Sourcebook of Technologies for Protecting the Ozone Layer

Flexible and Rigid Foams

September 1996 Update

Multilateral Fund for the Implementation of the Montreal Protocol
1800 McGill College Avenue, 27th Floor
Montreal, Quebec H3A 3JC
Canada

UNEP

United Nations Environment Programme
Industry and Environment
39-43 Quai André Citroën
75739 Paris Cedex 15
France

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Foreword

It is virtually universally accepted by the world's scientists, industries, policy-makers, NGOs and members of the public that chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs) and methyl bromide are responsible for the depletion of the stratospheric ozone layer, that segment of the earth's atmosphere which protects animal and plant life from the damaging effects of ultraviolet radiation.

Since September 1987, when nations concerned about this crisis signed the landmark Montreal Protocol that identified the major ozone-depleting substances (ODSs) and established a timetable for the reduction and eventual elimination of their use, the list of controlled substances has increased and a number of phase-out deadlines have been advanced through a series of amendments and adjustments .

Under the Protocol and its amendments, ODS production and consumption of the controlled substances are to be reduced and eliminated through the development of chemical substitutes and alternative manufacturing processes. Many companies in both the developing and developed world have already switched to non-ODS alternatives, and many countries have adopted even more ambitious phase-out schedules for some substances in light of the widespread availability alternatives. Information exchange to support this global technology transfer process is crucial.

Since mid-1991, a major role of the United Nations Environmental Programme (UNEP) in its capacity as an Implementing Agency of the Multilateral Fund has been (and continues to be) to provide Article 5 (i.e., developing) countries with clearinghouse services to assist their expeditious phase-out of controlled ODS. As enshrined in Article 10 of the Montreal Protocol, such information and training support is required by developing countries in order for them to make appropriate, informed decisions in relation to their investment project and policy-making decisions.

In order to better understand the changing needs of Article 5 countries, and hence design effective demand-driven services, UNEP's Industry and Environment Programme office (UNEP IE) maintains various regular feedback mechanisms. From these, it understands the broad information needs of Article 5 countries to be a step-wise process as follows:

° **awareness** about the implications of stratospheric ozone depletion and the necessity to phase out ODS;

° understanding what **technical options** currently exist to eliminate ODS;

° knowing **how to select an appropriate technical option** and **how to identify the worldwide suppliers of technologies, equipment and products** required to implement that option; and

° understanding how a company or organization can **successfully implement** an alternative technology or ODS phase-out programme.

In response to these needs, UNEP IE's OzonAction programme under the Multilateral Fund has developed a wide array of information services and other support activities specifically to assist industry in developing countries with the transition from ODS to non-ODS alternatives (see Annex A). This sourcebook responds to the third information need: how to select a technical option and identify the technology, equipment and chemical suppliers.

Introduction

Background and Overview

The Montreal Protocol and the Multilateral Fund

In 1974, Sherwood Rowland and Mario Molina of the University of California claimed that the man-made chemicals known as chlorofluorocarbons (CFCs) were damaging the stratospheric ozone layer. Subsequent research supported the theory, and it is now established that the stratospheric ozone layer -- which protects the earth from dangerously high levels of ultraviolet radiation from the sun -- is being destroyed by human activity. Ozone depleting substances (ODSs) including CFCs and carbon tetrachloride are used in the manufacture and operation of thousands of products, including aerosol products, sterilants, solvent applications, and miscellaneous uses.

The Montreal Protocol on Substances that Deplete the Ozone Layer was drawn up under the guidance of the United Nations Environment Programme (UNEP) in September 1987. The Protocol identified the main ODSs, and set specific limits on their production and consumption levels in the future. As of May 1996, 149 countries had ratified the agreement.

The Protocol has been continuously updated to reflect the changing scientific evidence and technological developments with the most recent (seventh) meeting of Parties being held in Vienna (November 1995).

London Amendments to the Montreal Protocol

It was always intended that the Protocol be continually updated as necessary to reflect the changing scientific evidence and technological developments. In June 1990, the Parties to the Protocol met in London to consider the implications of new scientific evidence that showed that the ozone layer was being depleted even faster than originally thought. The London meeting agreed to phase out the consumption and production of CFCs and halons by the year 2000, and to control other chemicals, namely carbon tetrachloride and 1,1,1-trichloroethane.

The London Amendments acknowledged the financial and technical assistance that developing countries would need, and to meet this need the Parties established the Multilateral Fund (MF) as part of a financial mechanism. The MF serves all countries that operate under paragraph 1 of Article 5 of the Protocol (known as "Article 5 countries"). United Nations Development Program (UNEP), the United Nations Development Programme (UNDP), and the World Bank were chosen to be the Fund's original implementing agencies, with the United Nations Industrial Development Organization (UNIDO) being added later.

Copenhagen Amendments to the Montreal Protocol

At their fourth meeting in Copenhagen, Denmark (November 1992), the Parties took decisions that advanced the phaseout schedules in non-Article 5 (i.e., developed) countries for several ODSs, included methyl bromide and HCFCs as new controlled substances, and continued the financial mechanism to assist Article 5 countries.

The London and Copenhagen Amendments were ratified by the required number of parties, and both amendments have entered into force.

Bangkok Meeting of the Parties

At their fifth meeting in Bangkok, Thailand (November 1993), the Parties approved a budget of US$ 510 million for the MF for the 1994-96 period. In light of the availability of banked halons and the efficiency of technical alternatives to halons, the Parties decided that in 1994 no exemptions for production of halon for essential uses were necessary for developed countries. The Parties also agreed, inter alia, that information on HCFC and methyl bromide alternatives and substitutes be updated annually.

Signatories to the Protocol have agreed to reduce and eliminate the use of the controlled ODSs even though substitutes and alternatives technologies were not yet fully developed.

Industries and manufacturers are starting to replace the controlled ODSs with less damaging substances, but a major obstacle in the conversion process is a lack of up-to-date, accurate information on issues relating to ODS substitutes and ODS-free technologies. UNEP is meeting this challenge through its OzonAction programme (see Annex A).

Nairobi Meeting of the Parties

At this, the sixth meeting of the Parties (October 1994), the main item requiring agreement was the definition of those uses of CFCs, halons and other ODSs which should be classified as 'essential uses' for the purposes of the Protocol. The meeting also commissioned studies on the relative effects of accelerated HCFC and methyl bromide controls ahead of the seventh meeting of the Parties in Vienna.

Vienna Meeting of the Parties

At their seventh meeting in Vienna, Austria (November 1995), the Parties focused on the progress made in CFC phaseout so far and, in particular, addressed the difficulties being experienced by Parties with Economies in Transition (e.g. the former USSR). Additional attention was paid to the acceleration of HCFC phase-out in non-Article 5 countries and a reduction in the maximum permissible annual production (often referred to as the CAP) agreed.

For the first time, a phase-out schedule for HCFCs was agreed in parallel for Article 5 countries. A freeze on consumption by the end of 2015 was agreed, with a subsequent phase-out by 2040. These dates will be reviewed in the light of further experience by the year 2000.

In addition, Article 5 countries will freeze methyl bromide consumption by 2002 at average 1995-1998 levels.

A summary of these decisions is provided in the table overleaf. Additionally, the full text of the reports of the Meetings of the Parties to the Montreal Protocol are available on-line at the UNEP Ozone Secretariat's World Wide Web home page (point your browser to: http:// www.unep.org/unep/secretar/ozone/home.htm)

Costa Rica Meeting of the Parties

The eighth meeting of the Parties will be held towards the end of 1996 with the primary issue being the replenishment of the Multilateral Fund. This will also be an important meeting in the context of the technology transfer process, of which this Sourcebook series plays a crucial part.

Latest Phase out Schedule agreed in 7th Meeting of the Parties, Vienna, 5-7 December 1995
[**Article 5 countries are in bold**; Non Article 5 countries are not]

DATE	CONTROL MEASURES
1 July 1989	Freeze of Annex A[1] CFCs
1 January 1992	Freeze of halons
1 January 1993	Annex B CFCs[2] reduced by 20% from 1989 levels Freeze of methyl chloroform
1 January 1994	Annex B CFCs reduced by 75% from 1989 levels Annex A CFCs reduced by 75% from 1986 levels Halons[3] phased out[6] Methyl chloroform reduced by 50%
1 January 1995	Methyl bromide frozen at 1991 levels Carbon tetrachloride reduced by 85% from 1989 levels
1 January 1996	HBFCs[6] phased out[4] Carbon tetrachloride phased out[6] Annex A and B CFCs phased out[6] Methyl chloroform phased out[6] HCFCs[5] frozen at 1989 levels of HCFC + 2.8% of 1989 consumption of CFCs (base level)
1 July 1999	**Freeze of Annex A CFCs at 1995-97 average levels**
1 January 2001	Methyl bromide reduced by 25%
1 January 2002	**Freeze of halons at 1995-97 average levels** **Freeze of methyl bromide at 1995-1998 average levels**
1 January 2003	**Annex B CFCs reduced by 20% from 1998-2000 average consumption** **Freeze in methyl chloroform at 1998-2000 average levels**
1 January 2004	HCFCs reduced by 35% below base levels
1 January 2005	**Annex A CFCs reduced by 50% from 1995-97 average levels** **Halons reduced by 50% from 1995-97 average levels** **Carbon tetrachloride reduced by 85% from 1998-2000 average levels** **Methyl chloroform reduced by 30% from 1998-2000 average levels** Methyl bromide reduced by 50%
1 January 2007	**Annex A CFCs reduced by 85% from 1995-97 average levels** **Annex B CFCs reduced by 85% from 1998-2000 average levels**
1 January 2010	HCFCs reduced by 65% Methyl bromide phased out **100% phase out of CFCs, halons and carbon tetrachloride as per the London Amendment** **methyl chloroform reduced by 70% from 1998-2000 average levels**
1 January 2015	HCFCs reduced by 90% **100% phase out of methyl chloroform**
1 January 2016	**Freeze of HCFCs at base line figure of year 2015 average levels**
1 January 2020	HCFCs phased out allowing for a service tail of up to 0.5% until 2030 for existing refrigeration and air-conditioning equipment
1 January 2040	**HCFCs phased out**

[1]Five CFCs in Annex A: CFCs 11, 12, 113, 114 and 115. [2]10 CFCs in Annex B: CFCs 13,111, 112, 211, 212, 213, 214, 215, 216 and 217. [3]Halons 1211, 1301 and 2402. [4]34 hydrobromofluorocarbons [5]34 hydrochlorofluorocarbons
[6]With exemptions for essential uses. Consult the *Handbook on Essential Use Nominations* prepared by the Technology and Economic Assessment Panel, 1994, UNEP, for more information.

Overview of ODS Applications

The ODSs controlled under the Protocol are used in a number of industrial processes as well as in consumer products. The principal applications are as follows (the terms in parentheses indicate the typical roles of the ODSs):

- Foam production (blowing agent, ancillary substance)
- Refrigeration and air conditioning (heat transfer medium)
- Solvents (cleaning of electronic circuit boards)
- Fire fighting (extinguishing agents)
- Sterilization (CFC-12 is used as subsidiary material in a mixture with ethylene oxide)
- Aerosols (propellant in a variety of aerosols, for example perfume, paints, etc.)

This Sourcebook deals exclusively with the foam sector (both rigid and flexible foams) supplying the following markets:

Rigid Foams

- Building & transport insulation
- Appliance insulation (e.g. refrigerators & freezers)
- Buoyancy and in-fill

Flexible Foams

- Cushioning
- Packaging
- Automotive safety
- Footwear

More detail is given on the types of foam used in these applications later.

Purpose of the Sourcebook

As the polymer foam manufacturing industry world-wide is a small and relatively well -defined group of companies, it is highly unlikely that manufacturers have failed to learn something of the need for the phase-out of the use of ODSs. However, the environmental importance of this action and the pivotal role of manufacturers in Article 5 countries may only have been recognised recently. For companies seeking to phase-out their use of ODSs, access to information on alternative technology options is critical. It is for this reason that Sourcebooks such as this are required.

Target Groups

This Sourcebook is intended to assist users in making a transition from ODSs to alternatives that do not threaten the ozone layer. It is targeted primarily at:

- **Plant engineers and managers** - those responsible for identifying, evaluating, and implementing these alternatives.
- **Owners of small and medium sized enterprises (SMEs)** - those who will provide the leadership for the phase-out process and ultimately sanction conversion.
- **Suppliers to the industry** - those who are supplying chemicals and machinery to the foam industry. They require guidance on trends in technology from documents such as the UNEP Technical Options Report on Foams and sourcebooks such as this.

- **National Ozone Units (NOUs)** - it is essential that the government office responsible for the management of the country's ODS phase-out programme has information about selecting and sourcing alternative foam sector technologies. Such information is required in order to assist their decision-making processes with regard to investment projects, and to provide to companies when they seek information about alternative technologies for use in foam manufacture.

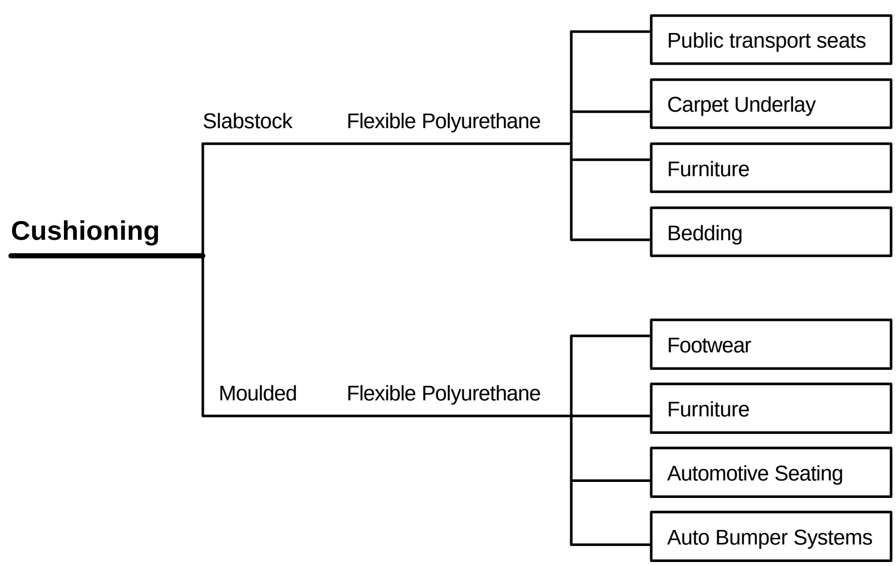
How to use this Sourcebook

This section is intended to assist the reader in understanding how to effectively use this Sourcebook.

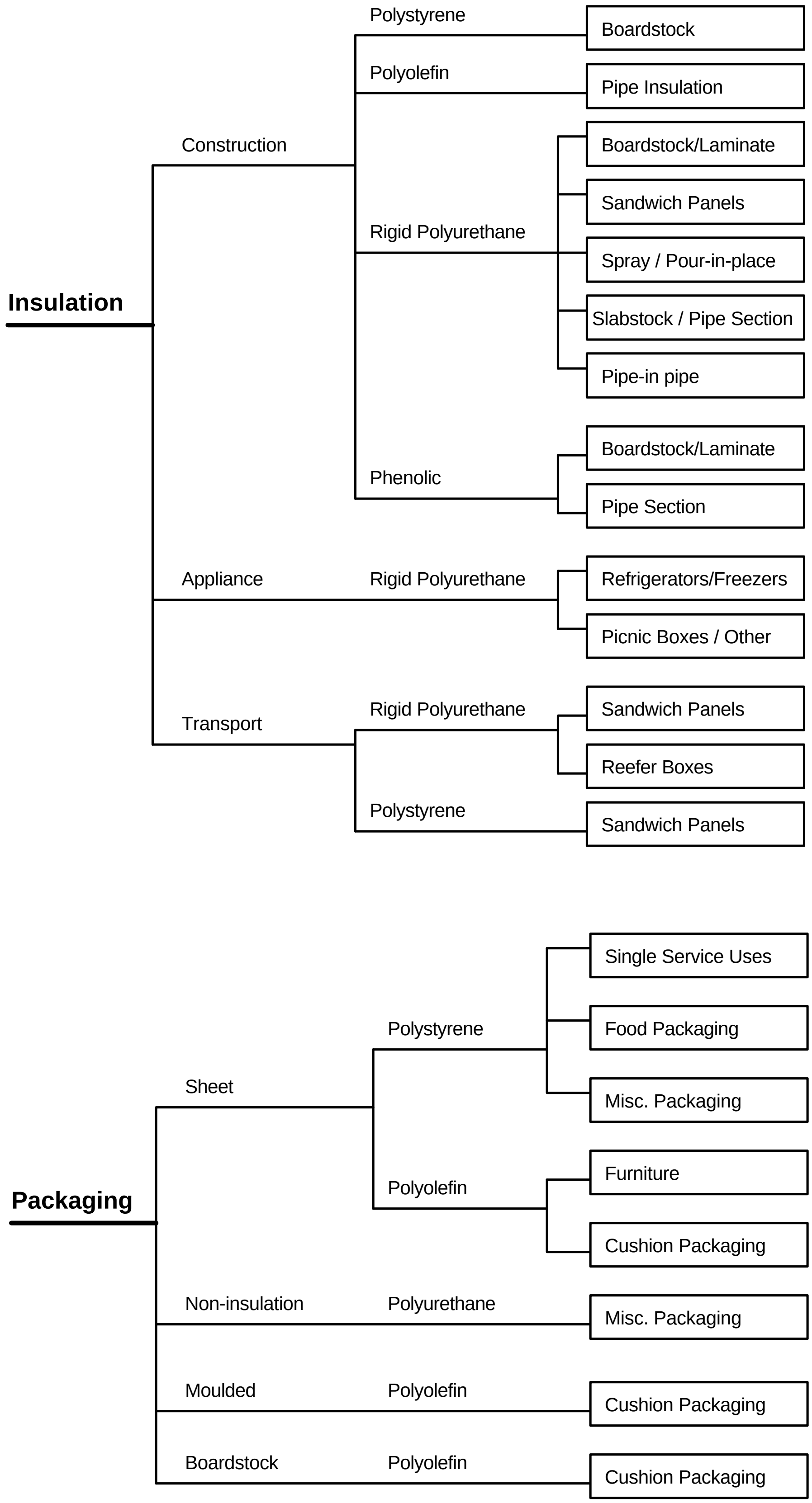
The Sourcebook consists of two principal components:

- Guidance for selecting non-ODS alternatives,
- An overview of specific technology options for each foam sector. This includes datasheets (which provide detailed information on commercially-available technology sources), an indicative list of suppliers and case studies of successful transitions.

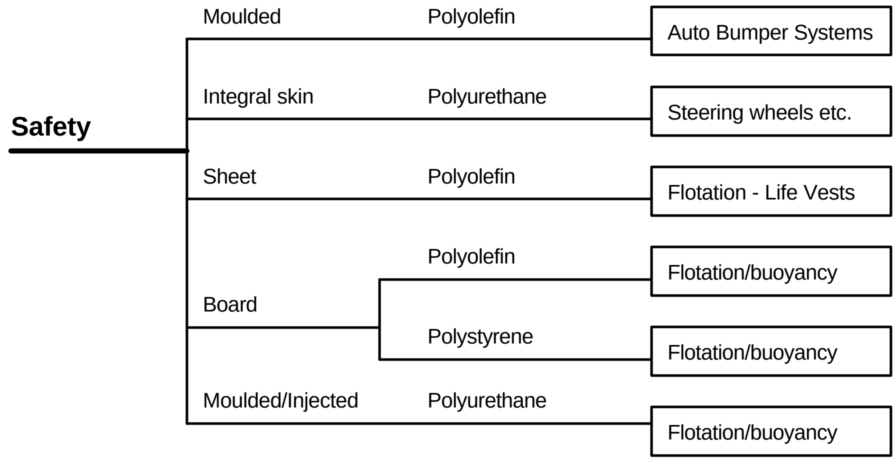
It is recognised that your decision process will most often take place within the confines of a generic product type, since it is unlikely that an existing foam manufacturer will wish to change the type of foam product already being manufactured whilst switching from one blowing agent to another. Notwithstanding this, the generic types of foam for each typical application area are shown below.



Based on 1994/95 UNEP TOC Report on Foams



Based on 1994/5 UNEP TOC Report on Foams



Based on 1994/95 UNEP TOC Report on Foams

For the purposes of this Sourcebook it is viewed as simplest to group technology datasheets, suppliers lists and case studies by generic product type rather than by application. However, sight should not be lost of the wider options set out above.

The 'Guidance for Selecting Non-ODS Technology' section is structured to provide an overview of the general technologies available and the issues to be considered for each application. This approach is built upon in the introduction of each section where the narrative covers the solutions adopted by each generic product type specifically. Matrices are provided relating individual technology sources to the category of solution offered.

Datasheets, Suppliers Lists & Case Studies

The generic classification of product type used in this Sourcebook follows the principles adopted in the 1994/95 Report of the UNEP Technical Options Committee for Flexible and Rigid Foams. These are:

- Polyurethane foam - flexible
- Polyurethane foam - rigid
- Phenolic foams
- Polystyrene foams
- Polyolefin foams

The technical options referred in each section are obtained from the above mentioned report, the contributing foam manufacturers and the quality reviewers. For further options, the reader is referred to Annex D, 'References and Further Reading'.

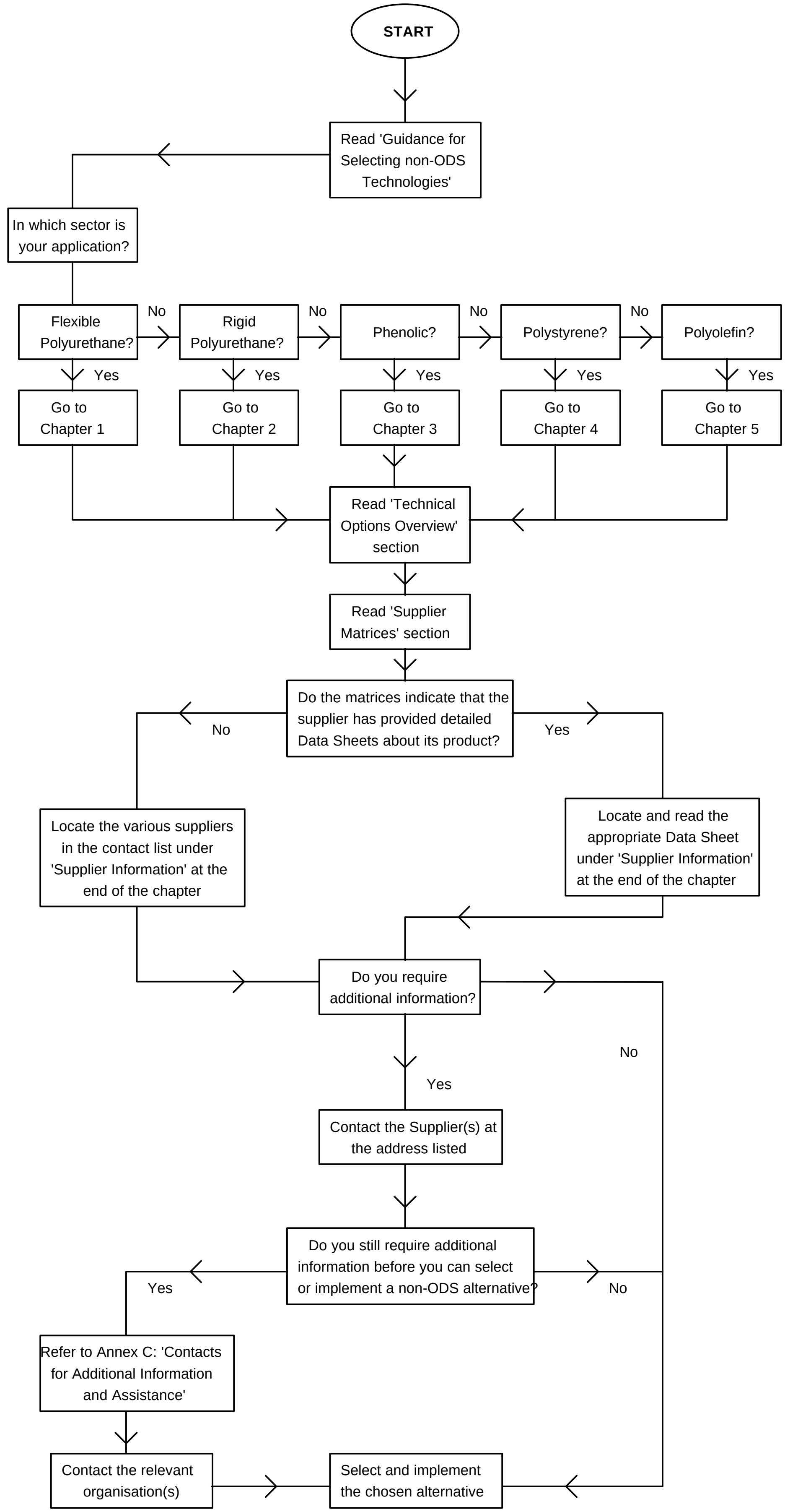
The following specific points should be noted:

(1) It has not been possible to draw a sharp borderline between the groups.

