



Feature

# The Future of Rigid Foam Insulation

All photos courtesy Mason Knowles

## Impact of the Canadian phase-out of ozone-depleting chemicals

By Mason Knowles

Despite the current emphasis on global warming, many seem to forget the most successful international environmental agreement, the *Montreal Protocol*, revolved around the elimination of ozone-depleting chemicals. Since the initial signing in September 1987, 191 countries have ratified the treaty and continue their phase-out of the manufacture and employment of ozone-depleting chemicals.'

The *Montreal Protocol* affected dozens of industries including the automobile, refrigeration, appliance, boat, cooler, packaging, and insulation sectors. Each country chose to meet the phase-out in different ways. The intent was to gradually reduce and eliminate ozone-depleting chemicals by specific dates as described in Figure 1. The phase-out began in the mid-1990s and will continue in some

countries until 2030. To achieve the treaty's goals, billions of dollars have already been spent around the globe, researching new formulas and processes, designing new equipment, and testing and approving new systems.'

Canada is fast approaching its January 2010 deadline for the last date certain hydrochlorofluorocarbons (HCFCs)-141b, 142b, and 22—can be used in the manufacture of rigid foam plastic insulation such as spray polyurethane foam (SPF), polyisocyanurate (polyiso), expanded polystyrene (EPS), and extruded polystyrene (XPS) foam.'

Foam insulation is used in a variety of commercial applications, such as cold-storage facilities, roofing assemblies, and interior and exterior insulation systems. Any type of building—from metal to brick to wood-framed—can use foam plastics. Spray-applied systems

Figure 1

## Ozone-depleting Chemicals Allowed

(non-Article 5 [or developed] countries)				
2004	2010	2015	2020	2030
35 per cent reduction	65 per cent reduction	90 per cent reduction	99.5 per cent reduction	Phase-out complete

such as SPF can be used to air-seal buildings while providing insulation. Foam plastics are typically used where high insulation value per inch is required to minimize the thickness of a wall, floor, or ceiling assembly.

This article addresses the phase-out of HCFC blowing agents in such building materials, examining what is in store for design professionals and building owners and how the insulation industry has responded to this regulatory deadline. (For more on these components, see "Blowing Agents of Change," page 28.)

### Ozone depletion overview

Many people confuse global warming and ozone depletion as being one and the same. However, they are completely different processes. Global warming is caused by infrared-radiation-absorbing gases



*Blowing agents—ingredients used to make foam insulation—have historically been ozone-depleting substances. As international laws change, Canadian building products will rely on new components.*

(e.g. carbon dioxide [CO<sub>2</sub>]) that get trapped in the lower atmosphere, causing an eventual warming of the planet's surface. Climate change is the potential result.<sup>4</sup>

Ozone depletion is another process entirely. The upper atmosphere (i.e. stratosphere) contains an ozone layer that shields Earth from the sun's harmful ultraviolet (UV) rays. Too much UV exposure can cause numerous health problems including skin cancer, premature aging, eye damage (cataracts), and suppression of the immune system.'

In 1974, scientists discovered the ozone layer over Antarctica was becoming thinner. It was further determined human-made chemical compounds called chlorofluorocarbons (CFCs) were a significant contributing factor to this depletion.'



**More than just hype.**

visit [www.bluebeam.com/results](http://www.bluebeam.com/results) or call 866.496.2140

**,SURs.**

Bluebeam customers reduce paper  
usage and distribution costs by 80%.

PDF markup and editing software  
(with substance)

1113 bluebeam®



*Exterior air barrier application. The Canadian phase-out of HCFC blowing agents need not have a negative effect on building professionals.*

Twenty years ago, reducing CFCs and protecting the ozone layer was considered a more immediate environmental concern than potential global warming. However, chemicals such as CFCs were simultaneously major global warming gases. In other words, reducing these ozone-depleting potential (ODP) chemicals could have the added benefit of lowering the potential for global warming.'

Global warming potential (GWP) is one of the inputs for a material's total environmental warming impact (TEWI)—the combined effect of direct (i.e. chemical) and indirect (i.e. energy-related) emissions on global warming. In the case of insulation products, the direct effect equals the total greenhouse gases (GHGs) released into the atmosphere. The indirect effect is calculated by estimating the equivalent carbon dioxide emissions based on how long the system remains in place before replacement, along with the total amount of fuel consumed. Since the world currently depends on fossil fuels for primary energy needs and carbon dioxide is the predominant contributor of GHGs for future global warming, energy efficiency is crucial.'

