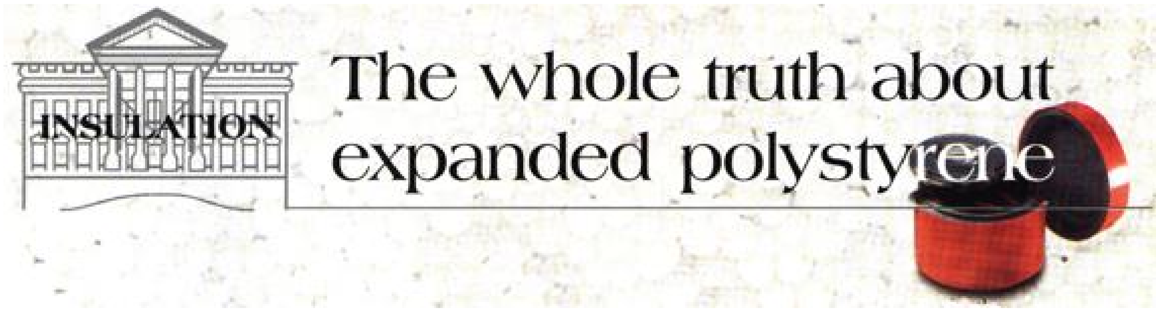


Recently articles promoting the use of polyurethane foam for the manufacture of metal-faced composite or sandwich panels have, by implication, stated that expanded polystyrene is not suitable for this application (11,12). Nothing could be further from the truth.

It is believed that incomplete information and misinformation can cause confusion to the detriment of the insulation industry as a whole, and it is strongly felt that more accurate scientific information would be to the benefit of all parties involved.

Both expanded polystyrene and polyurethane have been used as panel-core material for more than 30 years. It is factual that both products comply to the relevant regulations around the world for this application, and that the market share and popularity evolved, to a large extent, as a result of the availability and cost in individual countries around the world.

Purpose of thermal insulation

The purpose of thermal insulation is to conserve energy resources, and to help create comfortable living conditions. It is evident from all the different insulation materials and systems available that no one type of insulation material is capable of meeting all technical and cost criteria for every application.

A direct property-for-property comparison of different insulation materials usually does not tell the whole story, and in some European countries this practise is unlawful for commercial advertising purposes. It is, however, believed that a comparison will be made considering the following criteria:

- Thermal performance
- Cost
- Environmental considerations
- Safety: fire performance
- Safety: smoke toxicity

Thermal performance

This property is nowadays expressed under two possible headings:

- Thermal conductivity (k – Value in W/mK)
- Thermal Resistance (R – Value m^2K/W)

The relationship between thermal conductivity (k) and thermal resistance (R value) for homogenous solids is: $R=d/k$, where d is the actual thickness of the insulation in metres.

Cost

An objective comparison of cost could be done on sandwich panel price per unit of area per unit of R value ($R/m^2/m^2K/W$). Cost per square metre panel giving the same R value is given in the summary table overleaf. When the cost of space becomes very significant, polyurethane or PIC with the superior R value per unit of thickness becomes the material of choice.

Environmental comparisons (5,6,7)

Limited Resources

The most obvious resource limitation amongst materials used to produce synthetic insulation is the availability of fossil fuels. Polystyrene is produced from ethylene, a natural-gas component, and benzene, which is a derivative of petroleum.

Polyisocyanurate and polyurethane are made from polymeric methylene diisocyanate and polyol, both of which are derived from petroleum. While fossil fuels are not going to run out soon, cost will increase as resources start to dwindle.

Recycled content

Recycled content is the most recognised environmental feature of building products. Materials with recycled content have three advantages:

- They require less of the natural resource
- Material from the waste stream is diverted
- Less energy is expended in the manufacturing process

Expanded polystyrene product can contain up to 50% (on average 15%) recycled polystyrene. Simple recycling involves the crumbling of old moulded product into small pieces and remoulding into product with a significant portion of freshly expanded product. This recycling is mostly pre-consumer, but post-consumer recycling is possible, and will become feasible with increases in raw-material costs. The PU and PIC industry have not been able to significantly recycle any product.

Pollution from manufacture and use

Nearly all manufacturing processes generate pollution. Most of the pollution generated is as a result of energy consumption (the combustion of fossil fuels). A simple way, therefore, is to compare the manufacturing energy required, or the embodied energy.

It is important to know that the embodied energy levels are quite low compared with the energy a given amount of insulation will save over its lifetime. It is assumed reasonable that a GJ of energy consumed in one industry will result in approximately the same pollution in another industry. See the summary table overleaf for results.