(2) Foams based on polyisocyanurate are described under polyurethane foams.

(3) Semi-flexible foams are included under Moulded Foams (Section 1.2) and Integral Skin Foams (Section 1.3) as appropriate.

The flowchart on the following page provides further assistance in finding your way around the Sourcebook.


START
Read 'Guidance for Selecting non-ODS Technologies'
In which sector is your application?
Flexible Polyurethane?
Rigid Polyurethane?
Phenolic?
Polystyrene?
Polyolefin?
No
Yes
Go to Chapter 1
Go to Chapter 2
Go to Chapter 3
Go to Chapter 4
Go to Chapter 5
Read 'Technical Options Overview' section
Read 'Supplier Matrices' section
Do the matrices indicate that the supplier has provided detailed Data Sheets about its product?
Locate the various suppliers in the contact list under 'Supplier Information' at the end of the chapter
Locate and read the appropriate Data Sheet under 'Supplier Information' at the end of the chapter
Do you require additional information?
Contact the Supplier(s) at the address listed
Do you still require additional information before you can select or implement a non-ODS alternative?
Refer to Annex C: 'Contacts for Additional Information and Assistance'
Contact the relevant organisation(s)
Select and implement the chosen alternative

Request for information

This Sourcebook is a "living" document that will be updated on a regular basis to reflect technological advancement, new products, and changing control measures. Information is welcome both on alternatives to uses covered in the Sourcebook as well as on alternatives not discussed. UNEP requests that companies or individuals with such information use the form in Annex E to supply this information to:

Mr. Rajendra Shende, Co-ordinator
UNEP IE OzonAction Programme
Tour Mirabeau
39-43, Quai André Citroën
75739 Paris Cedex 15
France
Tel: (33) 1 44 37 14 50
Fax: (33) 1 44 37 14 74
Email: ozonaction@unep.fr

Guidance for Selecting Non-ODS Technologies

Introduction
This section discusses various criteria to be considered when selecting alternative blowing agents and technologies for foam plastics production. Further, the section presents general considerations to be made when deciding about conversions towards ODS-free production to and gives guidelines for evaluation and selection of the different alternatives.

General considerations
If your company is still using ODS, there are compelling reasons why you should quickly establish a conversion programme. As mentioned in the Introduction, production of important chemicals necessary for your foam production will be phased out in accordance with the requirements of the Protocol.

The potential for exporting your products should also be considered, as it is likely that a number of countries will ban or limit the importation of articles produced with ozone depleting substances. Also, labelling of products may turn customers towards products produced without ozone depleting substances, which could result in a marketing advantage to your company.

When your company takes the decision to change its production to non-ozone depleting production methods, a conversion programme should be planned.

In order to prepare an efficient and successful conversion programme, a number of issues specific to your product, your factory, your economic situation, etc. have to be given careful consideration. Below some general guidelines are given for selecting non-ozone depleting alternatives.

A sound conversion policy should take a long-term view and consider many aspects. The considerations concern, among other things, technical qualities and possibilities, costs of alterations, running costs, safety issues, and environmental impact. Where possible, technology suppliers offering a “turn-key package” should be preferred.

The choice of alternative products should also consider prospects for the future; environmental impacts should preferably be foreseen and transitional solutions - if it seems appropriate to introduce such options - should, if possible, be adjusted to existing machinery. In this way the investment costs of the alterations should not prohibit subsequent introduction of more sustainable solutions.

In addition it should be considered that the choice of alternatives can have far-reaching consequences for the whole production process and for the design of the final products.

Guidance for evaluation, comparison and selection of alternative technologies
Selection of the most favourable alternative technology for your production involves a number of evaluations and comparisons between several elements. There will inevitably be some trade-offs. The final choice will depend on the specific situation of your factory and no Sourcebook, however comprehensive, will be able to make the decision for you.

The key considerations are as follows:

- Environmental, health and safety
- Technical
- Costs and availability
- Regulatory

When applied to each generic product type, these considerations lead to a series of practical options which are set out in the individual chapters. Each set of considerations is discussed in more detail below following a brief overview of the main types of candidate blowing agents. The flow charts set out pages XVII to XIX attempt to highlight the key decision criteria which a company will face irrespective of the generic product group being considered.

The above-mentioned points stress the necessity to carefully consider in each individual case the technical demands the alternative product must fulfil, as well as the demands which should be fulfilled according to both national law and international agreements.

It should be pointed out that alternatives which are not plastic foam, might be appropriate in some applications, and that detailed investigations of these materials should also be considered (i.e. not-in-kind alternatives). Such materials, however, are not dealt with in this Sourcebook, because its prime purpose is to support the phase-out of ODSs in existing processes.

Additional important elements for successful implementation of your conversion programme.

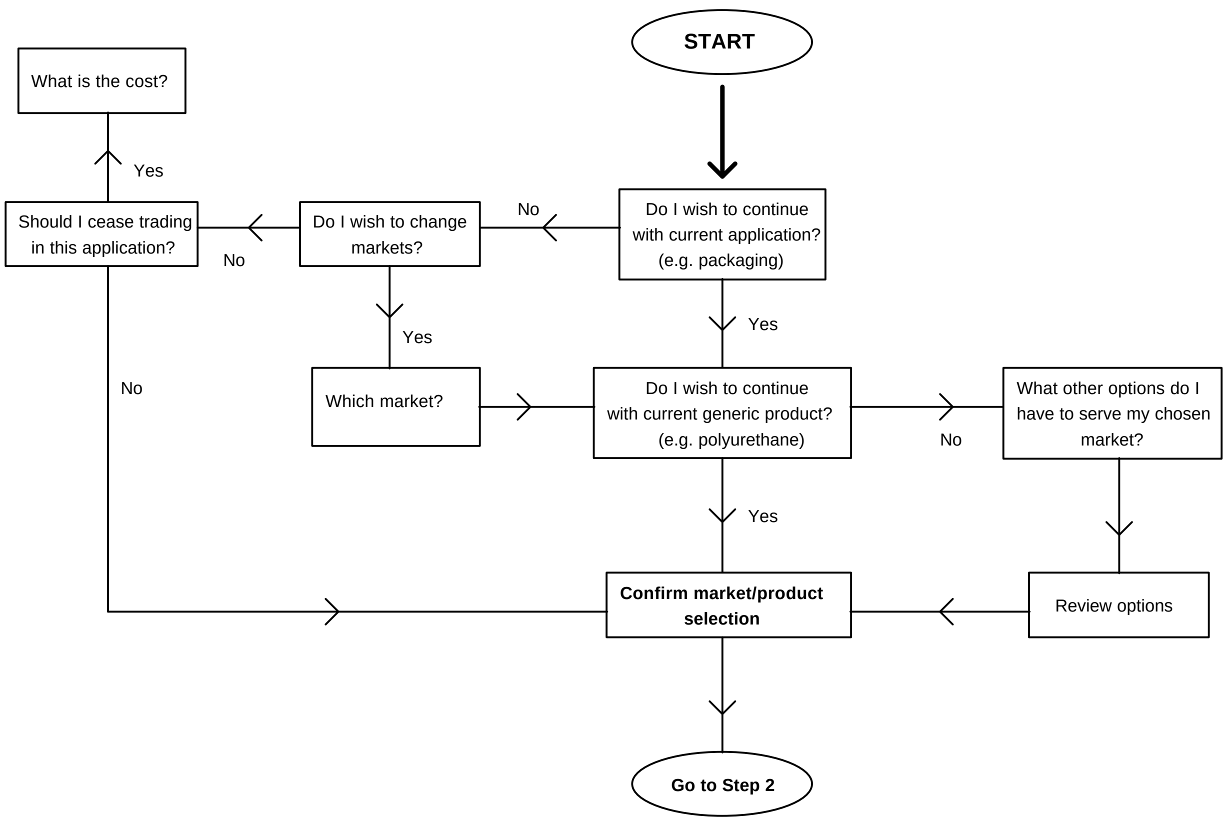
- Management must commit itself to the conversion policy and programme.
- Sufficient working capacity should be available for the implementation of the programme and a project team should be established.
- On the basis of the above points, a full project plan including objectives and schedules, should be prepared.

When you review your factory, also take the opportunity to examine possibilities for recycling and conservation of energy, raw materials, and waste.

The Decision Process

The following decision charts set out a methodology for assessing the way forward. It contains questions which will only be answered by more detailed consideration of specific options. Such considerations are outlined in more depth in the relevant product chapters.

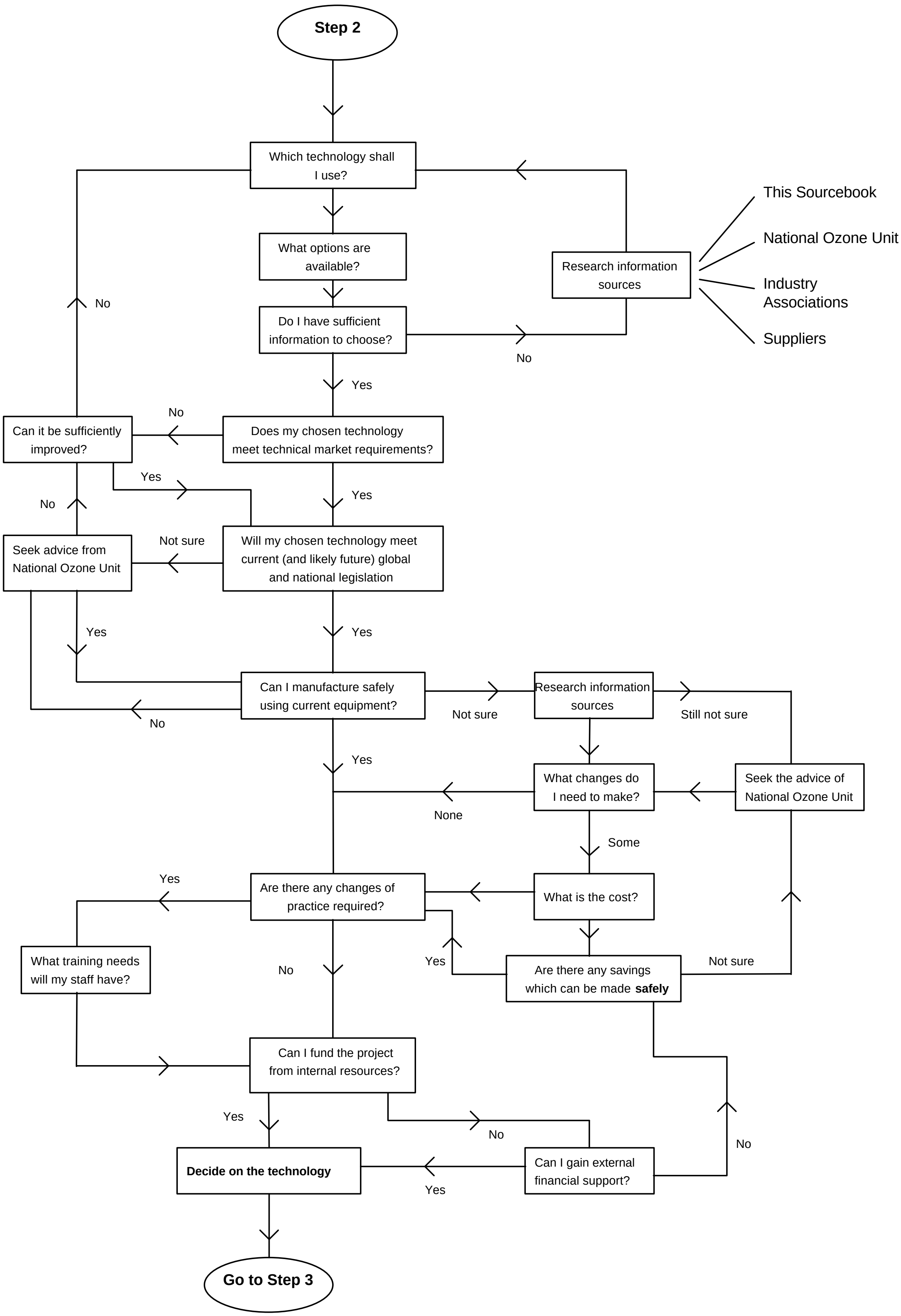
Step 1. **<u>Your Products and Markets</u>**



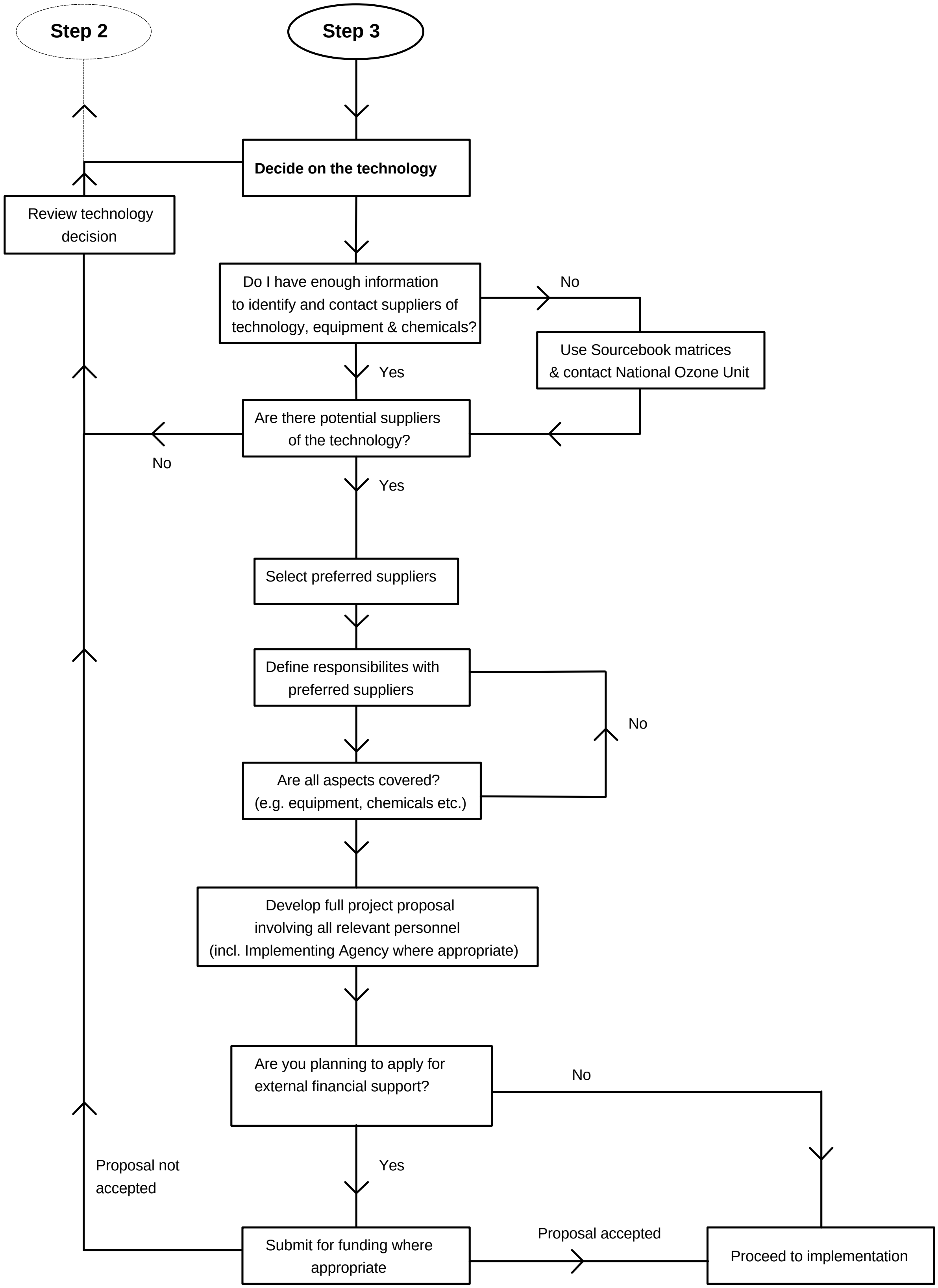
This part of the process may be a very short one if there are no changes in market or generic product type to be made. However, the discipline of considering you company's position on this wider basis is always useful before progressing to the more specific aspects of selection detailed overleaf.

Step 2 (overleaf) begins to develop the key decision points relating to technology - namely technical suitability, legislative compliance and safety in manufacture.

Step 2. Assessing the Technology Choices



Step 3. Sourcing the Chosen Technology & Developing the Project Plan



Overview of Candidate Blowing Agents

In general, the blowing agents can be divided into three groups, as shown below:

BLOWING AGENT TYPE

	DIRECT	**CHEMICAL**	**PHYSICAL**
FORM:	**Gas**	**Gas (In situ)**	**Liquid**
METHOD(S):	**Injected under pressure**	**Mixing reactants** **Thermal decomposition**	**Heat** **Reduced pressure**
EXAMPLES:	**Carbon Dioxide (PU)** **Carbon Dioxide (PO)** **Nitrogen** **Inert Gases (e.g. Helium)** **Some HCFCs & HFCs** **Butane & Propane**	**Carbon Dioxide (PU)** **Carbon Dioxide (PF)** **Nitrogen (Thermal)**	**Some HCFCs/HFCs** **Pentanes** **Methylene Chloride**

Table 1 overleaf gives some of the physical and environmental properties of various blowing agents under common consideration. For particulars on this issue, users are referred to suppliers' literature, the work of the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS) and the 1994 UNEP Report of the Flexible and Rigid Foams Technical Options Committee.

Table 1. Physical and environmental properties of some blowing agents.

	CFC-11	CFC-12	HCFC-22	HCFC-142b	HCFC-141b	Methylene Chloride	HFC-134a	Isopentane	Cyclo-pentane
Chemical formula	CFCl3	CCl_2F_2	$CHClF_2$	CH_3 $CClF_2$	CH_3CCl_2F	CH_3Cl_2	CH_2FCF_3	$CH_3CH(CH_3)$ CH_2CH_3	$(CH_2)_5$
Molecular weight	137	121	86	100	117	85	102	72	70
Boiling point °C	24	-30	-41	-10	32	40	-27	28	50
Gas Conduct. (mW/mK at 10°C)	7.4	10.5	9.9	8.4	8.8	N/A	12.4	13.0	11.0
Flammable limits in air vol %	None	None	None	6.7 - 14.9	7.3 - 16.0	None	None	1.4 - 7.8	1.4 - 8.0
TLV or OEL (ppm)	1000	1000	1000	1000	500	35 to 100	1000	1000	600
ODP	1.0	1.0	0.055	0.065	0.11	0	0	0	0
GWP	1.0	3.4	0.36	0.42	0.12	close to 0	0.25	< 0.001	< 0.001
ODP Class.	High	High	Low	Low	Low	Zero	Zero	Zero	Zero

Environmental considerations
It is difficult to find substitutes for ODSs which meet all of the technical requirements of a blowing agent whilst at the same time making a minimal impact on the environment. Some compromise is inevitably necessary and interim solutions may in some cases be the result.

When plant managers choose between blowing agent substitutes they should, in particular, consider the following:

<u>Global Issues</u>

Ozone-depleting potential
Some of the alternatives developed are HCFCs, for example HCFC-22, HCFC-141b, and HCFC-142b. However, these compounds contain chlorine and have both a measurable ozone depleting potential (ODP) and global warming potential, although significantly lower than that of CFCs. In spite of their ODP, HCFCs are regarded as substitutes for a transitional period in order to implement a rapid replacement of the more environmentally harmful CFCs. At the Fourth Meeting of the Parties to the Montreal Protocol in 1992 it was decided to phase out the use of HCFCs in developed countries over the period 2004-2030 and, as detailed in the Introduction, subsequent meetings have broadened this goal to include the phase out in developing countries by 2040. Consequently, industry should only use HCFCs where no more appropriate alternative exist and must develop and introduce alternatives for HCFCs as soon as is practicable .

Global Warming Potential
In addition to HCFCs, another class of CFC replacements are HFCs. These do not contain chlorine and hence have a zero ODP. Amongst the products currently available are HFC-134a and HFC-152a. Both of these were originally developed as CFC substitutes for refrigeration circuits. More HFCs are in the development phase. These include HFC-245, HFC-356, and HFC-365. However, these products, like HCFCs do have a measurable Global Warming Potential.

The global warming potential (GWP) of possible substitute blowing agents must be considered carefully, particularly for insulation foams. Some alternative products, although not having a global warming potential themselves, contribute indirectly to global warming by not having the same good insulating properties as other alternatives.

An example is the blowing of foam by means of CO_2 (water-blowing). This may result in an insulation material with higher thermal conductivity and thereby a lower insulating capability. This problem can, for example be solved by using an increased thickness of insulation to maintain the same insulating effect. If this is not feasible, the energy consumption throughout the lifetime of the product will be higher, due to the less effective insulation, giving rise to increased emissions of CO_2 and a further contribution to global warming. This phenomenon is captured in the concept of Total Equivalent Warming Impact (TEWI).

Total equivalent warming impact
The sum of the direct (direct emission of chemicals) and indirect (arising from the greenhouse gases, primarily CO_2 from energy production) emissions of greenhouse gases from the operation of a product, such as a domestic refrigerator is called the Total Equivalent Warming Impact (TEWI). In respect of insulation foam used in the construction sector, the comparative Total Equivalent Warming Impacts for various insulating materials are even more revealing and care should be taken to consider the net benefits of one insulation to the other as part of the technology selection process. More information about this can be obtained from the *Alternative Fluorocarbons Environmental Acceptability Study (AFEAS)* or UNEP IE.

<u>Local Issues</u>

Volatile organic compounds
Volatile organic compounds (VOCs) such as hydrocarbons can, through photochemical processes, contribute to the formation of ozone in the troposphere where it is harmful to both plants and animals and can cause the formation of smog. The extent to which this fact is significant will depend substantially on local conditions and resulting regulations. In some parts of the world legislation is strict on hydrocarbon use and the issue should be checked as part of any proposal to use hydrocarbons.

Health and Safety
Issues can be summarised as follows:

Toxicity and the working environment
Reasonable alternatives to the ozone depleting blowing agents should bring about an overall reduction of environmental damage and improvement of the working environment. The latter is, however, difficult when the generally inert character of CFCs is considered. Nonetheless, it is clear that significant new risks should be avoided where possible and managed properly where unavoidable.

Most chemical candidates have threshold limit values (TLVs) and occupational exposure limits (OELs) which define legally acceptable working limits and local legislation should be checked for any alternative blowing agents being considered.

Toxicity of substitute compounds to the ODSs is tested by, among others, the *Programme for Alternative Fluorocarbon Toxicity Testing, (PAFT)*. PAFT is a co-operative research effort sponsored by the leading ODS and alternative chemical producers. For further information on this programme manufacturers and producers can contact PAFT. The contact address can be found in Annex C. Most HCFCs have been reviewed together with HFC-134a under this programme and several other HFCs are also under evaluation by their potential producers.

Personal protective equipment should be reviewed to obtain sufficient protection for production with alternative blowing agents and other new substances necessitated by the alternative production.

Flammability
One of the technical advantages of CFCs is that they are not flammable. Partially flammable HCFCs can be used as alternative blowing agents, and fire and explosion hazards associated with these substances may involve changes in the processes and review of emergency procedures and safety and fire equipment (although the flammability of the HCFCs do not equal the flammability of hydrocarbons). Hydrocarbons (e.g. pentanes and cyclopentane) are highly flammable and the use of these substances in the production process demands extensive safety precautions.

To obtain the same fire properties of the final product when using hydrocarbons as blowing agent, the amount of flame retardants needs to be increased significantly. This may give rise to other environmental problems, such as waste management or the toxicity of fumes in a fire involving the product.