#### **The rules change**

From 1980 to 1990, carbon dioxide contributed 55 per cent of GHGs that affect future global warming. CFC blowing agents (which were used at that time in rigid foam insulation) contributed 17 per cent of greenhouse gases during the same period. Replacing CFC blowing agents in rigid foam insulation with HCFCs (and then later with HFCs) reduced the global warming potential of the blowing agents used to produce the foam by 79 per cent or higher. The insulation quality of rigid foams made with HCFCs or HFCs decreases the energy required for heating and cooling, further reducing carbon dioxide released into the atmosphere.'

The global warming potential of a gas is calculated from its infrared energy-absorbing properties over a specified time. The longer it takes



a gas to be purged from the atmosphere, along with its effectiveness in absorbing infrared radiation, the worse its GWP. It takes more

## Blowing Agents of Change

than 500 years for carbon dioxide emissions to disappear from the atmosphere. Even after a half-millennium, 19 per cent of carbon dioxide survives to affect global warming. Most of the HCFC 141b and HFC 245fa blowing agents have been decomposed by natural processes to become benign materials within a decade. Therefore, the phase-out of CFC blowing agents in rigid foam insulation, refrigeration, and aerosol cans provided greater protection against global warming as well as ozone depletion.<sup>m</sup>

Ozone-depleting substances (ODS) contain chlorine or bromine that can deplete the ozone layer if introduced to the upper atmosphere. The strategy of the *Montreal Protocol* (and the amendments adopted in four subsequent meetings) was to transition from CFCs to substances that had lower ODPs before moving to non-ODS altogether.<sup>n</sup>

HCFCs were accepted by most countries as a 'transitional' blowing agent. HCFCs contain chlorine, but only a small percentage of that chlorine can affect the ozone because most of the compound released at ground level is destroyed in the lower atmosphere before reaching the stratosphere. (HFCs are considered environmentally superior to HCFCs because they contain no chlorine and lack potential to deplete ozone.)<sup>2</sup>

In Canada and other developed countries, there were two phaseouts of ODS. The first phase-out in the polyurethane and polyiso foam industries transitioned from CFCs to HCFC 141b as the

hen introduced to a plastic resin formula, chemicals known as 'blowing agents' create a gas that allows liquid plastic to form W into a foam. In the case of foam board insulation, blowing agents are introduced into the system during the manufacturing process.

For sprayed polyurethane foam (SPF), the blowing agents are part of the 'B' component (e.g. polyol resin, surfactants, catalysts, fire retardants, etc.) mixed onsite in equal ratios with the 'A' side component (e.g. methylene diphenyl diisocyanate [MDI]) to create a rigid foam plastic. The type of blowing agents used can affect physical properties of the foam plastic, such as open cell content, R-value, and, in some cases, compressive strength, dimensional stability, and other properties.<sup>E.L.</sup>

primary blowing agent (with some formulas using HCFC 142b & HCFC 22 as an additional blowing agent). The HCFCs had 90 per cent less ozone-depleting properties than the CFCs. Additionally, the HCFCs provided significantly less global warming potential. The next phase-out-2010—is to transition completely away from ODP chemicals.<sup>o</sup>

Figure 2

### HCFC Rigid Foam Technology

Product	XPS (type IV)	SPF (Type II)	SPF (low-density)	Polyiso	EPS (Type XIII)
Blowing agent prior to HCFC phase-out	HCFC 142b HCFC 22	HCFC 141 b	CO <sub>2</sub> (water)	HCFC 141 b	Pentane or butane
R-value	5.0	6.0	3.5	6.0	3.9
Density	25 kg/m <sup>3</sup> (1.55 pcf)	32 kg/m <sup>3</sup> (2 pcf)	8 kg/m <sup>3</sup> (0.5 pcf)	32 kg/m <sup>3</sup> (2 pcf)	26 kg/m <sup>3</sup> (1.6 pcf)
Compressive strength	172 kPa (25 psi)	103 to 172 kPa (15 to 25 psi)	less than 21 kPa (3 psi)	110 to 138 kPa (16 to 20 psi)	138 kPa (20 psi)

### New Technology

Product	XPS (Type VI)	SPF (Type II)	SPF (low-density)	Polyiso	EPS (Type XIII)
Blowing agent prior to HCFC phase-out	HFC-134a	HFC 245fa	CO <sub>2</sub> (water)	Cyclopentane or other pentanes/mixtures	Pentane or butane
R-value (per inch)	5.0	6.0	3.5	6.0	3.9
Density	29 kg/m <sup>3</sup> (1.8 pcf)	24 to 32 kg/m <sup>3</sup> (1.5 to 2 pcf)	8 kg/m <sup>3</sup> (0.5 pcf)	24 to 32 kg/m <sup>3</sup> (1.5 to 2 pcf)	26 kg/m <sup>3</sup> (1.6 pcf)
Compressive strength	172 kPa (25 psi)	103 to 172 kPa (15 to 25 psi)	less than 21 kPa (3 psi)	110 to 138 kPa (16 to 20 psi)	138 kPa (20 psi)

