPS white with Polymeric FR	FR 18.4 – 19.6
EPS grey with HBCD, 2 Products	20.4 – 20.9 / 18.7 – 19.7
EPS grey with Polymeric FR, 3 Products	18.3 – 19.2 / 20.5 – 21.3 / 20.7 – 21.9
XPS with HBCD	33.3 – 34.7
XPS with Polymeric FR	33.9 – 35.1
Cellulose insulation class E (EN 13501-1)	64.8 – 87.7
Stone wool insulation class B (EN 13501-1)	224 – 287**
Stone wool insulation class A (EN 13501-1) Roof insulation	157**
Stone wool insulation class A (EN 13501-1) Product for ETICS	105**
Flax insulation	20**
Sheep wool insulation class E (EN 13501-1)	26**
Wood panel, pine	379 – 449
Cork	141 – 160
LD fibre board	12.1 – 13.5

* For all products the average from 5 measurements is given
** This product was difficult to measure and only an approximate value is given.

Table 1: Products tested

Test results

All tests were duplicated, in order to make sure that the results are reliable and repeatable.
Figure one and figure two show bar graphs of the average CIT values for the measured products. As some specimen did ignite in one test and not in the second test, single results might deviate considerably from the values of the individual tests.

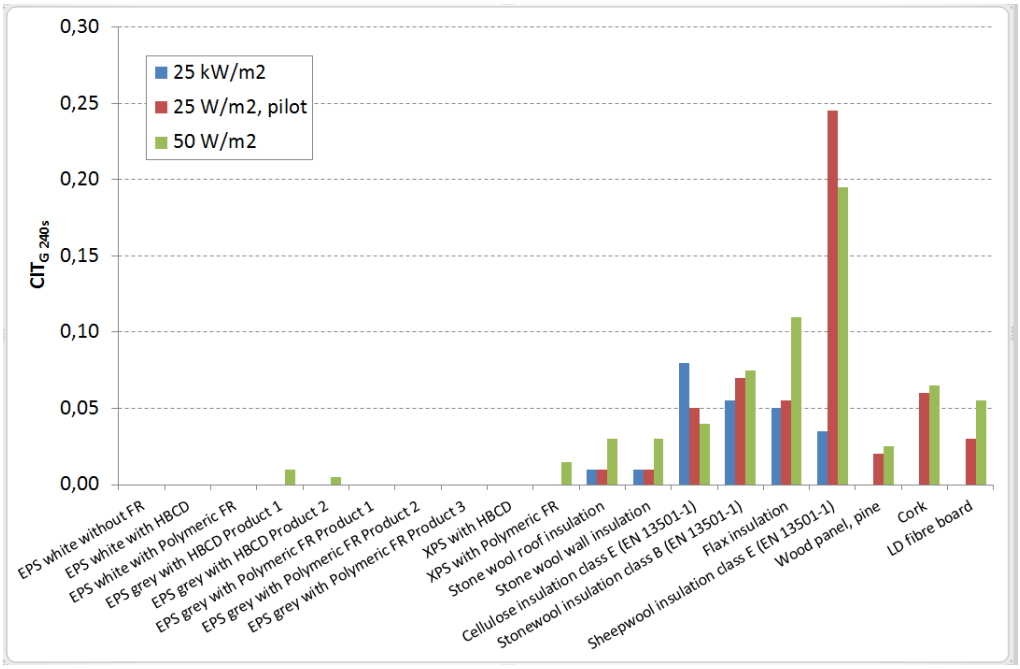

Figure 1 Graphic summary of CIT values at 240 s.