Flammability should also be considered with respect to transport, handling, and storage of the product. Increased ventilation may be necessary.

Technical considerations
Substitution of ODS-blowing agents with other and less environmentally harmful substances entails adjustments of systems and formulations to ensure optimum processing and end product quality.

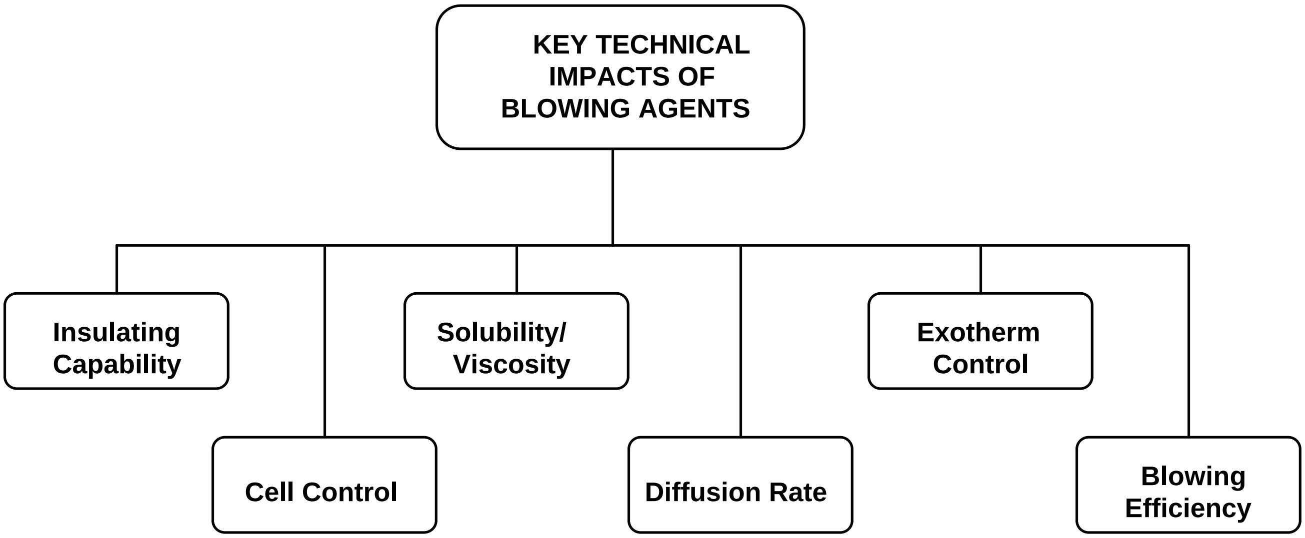
In this section some blowing agents are briefly reviewed, and the types of changes in quality and processes caused by new blowing agents are described. The specific chapters provide more detailed analysis of the effects of various options including individual data sheets in most instances. These provide existing examples of applied technology options for the specific foam types previously discussed.

Physical blowing agents should possess a range of attributes. For example they should be compatible with the polymer precursor, they must be chemically inert, and for insulation foams, they must have a low rate of diffusion in the polymer and possess a low thermal conductivity.

As an illustration, CFC-11 has for several years been the primary blowing agent for the urethane foam plastics industry. The successful use of CFC-11 is due to its physical and chemical properties, including a convenient boiling point, good insulation capacity, good solubility in the foam chemicals, chemically inert during the foaming process, and a low toxicity. In addition, CFC-12 and CFC-113 have been extensively used as blowing agents for other products such as polystyrene and phenolics.

Hydrocarbons continue to be used as blowing agents in many applications, for example n-pentane and its isomers, in expanded polystyrene foam. Among the halogenated hydrocarbons, methylene chloride is the most used for the production of flexible polyurethane foams.

In the following section, some key technical impacts of alternative blowing agents will be briefly reviewed, and production and quality problems indicated. These are shown schematically below:



Insulation capability
Elimination of the ODS-blowing agents in favour of other agents may often cause changes in the insulating capability of insulating foams. For example, the insulation capability of foams based on hydrocarbons are often lower than the insulation capabilities of CFC-based foams, and the flammability implies that special precautions have to be taken both in production and end-use.

A polyurethane foam blown with three different agents, i.e. CFC-11, CO_2, and atmospheric air, but otherwise identical, will show the following relative figures of heat transfer:

Blowing Agent	Relative Heat Transfer	Relative Thickness of Insulation
CFC-11 blown	1	1
CO_2 - blown	1.3	1.3
Atmospheric Air	1.8 - 2.0	1.8 - 2.0

Source: Rendan

In order to obtain the same insulation capability of the three foams, the thickness of the sheet must be increased as indicated.

Cell control and size
The manufacture of all high quality foams is dependent on maintaining good control of the cell formation process. This is achieved by a combination of surfactant chemistry, temperature control and the choice of blowing agent used with the polymer matrix. The effects can be seen in both visual and mechanical properties.

A particular benefit of such control is that the thermal conductivity of rigid insulation foams can be improved by reducing the foam cell size so as to reduce heat transfer by radiation across the cells. This technology can be applied in principle, to offset the higher gas conductivity of CFC-11 alternatives, at least in part, for rigid polyurethane insulating foams. This technology is based on the introduction of nucleating agents either in the form

of insoluble liquids or sparingly soluble gases, for example nitrogen or noble gases, or in the form of finely dispersed organic, inorganic, or metal powder.

Solubility/Viscosity
As explained in the previous section, substitution of the blowing agents can often result in changes in the mechanical properties unless appropriate measures are taken. As examples, CO_2-blowing (water-blowing) hardens flexible polyurethane foams. CO_2-blowing can (advantageously) harden rigid polyurethane foams but diffusion of CO_2 out of the foam can cause shrinkage (see *Diffusion Rates* section below).

However, some alternative blowing agents, such as HCFC-141b and cyclopentane, are more soluble in the solid foam matrices than CFC-11 and this can result in a softening of the foam and subsequent shrinkage. The problem needs to be counteracted by an increase in density of 10-20 percent.

Additionally, CFC-11 was advantageous as a blowing agent in that it had the capacity to reduce the viscosity of the foam mix at the early stages of processing, whilst becoming rapidly less soluble as the foaming reaction proceeded. This ensured that a good cell structure was achieved with optimum thermal performance, particularly if a nucleating agent was used. The problem with substitutes such as HFCs, HCFCs or hydrocarbons is that they tend to start either more soluble or less soluble than CFCs but without the change in solubility characteristics through the process. The trend has therefore been to use the less soluble options for better cell structure and sacrifice the mobility of the foam mix. This has necessitated the modification of equipment in certain instances to accommodate the increased viscosity.

Diffusion Rate
All blowing agents will eventually diffuse out to the atmosphere unless they are prevented from doing so by impermeable barriers such as steel facers on panels. However, the rate of diffusion of the various gases are very different varying from days in the case of CO_2 to hundreds of years for some CFCs, HCFCs, HFCs, and hydrocarbons. Another diffusion process is the ingress of air into the foam which takes place at an intermediate rate for polyurethane foams.

Unless CO_2-based foams are protected by an impermeable barrier the loss of CO_2 will result in a considerable (35-50 %) increase in thermal conductivity and can result in shrinkage for some foams. For materials at densities of 35 kg/m^3 and below, shrinkage can be prevented by a 10-20 % increase in foam density. However, above this density (e.g. foam for sandwich panels) no adjustment is required.

Air ingress into a polyurethane foam will increase the thermal conductivity by, typically, 30 % over a period of 6-12 months depending on its thickness. This process is effectively prevented by barriers such as an inner plastic liner in a refrigerator.

Products with foams based on CFC-11 with steel facers have been examined after many years of use and found to have retained their initial thermal conductivity.

Exotherm Control/antioxidants
Water-blowing of polyurethane foams is accompanied by heat generation, which may cause damage to flexible slabstock in the form of scorching. The reaction between polyols and isocyanates also generates heat, but CFCs and other halogenated blowing agents in the traditional foaming process can remove heat by endothermic evaporation.

Scorching causes discoloration of the foam and can also cause physical damage to the foam. It will often appear in the core of the foam, and may, in extreme cases, lead to self-ignition of the foam. It can be counteracted by the addition of antioxidants.and this can be necessary where the elimination of CFCs and increased water levels have increased the exotherm potential.

In the case of some phenolic foams, the water content of the system provides a limitation on the maximum permissible exotherm generation. If block exotherms exceed 90^oC the vapoure pressure of the steam so generated can cause cell damage. The exotherm is therefore controlled by moderating the reactivity of the chemicals and countering this by the addition of external heat.

Blowing Efficiency

The molecular weight/boiling point relationship is an important one for most blowing agents, since if the boiling point can be held in the required range using blowing agents with lower molecular weights the blowing efficiency is improved (i.e. less blowing agent is required to achieve a given density). This has benefit for both the economics of the process and the eventual environmental impact of the blowing agent itself.

Cost and availability

The economics of a potential alternative production process is extremely important for the evaluation of its practicability.

Ozone depleting blowing agents, in step with the phase-out of the production of these substances, will become more expensive. Because of this, alternative solutions, which at present may be more expensive than the traditional processes, are likely to be competitive within relatively short time. The implementation of the company's conversion programme can therefore be justified both in consideration of environmental protection and with reference to reliable supply of blowing agents.

It must also be recognised that the market for products produced with ozone depleting blowing agents will decline and eventually disappear. This means that the implementation of a conversion programme can be necessary for reasons of the survival of the company.

The availability of materials etc. may differ from country to country and the availability of the necessary raw materials, machinery, technical assistance, etc. should be considered carefully before decisions on conversions are taken. The Ozone Operations Resource Group (OORG)[1] at the World Bank have produced a series of Reports on, amongst other things, the availability of blowing agent alternatives across the world. Of course, differences in availability can introduce price differences between different parts of the world and these should be taken into account in reviewing any technology option.

Manufacturers and producers should consider the possibility of obtaining financial support to carry through a conversion programme. Developing countries which are Party to the Montreal Protocol and which meet certain criteria can apply to the Multilateral Fund to meet the incremental costs associated with replacement of ozone-depleting substances. For further information refer to Annex A and Annex C of this Sourcebook.

Regulatory considerations

The Montreal Protocol is a global agreement to which individual countries are signatories. All countries signed-up to the Protocol have to comply with the terms as a minimum. This does not preclude them from introducing specific national legislation which goes beyond the provisions of the Protocol itself. Accordingly, the reader must be aware of both the provisions of the Protocol itself and any national legislation prevailing.

A potential alternative blowing agent or an alternative chemical process should, in any event, conform to the legislation applying to the country in question. Regulations in countries to which the products are exported or to which export is being planned, should also be taken into account. Moreover, alternative blowing agents might present risks that involve legislation other than the environmental regulations covering chemical substances, for example transport and fire regulations.

Trade and handling of materials and chemicals are increasingly regulated by national and international law. Companies should keep abreast of developments and act accordingly.

[1] The Ozone Operations Resource Group (OORG) was assembled by the World Bank to provide specialised sector-based technical advice and assistance to the Bank in fulfilling its role as one of the four implementing agencies (with UNDP, UNEP and UNIDO) of the Multilateral Fund under the Montreal Protocol.

Flexible Polyurethane Foam

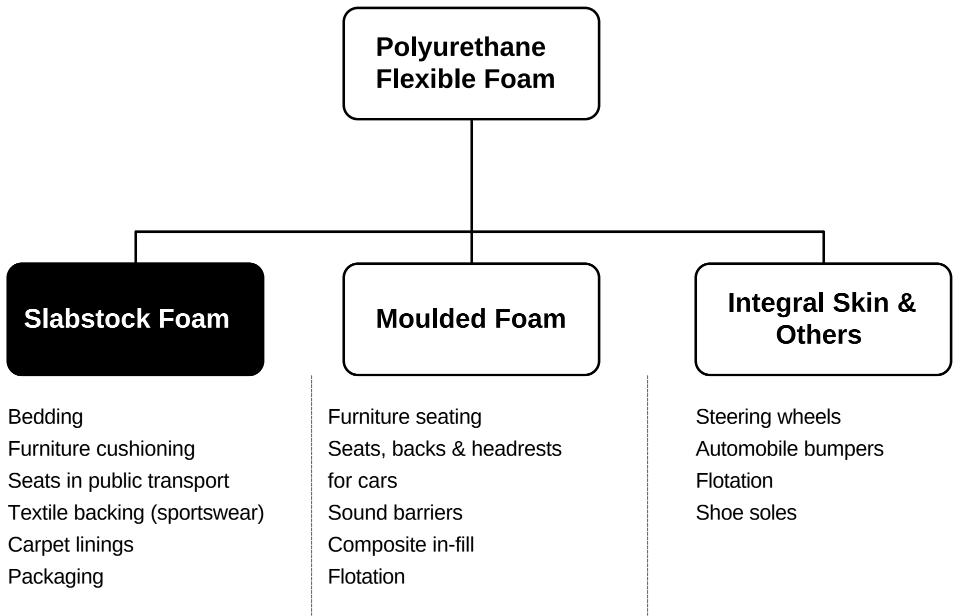
1 Flexible Polyurethane Foam

1.1 Flexible Polyurethane Foam - Slabstock Foam

Technical Options Overview

Description of Sector

The use of flexible polyurethane foams has developed in the past 40 years on the basis of their ability to meet the requirements of the cushioning (mostly furniture), packaging and safety products markets. This has been achieved through three predominant product types as shown below:



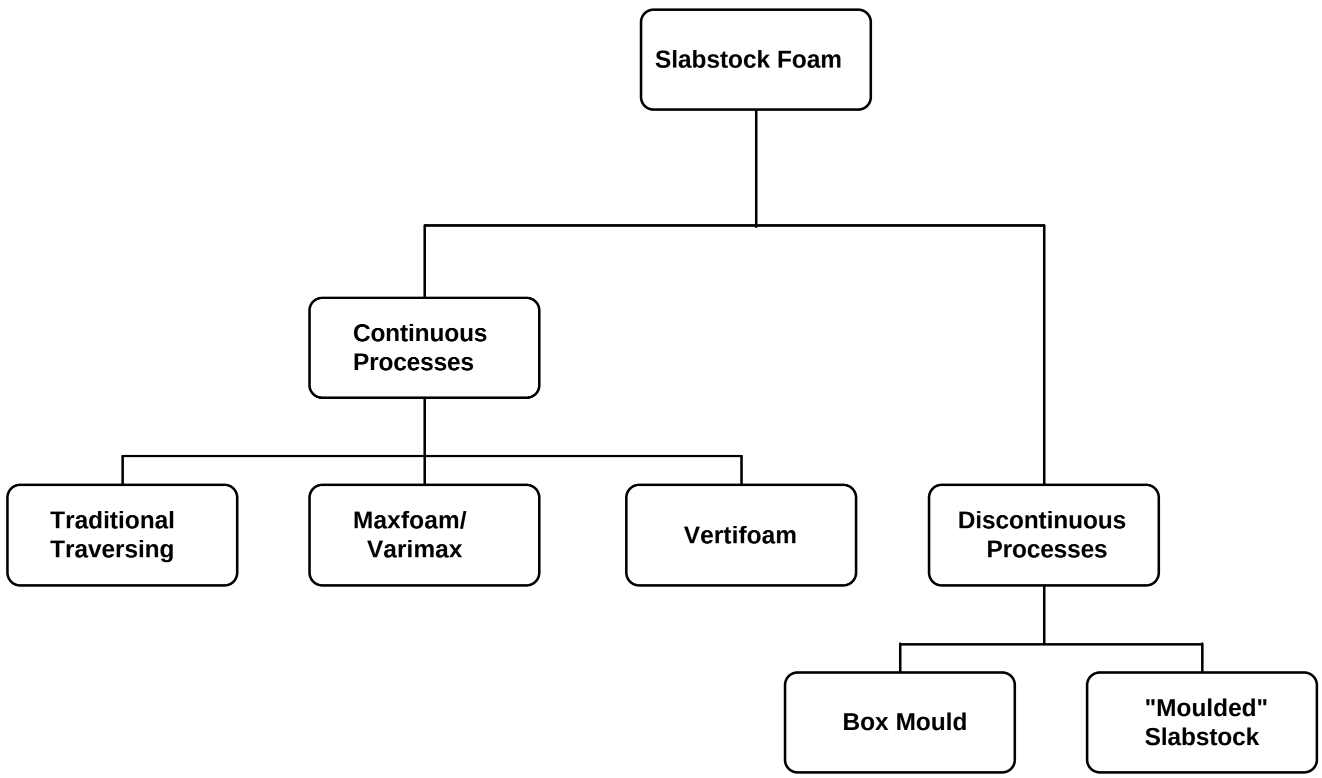
Slabstock Foam

Slabstock foams have tended to be lower density products and have found their main uses in cushioning and packaging applications. The density not only impacts on the cost of the products but also on their comfort. Density control has therefore always been a critical parameter for slabstock foams and CFCs have historically provided important versatility in this area.

Fire performance of these foams has also been a growing issue over the last 10-20 years and combustion-modified formulations are now common-place.

In seeking to replace CFC-use in slabstock foams, it has been necessary to either introduce alternative auxiliary blowing agents or to tighten the control over several process parameters to compensate. The situation is made more complex by the number of different processes which exist for slabstock foam. The range is shown schematically on the diagram overleaf.

The production processes commonly used for slabstock foams are shown below:



Summary of Available Technical Options

As mentioned above, CFCs have been used primarily as auxiliary blowing agents in slabstock foams across the range of processes indicated and hence phase out options in this sector do not tend to be process specific. These can be summarised as follows:

Methylene Chloride (dichloromethane - CH_2Cl_2)	-	Widely used option which is technically and commercially available today. The use of the product, however, requires some precaution because of its potential carcinogenic effect.
100% CO_2 (by reaction)	-	Requires changes in formulation and more frequently used with MDI-based formulations.
100% CO_2 (by injection - CarDio™)	-	A newly introduced technology showing substantial promise. Management of froth foaming may be a problem in some processes.
Acetone	-	Flammability and toxicity requires management. There are some drawbacks including the fact that its use is patented and requires a licence.

AB Technology	-	Based on CO_2 and CO as blowing agents, the latter is generated in-situ using formic acid. Because of carbon monoxide's toxicity, the process requires special equipment to ensure that local concentrations are avoided.
Reduced Pressure	-	Significant capital cost but highly efficient process. Product quality also improved.
Other processes not requiring auxiliary blowing agents	-	These include E-Max™, Envirocure™ & Rapid-Cure™ which all utilise enclosures and provide in some cases alternative cooling strategies.

<u>Less Preferred Options (measurable ODP)</u>

1,1,1 Trichloroethane (methyl chloroform)	-	Only an interim solution because of its agreed ODP. Costs are are higher than for methylene chloride and processing more difficult.
HCFCs	-	Only an interim solution. Several countries have regulated against their use and there is now a firm phase out proposal world wide.

Slabstock Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (1.11) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Flexible Polyurethane Foam chapter on page 1-67. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (1.12) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics)*** . Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 1. Contact the supplier to obtain detailed information.

Matrix 1.11 Suppliers which have provided detailed data sheets

Category of Techology, equipment or chemicals	Company	Alternative Technology						
		HFC	HCFC	Hydro-carbons	Methylene Choride	Carbon Dioxide	Water-blown	Other
Foam Manufacturer	Brdr. Foltmer A/s	X					X	
Polyurethane Systems	Bayer AG						X	
	Busing & Fesch		X				X	
	Elastogran	X	X	X			X	
	Enichem SpA							X
	ICI Polyurethanes						X	
	Shell Chemicals	X	X	X	X		X	
Flame Retardants	Allbright & Wilson	X	X	X	X		X	
Ancilliaries	Acmos Chemie.	X	X	X	X		X	
Machinery	Baxenden						X	
	Beamech			X				
	Cannon					X		

Matrix 1.12 *All suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albrecht Baumer KG		X			
Albright & Wilson				X	
Arco Chemicals	X				
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden		X			
Bayer AG	X				
Beamech Group Ltd		X			
Bomix Chemie GmbH					X
Borsodchem Rt. PUR Plant	X				
Busing & Fesch	X				
Cannon-Afros		X			
Cannon-Group		X			
Chem Trend A/S					X
Courtaulds Chemicals				X	
Crain Industries	X				
Crecimiento Industrial Co. Ltd		X			
Deltapur	X				
Dow Europe	X				
Elastogran	X				
EniChem SpA	X				
E.R. Carpenter Co.	X				
Fecken Kirfel		X			
FMC Corp. UK Ltd.				X	
General Foam	X				
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
Mica Machinery Ltd		X			
Nitroil Europe Handels GmbH	X				
Osi Specialities Inc.					X
Pelron/Ele	X			X	X
SAIP		X			
Shell Chemicals Europe Ltd	X				
Solvay Interox Ltd	X				
Sunkist Chemical Machinery		X			
Th. Goldschmidt AG					X
Tosoh Corporation	X				
TSE Industries					X
Unichema UK	X				

Slabstock Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Flexible Polyurethane Foam chapter on page 1-67 or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organised alphabetically by company name. After identifying a specific company in the matrix (1.13), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 1.13

Company	Alternative Technology				
	HFC	Methylene Chloride	Carbon Dioxide	Water Blown	Other
Brekke Industrial				X	
Brdr. Foltmar	X				
Cirrus AB					X
Domfoam Int.		X			
Dunlop		X			
Kayfoam-Woolfson		X	X		
Lystadun-Snaeland		X			
Norflex AB					X
Polyron		X			

<table>
<tr><td colspan="2">1. Company:

Name Brekke Industrier AS
Add. Øysand
N-7083 LEINSTRAND
Coun. Norway
Tel: +47 12 87 12 55
Fax: +47 12 87 2174
Telex: -
Contact T. Brekke, Executive Director.</td><td>Case Study Category 1.1 Flexible Polyurethane Slabstock

2. Products Flexible polyurethane foam, slabstock.</td></tr>
<tr><td>3. New Technology Applied</td><td colspan="2">CFC has been eliminated by substitution of water and a catalyst together with changes in the process. The production is carried out using the usual technology.</td></tr>
<tr><td>4. End product quality

Operational implications</td><td colspan="2">Density of the product is min. 23 kg/m^3.

Production of low-density products not possible.</td></tr>
<tr><td>5. Safety and Environmental issues</td><td colspan="2">The process has not required changes in the safety procedures.</td></tr>
<tr><td>6. Implementation, Operational and maintenance costs</td><td colspan="2">The new process has not involved implementation costs or additional costs for operation and maintenance.</td></tr>
</table>

1. Company:		**Category:** **Case Study**	**1.1** **Flexible Polyurethane Slabstock**
Name	**Brdr. Foltmar AS**		
Add.	Michael Drewsens Vej 11 DK 8270 Højbjerg		
Coun.	Denmark	**2. Products**	Flexible foam products e.g. mattresses etc.
Tel:	+45 8629 2311		
Fax:	+45 8929 2771		
Telex:	-		
Contact	Mr. Finn Mårtensson, vice dir.		

3. New Technology Applied	HCFC 141b was replaced by HFC as the blowing agent in continuous PUR manufacturing process. The technology is fully implemented with a scale of operation remaining the same as previous.
4. End product quality **Operational implications**	No new observations. The new technology requires higher temperature of the raw materials causing higher energy consumption.
5. Safety and Environmental issues	Increased fire risk with use of HFCs. High pressure handling is needed with blowing agent.
6. Implementation, Operational and maintenance costs	The new technology required US$ 126,000 investment, but no extra costs were incurred for operation and maintenance. Implementation was supported by raw material suppliers, Arco, Dow, Goldschmidt and Union Carbide.

1. Company:		**Case Study** **Category**	**1.1** **Flexible Polyurethane Slabstock**
Name	**Cirrus AB**		
Add.	Box 1007 S-57328 Tranås		
Coun.	Sweden	**2. Products**	Flexible polyurethane foam, slabstock.
Tel:	+46 0140 18000		
Fax:	+46 0140 14678		
Telex:	-		
Contact	Johnny Wendel, Technical Mger.		