CFCs and HCFCs

The most significant pollutant found in plastic insulation materials is chlorine-based chemicals that destroy the earth's protective ozone layer. Prior to 1993, CFC-11 was the only foaming agent for polyisocyanurate, polyurethane, and phenolic foam. In mid-1993, these industries moved to a less damaging foaming agent, HCFC 141b. Unfortunately for these industries, HCFCs that replaced the CFCs cannot be used for long, either. HCFC 141b is slated for phase-out by December 2002. While

HCFCs are only 5% to 11% as damaging to the ozone as CFCs (because they do not last as long in the atmosphere), they are almost as damaging for the period of time when they are there. All HCFCs are significant greenhouse gases believed to cause global warming.

CFC-free foam insulation

Expanded polystyrene is the only common rigid-foam board stock insulation made with neither CFCs nor HCFCs. During manufacture, polystyrene beads are expanded with pentane, a hydrocarbon that contributes to smog, but is not implicated in ozone depletion or global warming. The pentane quickly leaks out of the insulation and is replaced by air.

Durability

Both expanded polystyrene and polyisocyanurate and polyurethane foams will perform well over lifetimes measured in de-cades and even centuries. Rigid-foam insulation materials that were produced using low-conductivity blowing agents (CFCs and HCFCs) are prone to R value deterioration as the blowing agents leak out of the cell structure and get replaced by air. Polyisocyanurate foam comes from the factory with RSI/m value of 55 (R-8 per inch, but it may drop to a RSI/m of 59 (R-5.6 per inch). Depending on the material facing, the installation procedure and the application, this reduction may take several years and even decades.

Re-usability and recyclability

Polystyrene is easier to recycle than polyisocyanurate or polyurethane. Polystyrene is a thermoplastic, meaning that it can be melted and reformed into other product with little or no chemical modification. Polyisocyanurate and polyurethane are thermoset plastics that do not melt. Most of the research being carried out on recycling of these materials is focusing on the grinding and using the resultant powder as an additive in various unrelated materials.

Another issue of concern relating to the disposal of insulation is CFC blowing agents that have been ‘banked’ in our existing buildings. A large portion of the CFC blowing agents that have been used in building insulation in the last 20 years have not been released into the atmosphere; it is still in the insulation.

Fire Performance

Fire performance testing and standards in South Africa are out of date and not well developed. Fortunately we have the rest of the developed world to look to for our answers. A study of performance testing in the US, Canada and Australia (ASTM E84, ULC S102 and AS1530.3), and commentary by many, clearly show inadequacies pointing out the need for ‘real-life’ simulation test methods. In all cases of traditional ‘tunnel testing’, the effectiveness of the covering material, rather than the insulation material itself, determines the outcome. The following Are normally tested for: ignitability, flame spread, heat evolved and smoke evolved (the most important being spread of flame index and smoke developed index).

Building codes for domestic and commercial buildings normally call for a flame index of 0 and a smoke developed index of not more than 5. Both expanded polystyrene and polyurethane comply, and are generally accepted in this application. (1,2,3,4)

Generally the point of attack on expanded polystyrene by polyurethane producers centres around the fact that styrene is a thermoplastic that will melt at 93°C, and start flowing away from the flame front at around 120°C, rather than burn away. It is suggested that void ages created in this way could suck in air that would cause ignition of the molten styrene. On the other hand, polyurethane and isocyanurate burn like wood, remaining intact until burning through. (4,11)

The above argument looks credible until you consider the actual dynamics in a real-life situation. Please consider the following direct quotation from the Canadian Building Digest CBD-218 – Effect of Insulation on Fire Safety:

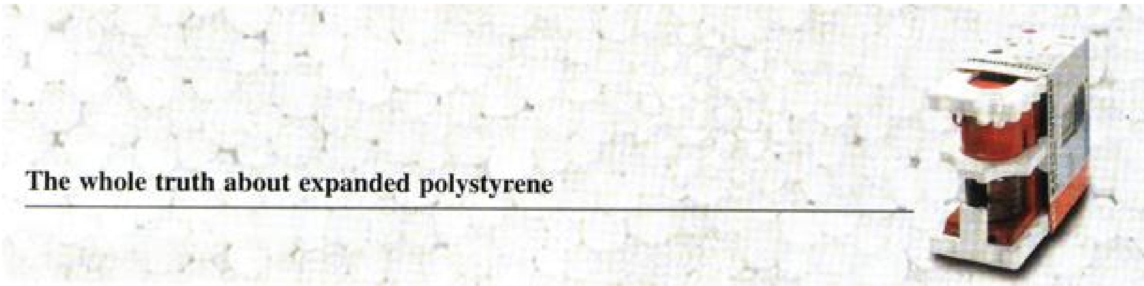
“Influence on growth of fire”

Adding insulation to the walls and ceiling of a room may increase the rate at which a fire will grow. The insulation will retain heat from the fire in the room in the same way as heat from heating systems is conserved. This accumulation of heat may result in the flashover stage being reached much earlier than in a room with less insulation.

