

FACT SHEET 13

Insulating Foam

1. Description of market sector

This market sector includes foam used for insulation of building envelopes, domestic and commercial appliances, pipes and vessels. Closed cell insulating foams are manufactured using a blowing agent that creates a cell structure in a polymer matrix. Some of the blowing agents in current use are HFCs.

Market sub-sectors

The foam market can be categorised in two distinct ways: by **foam type** and by **foam application**.

The main **foam types** that use HFC blowing agents are:

- 1) Extruded polystyrene (XPS)
- 2) Polyurethane (PU)
- 3) Polyisocyanurate (PIR)
- 4) Phenolic (PF)

These 4 foam types fall into 2 main groups. These are (a) XPS, a thermoplastic and (b) PU, PIR and PF which are thermosets. In this Fact Sheet the second group is referred to as “PU-type foam”. XPS uses gaseous blowing agents. Most PU-types use liquid blowing agents, although some formulations use gaseous agents.

The main **foam applications** include:

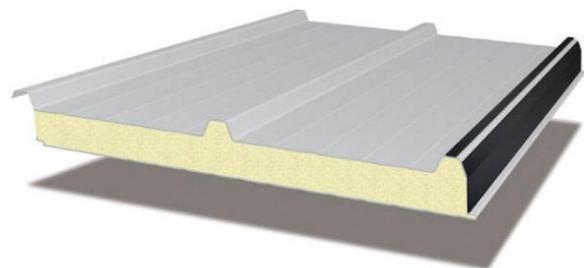
- 1) Panels and boards, used for wall, floor and roof insulation (with or without flexibly laminated facings)
- 2) Rigid-faced panels, used to fabricate insulated buildings (e.g. a cold store), vehicles or doors
- 3) Block foam, used for pipe and vessel insulation
- 4) Appliance insulation, e.g. domestic refrigerators, retail displays and water heaters
- 5) Flotation foam for marine vessels
- 6) Spray foam, used for roof and cavity wall insulation
- 7) Integral skin foams, e.g. for car steering wheels / dashboards



Laminated boards



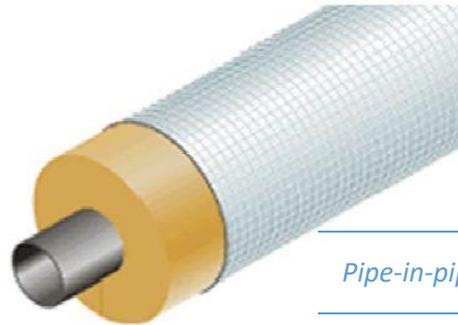
XPS board



Steel-faced panel



Spray foam installation



Pipe-in-pipe insulation



Integral skin foam products

With the exception of spray foam, all the above applications involve foam manufacture in a specialist factory. Spray foam is produced in-situ (i.e. using portable equipment at the site being insulated). This distinction is important as it affects the safety issues related to flammable blowing agents.

Alternative technologies

In many foam applications there are competing “not-in-kind” alternatives. Various types of insulation, such as mineral fibre, can be used in place of foam insulation for building fabric insulation and for pipe and vessel insulation. In markets where there is competition between different types of insulation, key properties include the effectiveness of the insulation (in terms of the thermal resistance for a given thickness) and the price. Where there are space constraints (e.g. thickness of a wall cavity) the high thermal resistance of some types of foam insulation is an important advantage, especially with increasingly stringent regulations on the required level of insulation.

It is worth noting that in some markets, such as appliances and steel faced panels, there is little competition with not-in-kind alternatives because the high structural strength of foam insulation is critical in these applications. Similarly, the moisture resistance of XPS boards make them especially advantageous for floor insulation.

Changes driven by ODS phase out

Prior to 1990 CFC-11 was the main blowing agent for PU-type foams and CFC-12 was used for XPS. In non-Article 5 countries there was a transitional shift to HCFC blowing agents between 1995 and 2010. HCFC-141b was used for PU-type foams and HCFC-142b and HCFC-22 were used for XPS. From around 2000 some parts of the foam market moved to HFC blowing agents (see Table 1 for details). Since the phase out of CFCs a significant part of the foam market has moved to non-fluorocarbon alternatives including HCs and CO₂.

HFC blowing agents used for insulation foam

The main HFC blowing agents currently used in the manufacture of foam insulation are summarised in Table 1.