3. New Technology Applied	The elimination of CFC-11 has been obtained by an increase in the product density to minimum of 21 kg/m^3. The use of special polyols and additives has made it possible to obtain sufficiently soft foam qualities. The technology is fully implemented.
4. End product quality	Only change is in density.
Operational implications	-
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	-

1. Company: Name **Domfoam International Inc** Add. 8785 Langelier Blud ST-Leonard, Que. Coun. Canada HIP 2C9 Tel: + 1 514 325 81 20 Fax: + 1 514 325 64 77 Telex: - Contact Walter Mackay, Technical Director.		**Category:** **1.1** **Case Study** **Flexible Polyurethane Slabstock** **2. Products** -
3. New Technology Applied	CFC-11 has been substituted by methylene chloride as a blowing agent (drop in). This is used with high pressure Hennecke foam machinery and Varimax low pressure machinery. The technology is fully implemented with a total production of approximately 6,300 tons of foam a year.	
4. End product quality **Operational implications**	The quality of the end product is the same as with the orginial process. The new process requires addition of a new catalyst specific to the use of methylene chloride. Small adjustments in the formulations. There are no changes in production rates material and energy consumption, waste generation, operating procedures or staff training requirements.	
5. Safety and Environmental issues	Health and safety requirements for methylene chloride must be noted; 50 ppm is not exceeded and requires monitoring.	
6. Implementation, Operational and maintenance costs	US$ 10,000 for new pumps but no changes in operational and maintenance costs.	

1. Company:	**Case Study Category**	**1.1 Flexible Polyurethane Slabstock**
Name **Dunlop Flexible Foams Group** Add. 36 Commercial Drive (BAG 1499) South Dandenog, Victoria, 3164 Coun. Australia Tel: + 61 3 9215 2020 Fax: + 61 3 9215 2015 Telex: - Contact Mr. D. Gilliver, Dunlop Flexible Systems.	**2. Products**	Polyurethane slabstock products in the range of 15 - 100 kg/m^3
3. New Technology Applied		CFC-11 replaced by methylene chloride as the blowing agent in a conventional PUR foaming process. Various softening agents have been added and the techniques have been modified <u>Original process</u> <u>New process</u> CFC-11 — Methylene chloride Polyols — "soft" polyols, softening additives, other techniques The technology has been fully implemented since July 1993, with a production of approximately 200 kg/minute per 1 hour day.
4. End product quality		No significant change in end product quality.
Operational implications		The technology uses half the quantity of methylene chloride in comparison with CFC-11 in the orginal process. Process rate of the new process is slightly increased, with no change in energy consumption. Machine flushing technique is changed. Increase demand for machine operator skills.
5. Safety and Environmental issues		The toxicity of methylene chloride requires :- implementation of process extraction control, additional personal protection/mechanised product handling systems. Reduction in airborne emissions and waste to landfill.
6. Implementation, Operational and maintenance costs		New process requires additional component metering units. Operational and maintenance costs have not changed significantly.

1. Company:		**Case Study Category**	**1.1 Flexible Polyurethane Slabstock**
Name	**Kayfoam - Woolfson Ltd.**	**2. Products**	Furniture and packaging
Add.	Bluebell Ind. Est. Dublin 12		
Coun.	Ireland		
Tel:	+ 353 0150 9055		
Fax:	+ 353 0156 2769		
Telex:	93783		
Contact	-		

3. New Technology Applied	CFC is substituted by CO_2 and methylene chloride as the blowing agents. Modifiers are used to reduce hardness. The technology is fully implemented, with an annual production of 5,500 tons.
4. End product quality	Some deterioration in the physical properties with low foam densities.
Operational implications	No technical constraints.
5. Safety and Environmental issues	Methylene chloride levels in the foam plant are restricted and must be below 100ppm.
6. Implementation, Operational and maintenance costs	No cost changes.

<table>
<tr><td colspan="2">1. Company:

Name Lystadún - Snæland HF
Add. Skútuvogi 11, Pósthólf 4113
IS-124 Reykjavík
Coun. Iceland
Tel: +354 91 814655/685588
Fax: +354 91 38312
Telex: -
Contact -</td><td>Case Study Category 1.1 Flexible Polyurethane Slabstock

2. Products Various products of flexible PUR slabstock foam.</td></tr>
<tr><td>3. New Technology Applied</td><td colspan="2">CFC-11 has been substituted by methylene chloride. Some other process modifications have been necessary. The technology is fully implemented with a polyol consumption of 600-1,200 kg per operation.</td></tr>
<tr><td>4. End product quality

Operational implications</td><td colspan="2">-

Up to 10% increase of silicone consumption is necessary.</td></tr>
<tr><td>5. Safety and Environmental issues</td><td colspan="2">No additional precautions are necessary. Use of TDI requires precautionary measures.</td></tr>
<tr><td>6. Implementation, Operational and maintenance costs</td><td colspan="2">-</td></tr>
</table>

1. Company:		**Case Study Category**	**1.1 Flexible Polyurethane, Slabstock**
Name	**Nordflex AB**		
Add.	Box 507 332 28 Gislaved		
Coun.	Sweden	**2. Products**	Polyurethane slabstock foam. Mattresses, cushions for furniture, automotive parts for interior design, sponges, products for household and industry.
Tel:	+46 371 84500		
Fax:	+46 371 82038		
Telex:	70131 Nordflex S		
Contact	Sven Damne, Chemial Engineering Manager.		

3. New Technology Applied	The elimination was obtained by substitution of chemicals and partly by process changes. Moreover, all products with a density lower than 21 kg/m³ were eliminated. Plasticisers were used and "soft" polyols were introduced. The production takes place in a Hennecke (UBT) slabstock foam machine, and no other blowing agents but water are used. All glues containing 1,1,1 trichloro-ethane have been exchanged for water-based or hot melt glues. The technology has been fully implemented since 1991 with a production of 5,500 tons per year.
4. End product quality	-
Operational implications	The plasticisers used give a less flexible foam, and special polyol and plasticisers can cause less resistance to physical stress. The production of low-density foam (<20 kg/m3) is not possible, and the process can give rise to scorching (discolouration). More efficient antioxidants are applied to counteract this.
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	Development costs are approximately US$ 100,000. No change in operational and maintenance costs.

1. Company:		**Case Study Category**	**1.1 Flexible Polyurethane Slabstock**
Name	**Polyron**		
Add.	Kibbutz Zikim, Ashkelon, 71140		
Coun.	Israel	**2. Products**	Furniture bedding, upholstery lamination for clothing and automobile industry,acoustics,packaging, flame lamination
Tel:	+ 972 7746 600-02-03		
Fax:	+ 972 7731 420		
Telex:	-		
Contact	Dan Caplan, Foam Production Mger.		

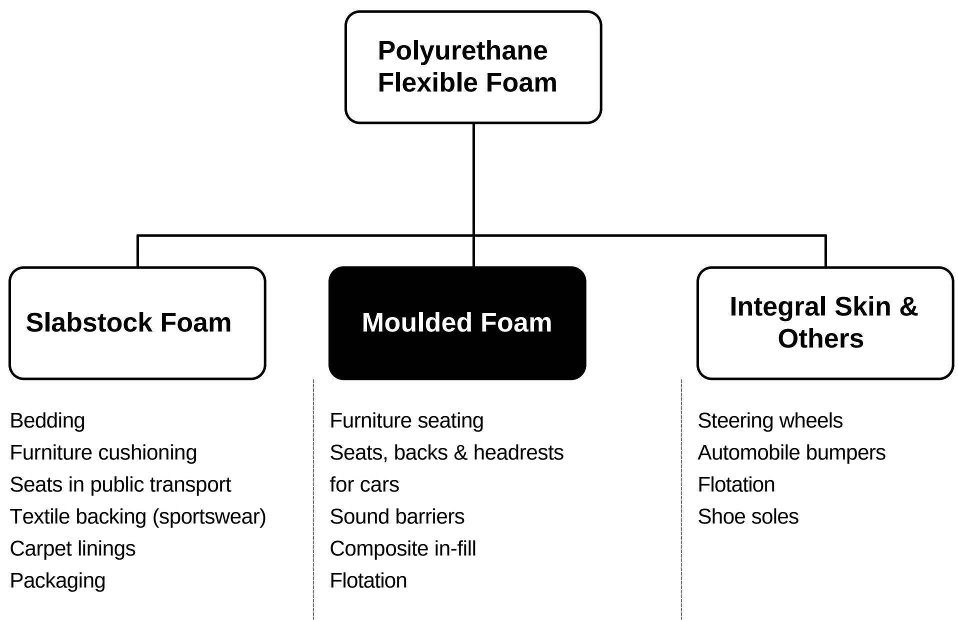
3. New Technology Applied	CFC was used as the blowing agent in a low pressure continuous PUR slabstock foaming process. To eliminate the use of CFCs in upholstery, polyurethane has been substituted with alternative soft materials. Substitution with methylene chloride, new polyol types and use of additives have also be implemented.
4. End product quality	The quality and appearance of the product is reduced.
Operational implications	Implementation of the new process requires personnel training. The technology requires additional equipment (eg pump, motor, piping, electronic).
5. Safety and Environmental issues	Safety issues associated with the technology are not known.
6. Implementation, Operational and maintenance costs	Additional equipment is about US$ 10,000. Operational and maintenance costs are not known.

1.2 Flexible Polyurethane Foam - Moulded

Technical Options Overview

Description of Sector

The use of flexible polyurethane foams has developed in the past 40 years on the basis of their ability to meet the requirements of the cushioning (mostly furniture), packaging and safety products markets. This has been achieved through three predominant product types as shown below:



Moulded Foams

Moulded foams tend to occupy the interim range of densities for applications where some load-bearing requirement exists (e.g. automotive and transport seating). However, the divide between this sector and that occupied by integral skin formulations is somewhat blurred since skin formation is a natural property of polyurethane systems when moulded. The key distinction is ultimately the control of the skinning process and the higher performance specification often demanded in the integral skin sector.

Moulded foams are typically produced using 'oyster' type moulds, where the mixed chemical reactants are poured into an open mould and the hinged lid is then shut until the foam rises and cures. There are variations in the process dependent on the end application but the most distinctive aspect of the process is the temperature of cure. Here, there are two broad categories:

	Share of world production	Applications
♦ **Hot Cure**	33%	Exclusively automotive seating & headrests
♦ **Cold Cure**	67%	Automotive and furniture

Summary of Available Technical Options

Several alternative technologies have been considered but water-blown systems are now predominating. There has also been reduction in CFC use by increasing foam densities for automotive applications. Flowability of the formulation can be a problem in such cases, however.

Moulded Foam Technology Matrices

<u>About the Matrices</u>

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

<u>How to Use the Matrices</u>

The ***first matrix*** (1.21) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the “Supplier Information - Data Sheets” at the end of the Flexible Polyurethane Foam chapter on page 1-61. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (1.22) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics)***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in “Supplier Information - Contacts” at the end of chapter 1. Contact the supplier to obtain detailed information.

Matrix 1.21 Suppliers which have provided detailed data sheets

Category of technology, equipment or chemicals	**Company**	**Alternative Technology**					
		HFC	**HCFC**	**Hydro-carbons**	**Methylene Chloride**	**Carbon Dioxide**	**Water-blown**
Polyurethane Systems	Bayer AG						X
	Busing & Fasch		X				X
	Elastogran	X	X	X			X
	ICI Polyurethanes						X
Flame Retardants	Allbright & Wilson	X	X	X	X	X	X
Ancilliaries	Acmos Chemie	X	X	X	X	X	X
Machinery	Baxenden						X
	Cannon					X	
	Krauss-Maffei		X	X			X

Matrix 1.21 *All Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
Arco Chemicals	X				
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden		X			
Bayer AG	X				
Bomix Chemie GmbH					X
Borsodchem Rt. PUR Plant	X				
Busing & Fasch Gmbh & CO.	X				
Beamech Group Ltd.		X			
Cannon-Afros		X			
Chem Trend A/S					X
Courtaulds Chemicals				X	
Crecimiento Industrial Co. Ltd		X			
Deltapur	X				
Dow Europe	X				
Elastogran GmbH	X				
EniChem SpA	X				
Hoescht AG				X	
Hoocker	X				
Krauss-Mafei		X			
ICI Polyurethanes	X				
Nitroil Europe Handels GmbH	X				
Osi Specialities Inc.					X
Pelron/Ele	X			X	X
Solvay Interox Ltd	X				
Shell Chemicals Europe Ltd	X				
Th. Goldschmidt AG					X
Tosoh Corporation	X				
TSE Industries					X
Townsend Chemicals Pty Ltd.	X				
Unichema UK	X				
Witco Corporation	X				

Moulded Foam Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Flexible Polyurethane Foam chapter on page 1-61, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company in the matrix (1.23), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix **1.23**

Company	Alternative Technology			
	HCFC	Methylene Chloride	Carbon Dioxide	Water Blown
Camatic Pty Ltd				X
Finnfoam-Eristeet	X			
Tanex Plasty a.s.				X

1. Company:

Case Study **1.2**
Category **Flexible Polyurethane Moulded**

Name	**Camatic Pty Ltd.**
Add.	93 Lewis Road Wantirna South, Victoria 3152
Coun.	Australia
Tel:	+ 61 03 8870 522
Fax:	+ 61 03 8870 018
Telex:	-
Contact	Mr. David Fisher, General Manager, Mr. Graeme Patching, Director G.V.U.T. Pty. Ltd.

2. Products -

3. New Technology Applied

The flexible foams were produced by pouring the liquid components, either through a bung hole or open pouring, into a die made from aluminium, epoxy, or glass reinforced polyester. CFC-11 was used to reduce the density and to soften the foam.

The reduction of CFC-11 has been achieved by process change and substitution of chemicals which was developed in house:

For higher density foams, CO_2 blowing is used as the only blowing method combined with delayed action catalyst. Low density foams demands further CO_2 blowing, another polyol, delayed action catalyst, and some methylene chloride.

	CFC-blown foams	CO_2-blown foams
Blowing agent	CO_2 and/or CFC-11	CO_2 and/or MECL
Isocyanate	MDI	MDI
Polyol	Polyether	Polyether (diff.)
Catalyst	Amines	Amines
Stabilizer	Silicone	Silicone

The share of CFC-free foams was zero in 1990, 60% in 1992 and 100% in 1993.

Soft foam density reduction development is almost complete.

4. End product quality

Harder foams are softer but slightly denser.

Operational implications

The production rates have not changed.

New polyol and catalysts are required. Rejects are lower. Waste amount is unchanged.

The operating procedures are not changed, and there is no change in training requirements.

Energy consumption increased through higher die temperatures.

5. Safety and Environmental Issues	There are certain problems regarding the toxicity of methylene chloride mainly because of insufficient legislation. Otherwise, no changes in safety procedures necessary.
6. Implementation, Operational and maintenance costs	The cost of production has reduced slightly (13% to 9.5%). No investment costs.

1. Company: Name **Finnfoam-Eristeet OY** Add. Joensuunkatu 2 SF 24100 Salo Coun. Finland Tel: +358 24 77 7300 Fax: +358 24 77 73020 Telex: - Contact -	**Case Study** **1.2** **Category** **Flexible Polyurethane, Moulded** **2. Products** Seats for buses etc.
3. New Technology Applied	The original process was a conventional PUR moulding process using CFC-11 as blowing agent. In the new process CFC-11 has been substituted although the identity of the blowing agent is undisclosed. The technology is fully implemented but regarded as a transitional solution.
4. End product quality **Operational implications**	No significant changes of the product quality. No significant waste problems. Consumption of raw materials and energy is approximately the same. Additional personnel training is required.
5. Safety and Environmental issues	No significant safety issues
6. Implementation, Operational and maintenance costs	The implementation costs are not specified, but operation costs are slightly higher.

1. Company:		**Case Study** **Category**	**1.2** **Flexible Polyurethane Moulded**
Name	**Tanex Plasty a.s.**		
Add.	Husova 249 551 01 Jaromer		
Coun.	Czech Republic	**2. Products**	Headrests, seats
Tel:	+ 42 4424 1111		
Fax:	+ 42 4423 591		
Telex:	194 552		
Contact	Mr. Jaroslav Kozak, Development Manager.		

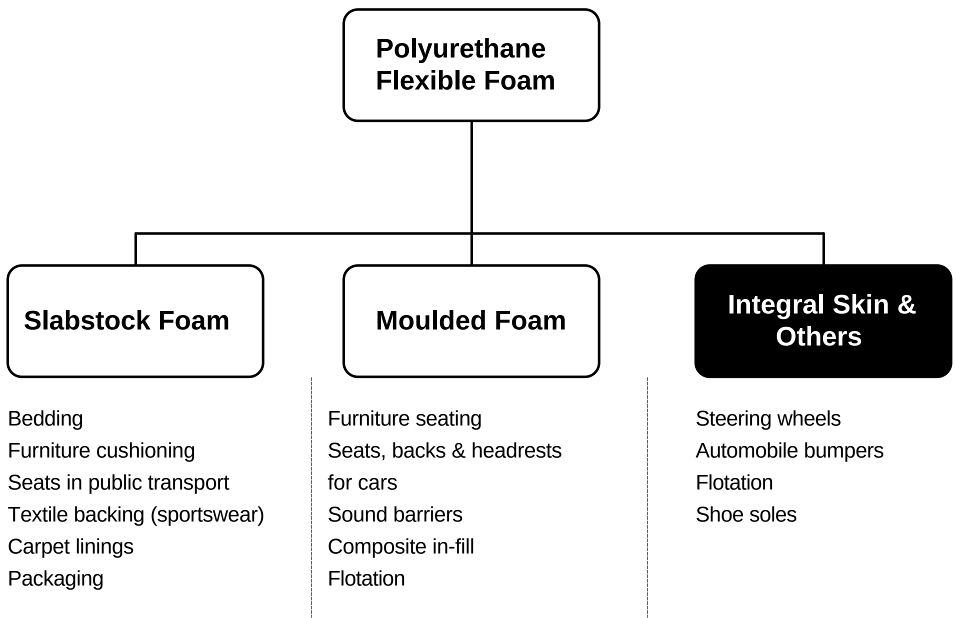
3. New Technology Applied	In the original process the production was carried out in high pressure foaming machines with CFC-11 as blowing agent. CFC-11 has been substituted by water. Blowing agent: Water Isocyanate: MDI Polyol: Polyether Catalyst: Amines This technology is considered to be the best solution. Production is running at 1.8 million pieces annually.
4. End product quality	The water blown foam has a thermal conductivity approximately 15 per cent higher than the CFC-blown foam.
Operational implications	The density of the water blown foams can be set at 45-70 kg/m^3 The production rate is reduced owing to the new technology. The new production requires new polyol types and an increased isocyanate consumption. The moulds have a higher temperature and pressure. The waste streams are unchanged.
5. Safety and Environmental issues	The new technology has not resulted in any changes in relation to safety issues.
6. Implementation, Operational and maintenance costs	The total costs including development, tests, moulds and other equipment has been approximately US$ 0.5 m. No data is available for operational and maintenance costs.

1.3 Flexible Polyurethane Foam - Integral Skin

Technical Options Overview

Description of Sector

The use of flexible polyurethane foams has developed in the past 40 years on the basis of their ability to meet the requirements of the cushioning (mostly furniture), packaging and safety products markets. This has been achieved through three predominant product types as shown below:



Integral Skin Foams

Integral skin foams are moulded foams, and they are manufactured either by injection into closed, vented moulds (as in the case of steering wheels) or into open moulds (as is the case with shoe soles). These foams are characterised by a high density outer skin and a low density, softer core. The density gradation results from a combination of:

(a) blowing agent condensation at the mould surface

and

(b) over-packing of the mould

Parts with tight dimensional tolerances can be produced when high density, microcellular foams are moulded. This process is commonly known as RIM (Reaction Injection Moulding). In this case, the microcells are formed from nucleated air and also from small amounts of CO_2.

Most flexible integral skin foams are open cell. However, where rigid foam formulations are used, closed cell products can result.

Summary of Available Technical Options

Technical options to eliminate CFCs are more limited than for slabstock or moulded applications. This is primarily as a result of the higher performance requirements in safety applications. The options can be summarised as follows:

Preferred

Pentane	-	Used primarily in Europe & Canada at the moment for armrest production.
All H_2O	-	Still some problems in reaching the same physical properties as CFC and HCFC-blown foams but this route is anticipated to be the future for many integral skin applications.
HFC-134a	-	Usable in several applications. Liquid HFCs may also be an option in the future.
Molecular Sieve	-	This involves the water trapped in a micro porous structure being released via heat of reaction during the foaming process. With the isocyanate no longer available for reaction, the water vapour condenses at the mould surface, forming a thin skin.

Less Preferred Options (measurable ODP)

HCFCs 22 & 141b	-	Widely used, since the skin is relatively thick and its surface sufficiently smooth for painting. Some parts of the world permit HCFC use for safety applications only and some original equipment manufacturing (OEM) specifications cannot be met without their use.

Integral Skin Foam Technology Matrices

<u>About the Matrices</u>

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

<u>How to Use the Matrices</u>

The ***first matrix*** (1.31) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Flexible Polyurethane Foam chapter on page 1-67. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (1.32) lists all known suppliers: these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics)*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 1. Contact the supplier to obtain detailed information.

Matrix 1.31 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology					
		HFC	HCFC	Hydro-carbons	Methylene Chloride	Carbon Dioxide	Water-blown
Polyurethane Systems	Bayer AG						X
	Busing & Fasch		X				X
	Elastogran	X	X	X			
	ICI Polyurethanes						X
Flame Retardants	Albright & Wilson	X	X	X	X	X	X
Ancilliaries	Acmos Chemie	X	X	X	X	X	X
Machinery	Baxenden						X
	Cannon					X	
	Krauss-Maffei		X	X			X
	Impianti OMS	X	X	X			X

Matrix 1.31 *All Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**	**Ancilliaries**
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Arco Chemicals	X				
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden		X			
Bayer AG	X				
Bomix Chemie GmbH					X
Borsodchem Rt. PUR Plant	X				
Busing & Fasch GmbH & CO.	X				
Cannon-Afros		X			
Chem Trend A/S					X
Crecimiento Industrial Co. Ltd		X			
Deltapur	X				
Dow Europe	X				
DuPont de Nemours Int. S.A.			X		
DuPont Chemicals			X		
Edulan A/S	X	X			
Elf Atochem SA			X		
Elastogran GmbH	X				
EniChem SpA Polyurethane	X				
FMC Corp. UK Ltd				X	
Gusmer Inc		X			
Hoocker	X				
ICI Polyurethane	X				
Isothane Ltd	X				
Krauss-Maffei Kunstofftechnik		X			
La Roche Chemicals			X		
Isotherm AG		X			
Nitroil Europe Handels GmbH	X				
Osi Specialities Inc.					X
OMS Impianti Group		X			
Pelron/Ele	X			X	X
SAIP		X			
Solvay Interox Ltd	X				
Solvay Fluor und Derivate			X		
Shell Chemicals Europe Ltd	X		X		
Th. Goldschmidt AG					X
Tosoh Corporation	X				
TSE Industries					X
Townsend Chemicals Pty Ltd.	X				
Unichema UK	X				
Witco Corporation	X				

Integral Skin Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to "ozone friendly" alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Flexible Polyurethane Foam section on page 1-67, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organised alphabetically by company name. After identifying a specific company in the matrix (1.33), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 1.33

Company	Alternative Technology				
	HFC	Methylene Chloride	Carbon Dioxide	Water Blown	Other
Gallino Comp.	X				
Tanex Plasty a.s.				X	

1. Company:		**Case Study Category**	**1.3 Flexible Polyurethane Integral Skin**
Name	**Gallino Componenti Plastici S.p.A.**		
Add.	Via L. Einaudi, 154 10040 - Rivalta (Torino)		
Coun.	Italy	**2. Products**	Steering wheels, rear spoilers
Tel:	+ 39 (011) 90 28 1		
Fax:	+ 39 (011) 90 91 960		
Telex:	215050 GALPLA		
Contact	-		

3. New Technology Applied	HCFC-22 was originally used as the blowing agent for conventional moulding of polyurethane integral skin. HCFC-22 has been replaced by HFC 134a. This technology is fully implemented. This involves a consumption of approximately 20 tons HFC 134a per year, producing a total of 1000 tons for 1995.
4. End product quality **Operational implications**	- -
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	-

1. Company: Name **Tanex Plasty a.s.** Add. Husova 249 551 01 Jaromer Coun. Czech Republic Tel: + 42 4424 1111 Fax: + 42 4423 591 Telex: 194 552 Contact Mr. Milan Patzelt, Development Manager.	**Case Study Category** **1.3 Flexible Polyurethane Integral Skin** **2. Products** Various parts, spoilers, armrests etc.
3. New Technology Applied	CFC-11 has been substituted by water in high pressure foaming machines. Where necessary, CFC-11 is substituted by HCFC-22. Blowing agent: CFC-blown foam: CFC-11; CO_2-blown foam: Water Isocyanate: MDI; MDI Polyol: Polyether; Polyether Catalyst: Amines; Amines The technology is considerated to a transitional solution. 1.4 million pieces are produced per year.
4. End product quality **Operational implications**	The water blown foam has a thermal conductivity approximately 15 per cent higher than that of CFC-blown foam. The density of the water blown foam is higher than that of CFC-11 blown foams. The production rate is reduced by 20 per cent owing to the new technology. The new production requires new polyol types and an increased isocyanate consumption. The moulds have higher temperature and pressure.
5. Safety and Environmental issues	The waste streams are unchanged.
6. Implementation, Operational and maintenance costs	The total costs including development, tests, moulds and other equipment have been approximately US$ 0.4 m. No exact data is available for operational and maintenance costs.