Note: Types of rigid foam are defined per ASTM International standard specification specific to each material as follows:

- EPS and XPS: ASTM C 578, *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*;
- SPF: ASTM C 1029, *Standard Specification for Spray-applied Rigid Cellular Polyurethane Thermal Insulation*; and
- polyiso: ASTM C 1289, *Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board*.

Low-density SPF does not have an ASTM standard, but its properties are identified by Spray Polyurethane Foam Association (SPFA) AY 112, *Spray Polyurethane Foam for Building Envelope Insulation and Air Seal*.

## Canada and the new phase-out

Most of the rigid foams produced in Canada are manufactured with polyurethane or polystyrene resins. (This article focuses on XPS, polyiso, SPF, and EPS; other rigid foams such as phenolics or polyolefins are manufactured in lesser quantities and are not discussed.) Before the *Montreal Protocol*, chlorofluorocarbons (i.e. CFC 11 and CFC 12) were the main blowing agents used for rigid foam plastics."

HCFC 141b, HCFC 142b, and HCFC 22 were adopted by the XPS, polyiso, and SPF industry as transitional blowing agents, away from CFCs. Expanded polystyrene foam, however, uses hydrocarbons such as pentane or butane infusion into the beads and a two-stage steam expansion. The phase-out would replace the HCFCs with a variety of blowing agents, including:

- HFCs;
- hydrocarbons (e.g. pentanes, butanes);
- CO<sub>2</sub> generated by the reaction of isocyanate and water; and
- liquid CO<sub>2</sub>.<sup>5</sup>

Currently, most insulating foam products use HCFCs or HFCs due to the insulation properties they impart. The use of hydrocarbons and water or liquid CO<sub>2</sub> in insulating foams typically provides lower insulative properties. In most construction applications and appliances, it is desirable to limit the total thickness of the insulation and a higher R-value per inch is needed. In other applications, such as packaging or flotation, the thickness of the rigid foam is not a factor and a less insulative blowing agent may be used.<sup>6</sup>

There are exceptions to this generalization. For instance, some polyisocyanurate foam manufacturers employ cyclopentane as the blowing agent, while low-density SPF and EPS use water or butane as blowing agents, respectively. As indicated by Figure 2, the insulation efficiency of each product is determined by its blowing agent."

## Impact on industry

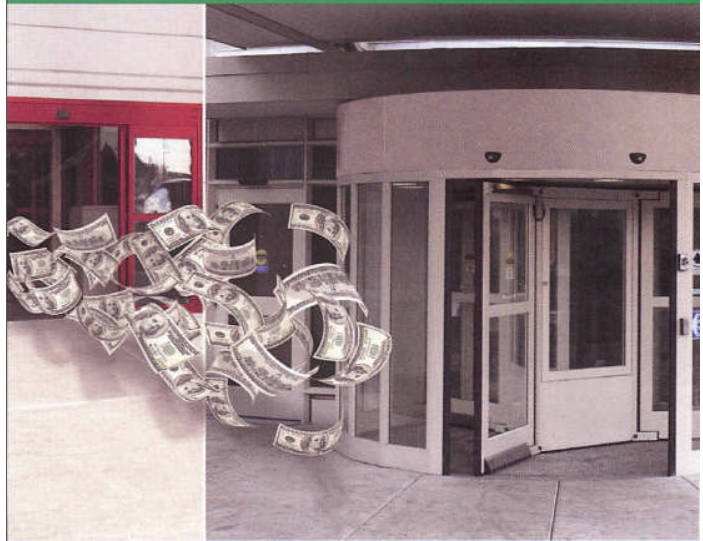
Canada's 2010 phase-out of HCFC 141b, HCFC 142b, and HCFC 22 means all foam plastics using HCFCs must be reformulated to a non-ozone-depleting blowing agent. When use of CFCs was eliminated in the early 1990s, the rigid foam insulation industry had a few years of adjustment where critical issues were identified and addressed.