Table 1: HFC Foam Blowing Agents

Blowing Agent	GWP ¹	Flammability	Types of foam product
HFC-134a	1430	Non-flammable	XPS and some PU-type
HFC-134a / HFC-152a blends	varied		XPS
HFC-245fa	1030		PU-type foams
HFC-365mfc / HFC-227ea blends	960 to 1100		PU-type foams
HFC-134a / HFC-245fa blends	1100 to 1300		Some PU spray foams

The HFC blowing agents are all non-flammable². This has been an important consideration in the selection of HFC blowing agents, in relation to safety in the foam manufacturing process and to the fire performance of finished products. The HFCs are usually more expensive than the alternative blowing agents (such as hydrocarbons) but in some parts of the market and some geographic regions it is a benefit or requirement to have a non-flammable blowing agent.

2. Alternatives to currently used HFC blowing agents

Lower GWP alternatives to HFC blowing agents are summarised in Table 2. It should be noted that:

- All the alternatives have very low GWPs (most are below 10). This is quite different to the refrigeration and air-conditioning market, where many alternatives being considered have GWPs in the 200 to 1000 range.
- Some of the alternatives have high flammability

Since the phase out of ODS blowing agents in the 1990s, the foam market began to use non-fluorocarbon alternatives where this was technically and economically acceptable. Large parts of the global foam market already use the lower GWP alternatives that are summarised in Table 2. This has often been driven by the lower blowing agent costs of a hydrocarbon (HC) blown foam. However, in parts of the market, issues related to safety or product performance have created an on-going demand for the HFCs listed in Table 1.

The current use of lower GWP alternatives also varies on a regional basis. In particular the US makes less use of flammable blowing agents and most of Article 5 countries are still using HCFCs.

¹ All GWP values are based on the IPCC 4th Assessment Report

² Note: HFC-365mfc is flammable. It is used in blends with HFC-227ea (7% or 13%) that are non-flammable. Similarly, HFC-152a is flammable, but it is used in non-flammable blends with HFC-134a.

PU-type boards, panels, appliances and block foam already make significant use of HCs.

PU-spray foam mainly uses HFCs although there is some use of CO₂ and supercritical CO₂ in Japan.

XPS still uses significant amounts of HFC-134a, although in some regions there is widespread use of CO₂ / CO₂ blends and some use of HFO-1234ze. In Japan, iso-butane is also widely used. However, in markets where the thermal insulating characteristics of XPS are prioritised and building code flammability requirements increased, such as in the United States and Canada, CO₂ alone or flammable blowing agents are not suitable alternatives for all applications..

Table 2: Lower GWP Alternatives for Foam Blowing Agents

Blowing Agent	GWP	Flammability	Types of foam product
Hydrocarbons			
c-pentane	5	Flammable	PU-type foams (excluding spray foam)
iso-pentane	5		
n-pentane	5		
Blends of pentanes	5		
Propane / butane	3	Flammable	One component foam aerosols XPS (Japan)
Oxygenated Hydrocarbons			
Dimethyl ether	1	Flammable	Co-blowing agent in XPS
Methyl formate	<25	Flammable	PU-type foams (excluding spray foam) Integral skin foams
Methylal	<25		
HFOs (hydro-fluoro-olefins, also referred to as unsaturated HFCs)			
HFO-1234ze	7	Non-flammable ³	XPS and some PU-type foams
HFO-1336mzz	9	Non-flammable	PU-type foams (including some types of spray foam)
HFO-1233zd	5		
Other			
CO ₂	1	Non-flammable	XPS PU-type foams
CO ₂ with co-blowing agent	1	Flammable	Alcohols and ethers sometimes used with CO ₂ as co-blowing agents
Supercritical CO ₂	1	Non-flammable	Spray foam

³ HFO-1234ze is designated as non-flammable for foam applications in most regions. It is designated as lower flammability in Japan and for refrigeration and air-conditioning applications.