	CFC-blown foam	CO_2-blown foam
Blowing agent:	CFC-11	Water
Isocyanate:	MDI	MDI
Polyol:	Polyether	Polyether
Catalyst	Amines	Amines

1.4 Supplier Information

<u>About the Supplier Information</u>

This section includes all of the known suppliers of technology, equipment and chemicals for this sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in *Supplier Data Sheets.*

<u>How to Use this Information</u>

Part 1: Contacts provide a ***comprehensive contact list for all suppliers,*** including both those which contributed Data Sheets as well as those that did not. This section is organised sequentialy into PU Systems, Machinery, Blowing Agents, Flame Retardants and Anxcilliary and within these sections, alphabetically by company name. After locating a specific supplier, contact the company to obtain detailed information.

Part 2: Data Sheets contain ***detailed process information when provided by the supplier.*** These sheets contain data that can help you better evaluate a particular technical option. This section is organised sequentially into Foam manufacturers, Polyurethane Systems, Blowing Agents, Flame Retardants, Ancilliary and Machinery, and within these sections, alphebetically by company name. After locating and reading the specific data sheet, contact the supplier to obtain additional information.

DISCLAIMER

Please note that the information contained in the Data Sheets is of a commercial nature and it is up to the reader to verify any claims about performance, safety, costs, etc. made by the company. UNEP IE in no way endorses or recommends any company, product, process or claims referred to in these Data Sheets, as they are provided for information purposes only.

PART 1 - CONTACTS

PU Systems

Air Products and Chemicals Inc.
Chemical Products Group
7201 Hamiltion Boulevard
Allentown, PA 18195-1501
United States
Tel. (1) 610-481-6799
Fax. (1) 610-481-4381
Main Products: Amine & tin catalysts, silicone & other surfactants, release agents etc.

Arco Chemical Co.
3801 West Chester Pike
Newtown Square
PA 19073-2387
USA
Tel. (1) 610 3592000
Fax. (1) 610 3592722
Main Products: Polyols & polyurethane systems

BASF AG
Intermediates Marketing
67056 Ludwigshafen
Germany
Tel.
Fax. (49) 621-60-20805
Main Products: Amine catalysts, chain extenders

Bayer AG
51368 Leverkeusen
Germany
Tel. (49) 214-301
Fax. (49) 214-306-6411
Main Products: Polyurethane systems

Borsodchem Rt. PUR Plant
H-3702 Kazincbarcika P.O.B. 208
Hungary
Tel. (36) 48-310-211
Fax. (36) 48-310-277
Main Products: Polyols & MDI

Busing & Fasch GmbH & Co.
Zum Damm 6
26180 Rastede
Germany
Tel. (49) 4402-1065
Fax. (49) 4402-1064
Main Products: Polyurethane systems

Crain Industries
P.O. Box 6478
Forth Smith, Arkansas, 72903
United States
Tel. (1) 501-648-3230
Fax. (1) 501-648-3745
Main Products: Envirocure technology

Deltapur
36065 Mussolente (VI)
Via Dante Alighieri, 27/B
Italy
Tel. (39) 424-579511
Fax. (39) 424-579500
Main Products: Polyurethane systems

Dow Europe
Bachtobelstrasse 3
CH-8810 Horgen
Switzerland
Tel. (41) 1 728-2818
Fax. (41) 1 728-2096
Main Products: Polyurethane systems

Edulan A/S
Jens Olsens Vej 3
DK-8200 Aarhus N
Denmark
Tel. (45) 86-10-90-90
Fax. (45) 86-10-92-88
Main Products: Polyurethane systems and equipment

Elastogran GmbH
Systems Division
Geiselbullach Factory
Industriestrasse 1
D - 82140 Olching
Germany
Tel. (49) 81-42-1780
Fax. (49) 81-42-178-213
Main Products: Flexible, spray & insulation systems

EniChem SpA Polyurethane
Via Taramelli, 26
20124
Milan
Italy Tel. (39) 2-69771
Fax. (39) 2-6977-8183
Main Products: Polyurethane Systems

E.R. Carpenter Co.
5016 Monument Avenue
Richmond, Virginia, 23230
United States
Tel. (1) 804-3-59-08-00
Fax. (1) 804-3-58-99-43
Main Products: Flexible PU foam technology

General Foam
PMC Division
W. 100 Century Road
Paramus
New Jersey, 07652
United States
Tel. (1) 201-262-7500
Fax. (1) 201-262-3159
Main Products: 'Rapid Cure' Technology

Hoocker (Synthesia Espanola)
62 Conde Borrell Street
08015 Barcelona
Spain
Tel. (34) 3-325-77-50
Fax. (34) 3-426-46-82
Main Products: Polyols & polyurethane systems

ICI Polyurethanes
Everslaan 45
3078 Everberg
Belgium
Tel. (32) 2-758-9211
Fax. (32) 2-759-5501
Main Products: Polyurethane systems

Isothane Limited
Newhouse Road
Huncoat Business Park
Accrington
Lancashire BB5 6NT
United Kingdom
Tel. (44) 1254-872555
Fax. (44) 1254-871522
Main Products: Polyurethane systems

Nitroil Europe Handels GmbH
Zippelhaus 1-2
D - 20457
Hamburg
Germany
Tel. (49) 40-325-6560
Fax. (49) 40-325-65616
Main Products: Amine catalysts

Pelron/Ele Corporation
7847 West 47th Street
Lyons, 60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols, amine catalysts, flame retardants & silicones

Shell Chemicals Europe Ltd
Shell Centre
London
SE1 7NA
England
UK
Tel. (44) 171 9341234
Fax. (44) 171 9343359
Main Products: Polyurethane systems & hydrocarbon blowing agents

Solvay Interox Ltd
Caprolactones Business Unit
Baronet Works - Baronet Road
Warrington
Cheshire, WA4 6HB
United Kingdom
Tel. (44) 1925-651277
Fax. (44) 1925-232207
Main Products: CAPA polyols

Tosoh Corporation
Fine Chemicals Division
PU Catalysts International Group
1-7-7, Akasaka, Minato-ku
Tokyo
Japan
Tel. (81) 3-3585-9891
Fax. (81) 3-3585-5556
Main Products: Amine catalysts

Townsend Chemicals Pty Ltd.
114-126 Frankston-Dandenong Road
P.O. Box 1009
Dandenong
Victoria 3175, Australia
Tel. (61) 3-9793-6000
Fax. (61) 3-9794-0723
Main Products: Footwear, urethane systems

Unichema UK
Bebington
Wirral
Merseyside L62 4UF
England
UK
Tel. (44) 151 6452020
Fax. (44) 151 6459197
Main Products: Polyester Polyols

Witco Corporation
Polyester/Polyurethane Group
One America Lane
Greenwich
CT 06831-2559
United States
Tel. (1) 203-861-6277
Fax. (1) 203-861-6323
Main Products: Polyester Polyols, coating resins

Machinery

Albrecht Baumer KG
Asdorfer Strasse 96-106
D-57258 Freudenberg
Germany
Tel: (49) 2734-450
Fax: (49) 2734-3056
Main Products: Block handling and cutting equipment

Beamech Group Limited
Tenax Road
Trafford Park
Manchester, M17 ?UT
United Kingdom
Tel. (44) 161-848-0316
Fax. (44) 161-873-7718
Main Products: VPF and other PU and PF equipment

Cannon-Afros
Via Galileo Ferraris, 65
21042 Caronno Pertusella (Varese)
Italy
Tel. (39) 2-96531
Fax. (39) 2-9656897
Main Products: PU metering and mixing equipment

Cannon-Viking
Viking House, Unit 1
Parkway Trading Estate
Barton Dock Road, Stretford
Manchester, M32 OTL
Tel. (44) 161-866-9909
Fax. (44) 161-866-8808
Main Products: Slabstock and Lamination Plants

Crecimiento Industrial Co. Ltd.
Office No. 348
Chien Teh St.
40107 Taichung
Taiwan
Republic of China
Tel. (886) 4-2116453
Fax. (886) 4-2111543
Main Products: Post-applied facing laminators, PU Dispensers, Batch mixers, Cutting equipment

Edulan A/S
Jens Olsens Vej 3
DK-8200 Aarhus N
Denmark
Tel. (45) 86-10-90-90
Fax. (45) 86-10-92-88
Main Products: Polyurethane systems and equipment

Fecken Kirfel
Goebbelgasse 1-15
Postfach 725
Aachen
D52008
Germany
Tel. (49) 2 41182020
Fax. (49) 2 411820213
Main Products: Machinery - cutting

Gusmer Inc.
One Gusmer Drive
Lakewood
New Jersey, 08701
United States
Tel. (1) 908-370-9000
Fax. (1) 908-905-8968
Main Products: Spray foam, panel & integral skin equipment

Isotherm AG
PUR-Anlagenbau
Aarestrasse 13,
CH-3627
Heimburg
Switzerland
Tel. (41) 33-379393
Fax. (41) 33-375019
Main Products: Spray and injection dispensers

Krauss-Maffei Kunstofftechnik GmbH
Krauss-Maffei-Strasse 2
80997 Munchen
Federal Republic of Germany
Tel. (49) 89-88-99-0
Fax. (49) 89-88-99-31-51
Main Products: PU - Panel, injection & spray machinery

Mica Machinery (Sales) Ltd
Mica House
Hyde Road
Denton
Manchester M34 3AJ
United Kingdom
Tel: (44) 161-320-3356
Fax: (44) 161-320-3356
Main products: cutting and granulating machinery

OMS Impianti Group
via Sabbionetta 4
20050 Verano Brianza
Milano
Italy
Tel. (39) 362-983-1
Fax. (39) 362-900581
Main Products: Flexible & rigid PU foam equipment

SAIP
Via Bressanella, 3
22044 Romano Di Inverigo
Como.
Italy
Tel. (39) 31 605762
Fax. (39) 31 606934
MainProducts: Polyurethane dispensing equipment

Sunkist Chemical Machinery Ltd.
10th Floor, 200 Kingshan S. Road, Sec 2
Taipei
Taiwan
Tel. (886) 2-395-56686
Fax. (886) 2-321-7266
Main Products: Flexible foam equipment, cutting & laminating

Blowing agents

Allied Signal
20 Peabody Street
Buffalo
New York, 14210
United States
Tel. (1) 716-827-1407
Fax. (1) 716-827-6275
Main Products:HCFC-141b, HFC-245a

Elf Atochem SA
4 Cours Michelet-Cedex 42-92091
Paris
La Defense 10
France
Tel. (33) 1 49007425
Fax. (33) 1 49007021
Main Products: Blowing Agents-HCFC 141b, 142b, 22, HFC 134a

DuPont Chemicals
Customer Service Centre
B-15305
Wilmington
DE 19898
United States
Tel. (1) 302-774-2099
Fax. (1) 302-774-2370
Main Products: Blowing Agents - HFC 134a, HCFC141b

DuPont de Nemours Int. S.A.
2 Chemin du Pavillion
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel. (41) 22-717-5111
Fax.
Main Products: Blowing Agents - HFC 134a, HCFC141b

La Roche Chemicals
P.O. Box 1031
Baton Rouge
Louisiana 70821
United States
Tel. (1) 800-248-6336
Fax. (1) 504-652-9945
Main Products: HCFC-141b

Shell Chemicals Europe Ltd
Shell Centre
London
SE1 7NA
England
UK
Tel. (44) 171 9341234
Fax. (44) 171 9343359
Main Products: Polyurethane systems & hydrocarbon blowing agents

Solvay Fluor und Derivate
Hans-Bockler-Allee 20
D-30173 Hannover
Germany
Tel. (49) 511-8570
Fax. (49) 511-817338
Main Products: HCFC-141b, HCFC-142b, liquid HFC development

Flame Retardants

Albright & Wilson UK Ltd.
210-222 Hagley Road West
Oldbury
Warley
West Midlands B68 0NN
United Kingdom
Tel. (44) 121 420 5117
Fax. (44) 121 420 5545
Main Products: A & W Amgard range for PU foam

Akzo Chemicals B.V.
Stationsplein 4
P.O. Box 247
3800 AE Amersfoort
The Netherlands
Tel. (31) 676-767
Fax. (31) 676-150
Main Products: Phosphorus-based flame retardants

Courtaulds Chemicals
Water Soluble Polymers
PO Box 5
Spondon
Derby, DE21 7BP
United Kingdom
Tel. (44) 332-661422
Fax. (44) 332-280610
Main Products: Phosphate-based fire retardants

FMC Corp. UK Ltd.
Process Additives Division
Tanex Road
Trafford Park
Manchester M17 1WT
Tel: (44) 161 872 2323
Fax: (44) 161 873 7271
Main Product: Phosphate-based flame retardants

Hoescht AG
Business Unit Additives
Marketing Flame Retardants &
Performance Chemicals
D-65926
Frankfurt
Germany
Tel. (49) 69-305-2317
Fax. (49) 69-305-15671
Main Products: Phosphate-based flame retardants

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols,amine catalysts, flame retardants & silicones

Ancilliaries

Air Products and Chemicals Inc.
Chemical Products Group
7201 Hamiltion Boulevard
Allentown
PA 18195-1501
United States
Tel. (1) 610-481-6799
Fax. (1) 610-481-4381
Main Products: Amine & tin catalysts, silicone & other surfactants, release agents etc.

Bomix Chemie GmbH
Gildeweg 6-10
48291 Telgte
Germany
Tel. (49) 2504-9240
Fax. (49) 2504-1542
Main Products:PU coatings, lacquers and release agents

Chem-Trend A/S
Smedeland 14
DK 2600
Glostrup
Denmark
Tel. (45) 42-45-67-11
Fax. (45) 43-63-03-50
Main Products: Mould release agents

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols, amine catalysts, flame retardants & silicones

Th. Goldschmidt AG
Goldschmidtstrasse 100
D-45127 Essen
Germany
Tel. (49) 201 173 01
Fax. (49) 201 173 2691
Main Products: Range of silicone release agents, amine & tin catalysts, foam stabilisers, colour pastes

TSE Industries
5260 113th Avenue North
Clearwater
Florida 34620
United States
Tel. (1) 800-237-7634
Fax. (1) 813-572-0415
Main Products: Water-based mould release agents

PART 2 - DATA SHEETS

1. Company:		**Data Sheet** **Category**	**1.4** **Foam Manufacturer**
Name	**Brdr. Foltmar A/S**		
Add.	Holmensvej 9 3600 Frederikssund		
Coun.	Denmark	**2. Products**	PUR, Polyether, Polyether, CMHR
Tel:	+ 45 4231 1616		
Fax:	+ 45 4231 1700		
Telex:	-		
Contact	A. Kronborg Hensen		

3. Original process	In some foam grades, CFC-11 was used as an auxiliary blowing agent. This was especially the case for low density and soft grades.
4. Reduction/elimination method	All low and high density foams are produced fully waterblown. HCFC is now obsolete.
5. Implications of the new technology	
End product quality	Low index recipes give rise to an increased number of “smell incidents”. Low density foams produced with low index technology are less elastic and have higher compression set values than the same grades blown with CFC-11.
Operational implications	-
6. Scale of operation	-
7. Technical constraints	-
8. Restrictions of technology	-
9. Stage of technology	The technology is fully implemented.
10. Level of commercialization	The technology is commercially available.
11. Investment costs	The development costs have been approx. US$ 500,000. No costs required to implement the technique used at Foltmar A/S Frederikssund.
12. Operational and maintenance costs	These costs are unchanged.
13. Safety issues	Fully waterblown foams show a higher risk of self-ignition. Extraordinary monitoring of temperature necessary.
14. Development of technology	The technology has been developed independently by Brdr. Foltmar A/S.

15. Other	-

1. Company: Name **Bayer AG** Add. 51368 Leverkusen Coun. Germany Tel: +49 0214/30-1 Fax: +49 0214 30-66411 Telex: 85101-0 by d Contact local Bayer AG sales offices.	**Data Sheet Category** **1.4 Suppliers of Polyurethane Systems** **2. Products** Raw materials for polyurethane foams, foaming component systems and foaming machinery. Bayer AG is a supplier of a wide range of systems specific for each application: - Flexible PUR foams - Integral PUR foams - Rigid foams
3. Original process	The original systems were based on CFCs.
4. Reduction/elimination method	The elimination methods are based on a number of solutions specific for each application. The new technologies are based on alternative process equipment, redesign of the products, substitution of chemicals, process modification, etc. The most important systems are: Foam system — Alternative blowing/insulation agent Flexible PUR foams — CO_2 Integral PUR foams — CO_2, HCFCs, pentane Rigid foams — CO_2, HCFCs, HFCs, pentane, cyclopentane Where no drop-in solution has been possible, modified or new equipment for processing has been developed. Except for HCFC-141b, which offers a "drop in solution" most other alternatives require modification of existing equipment/installations. In general, there is no change in isocyanates, whereas polyol formulations are adapted to the blowing agent. Except for CO_2 the quantity and ratio of the main components equal CFC-technologies.
5. Implications of the new technology	This depends on the choice of CFC-free foam system.
End product quality	-

	Operational implications	-
6.	**Scale of operation**	-
7.	**Technical constraints**	This depends on the choice of CFC-free foam system.
8.	**Restrictions of technology**	-
9.	**Stage of technology**	The technologies are fully implemented.
10.	**Level of commercialization**	Raw materials and machinery are commercially available. Raw materials and machinery are being widely used by the industry.
11.	**Investment costs**	This depends on the choice of CFC-free foam system.
12.	**Operational and maintenance costs**	This depends on the choice of CFC-free foam system.
13.	**Safety issues**	Pentanes are flammable and require appropriate safety precautions.
14.	**Development of technology**	Bayer AG is one of the major producers of raw materials for polyurethane foams and have intensively been engaged in the development of alternative blowing agents and appropriate foam systems for each application.
15.	**Other**	-

1. Company: Name **Büsing & Fasch GmbH & Co.** Add. Zum Damm 6, 26180 Rastede Mail Postfach 1504, 26173 Rastede Coun. Germany Tel: +49 04402/1065 Fax +49 04402/1064 Telex Contact Dipl. Ing. Lutz Ohmstede.	**Data Sheet Category** **1.4 Suppliers of Polyurethane Systems** **2. Products** Chemicals for polyurethane foam systems: Rigid polyurethane insulation foams, flexible moulded foams and integral skin foams used for insulation, in the motor industry, in the furniture industry etc.

3. Original process	Büsing and Fasch GmbH & Co. is a supplier of polyurethane systems, selling systems on the base of polyols. Isocyanates are exclusively sales products. Chemicals are purchased, and polyurethane systems are produced by mixing the polyols and additives. The composition of the polyurethane systems depends on the final use and function of the product, and each system has a special formula.
4. Reduction/elimination method	The new blowing agents are pentane and HFC 134a. New polyether polyols are used.
5. Implications of the new technology	
End product quality	The end product quality depends on the specific application.
Operational implications	The waste stream generation and composition has not changed.
6. Scale of operation	-
7. Technical constraints	-
8. Restrictions of technology	There are no restrictions.
9. Stage of technology	-
10. Level of commercialization	The technology is commercially available.
11. Investment costs	Basic equipment for pentane: approx. US$ 330,000 Basic equipment for HFC-134a: approx.: US$ 330,000-660,000 US
12. Operational and maintenance	Unknown

costs	
13. Safety issues	There is a risk with hydrocarbons (pentane) so safety devices must be considered. No risks form HFC-134a.
14. Development of technology	The technology has been developed in cooperation with Bayer AG and other producers of foaming systems.
15. Other	-
16. Additional information	Other producers: Bayer AG and Bereich PUR.

1. Company:		**Data Sheet** **Category**	**1.4** **Suppliers of Polyurethane Systems**
Name	**Elastogran (BASF)**		
Add.	Geschäftsbereich Halbzeug und Bauteile Werk Lemförde Postfach 1160 D-2844 Lemförde		
Coun.	Germany	**2. Products**	Foaming components systems, and foaming machinery. Systems for: Flexible moulded foam, semi rigid foam, packaging foam, rigid foam for appliances, sandwich panels, district heating pipes, spray foam, slabstock, and insulating panels. Flexible integral skin foam, shoe soles.
Tel:	+49 5443/120		
Fax:	+49 5443/12456		
Telex:	-		
Contact	-		

3. Original process	In the original process CFC-11 was used as a blowing agent.
4. Composition of plastic foam	The new blowing agents in place of CFC-11 are HCFC-22, HCFC-22/142b mixture, HCFC-141b, HFC-134a, n-pentane, isopentane, cyclopentane, water, or combination of two or more of these blowing agents. The other ingredients include polyether or polyester polyols, cross linkers, silicone surfactants, flame retardants, catalysts, and pigments. The isocyanate component may be polymeric MDI or a pre-polymer of monomeric MDI or a mixture of both. The other ingredients are the same as used previously, although different grades are required to achieve properties as close to the original material as possible.
5. Implications of the new technology **End product quality** **Operational implications**	In general some deterioration in most properties including insulation, compression strength, compression set, skin formation and flame retardancy is expected. Changes in production rates are not expected. Waste generation and composition, and energy requirements are not expected to be changed, but an increase in consumption of isocyanates and flame retardants is expected. Special procedures to add gaseous and flammable blowing agents is needed, and continuous training of personnel is required.
6. Scale of operation	Batch-production of 200 kg - 20 tons.
7. Technical constraints	Many of the CFC-free formulations have tighter processing

	parameters than their CFC-containing predecessors.
8. Restrictions of technology	Regarded highly confidential, but no patents.
9. Stage of technology	The processes are fully implemented, but is still under further planning and developing.
10. Level of commercialization	Most of the technology is commercially available (some in limited quantities, e.g. up to 1 ton batches). Much of the technology is being applied already, though some users maintain the old CFC-technology as long as possible.
11. Investment costs	Confidential information.
12. Operational and maintenance costs	Confidential information.
13. Safety issues	Flammable blowing agents (e.g. pentanes) pose serious risks.
14. Development of technology	Technology development in co-operation between members of the BASF/ELASTOGRAN Group.
15. Other	-

1. Company:		**Data Sheet**	**1.4**
Name	**Enichem S.p.A.**	**Category**	Suppliers of Polyurethane Systems
Add.	Via Taramelli 26 20124 Milano		
Coun.	Italy	**2. Products**	-
Tel:	+ 39 2 6977 8263		
Fax:	+ 39 2 6977 8072		
Telex:	-		
Contact	see 16.		