Once a material, such as the lining in a room, is ignited, the temperature of the surface of the material will largely determine the speed of flame propagation. An increase in the rate at which surface temperature rises will result in more rapid flame propagation and production of flammable gases. For example, foam plastics in a fire will attain a surface temperature of 200°C in a few seconds whereas wood, under the same circumstances, requires ten minutes to reach that temperature. The very rapid surface temperature rise of foam plastics is probably why some of them propagate flames so quickly – particularly thermosetting foam plastics. Thermoplastic foam may melt before its temperature reaches a critical value. If that occurs, extremely fast propagation of fire is unlikely.

In actual cases of fires in buildings with panels, both expanded polystyrene and polyurethane have fared well. We have the example of the Woodmead Makro polyurethane cold store that remained intact despite the surrounding blaze. In actual cases of fires in buildings constructed from expanded polystyrene panelling, very similar observations are reported. In one case in Kentucky in 1987, a panellised restaurant caught fire. (4)

Although temperatures in the ceiling areas exceeded 538°C and 93°C near the floors, the kitchen wall panels and the ceiling remain intact. It would appear that a lack of oxygen reportedly caused fires in foam-core panel buildings to extinguish



themselves, as there was simply no oxygen available to facilitate the burning of the core. (4)

In a comparative survey by others (2), polystyrene, polyisocyanurate and polyurethane were scored, based on a qualitative assessment of all test data available. The resulting scores are extremely close. We therefore have to conclude that available publications by researchers in no way support statements recently made about polystyrene in this application.

Toxicity of smoke emissions

Test methods in place for smoke emissions normally make no attempt to assess toxicity of the smoke/gases evolved, but rather concentrate on the density of the smoke which impacts on the vision of humans, especially firefighters. (7,8,9)

Products of pyrolysis may include CO_2, CO, H_2O, CH_4 and HCN. (2) Carbon monoxide and hydrogen cyanide are colourless but highly poisonous, and are of concern due to their low LC50 (dangerous to live in 30 minutes exposure) concentrations.

From the Naval Engineering Standard, NES 713, a method that calculates a toxicity index based on 14 quantitatively determined combustion and/or thermal decomposition gases, we see a toxicity index for expanded polystyrene of 1.8, and 40 and 45 respectively for polyisocyanurate and polyurethane.

In a comparative study (2), a toxicity model was proposed that includes the insulation value, the *in situ* density and the decomposition temperature. The 'Acute Lethal Hazard' is defined as ALH = k x D/T/LC50 (where k = thermal conductivity, D = density, T = decomposition temperature and LC50 is the sample weight lethal to 50% of test animals).

In this study, polystyrene is regarded as the material of choice, and polyisocyanurate and polyurethane are scored the same in second place. It must be stated that although plastic insulations emit toxic gases while burning, experts believe that toxic gases released by the burning surrounds and furnishings appear more dangerous than the foam core hidden behind metal sheathing.

Summary

An increasing number of structures are being erected using foam-core panels because of the attraction of high insulation value combined with the ease and speed of erection. Although fire safety is always a concern, properly installed foam-core insulation panels made from either expanded polystyrene or polyurethane appear to be quite safe.

Expanded Polystyrene Association of South Africa (EPSASA).
Tel. (011) 314-4021/7, Fax (011) 314-3764

REFERENCES:

1. CANADIAN BUILDING DIGEST: CBD 218 – Effects of Insulation on Fire Safety.
2. Insulation Products – "A Comparative Survey" – presentation by R. Ansems / Ansems Engineering & Manag/Me
3. CANADIAN BUILDING DIGEST: CBD 178 – Fire and Plastic Foam insulation Materials.
4. Foam-Core Panels, http://doityourself.com/insulate/foamcorepanels.htm
5. Insulation Materials: Environmental Comparisons – EBN Volume 4 JAN/FEB 1995
6. The Montreal Protocol – Fifth Edition (2000)
7. New Blowing Agents for Insulate Panels – www.ifs-group.com/new-blowing-agents-for-insulated-panels.htm
8 CANADIAN BUILDING DIGEST: CBD 197 – Evaluation The Toxic Hazard of Fires
9. CANADIAN BUILDING DIGEST: CBD 249 – Contol of ignition in Building Materials.
10. CANADIAN BUILDING DIGEST: CBD 144 – Toxic Gases & Vapours Produced at Fires
11. SA Builder NOV/DEC 2001
12. Architect $ Specificator JAN/FEB 2002

Click here for table