3. Discussion of key issues

Safety and practicality

Foam Manufacture

PU-type foams: Most are blown in specialist factories. Where production levels are high (e.g. continuous board / panel manufacturing) it has been shown that the one-off capital investments required to use high flammability blowing agents safely, can be justified against reduced on-going production costs. A significant proportion of world production already uses HCs for high volume PU-type products. Where production levels are low (e.g. discontinuous panel manufacturing) it is still technically feasible to use HCs safely in most instances, but investment costs are more difficult to justify. Conversion to non-flammable HFO blowing agents may be an appropriate option for low volume factories. This is an especially important issue where it is not technically feasible to use HCs safely, where gaseous blowing agents are used, and in Article 5 countries where low volume production plants are common.

PU-spray foam: This type of foam is always blown at the site being insulated. It is not considered safe to use flammable blowing agents. Certain market segments can use the newly introduced HFOs, possibly co-blown with CO₂ (water). Another option for some market segments is supercritical CO₂ that is already used in Japan.

XPS foams: The main low GWP alternatives for XPS are either non-flammable (CO₂) or lower flammability (HFO-1234ze), so safety during manufacture is not a major concern. There can be practical difficulties in getting good foam quality solely with a CO₂ blowing agent. Therefore, alcohols and ethers are sometimes used at low levels as co-blowing agents. Ethers (particularly di-methyl-ether) are also used as co-blowing agents more widely and, in those circumstances, flammability can become more of a hazard.

Usage of a foam product

Tests have shown that most HC-blown foams can have approximately equal fire performance to an HFC-blown foam, although greater use of flame retardants or polyisocyanurate may be necessary.

Commercial availability

Many of the foam blowing agents listed in Table 2 have been widely used for a number of years and are fully available in most regions.

The HFOs are new to the market and it could be some years before these are widely available for all relevant foam products. Their use in North America is increasing rapidly in certain PU foam market segments.

Cost

Cost is a critical issue, especially in those markets where there is competition with not-in-kind alternatives.

HC blown foams are generally cost competitive, although the initial investment costs create a significant barrier for factories with low production volumes.

HFOs will be more expensive to use than HCs. This barrier may be overcome by (a) the improved thermal performance of HFO-blown foams over HC-blown foams and (b) the blending of HFOs with other lower cost blowing agents. As these products are new to the market there is still a lot of development work and product testing required to optimise the processing of HFO-blown foams.

Energy efficiency

Insulation foam must have good thermal performance and this will become increasingly important as energy-related climate change policies push for better standards of insulation in buildings.

Energy efficiency issues are closely related to cost issues – an insulating material with improved thermal performance requires a lower thickness when compared to competing products. This can give lower installed cost even if the foam itself uses a more expensive blowing agent.

For HCs there is a slight disadvantage in thermal performance, compared to the HFCs listed in Table 1, although HC technology has improved substantially over the last 20 years as cell size and uniformity has been optimised. For HFOs, early deployment in some markets indicates that they will have a thermal advantage over current HFCs and a more significant advantage over HCs.

The importance of thermal performance is application specific. If there is no constraint on thickness, then a lower thermal resistance can be offset by using a thicker product. But if thickness is a constraint (e.g. domestic refrigerators, refrigerated trucks or cavity walls) then the high thermal resistance of an HFO-blown foam may become an advantage.

Applicability in high ambient

There are no particular issues about use of foams in high ambient conditions.

Polyol formulation with blowing agents can be an issue if ambient temperatures are above the boiling points of the blowing agent. System houses producing polyol / blowing agent mixtures may require temperature-controlled factories.

Technician training

Factory operatives need training if a foam blowing factory is converted to use HCs.

Spray foam operatives may require training, but if a non-flammable blowing agent such as an HFO is used, this does not create major difficulties.

There are no additional training issues related to the installation of factory blown foam products in the field.

Minimising emissions from foam products

There is a large bank of foam products in existing buildings and appliances. A significant proportion are CFC or HCFC blown foam and a small proportion contains HFCs.

There is some gradual emission of blowing agent from these products during their “in-life” phase – nothing can be done to reduce these emissions, since intervention would accelerate release.

At end-of-life, a significant proportion of the blowing agent may still be in the foam. There is an opportunity to recover and destroy some of this, although the cost-effectiveness depends on the type of product. Foams in appliances and steel-faced panels can often be segregated at end-of-life and sent to specialist recovery facilities. Foam boards and laminated panels (e.g. used for roof, wall or floor insulation) are much more difficult to segregate cost-effectively during a building demolition process. They will often end up in land-fill with demolition waste. PU Spray foam is particularly challenging because of its adhesive properties.