3. Original process	In the original process, high levels of CFC or other halogenated solvents were used for making slabstock foams of densities below 21 Kg/m^3. Using only H_2O as the foaming agent in this density range, causes the severe hazard of self combustion of the foam.
4. Reduction/elimination method	The elimination of CFC/HCFC was obtained by the substitution of the base polyol with Tercaflex 99, a new semiformulated polyol containing a blend of water and a propreitary non halogenated, non dangerous foaming agent.
5. Implications of the new technology	
End product quality	No scorch effects and excellent physical properties down to 17 Kg/m^3 density.
Operational implications	It is substantially a drop-in substitution of the previous polyol with minimum variations of the original water and silicon surfactant levels.
6. Scale of operation	Full industrial production and application.
7. Technical constraints	In some cases, depending on the foamin plant characteristics, VOC emission levels above local permitted values are measured from the chimneys.
8. Restrictions of technology	Worldwide patent coverage.
9. Stage of technology	No major developments anticipated.
10. Level of commercialization	Approximately 800 ton/month is currently sold, principally in Italy and Western Europe.
11. Investment costs	No investment is required for the introduction of the new technology (in case VOC emission levels are locally acceptable).
12. Operational and maintenance costs	Significant savings registered by foam manufacturers due to low cost of Tercaflex 99 vs the high costs (and availability problems) of CFC/HCFC to be substituted.
13. Safety issues	Possible VOC emissions (see 7)
14. Development of technology	EniChem S.p.A. - Polyurethane Division Only
15. Other	-

16. Additional Information	Contacts Mr. GF. Lunardon/EniChem/P. Marghera (VE) - Tel +39 412913734 Mr M. Migliorini/EniChem/Milano - Tel +39 2 6977 8034 Mr G.C. Battiston/EniChem - Plascofoam/Cardano al Campo (VA) Tel +39 331 269202

1. Company:		**Data Sheet Category**	**1.4 Suppliers of Polyurethane Systems**
	ICI Polyurethanes		
Add.	Everslaan 45 3078 Everberg		
Coun.	Belgium	**2. Products**	Raw materials for foaming systems. ICI is a supplier of chemicals for a wide range of CFC-free foams and foaming systems: - Rigid PUR, appliance insulation, sprayed, slabstock, poured-in-place - Rigid laminated polyisocyanurate foam - Flexible PUR slabstock, moulded - Integral skin foams
Tel:.	+32 2 758 9211		
Fax:	+32 2 759 5501		
Telex:	26151 ICIEVB B		
Contact	Dr. Mike Jeffs, Belgium, or local sales offices.		

3. Original process	ICI Polyurethanes previously supplied a range of systems using CFC-11 for rigid PUR, e.g. appliance insulation, sprayed, slabstock, poured-in-place, rigid laminated polyisocyanurate foam and flexible moulded PUR. Systems were also supplied for integral skin foams. ICI Polyurethanes did not supply chemicals or systems for flexible slabstock foam.
4. Reduction/elimination method	Elimination of CFC was obtained by product redesign, substitution, and alternative use pattern. The substitution methods within the foam sectors were as follows: Rigid polyurethane foams: Substitution of CFC and system optimization with HCFC and HFC, pentane, or CO_2 (water-isocyanate reaction). Flexible slabstock: Proprietary Waterlily technology (water-blown). Integral skin foam: Water, HCFC, or hydrocarbon blown. Moulded flexible foams: Water (CO_2) Proprietary isocyanates and polyols are used. Rigid foam systems for use with HCFC-141b, HCFC-22/HCFC-142b, HFC-134a, isopentane, n-pentane, and cyclopentane. Integral skin foam systems use HCFC-141b or isopentane. The other foam systems are water blown (CO_2).
5. Implications of the new technology	

	End product quality	For rigid foams the insulation capacity is retained with HCFC-141b and cyclopentane as the blowing agent. HFC-134a causes up to ten per cent increase in thermal conductivity. The insulation values for the other agents are intermediate.
	Operational implications	The Waterlily technology gives a new and better level of comfort. The production rate resulting from the new technologies has not been changed significantly. The new technologies have not given rise to any changes in the waste streams with the exception that the waterlilly technology gives the possibility of recycling. The new systems have not caused significant changes in the raw material consumption rates except increased isocyanate usage in rigid foams through increased water co-blowing. New safe procedures are essential when hydrocarbons are used. Training of the staff is required and can be provided by ICI Polyurethanes. The new technologies do not cause changes in energy consumption.
6.	**Scale of operation**	World scale chemical production units.
7.	**Technical constraints**	There are no technical constraints.
8.	**Restrictions of technology**	Waterlily flexible slabstock technology is proprietary. ICI holds numerous other patents.
9.	**Stage of technology**	The technologies are fully commercially available.
10.	**Level of commercialization**	All the technologies are either in production or in advanced pre-production trial stage.
11.	**Investment costs**	For gaseous blowing agents, equipment modifications on scale of US$ 50,000 are necessary. Safe precautions for implementation with hydrocarbons may cost more than US$ 1 m depending on factory size.
12.	**Operational and maintenance costs**	Only minor changes in operational and maintenance costs. More information about that can be obtained from contact names.
13.	**Safety issues**	No significant changes are necessary regarding toxicity. Precautions necessary due to flammability of hydrocarbons. Full safety information is available from ICI Polyurethanes.
14.	**Development of technology**	The technologies have been developed in-house by ICI Polyurethanes.
15.	**Other**	-

1. Company Name **Shell Chemicals Europe Ltd** Add. Shell Centre London SE1 7NA Coun. United Kingdom Tel +44 71 934 6108 Fax: +44 71 934 3359 Telex: - Contact Mr. J. Vandichel, Market Development Manager.	**Data Sheet Category** **1.4 Suppliers of Polyurethane Systems** **2. Products** Additives and additive polyols for flexible polyether polyurethane slabstock

3. Original process	-
4. Reduction/elimination method	Shell has developed technologies for CFC elimination in most application areas of polyurethanes. However, our business interests outside Europe are confined to flexible polyurethane slabstock foams and hence our ability to service our customers and supply the necessary know-how are also thus confined. Modification of polymer morphology is carried out either through the addition of small quantities of a softening additive to basic formulation, or substitution of part of the standard polyol quantity by an additive polyol.
5. Implications of the new technology	
End product quality	Same as previous quality or improved
Operational implications	Minimal, can be used on most machines with no or minor changes.
6. Scale of operation	Fully commercial
7. Technical constraints	None
8. Restrictions of technology	Shell patent application on additive (Carapor 2001™) technology
9. Stage of technology	Fully commercial
10. Level of commercialization	Products commercially available
11. Investment costs	Minimal
12. Operational and maintenance costs	-
13. Safety issues	-
14. Development of technology	Ongoing

15. Other	-

1. Company:		**Data Sheet Category**	**1.4** **Suppliers of Flame Retardants**
Name	**Albright & Wilson UK Ltd.**		
Add.	210-222 Hagley Road West Oldbury, Warley West Midlands B68 0NN		
Coun.	United Kingdom	**2. Products**	Fire retardants for polyurethane foam systems.
Tel:	+44 121 4205117		
Fax:	+44 121 4205545		
Telex:	336291 Albriw G		
Contact	-		

3. Original process	For use in rigid foams, standard flame retardants such as Tris Mono Chloroisopropyl Phosphate (TMCP) were effective where CFCs were the blowing agents. CFCs are inherently flame retardant and also act as viscosity suppressors. High efficiency, viscosity reducing flame retardants were not normally used as standard. In the flexible foam industry, CFCs not only acted as blowing agents but also had a cooling effect on the urethane reaction in the centre of the block. The elimination of CFCs has resulted in a new emphasis on foam quality, such as discolouration (scorch) and automotive standards.
4. Reduction/elimination method	For use in rigid foams, Albright & Wilson have developed a range of higher efficiency flame retardants to meet the new challenges of non-CFC blown faoms. The AMGARD V490 range (V490, V485, V475, V4000) is a group of products which can be used in water, 141b or pentane blown systems to meet a range of standards such as BIN4102 B2 & B3. LOIs of 22.4% to 2.8% can also be achieved. The products are halogen free, efficient and 2K system stable. In addition they all posses a degree of viscosity suppression which is vital due to the widespread use of highly viscous polyester polyols. In the flexible foam industry, Albright & Wilson have developed a range of flame retardants specifically designed to meet the new challenges of non-CFC blown systems. Our range includes those which meet international and automotive standards, low fogging products and products where low scorch is important.
5. Implications of the new technology	
End product quality	The new generation of flame retardants, such as the AMGARD V490 range have enabled foam manufacturers to continue to supply the rigid foam industry and to meet the flammability standards demanded by the customer. The AMGARD range of flame retardants fo flexible foams have enabled foamers to produce foams of better quality then previously.
Operational implications	The viscocity suppression properties of the AMGARD V490 range have aided the use of more inherently flame retardant, high

	viscocity polyester polyols in rigid foams.
6. Scale of operation	All products offered for both rigid and flexible foams are in full commercial production.
7. Technical constraints	None.
8. Restrictions of technology	AMGARD V490 is covered by the Australian Convention. To sample or supply countries who are not members of the Convention, Albright & Wilson has to apply for an Export Licence. For countries who are members of the Convention, Albright & Wilson require an end-user statement before sampling or supply of the product.
9. Stage of technology	Albright & Wilson are committed tocontinuing the development of new, halogen free products for both the flexible and rigid foam industries. These new developments will be designed to meet more severe standards in rigid foam and improve efficiency, scorch performance and fogging in flexible foam. In all cases the impact on the environment, both in terms of the raw material and also recycling of the finished foam is considered.
10. Level of commercialization	Our products are sold throughout Europe, Asia and North America.
11. Investment costs	None required.
12. Operational and maintenance costs	Slight increases in total formulation costs may be seen. However, due to the increased efficiency of the new flame retardants, and care choice of other additives in the formulation, then these costs can be kept to a minimum. In the flexible foam industry there may be some slight increases in overall formulation costs. However, this does mean that our customers can meet flammability and functional standards demanded.
13. Safety issues	Please apply to Albright & Wilson for a copy of the relevant Health & Safety datasheet.
14. Development of technology	Development is inhouse: Albright & Wilson Polyurethane Flame Retardants Technical Service and Albright & Wilson International Technical Centre.
15. Other	We offer a comprehensive range of flame retardants for use in both rigid and flexible polyurethane foams. The range includes 8 products for rigid foams and 13 products for flexible. Of the latter, there are three low fogging additives and one antistatic. We also offer two plasticisers in the AMGARD range namely AMGARD TBEP and TOF.
Additional Information	Please see our list of worldwide offices and production sites.

1. Company:		**Data Sheet Category**	**1.4** **Suppliers of Ancilliaries**
Name	**Acmos Chemie GMBH & CO.**		
Add.	P.O. Box 10 10 69 28010 Bremen		
Coun.	Germany	**2. Products**	Release agents for polyurethane foam systems
Tel:	+ 42 151890		
Fax:	+ 42 1511415		
Telex:	245116 acoms d		
Contact	-		

3. Original process	In former times the carrier medium used in relase agents was alternatively freon R11 or 1,1,1-trichloroethane. For the demoulding of polyurethane foam systems a release agent has to be applied to avoid the tearing or breaking of moulded parts when taken out of the mould. The ideal release agent uses a carrier medium which is neutral in smell, non-flammable and has a very high volatility to flash-off quickly. R11 and 1,1,1-trichloroethane (with exception to smell) were ideal solvents for the purpose of release agents.
4. Reduction/elimination method	1. Substitution of R11 or 1,1,1-trichloroethane by highly volatile hydrocarbons for example hexan. Disadvantage: extremely flammable with a flash-point below 0^oC. 2. Substitution of R11 or 1,1,1-trichloroethane by methylene chloride or a blend of methylene chloride with hydrocarbons. Disadvantages: odour, human health risks, and restrictions of 50ppm in the workplace in many countries. 3. Introduction of high solids eliminating the carrier medium and dissolving the active substances in a low volatile hydrocarbon with a flash-point of more than 60^oC and therefore with almost no risk of flammable vapours. The amount applied to the moulds are reduced by upto 90%. The results are achieved with a cheap air assisted spraygun witha 0.3 mm nozzle (spraygun approx. US$ 300,000). 4. Waterbased products: substitution of R11 and 1,1,1-trichloroethane as carrier medium by water. Spraying method has to be adapted.
5. Implications of the new technology	
End product quality	Normally the end product quality is higher or at least equivalent.
Operational implications	The process parameters have more restricted tolerances. The sprayguns have to be adapted.
6. Scale of operation	The process is proved to be cost neutral and introduced in several plants worldwide including underdeveloped countries.
7. Technical constraints	In applying the release agent, certain care has to be taken. Training in the operation of the spraygun is therefore needed. The

	technology and the products are available at ACMOS or ACMOS representatives worldwide.
8. Restrictions of technology	None.
9. Stage of technology	Fine tuning of the technology is carried out whenever the client has specific requirements.
10. Level of commercialization	The technology is available worldwide. In Germany, ozone depleting solvents are banned in the use of release agents.
11. Investment costs	Approx. US$ 300,00 per spray unit. Depending on the pumps and valves, another US$ 1,000 might need to be invested to adjust the pumps and the valves to the restricted process parameters.
12. Operational and maintenance costs	No specific maintenance costs is required. In the beginning, the operational costs might be higher. After a week or two, productivity has no restrictions in terms of speed.
13. Safety issues	There is a risk of flammability with the use of low volatile hydrocarbons thus safety measures have to be considered. In the case of using methylene chloride the maximum concentration allowable in the workplace must be appropriate to local regulations.
14. Development of technology	Development was carried out between ACMOS and some key clients.
15. Other	-

1. Company:		**Data Sheet Category**	**1.4 Suppliers of Foam Machinery**
Name	**Baxenden Scandinavia A/S**		
Add.	Fuldbyvej 4 Pedersborg DK-4180 Sorø		
Coun.	Denmark	**2. Products**	PUR, machinery, component system
Tel:	+45 53 63 33 33		
Fax:	+45 53 63 49 66		
Telex:	40 101 Isoform		
Contact	H Nygaard		

3. Original process	The foam was blown with CFC-11 and CFC-12.
4. Reduction/elimination method	The use of CFC-11 and CFC-12 was reduced by product redesign, process modification, and substitution of chemical components. The content of CFC-11 and CFC-12 has been eliminated.
5. Implications of the new technology	
End product quality	The quality of the new and the old product does not differ significantly.
Operational implications	The production rate as well as the quality are unchanged. Operating procedures have been changed, but the new operating procedures are considered trade secrets. There are no additional requirements for staff training. Energy consumption is unchanged.
6. Scale of operation	-
7. Technical constraints	None.
8. Restrictions of technology	The technology is not patented.
9. Stage of technology	The technology is fully implemented.
10. Level of commercialization	The technology is commercially available.
11. Investment costs	The investment costs are considered trade secrets.
12. Operational and maintenance costs	These costs are considered trade secrets.
13. Safety issues	The new products might have lower hygienic limits and contain flammable constituents.
14. Development of technology	The technology is developed independently by Baxenden Scandinavia A/S.
15. Other	-

1. Company:		**Data Sheet Category**	**1.4** **Suppliers of Foam Machinery**
Name	**Beamech Group Ltd.**		
Add.	Tenax Road, Trafford Park Manchester M17 1JT		
Coun.	UNITED KINGDOM	**2. Products**	**Flexible polyurethane foam equipment**
Tel:	+44 161 8480316		
Fax:	+44 161 8737718		
Telex:	-		
Contact	Bill Blackwell (also see 16)		

3. Original process	-
4. Reduction/elimination method	Using Beamech High Pressure CO_2™ Process (patent applied for) which meters and mixed liquid CO_2 into the mixing head after which the pressure is reduced in a precised and controlled manner, givig a froth of mixed chemicals which is then deposited on the Maxfoam type fallplate, Vertifoam or Conventional Slabstock Inclined Conveyor.
5. Implications of the new technology	
End of product quality	High quality of foams are produced with good cell structure and avoiding holes in the foam associated with Maxfoam or Trough processes. Excellent quality foams made on Conventional Inclined Conveyor equipment.
Operational implacations	A wide range of excellent foams without the use of any auxillary blowing agents including H.R. Ultracel Foams. Available to all size of Continuous Foam Slab Producers.
6. Scale of operation	Over 200 foam made on equipment 1.5 meters wide and full production unit will be shortly in operation.
7. Technical constraints	None.
8. Restrictions of technology	None.
9. Stage of technology	Anticipate further examination of the benefits on other urethane processes.
10. Level of commercialization	Full commercialisation during second quarter of 1996.
11. Investment costs	Costs will vary with type of existing equipment. If completely new, high pressure metering units for all chemical streams are US$ 320,000.
12. Operational and maintenance costs	Depends on the output of machinery.
13. Safety issues	No additional safety problems other than for high pressure metering and mixing.

14. Development of technology	Beamech Group Ltd.
15. Other	Further information can be obtained directly from Beamech on the signing of a confidentiality deed.
16. Additional Information	Contact Eric Marsden LME-Beamech Inc, 240 Creek Road, Delanco, NJ 08075, USA. Fax: 609 461 6264

1. Company: Name **Beamech Group Limited** Add. Tenax Road, Trafford Park Manchester MI7 UT Coun. United Kingdom Tel +44 61 848 0316 Fax: +44 61 873 7718 Telex: - Contact -	**Data Sheet Category** **1.4 Suppliers of Foam Machinery** **2. Products** 1. Variable pressure foaming VPF Projects 2. Rapid cure process

3. Original process	-
4. Reduction/elimination method	1. VPF: Reduced ambient foaming pressure means that no auxiliary blowing agents (ABA) are needed to make low density foams. 2. Rapid cure: All water blown formulations are used in conjunction with a special process for curing the foam blocks to make low density foams without ABAs.
5. Implications of the new technology	1. VPF: Full range of excellent foams can be made without any ABAs. 2. Rapid cure: As above.
End product quality	Excellent quality and improved quality foams can be made.
Operational implications	
6. Scale of operation	1. VPF: Medium to large scale producers. 2. Rapid cure: All sized producers.
7. Technical constraints	None
8. Restrictions of technology	None
9. Stage of technology	1. VPF: Fully developed and used commercially 2. Rapid cure: Fully developed and used commercially
10. Level of commercialization	Complete - 100%
11. Investment costs	1. VPF: US$ 1.5 million 2. Rapid cure: US$ 300,000
12. Operational and maintenance costs	Depends on output of machinery.
13. Safety issues	1. VPF: No safety problems, all equipment specially designed. 2. Rapid cure: Full safety back-up systems provided.
14. Development of technology	-
15. Other	-

1. Company:		**Data Sheet Category**	**1.4 Suppliers of Foam Machinery**
Name	**Cannon Group**		
Add.	Via Colombo 49 20090 Trezzano S/N -Milan		
Coun.	Italy	**2. Products**	CarDio™ Technology: Liquid carbon dioxide blowing technology
Tel	+39 2 484 00 765		
Fax:	+39 2 445 65 08		
Telex:	352662		
Contact	-		

3. Original process	Use of liquid carbon dioxide as auxiliary blowing agent, in substitution of CFC-11 and volatile organic compounds (methylene chloride, acetone.)
4. Reduction/elimination method	Liquid carbon dioxide pre-expands the foam by up to 30% of final expansion - eliminating CFCs and VOCs from all grades of foam.
5. Implications of the new technology	Dramatic cost reduction, CFC elimination, VOC elimination, process simplification.
End product quality	As good as in the past. With softest grades it is possible to reach low densities which are difficult to process with other blowing agents.
Operational implications	Equipment modification.
6. Scale of operation	Industrial. The first system in Italy since May 1994. More than 10 plants new in operation around the world.
7. Technical constraints	Specially designed equipment required to handle the metering and mixing liquid carbon dioxide. Patented laydown device for controlling the rapid froth development when the liquid carbon dioxide expands.
8. Restrictions of technology	Not yet defined. It seems applicable in all cases where CFCs are used.
9. Stage of technology	Industrial production, with further R&D work undergoing for extension of this technology to other products.
10. Level of commercialization	Available, with license contract.
11. Investment costs	Comparable with current equipment.
12. Operational and maintenance costs	Lower than current equipment.
13. Safety issues	Much better than current equipment: liquid carbon dioxide is non-toxic, non flammable , available and cheaper.
14. Development of technology	Ongoing research and development in progress to extend this process to other types of foam such as High Resilient Flexible, Combustion Flexible, filled foams, continuous rigid foam panels.

15. Other	-

1. Company: Name **Cannon Group-Afros SpA** Add. Via G. Ferraris 65 21042-Garonno Pertusella (VA) Coun. Italy Tel +39 2 96531 Fax: +39 2 9656897 Telex: 333063 Contact General Manager	**Data Sheet Category** **1.4 Suppliers of Foam Machinery** **2. Products** Polyurethane foaming equipment Cannoxide
3. Original process	Expansion of polyurethane foams have used CFCs for years. Cannon - Afros Division, has developed a technology to substituted CFC in the discontinuous process (moulding) replacing them with injected liquid CO_2.
4. Reduction/elimination method	Blowing effect of CFC has been replaced with a combination of 1) Liquid of CO_2 that provides initial pre-expansion. 2) Addition of small percentages of water to the formulation to complete the foam expansion.
5. Implications of the new technology	
End product quality	Better flexible foams (specially the softer grades) Better rigid foam (mechanically stronger) Cheaper foams in all applications
Operational implications	Adapt existing equipment with new CO_2 storage, metering, blending and mixing devices, or use new dedicated equipment for this application.
6. Scale of operation	Industrial evaluation at some European customers. 100 of pilot and laboratory trials successfully made in 1994 and 1995.
7. Technical constraints	Adapt equipment with new hardware.
8. Restrictions of technology	Metering pump, blending system, mixing head are 3 patented items. No license involved.
9. Stage of technology	This technology is in constant evolution: developments include rigid applications (refrigeration panel) and automotive industry (seats).
10. Level of commercialization	Some equipment supplied in late 1995 in Europe. For the first quarter of 1996, delivery in Europe and USA. Expected full industrial production in 1996.
11. Investment costs	One new metering machine equipped with liquid CO_2 metering kit costs around US$ 200,000.
12. Operational and maintenance	No significant increase in maintenance costs. Very significant saving when comparing the cost of CO_2 with CFCs and

costs	alternatives.
13. Safety issues	Less risk than before: CO_2 is a safe chemical.
14. Development of technology	Cannon has developed the equipment. Major raw material suppliers (e.g. Dow, BASF) has also contributed along with manufacturers of furniture, automotive parts, refrigeration and panels.
15. Other	This technology is derived from the CarDio^{TM} Technology, developed by Cannon to expand continuous foams (slabstock), now in operation at 11 plants in Europe and the USA.

1. Company:		**Data Sheet** **Category**	**1.4** **Suppliers of Foam Machinery**
Name	**Krauss-Maffei** Kunstofftechnik GmbH		
Add.	P. O. Box 50 03 40 80973 Munchen		
Coun.	Germany	**2. Products**	Mixing metering machines clamping units, plant systems premixing stations for white appliances, automotive, construction, furniture and technical parts.
Tel:	+49 89 8899-2168		
Fax:	+49 89 8899-4000		
Telex:	523163-22		
Contact	Mr. A. Bauer (KT 2) Mr.W. Dausch (KT 21)		

3. Original process	Plant and machine manufacturers of polyurethane foam system dispensing machinery in conjunction with CFC-11 and CFC-12 in the past.
4. Reduction/elimination method	Redesigned plant and machinery for processing CFC-free systems: e.g. water-blown flexible foams or cyclopentanes for insulating foams. Other CFC-free blowing agents catered for are: HCFC: 141b, 134a, R22 & 142b blend.
5. Implications of the new technology	
End product quality	The product quality is the same.
Operational implications	In the case of pentane, X-protected structural units are required additional to original, redesigned plant.
6. Scale of operation	Full production on 50 machines worldwide since the change-over.
7. Technical constraints	Where pentane is used, safety precautions applicable to that country must be observed.
8. Restrictions of technology	We sell machines and plants, plus the ‘know-how’. Authorisation is part and parcel of sales.
9. Stage of technology	Our machinery is continuously updated to suit new blowing agents.
10. Level of commercialization	Worldwide.
11. Investment costs	Costs are subject to the type of blowing agent and the size of the plant.
12. Operational and maintenance costs	These vary from factory to factory. We are not involved as suppliers.
13. Safety issues	Our machinery conforms to the statutory health and safety regulations laid down by the European Union.
14. Development of technology	Co-operation with raw material manufacturers.

15. Other	Information on the technology is available from all renowned raw material manufacturers.

1. Company: Name **IMPIANTI OMS Spa** Add. Via Sabblonetta 20050 VERANO BRIANZA Coun. ITALIA Tel +39 362 9831 Fax: +39 362 900581 Telex: 335340 OMSVER I	**Data Sheet** **1.4** **Category** **Suppliers of Foam Machinery** **2. Products** Equipment for: PENTANE, CO_2, HCFC-141B, HFC-134a, HCFC -22. Household and Industrial refrigerators Insulated panels, steering wheels, armrests, car seats, blocks. Phenolic foam.
3. Original process	High pressure units (machines) with premixing (Ecoblend - Pentablend) according to blowing agents type.
4. Reduction/elimination method	CFC is substituted by pentane and C-Pentane™. Use of high pressure units self-cleaning heads and pre-mixing systems. Specific models Ecoblend/Pentablend™.
5. Implications of the new technology	Specific plants for use of alternative blowing agents.
End product quality	Same features obtained as with CFC blown foams
Operational implications	Modification to plants adopting devices, safeties and side protection according to used blowing agents.
6. Scale of operation	Full production.
7. Technical constraints	No limitation
8. Restrictions of technology	There is no disadvantage compared to HCFC technology
9. Stage of technology	
10. Level of commercialization	Very high level; mainly on white appliances sector (refrigerators), panels, automotive.
11. Investment costs	From US$ 200,000 to US$ 300,000, according to type of machine standard, turn key plants US$ 1 m.
12. Operational and maintenance costs	Similar to the costs for presently used machines;
13. Safety issues	High level of safety for use of pentane is necessary
14. Development of technology	Continuous research with raw material suppliers.
15. Other	-
16. Additional information	Our technical department is at your disposal for any information on C-Pentane.