For example, the polyisocyanurate industry dealt with facer delamination, while the SPF industry struggled with moisture sensitivity issues and adhesion with some formulas. While these issues were eventually corrected, the rigid foam industry did not want to revisit problems of this type when transitioning to next-generation foam systems.<sup>8</sup>

To that effect, the rigid foam industry producers, manufacturers, and trade groups spent considerable time and money researching the best possible alternatives for the transition and conducted extensive field trials to identify potential concerns and issues. The good news for Canadian companies is the United States began transitioning to a non-ozone-depleting blowing agent in January 2003. This five-year 'head start' provided Canadian foam plastic manufacturers with a good road map on fine-tuning new systems without having to experiment as much with their own applications.

For example, this author has observed a few cases of foam shrinking away from wood studs with next-generation SPF systems used in the United States. The condition has been limited in scope, affecting only a few manufacturers. These companies have since taken measures to address the concern.

## REVOLVING DOOR SYSTEMS



## Stop blowing money and energy away.

### Turn to the greener choice: Horton revolving doors®

With energy costs escaping everyone's grasp, revolving door systems from Horton Automatics may be a more attractive alternative to sliding or swing doors for your building design. Revolving doors maintain a constant barrier to drafts, dust and noise, making any entrance design more energy-efficient as well as beautiful. In high traffic buildings, the resulting savings can be particularly dramatic.

Visit [hortondoors.cortio](http://hortondoors.cortio) learn more about the new economics of revolving doors.

#### Horton Revolving Doors: Always Open: Always Closed



#### Gram® Large Diameter Vestibule Systems



#### AutoFlow® Automatic Entrance Systems



#### ControlFlow® Automatic Security Door Systems



### Did You Know?

Regular foot traffic. If a large building can result in air leaks of up to 30,000 cubic feet per minute, vast savings can be realized.

#### EasyFlow'



Manual Door Systems

United States/Canada  
1.800.531.3111

United Kingdom  
+44 (0) 19 5267 0169

Pieddc



*In Canada, cold-weather considerations are critical in selecting foam insulation. New products need to be able to perform.*

## Specifying and Using a New Foam System

1. Verify the foam meets or exceeds all Canadian regulatory requirements.
2. Verify the foam is suitable for the project.
3. Verify the contractor has ample experience with installing the particular system and is licensed and certified to install the foam as required.
4. For the actual material being specified, obtain references of its use in similar projects.
5. Determine procedures to ensure quality control. Depending on the project, these include inspection measures, minimum compressive strengths, minimum thicknesses, substrate conditions, and climate limitations on applications.<sup>11</sup>

Blowing agent replacement candidates have been researched since the early 1990s. Companies have spent almost two decades on the development of new HFC blowing agents in polyurethane foams; chemical manufacturers have worked for more than a dozen years alongside the polyisocyanurate foam industry in developing technology using hydrocarbons, including cyclopentane.<sup>9</sup>

On a similar note, an attempt was made to adapt the hydrocarbon technology for SPF systems, but the requirement to purchase new equipment (to reduce the hazards of using a flammable material) by the contractor/applicator and the supplier has limited the employment of these systems in North America."

### Overcoming hurdles

In transitioning to the blowing agent most suitable for its industry, the challenge is to maintain insulative values and the suitable physical properties that make each rigid foam work for its specific purpose. Manufacturers considered several factors when developing an SPF insulation system that would perform best in Canada.

#### *Storage*

Most SPF contractors buy in multiple drum lots and store materials in their warehouse for up to three months before use. To be practical, the materials should therefore be able to withstand 10 to 27-C (50 to 80-F) storage temperatures for this period without material separation or loss of reactivity profile.

#### *Processibility*

The liquid components should be easily mixed by existing equipment with only minor adjustments to heat and pressure.

#### *Dimensional stability*

As Canadian winters can be rough, an SPF system needs to resist shrinkage and cracking from cold temperatures.

#### *Adhesion*

SPF is field-applied and requires excellent adhesion to wood, concrete, and metal. For success, any new system must adhere well to these common building materials.

#### *Temperature application range*

In this country, construction does not wait for winter to be over. Since Canadian contractors spray foam year-round, the new systems must be able to be installed when outside temperatures are very low.

### Enter HFC 245fa

To meet these needs, most U.S. and Canada foam suppliers have adopted the use of HFC 245fa blends for the manufacture of closed-cell SPF. In field trials, this blowing agent gave the best combination of desirable physical properties, processibility, storage, and insulative value for the majority of the closed-cell SPF market in roofing, insulation, and air barrier applications.<sup>21</sup>

HFC blowing agents cost more than HCFC blowing agents, adding approximately 10 cents per pound to the cost of a drum set of material. However, with the increase in oil and natural gas prices, and the subsequent rise in raw material costs, the new blowing agent expense has been less significant in the total cost of the product than first expected.