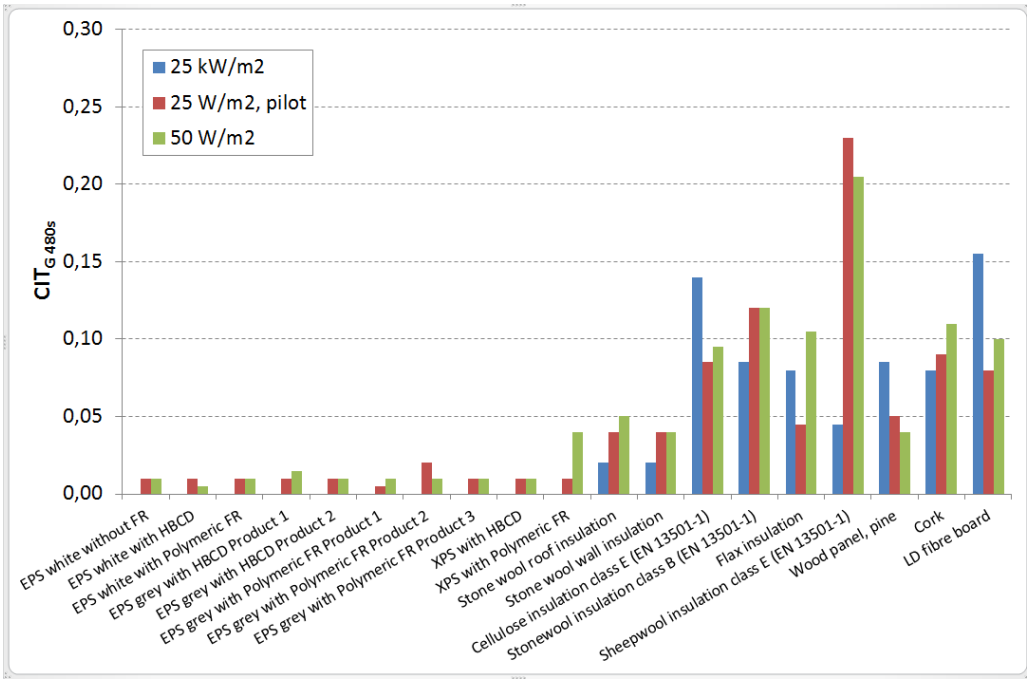

Figure 2 Graphic summary of CIT values at 480 s.

Discussion of results

As combustion gases from any burning product are always toxic, fires inside buildings will often rapidly lead to untenable conditions near the origin of the fire and in adjacent rooms, which already occurs before construction products start contributing to spread of fire and development of toxic gases. This especially applies to insulation products, which normally are covered by non-combustible layers. Therefore the comparative level of toxicity due to the composition of combustion gases from construction products becomes irrelevant and not anymore of importance for safety of inhabitants and fire brigades. This is why building regulators mainly focus on limitation of development and spread of fire and smoke, presence of escape routes and compartmentation. Additionally the installation of smoke alarms is increasingly required by law in many European countries.

Nevertheless, sometimes a comparison is requested between toxicity of smoke gases from natural and/or inorganic construction products and plastic products. This is why this comparison has been made between PS insulation foams, which are widely used in construction and some natural and (partly) inorganic construction products.

Summary of Test results

- **CIT (Conventional Index of Toxicity) values for EPS and XPS vary between 0 and 0.04.**
- **XPS values are slightly higher than EPS values, because of the higher density of the product, but even for that high density the following conclusions fully apply.**
- **Results from all tested types of EPS and XPS foams are within the same order of magnitude independent of the presence and type of FR used (HBCD or polymeric FR), and the presence of additive for improving the insulation value (grey EPS).**
- **CIT values for natural products vary between 0.05 and 0.23.**
- **The tests according to EN 45545-2 show, that combustion gases from EPS and XPS are considerably less toxic than those from various natural products including wood products, sheep-wool, cork and flax.**
- **Tested mineral wool products showed average CIT values between 0.01 and 0.13, which means that the values for some mineral wool products are higher than those found for EPS and XPS foams. In addition from the mineral wool products a considerable amount of isocyanates was detected, which by definition is not included in the CIT calculation.**

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[i] ***SP Technical Research Institute of Sweden**

[1]: *3167,* Fire behaviour of EPS, APME September 2002