Rigid Polyurethane Foam

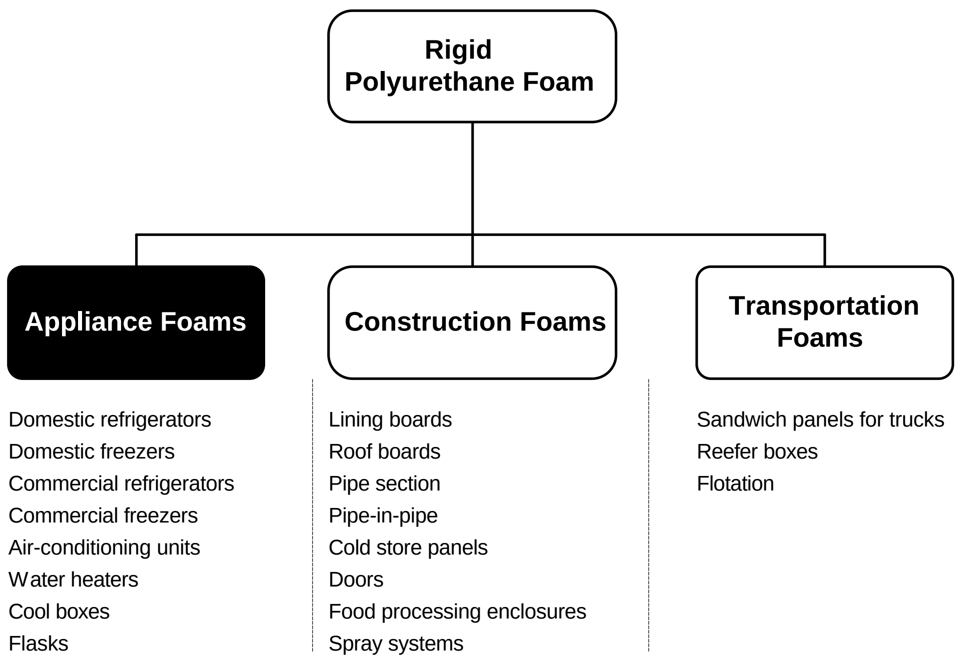
2 Rigid Polyurethane Foam

2.1 Rigid Polyurethane Foam - Appliance Insulation

Technical Options Overview

Description of Sector

The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

Appliance Foams

- Domestic Refrigerator and Freezer Insulation

Rigid polyurethane foams are the dominant insulation materials used in domestic refrigerators and freezers. The prime reason for this fact is that the foam not only provides highly efficient thermal insulation but contributes substantially to the structural integrity of the unit. The strong adhesive characteristics of polyurethane systems coupled with the added value of a composite sandwich structure allows the use of very thin metal and/or plastic skins in the construction of cabinets. Although energy efficiency standards and other design requirements vary from market to market, it has been found that rigid polyurethane foams can meet most, if not all, of these when appropriately formulated using a choice of the technical options outlined in this chapter.

- <u>Commercial Refrigerator and Freezer Insulation</u>

Very similar requirements exist for these applications as for the domestic market. However, there are some additional considerations, such as the need for open top display units. Nonetheless, the preferred insulation material remains rigid polyurethane foam for all of the reasons given above.

- <u>Other Appliances</u>

These include water heaters, picnic boxes (coolers), flask and other thermoware. All of these applications benefit from the structural properties of rigid polyurethane foam but the light weight and thermal efficiency are particularly vital for portable products.

Summary of Available Technical Options

The processes involved in the manufacture of the wide variety of appliances listed above are, in fact, very similar to one another and can be summarised by the following description.

“Liquid chemicals are injected between the outer shell and the interior liner of an appliance cabinet where they react, flow and expand to form rigid polyurethane foam throughout the cavity. Substantial fixtures are provided to support the walls which come under pressure from the foam. Typically, a few per cent of the blowing agent escapes from the chemical mixture and is vented during the foaming process. Production systems do not readily lend themselves to recovery of this lost blowing agent and it has been historically vented to atmosphere.

Over time, foam suppliers have developed formulations (using CFCs) which have had properties (viscosity, reaction speed, exotherm etc.) that meet the needs of production processes. With any new blowing agent, these properties must be maintained in order to produce quality products and control costs.”

(Source 1994 UNEP TOC Report)

In line with the volume of chemicals used in this sector, appliance foams have probably attracted more attention than any other foam system previously involving CFCs. The abstract database on the OzonAction Information Clearinghouse is a good source of such information as are the books of papers of recent polyurethane conferences. Nonetheless, the options for these products are highly constrained by the performance characteristics outlined above. The main options are summarised below:

Cyclopentane and other pentane blends - This technology is widely used in Europe, and a growing percentage is used in Japan, but it has not been taken up in North America because of the poorer insulation values gained from cyclopentane blown systems.

HFC-134a - Several European manufacturers had initially adopted this technology but the blowing agent has poorer insulation properties than other materials and also is more soluble in the polyol. Equipment modifications are also required to handle the gaseous blowing agent and the technology has more recently fallen out of favour.

Liquid HFCs - These materials could represent the future for major appliance manufacturers around the world. However, they are unlikely to be available much before the year 2000. Additionally, their

measurable Global Warming Potential (albeit negated by efficiency savings) may be a barrier to the technology in certain parts of the world.

Less Preferred Options (measurable ODP)

HCFCs (141b, 22 & 22/142b) - Widely used and proven technology, but clearly only represents an interim step to other materials. In particular, some manufacturers are using them to ‘bridge the gap’ to liquid HFCs, thereby avoiding the major expense of moving to hydrocarbons before returning to non-flammable materials.

Appliance Insulation Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.11) summarises the detailed information for those companies **which** *provided Data Sheets.* Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the “Supplier Information - Data Sheets” at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.12) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in “Supplier Information - Contacts” at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.11 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology			
		HFC	HCFC	Hydro-Carbons	Water-blown
Polyurethane Systems	Baxenden				X
	Bayer AG				X
	Busing & Fesch		X		X
	Elastogran	X	X	X	
	Hennecke			X	
	ICI Polyurethanes				X
Blowing Agent	AlliedSignal	X	X		
	Exxon Chemicals			X	
	Solvay Fluor	X	X		
Flame Retardants	Albright & Wilson	X	X	X	X
Ancilliaries	Acmos Chemie	X	X	X	X
	3M	X	X	X	
Machinery	Cannon	X	X	X	X
	Edulan				X
	Hennecke			X	
	Impianti OMS	X	X	X	X
	Krauss-Maffei		X	X	X
	Perros		X	X	

Matrix 2.12 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden		X			
Bayer AG	X				
Beamech Group Ltd		X			
Borsodchem Rt. PUR Plant	X				
Busing & Fasch					
Cannon-Afros		X			
Chem Trend A/S					X
Courtaulds Chemicals				X	
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPond de Nemours Int. S.A.			X		
Edulan		X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals Belgium			X		
FMC. Corp. UK Ltd				X	
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
ICI Klea			X		
Krauss-Maffei Kunstofftechnik		X			
La Roche Chemicals			X		
Maschinenfabrik Hennecke GmbH		X			
Mica Machinery Ltd		X			
Nitroil Europe Handels GmbH	X				
Oxid Inc.	X				
OMS Impianti Group		X			
Pelron/Ele	X			X	X
Perros		X			
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				
Witco Corporation	X				
3M					X

Appliance Insulation Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (2.13), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.13

Company	Alternative Technology		
	HCFC	Water Blown	Cyclopentane
Calex	X		
Electrolux			X
GMP Poliuretani SRL		X	
Hitachi Ltd.	X		X
Norfrost Ltd.			X

1. Company: Name **CALEX a.s.** Add. Továrenská ul. 49 953 36 Zlaté Moravce Coun. Slovak Republic Tel: + 42 814 23183 Fax: + 42 814 21360 Telex: 098471 / 09 84 72 Contact Ing. Peter Sugra, Technical Director	**Case Study** **2.1** **Category** **Rigid Polyurethane Appliance Insulation** **2. Products** Refrigerators and freezers.
3. New Technology Applied	Since 1994, HCFC 141b replaced CFC-11 in low pressure and high pressure foaming processes. This is considered to be an intermediate transition with the ultimate blowing agent to be cyclopentane in 1996/1997. (Blowing agents also considered to be intermediates are a mixture of HCFC-22 and HCFC-142b or HFC-134a.) The content of CFC-11 was reduced by 50% from 1989, with the preparation for the total elimination of CFC-11 commencing from 1993. The new technology is at the bench stage and is not yet implemented. The annual production is approximately 300,000 refrigerators and freezers with HCFC R141b as the blowing agent and 1.5 million of compressors for R 134a. This corresponds to an annual consumption of components of about 700 tonnes.
4. End product quality **Operational implications**	The physical and mechanical properties of the products produced from the new PUR systems are expected to be comparable with those of the original system. However, the thermal conductivity will increase by about 10-15 per cent. The new process requires close control of the mixing proportion of the components.
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	Implementation of the new technology is expected to require an investment of about US$ 6.5 m.

<table>
<tr><td colspan="2">1. Company:

Name Electrolux Fryseboxe AS
Add. Lundtoftevej 160
DK 2800 Lyngby
Coun. Denmark
Tel: +45 4588 9700
Fax: +45 4593 0939
Telex:
Contact Mr. P. Andreasen</td><td>Case Study Category 2.1 Rigid Polyurethane Appliance Insulation

2. Products Rigid PUR insulation of domestic freezers</td></tr>
<tr><td>3. New Technology Applied</td><td colspan="2">CFC-11 has been substitued by cyclopentane. This has required changes of the conventional PUR production process, implementation of new machinery and changes in product design.

The technology is fully implemented with an annual production of approximately 200,000 domestic freezers.</td></tr>
<tr><td>4. End product quality

Operational implications</td><td colspan="2">-

The new technology requires a new mixing procedure and a new injection device.</td></tr>
<tr><td>5. Safety and Environmental issues</td><td colspan="2">Explosion risk in connection with the use of cyclopentane has been considered and approprate safety devises installed.</td></tr>
<tr><td>6. Implementation, Operational and maintenance costs</td><td colspan="2">-</td></tr>
</table>

1. Company:		**Case Study Category**	**2.1 Rigid Polyurethane Appliance Insulation**
Name	**GMP Poliuretani SRL**		
Add.	Via Padova, 5 31046 Oderzo (TV)		
Coun.	Italy	**2. Products**	Any kind of parts for medical equipment, electronic equipment, commercial refrigerator equipment, domestic refrigerator equipment.
Tel:	+ 39 04 2281 4524		
Fax:	+ 39 04 2271 8130		
Telex:	-		
Contact	Mr Maria Damo, General Manager In. Giuliano Perini, Sales Manager		

3. New Technology Applied	The original process was based on CFC and polyol mix to produce foamed polyurethane products. CFC has been substituted; water is added to polyol and air is increased to 40% to aid nucleation. The technology is fully implemented and operation is at full production. It is continuously developed along with technological progress of raw materials.
4. End product quality	Without the use of CFC, the thickness of the compact surface has decreased. To compensate, the productive system was increased to aid the minor expansion pressure of the new system.
Operational implications	To increase equipment efficiency, modification of the air inlet was necessary to aid nucleation. No technical restraints.
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	US$ 40,000 per foaming machine. No extra costs incurred through operation and maintanence.

1. Company:		**Case Study Category**	2.1 Rigid Polyurethane Appliance Insulation
Name	**Hitachi Lid.**		
Add.	800 Tomita Ohira-mati Shimotuga-gun, Tochigi-Ken 329-44		
Coun.	Japan	**2. Products**	Commercial refrigerator equipment, domestic refrigerator equipment.
Tel:	+81 282 1111 (ext 2262)		
Fax:	+81 282 431177		
Telex:	-		
Contact	Kuninari Araki		

3. New Technology Applied	CFC-11 was used as the blowing agent in a rigid foam manufacturing process for refrigerators. The reduction method was achieved by using a special polyol component and an isocyanate componet under the suitable formation (UR-93) in the presence of a blowing agent comprising water and HCFC 141b. This gives a good balance in physical properties for refrigerators. The technology is fully implemented, but the use of HCFC 141b is regarded as transitional because of its ODP. As a result, Hitachi are using cyclopentane as a blowing agent in one manufacturing line to establish the next stage of technology.
4. End product quality	The new PUR formulation provides a well balanced product with good physical properties: shows only slight expansion after moulding using HCFC-141 as a blowing agent, so that the quality of refrigerators is kept high.
Operational implications	The new technology requires higher preheating temperatures before injection into refrigerators.
5. Safety & Environmental Issues	Increased fire risk because of the use of HCFC 141b.
6. Implementation, operational and maintenance costs	Investment costs depend on the scale of production, though operational and maintenance costs are the same as for CFC-11.

1. Company:		**Case Study Category**	**2.1 Polyurethane Foam Appliance Insulation**
Name	**Norfrost Ltd.**		
Add.	Murrayfield Castletown,Caithness Scotland KW14 7DW		
Coun.	United Kingdom	**2. Products**	Freezer Insulation
Tel:	+44 1847 821333		
Fax:	+44 1847 821291		
Telex:	-		
Contact	-		

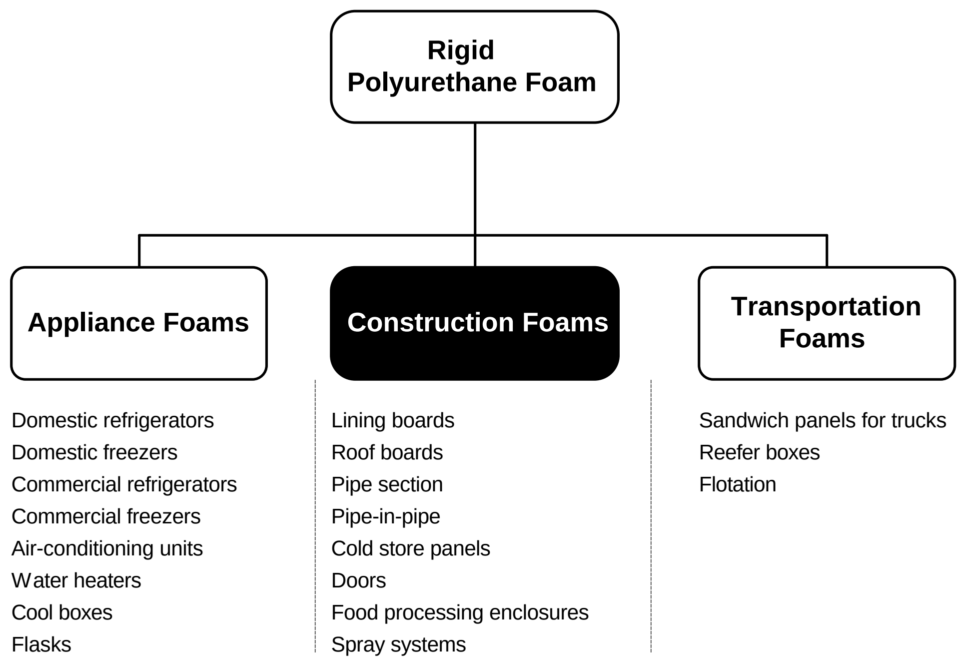
3. New Technology Applied	Rigid polyurethane foam with a CFC blowing agent was used as an insulation material in freezers. CFC was substitued by cyclopentane. It is fully implemented. Research is being undertaken to reduce the cost of cyclopentane and to improve the insulating properties.
4. End product quality **Operational implications**	The efficiency of the insulation is slightly reduced. See 5.
5. Safety and Environmental Issues	Cyclopentane is highly flammable. Extraction equipment is required at the foaming machinery, all equipment must be earthed, and gas detection and alarms are required.
6. Implementation, operational and maintenance costs	Investment costs depend on the specific application and production volume. It is unlikely to less than US$365,000. No significant change to operational and maintenance costs.

2.2 Rigid Polyurethane Foam - Boardstock/Flexible Faced Lamination

Technical Options Overview

Description of Sector

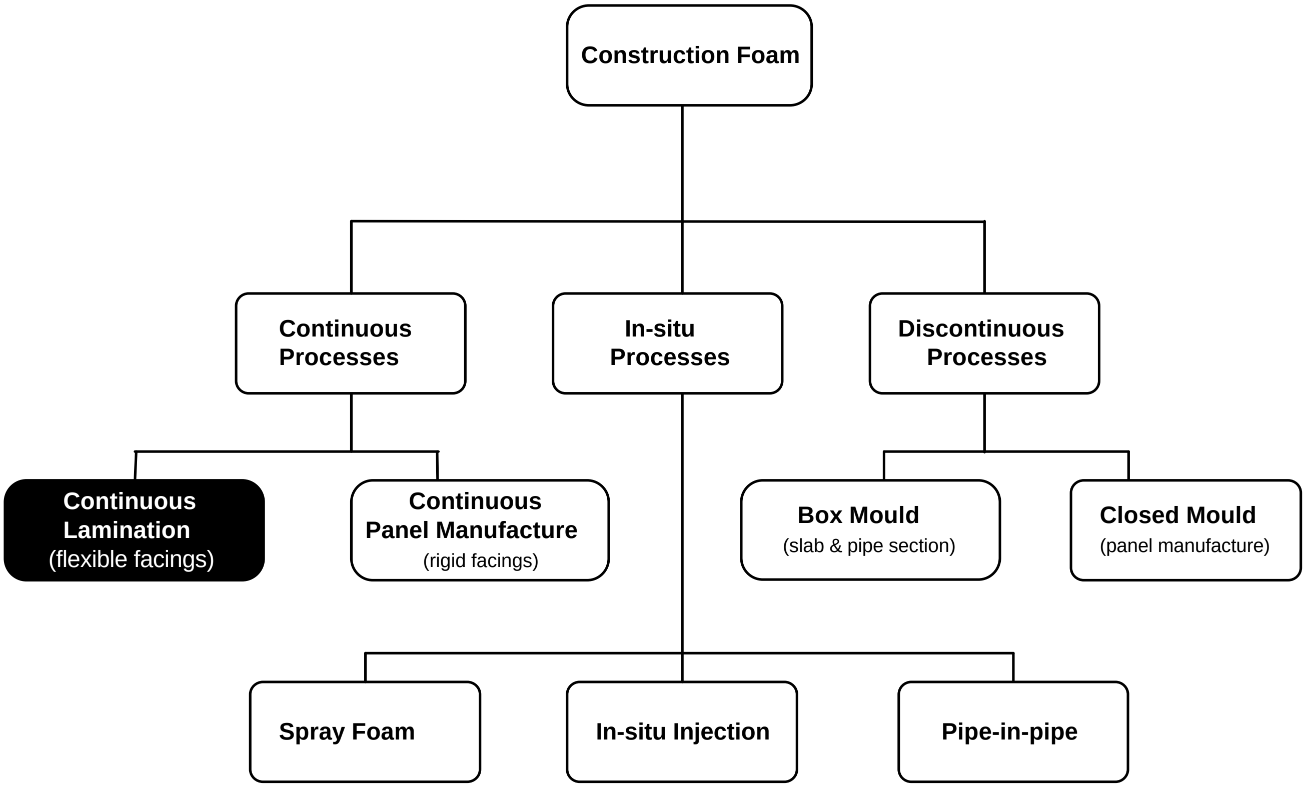
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

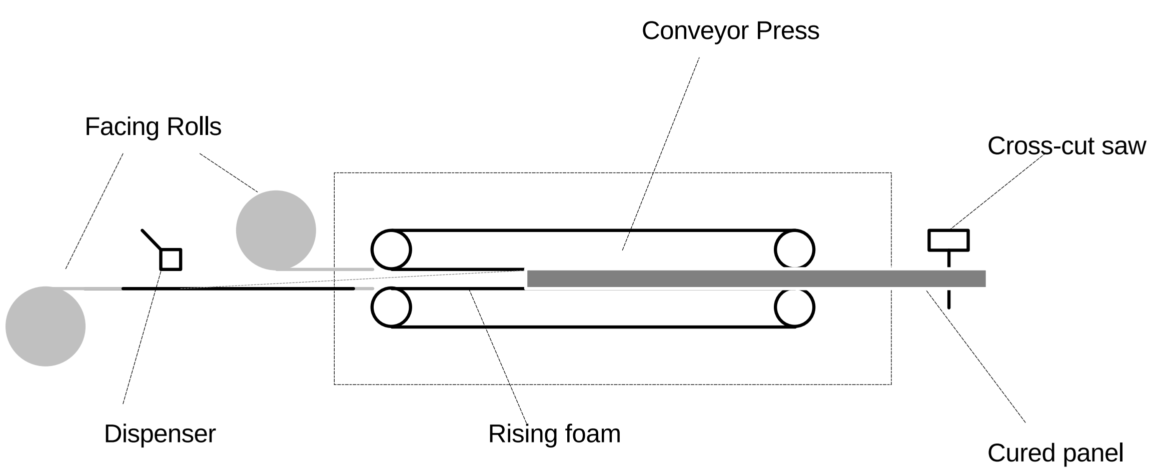
Construction Foams

There are a substantial number of products and processes involved in this sector. These are best summarised in the diagram overleaf:



Continuous Lamination

Continuous lamination represents the single largest production technique for rigid polyurethane foams in the construction sector, providing both lining and roofing boards for domestic and commercial buildings to a thickness of 120mm. Facing materials can include aluminium, paper, glass roofing felts and even plaster board. In the latter case, the process used is a slightly modified version, known as inverse lamination where the flexible facing is used to carry the foaming system onto the plasterboard from above. The more orthodox continuous lamination equipment is shown schematically below:



Summary of Available Technical Options

Although there are detailed formulation issues affecting each of the products manufactured by the continuous lamination process, the general requirements of all foams formulations are

- Low thermal conductivity
- Fire performance
- Strength/density ratio
- Ease of processing
- Ease of use and handling

The options can therefore be summarised as follows:

n- & iso-Pentane	-	Requires control of flammability issues in both process and product. Most formulations contain increased fire retardant levels to accommodate the change. Pentane is also a VOC and its emissions may need to be controlled in certain parts of the world.
Liquid HFCs	-	Similar comments as noted under the appliance section (Sec. 2.1.). Again the major problem for the industry is availability (around 2000) and the potential impact of local global warming legislation. Additionally, the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.
CO_2 (Water blown)	-	Useful in applications where insulation efficiency is less important. However, density increases are also evident and the technology, in its current form is not very attractive. Further developments are on-going.

Less Preferred Options (measurable ODP)

HCFCs (141b & 22/142b)	-	These are widely used for insulation applications since they provide the strongest combination of product characteristics available. Many companies are waiting for the arrival of liquid HFCs which should provide similar performance rather than switching to hydrocarbons. Nonetheless, HCFCs must be recognised as an interim solution by all using them.