*Sprayed polyurethane foam (SPF) shrinkage on wood studs. Different foam plastics rely on different 'ingredients.'*

Field trials and observations have demonstrated closed-cell SPF systems made with the HFC 245fa have favourable properties of compressive and tensile strength, dimensional stability, R-value, adhesion, and ability to be applied with existing spray equipment." As shown in Figure 2, physical properties are virtually identical to the HCFC foam formulas. Consequently, design teams and architects should not require special changes when specifying these newer products." Other important factors include:

- storage considerations;
- application window;
- surface temperature; and
- yield versus strength.

This author knows of at least two Canadian SPF manufacturers currently selling next-generation closed-cell sprayfoam formulations containing HFC 245fa. An additional benefit to these systems is both products have high recycled plastics content and employ resins made from bio-based sources such as soybeans and castor oil.

## Conclusions

It is too soon to identify all possible consequences from the phase-out of hydrochlorofluorocarbon blowing agents in rigid foam insulation. However, the significant research, field trials, and testing indicate this transition will run much smoother than the CFC-to-HCFC transition."

It should be noted contractors require an adjustment period to become accustomed to the new formulas. This typically involves adjusting pressures and temperature settings of the equipment until the foam exhibits the desirable spray characteristics, curing, and physical properties. Spray techniques may vary as well.

However, most contractors follow a similar 'acclimatization' period when simply switching to a different brand of SPF. For example, when 'dialing in' a new sprayed foam system, an applicator adjusts the temperature and pressure on the equipment until the spray pattern and finished foam product is desirable. In some cases, the most effective application may require thinner or thicker foam lifts."

Based on this author's own observations of field applications of

next-generation foam formulas in the United States over the last three years, it is unlikely building owners will notice significant differences in the post-HCFC foams. However, the design team should ensure the foam is suitable for the intended project. <sup>4</sup>.

## Notes

<sup>1</sup> See the U.S. Environmental Protection Agency's (EPA's) 2008 document, "*The Montreal Protocol on Substances that Deplete the Ozone Layer*."

<sup>2</sup> See Environment Canada's 2002 report, "Halocarbon & Control Technologies in Foam Manufacturing."

<sup>3</sup> Ibid.

<sup>4</sup> See the U.S. Department of Energy's (DOE's) 1999 alternative fluorocarbons environmental acceptability study, "Atmospheric Chlorine: CFCs and Alternative Fluorocarbon."

<sup>5</sup> Ibid.

<sup>6</sup> See note 2.

<sup>7</sup> See note 4.

<sup>8</sup> See "Energy and Global Warming Impacts of CFC Alternative Technologies, Executive Summary," from the same DOE study cited in note 4.

<sup>9</sup> Ibid.

<sup>10</sup> Ibid.

<sup>11</sup> See "The Clock Is Ticking for HCFCs," a 2000 article from *Plastics Technology Online*. Visit [www.ptonline.com](http://www.ptonline.com).

<sup>12</sup> Ibid.

<sup>13</sup> Ibid.

<sup>14</sup> See note 2.

<sup>15</sup> See the Alliance for Responsible Atmospheric Policy's 1999 AD Little report, "Foam Insulation."

<sup>16</sup> See "Enovate 3000 Blowing Agent Blend Technology for the Global Polyurethane Spray Foam Industry," a 2003 paper by Mary Bogdan and Jason M. Hoerter, presented at that year's Polyurethanes Conference.

<sup>17</sup> See "Final Report: Spray Polyurethane Foam Field Study on Next-generation Blowing Agent Formulations," published in 2005 under EPA Grant No. 8292901.

<sup>18</sup> See the Spray Polyurethane Foam Alliance's (SPFA's) "Guideline for the Application of SPF for the Building Envelope."

<sup>19</sup> See "A Blowing Agent Update," by Lorraine Ross, which appeared in a 2003 issue of *Professional Roofing*.

<sup>20</sup> See note 16.

<sup>21</sup> See note 11.

<sup>22</sup> See note 17.

<sup>23</sup> See notes 17, 18, and 19.

<sup>24</sup> See note 17.

<sup>25</sup> See note 17.

*Mason Knowles chairs the ASTM International Subcommittee on Spray Polyurethane Foam Roofing and the organization's task group for the SPF standard specification. He has more than 35 years of experience in the polyurethane industry as a contractor, material supplier, equipment manufacturer, and trade association professional. A former executive director of the Spray Polyurethane Foam Alliance (SPFA), Knowles has also been a technical director for the American Plastics Council (APC), now a division of the American Chemistry Council (ACC). He can be contacted via e-mail at [masonknowles@aol.com](mailto:masonknowles@aol.com).*