Boardstock/Flexible Faced Lamination Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.21) summarises the detailed information for those companies **which *provided Data Sheets.*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.22) lists all known suppliers: these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.21 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology			
		HFC	HCFC	Hydro-carbons	Water-blown
Polyurethane Systems	Baxenden				X
	Bayer AG				X
	Busing & Fesch		X		X
	Elastogran	X	X	X	
	ICI Polyurethanes				X
Blowng Agent	AlliedSignal	X	X		
	Exxon Chemicals			X	
	Solvay Fluor	X	X		
Flame Retardant	Albright & Wilson	X	X	X	X
Ancilliaries	Acmos Chemie	X	X	X	X
	3M	X	X	X	
Machinery	Cannon				X
	Edulan				X

Matrix 2.22 *All KnownSuppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Beamech Group Ltd		X			
Borsodchem Rt. PUR Plant	X				
Busing & Fasch	X				
Cannon-Afros		X			
Cannon-Viking		X			
Courtaulds Chemicals				X	
Crecimiento Industrial Co. Ltd		X			
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPond de Nemours Int. S.A.			X		
Edulan		X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals			X		
Fecken Kirfel		X			
FMC Corp. UK Ltd.				X	
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
ICI Klea			X		
Isothane Ltd.	X				
La Roche Chemicals			X		
Maschinenfabrik Hennecke GmbH		X			
Nitroil Europe Handels GmbH	X				
NRG Barriers Inc.	X				
Oxid Inc.	X				
Pelron/Ele	X			X	X
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Sunkisk Chemical Machinery Ltd		X			
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				
Witco Corporation	X				
Zaco PTI b.v.		X			
3M					X

Boardstock/Flexible Lamination Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (2.23), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.23

Company	Alternative Technology		
	HFC	Water Blown	Pentane
Efisol			X
Vapotherm B.V.			X

1. Company:		**Case Study Category**	**2.2 Rigid Polyurethane Boardstock/ Flexible Faced Lamination**
Name	**EFISOL**		
Add.	5, Rue du Dôme 75116 Paris		
Coun.	France	**2. Products**	Panels produced on double-band laminators with different faces:
Tel:	+ 33 4755 5341		Bitumen paper, polyethylene/glass fibre, mineral paper, aluminium paper
Fax:	+ 33 4704 3543		or aluminium sheet.
Telex:	640 581		
Contact	-		

3. New Technology Applied	The original process was a conventional polyurethane foaming on a continuous line with CFCs as blowing agents. CFC was replaced by pentane. <u>The share of CFC-free production:</u> Less than 1% in 1992 Approx. 10% (assumption) in 1993 Approx. 50% (assumption) in 1994 The process is fully implemented.
4. End product quality	The end product has reduced insulation properties. The cost of the end product is a little higher than that of the CFC technology.
Operational implications	The production rate of the process is lower with the new technology. The pentane technology requires 15-20% additional energy for ventilation. The new process requires staff training.
5. Safety and Environmental Issues	The high flammability of pentane requires advanced technology installations for detection, control and safety.
6. Implementation, operational and maintenance costs	The maintenance costs are around 10% higher than before, due to the personnel training requirements.

1. Company:		**Case Study Category**	**2.2 Rigid Polyurethane Boardstock/ Flexible Faced Lamination**
Name	**Vapotherm B.V.**		
Add.	Gnephoek 2A P.O. Box 257 2400 AG. Alphen aan den Rijn		
Coun.	The Netherlands	**2. Products**	Rigid polyurethane boards for the construction industry.
Tel:	+ 31 1720 431 951		
Fax:	+ 31 1720 433 368		
Telex:	-		
Contact	-		

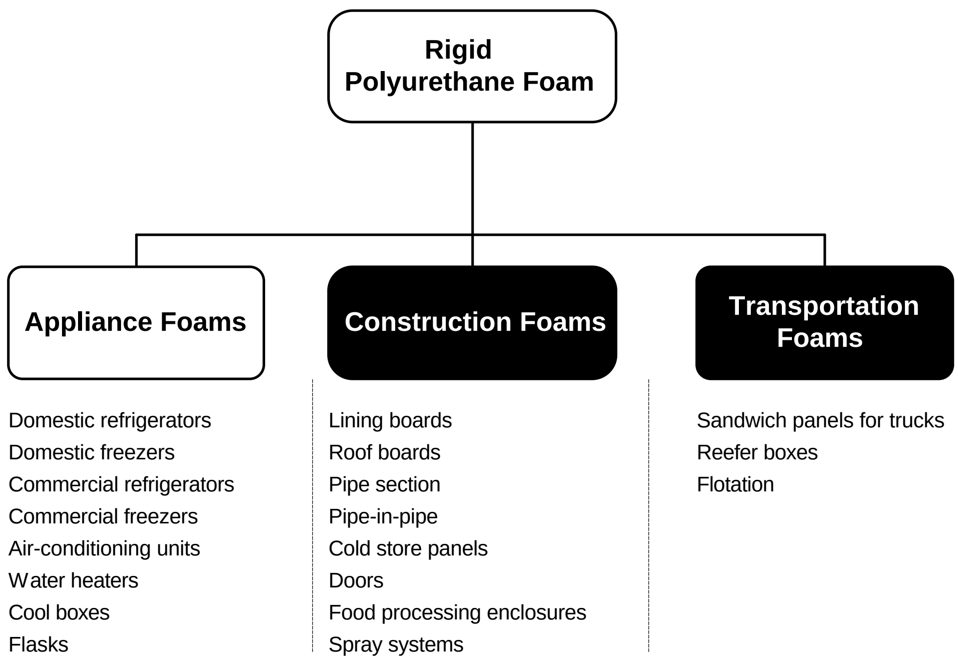
3. New Technology Applied	CFC-11 has been substituted by pentane as blowing agent in the manufacture of PU boards. The equipment (double band laminators, 2 compression types and 1 free rise type (inverse)), has been modified for use with pentane. This is fully implemented and the introduction of equipment for measuring N-pentane, polyol resin and MDI is anticipated.
4. End product quality	The end product has reduced insulation properties compared to the previous technology. Thicker boards in the range of 80-140mm are difficult to produce to B2 quality. Dimensional stability is vulnerable.
Operational implications	There are in general no changes in the process except for the hazards in connection with pentane. Dosing and mixing is more complicated with pentane as blowing agent. A slight modification is demanded regarding the use of surfactant etc. The generated waste stream equals the stream of the previous process. Product cooling requires more handling and equipment. The operational procedures are more strict than previously, and training of personnel is required. There is no change in the energy consumption.
5. Safety and Environmental Issues	Staff training is required as pentane is highly flammable.
6. Implementation, operational and maintenance costs	The running costs have increased by 10%.

2.3 Rigid Polyurethane Foam - Sandwich Panels

Technical Options Overview

<u>Description of Sector</u>

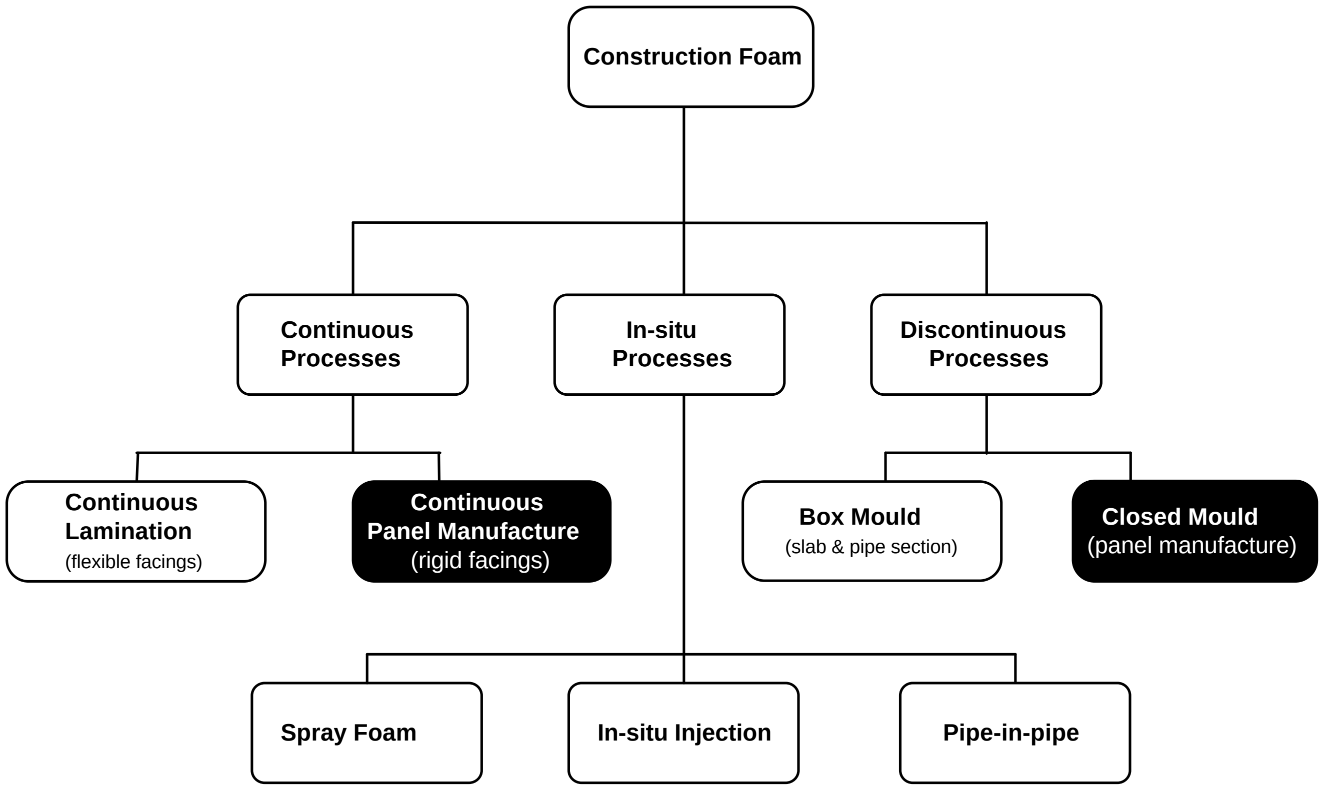
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

<u>Construction Foams</u>

Sandwich panels are used in the construction sector for roof cladding, wall facades and, sometimes, doors. They are used typically in commercial buildings and particularly in cold stores and food processing factories where they provide excellent insulation performance as well as structural integrity. Spans in excess of 15 metres can be achieved with some profiled panels and this saves in supporting structural steelwork. The bulk of the panels (and particularly the longer ones) tend to be produced by continuous processes, whereas others can be produced in discontinuous multi-daylight presses. The diagram overleaf highlights these options:



Transportation Foams

Sandwich panels are used in the transportation sector as insulation panels for trucks and other vehicles. The high thermal efficiencies of these panels enable thin sections to be used, thereby maximising the loading space. Additionally, the relatively low weight of the panels ensures optimum fuel economy. Most vehicle panels are produced discontinuously since they often have specific fixing detail which requires a moulding approach.

Summary of Available Technical Options

Although there are detailed formulation issues affecting each of the products manufactured, the general requirements of all foams formulations are

- Low thermal conductivity
- Fire performance
- Strength/density ratio
- Ease of processing
- Ease of use and handling

The options can therefore be summarised as follows:

n- & iso-Pentane	-	Requires control of flammability issues in both process and product. Most formulations contain increased fire retardant levels to accommodate the change. Pentane is also a VOC and its emissions may need to be controlled in certain parts of the world.
Liquid HFCs	-	Similar comments as noted under the appliance

section (Sec. 2.1.). Again the major problem for the industry is availability (around 2000) and the potential impact of local global warming legislation. Additionally, the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.

CO_2 (Water blown) - Useful in applications where insulation efficiency is less important. However, density increases are also evident and the technology, in its current form is not very attractive. Further developments are on-going.

Less Preferred Options (measurable ODP)

HCFCs (141b & 22/142b) - These are widely used for insulation applications since they provide the strongest combination of product characteristics available. Many companies are waiting for the arrival of liquid HFCs which should provide similar performance rather than switching to hydrocarbons. Nonetheless, HCFCs must be recognised as an interim solution by all using them.

Cyclopentane - Is used by a few discontinuous foam manufacturers. Slightly better insulation value at a slightly higher cost.

Sandwich Panel Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.31) summarises the detailed information for those companies **which *provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.32) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.31 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology				
		HFC	**HCFC**	**Hydro-carbons**	**Water-blown**	**Other**
Polyurethane Systems	Baxenden				X	
	Bayer AG				X	
	Busing & Fasch		X		X	
	Elastogran	X	X	X		
	Hennecke			X		
	ICI Polyurethanes				X	
	I.F.S. Chem					X
Blowing Agent	AlliedSignal	X	X			
	Exxon Chemicals			X		
	Solvay Fluor	X	X			
Flame Retardants	Albright & Wilson	X	X	X	X	
Ancilliaries	Acmos Chemie	X	X	X	X	
	3M	X	X	X		
Machinery	Cannon				X	
	Edulan				X	
	Hennecke			X		

Matrix 2.32 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**	**Ancilliaries**
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Beamech Group Ltd		X			
Borsodchem Rt. PUR Plant	X				
Busing & Fasch GmbH & Co.	X				
Cannon-Afros		X			
Cannon-Viking		X			
Courtaulds Chemicals				X	
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPond de Nemours Int. S.A.			X		
Edulan	X	X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals			X		
FMC Corp. UK Ltd.				X	
Gusmer		X			
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
ICI Klea			X		
IFS Systems	X				
Isothane Ltd.	X				
Isotherm AG		X			
Krauss-Maffei Kunstofftechnik GmbH		X			
La Roche Chemicals			X		
Maschinenfabrik Hennecke GmbH		X			
Nitroil Europe Handels GmbH	X				
NRG Barriers Inc.	X				
Oxid Inc.	X				
OMS Impianti Group		X			
Pelron/Ele	X			X	X
Perros		X			
Resina Chemie	X				
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				

Zaco PTI b.v.		X			
3M					X

Sandwich Panel Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (2.33), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.33

Company	Alternative Technology			
	HFC	HCFC	Water Blown	Pentane
Cardo Door			X	
Isocab N.V.	X	X		X

1. Company: Name **Cardo Door Production AB** Add. Hangarvägen 3, box 160 S-42321 Torslanda Coun. Sweden Tel: +46 031 560100 Fax: +46 031 563866 Telex: 21437 Contact Tryggve Johansson	**Case Study Category** **2.3 Rigid Polyurethane Sandwich Panels** **2. Products** Pre-insulated laminated panels for industrial and garage doors

3. New Technology Applied	In the original process CFC was used as blowing agent. The foam is produced at a double conveyor, high pressure, 8 meters per minute. CFC has been substitued by water (drop-in), with an increase in the ratio of isocyanate/polyol (500 tons/yr). The technology is fully implemented.
4. End product quality **Operational implications**	The thermal conductivity has increased. No other production conditions were influenced significantly. Stringent process control is needed with the new production.
5. Safety and Environmental Issues	The new process has not significantly influenced safety aspects.
6. Implementation, operational and maintenance costs	The new process has not caused changes in maintenance costs or labour expenses. Investments have not been necessary.

1. Company:	**Case Study Category**	**2.3 Rigid Polyurethane Foam Sandwich Panels**
Name **Isocab N.V.** Add. Treurnietstraat 10 8531 Harelbeke Coun. Belgium Tel: +32 5673 4311 Fax: +32 5673 4322 Telex: 85934 Isocab Contact Johan Schedin, R&D Manager	**2. Products**	Insulation for coolers, coldstores, freezers, industrial wall and roof cladding, facing for housing etc.

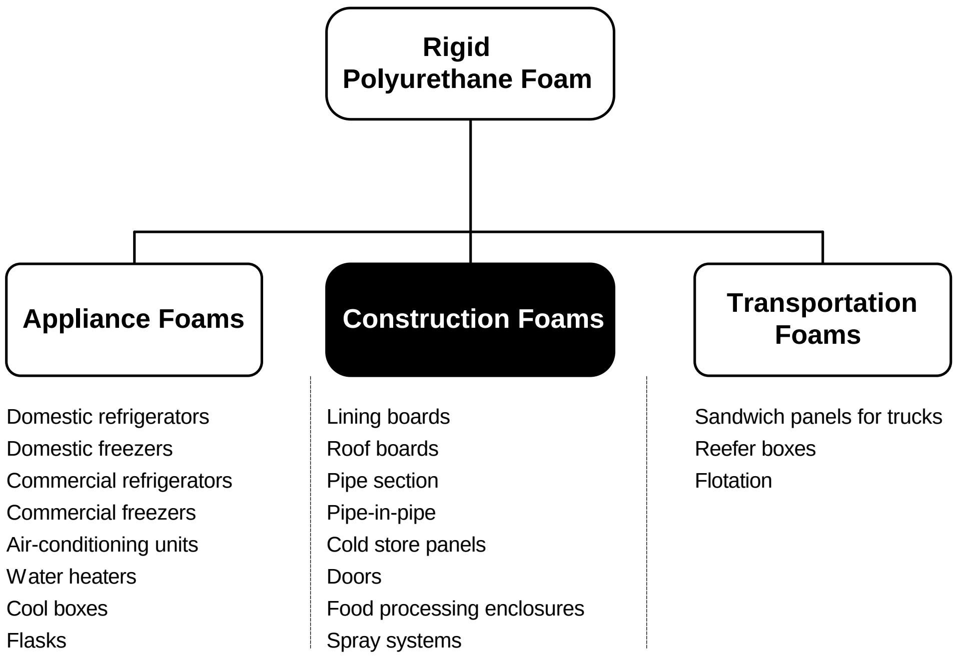
3. New Technology Applied	The blowing agents used in continuous and discontinuous production of sandwich panels are: 1. HFC 134a and CO_2 - fully implemented 2. HCFC 141b - full production for continuous, phased-out in discontinuous. 3. Replacement by pentane for continuous processing -test on approx.40,000m^3.
4. End product quality	1. Lambda values slightly increased to 0.24 after aging (W/mK). 2. Lambda 0.22 W/mK 3. Lambda 0.23 W/mK
Operational implications	1. Density of foam not less than 40 Kg/m^3 2. Density of foam not less then 40 Kg/m^3- risk of shrinkage. 3. Fire and explosion risks in production, need more fire retardants to obtain the same effect.
5. Safety and Environmental Issues	1. & 2.: no significant safety issues compared to CFCs. 3. Explosion risks.
6. Implementation, operational and maintenance costs	Investment depends on the existing equipment but solutions 1. and 2. have low investment costs. 3. has high investment costs. 1. & 2.: no new or expected costs. 3. Surveillance costs due to explosion risks. All three solutions cost more than the original CFC blown foams.

2.4 Rigid Polyurethane Foam - Spray Foam Insulation

Technical Options Overview

Description of Sector

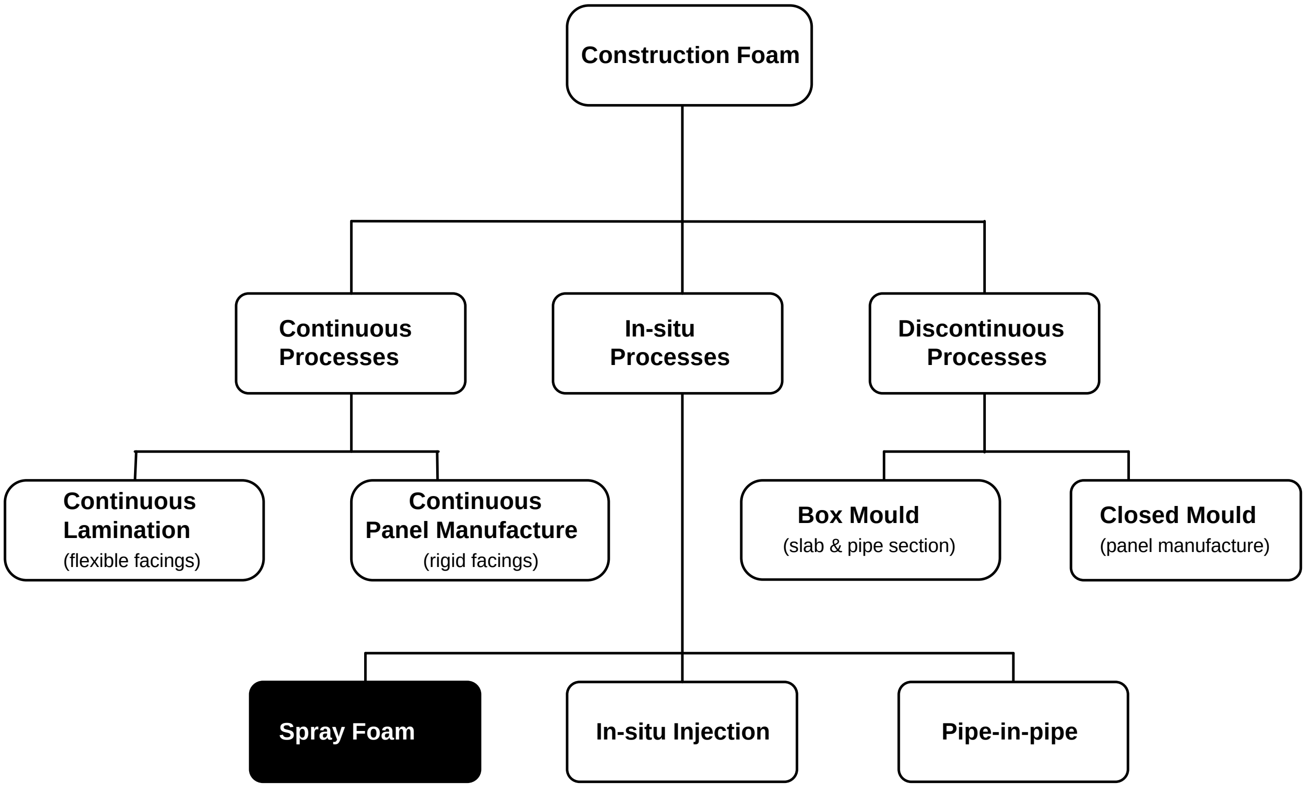
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

Construction Foams

There are a substantial number of products and processes involved in this sector. These are best summarised in the diagram overleaf:



Spray Foams

Although spray foams are often slightly poorer insulators than other factory made polyurethane foams, they find widespread use because of their ability to accommodate difficult shapes. Accordingly, they are used extensively in the insulation of tanks and other process plant. Additionally, they are used to overspray existing flat roofs. They are even used inside existing roofs spaces to provide not only insulation but also consolidation for tiled roofs.

The equipment used in this process has inevitable differences over its factory-based counterparts since it needs to be portable and versatile. Accordingly, machinery suppliers tend to be specific to this and the other in-situ applications.

Summary of Available Technical Options

Although there are detailed formulation issues affecting each of the applications highlighted above, the general options for the spray foam process are set out below. The general requirements of all foams are

- Low thermal conductivity
- Fire performance
- Adhesion
- Strength/density ratio
- Versatile processing, particularly with respect to temperature of application

The options can therefore be summarised as follows:

Liquid HFCs - Similar comments as noted under the appliance section (Sec. 2.1.). Again the major problem for the industry is availability (around 2000) and the potential

		impact of local global warming legislation. Additionally, the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.
CO_2 (Water blown)	-	Useful in applications where insulation efficiency is less important. However, density increases are also evident and the technology, in its current form is not very attractive. Further developments are on-going.

Less Preferred Options (measurable ODP)

HCFC-141b	-	These are widely used for insulation applications since they provide the strongest combination of product characteristics available. Many companies are waiting for the arrival of liquid HFCs which should provide similar performance rather than switching to hydrocarbons. Nonetheless, HCFCs must be recognised as an interim solution by all using them.

Spray Foam Insulation Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.41) summarises the detailed information for those companies which ***provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.42) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as welll as those companies ***which provided Data Sheets (in bold Italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.41 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology			
		HFC	HCFC	Hydro-carbons	Water-blown
Foam Manufacturer	Icynene				X
Polyurethane Systems	Baxenden				X
	Bayer AG				X
	Busing & Fesch		X		X
	Elastogran	X	X	X	
	ICI Polyurethanes				X
	Tagos SRL				X
Blowing Agent	AlliedSignal	X	X		
	Exxon Chemicals			X	
	Solvay Fluor	X	X		
Flame Retardants	Albright & Wilson	X	X	X	X
'Ancilliaries	3M	X	X	X	
Machinery	Cannon				X
	Edulan				X
	Gusmer Corp.	X	X	X	X

Matrix 2.42 *All Known Suppliers*

Company	**Category of Technology, Equipment or Chemicals**				
	PU Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**	**Ancilliaries**
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Borsodchem Rt. PUR Plant	X				
Busing & Fasch	X				
Cannon Group		X			
Cannon Afros		X			
Courtaulds Chemicals				X	
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPond de Nemours Int. S.A.			X		
Edulan	X	X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals			X		
Graco Inc.		X			
Gusmer		X			
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
IFS Systems	X				
Isothane Ltd.	X				
Isotherm AG		X			
Krauss-Maffei Kunstofftechnik GmbH		X			
La Roche Chemicals			X		
Nitroil Europe Handels GmbH	X				
Oxid Inc.	X				
Pelron/Ele	X			X	X
Resina Chemie	X				
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Tagos	X				
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				
Witco Corporation	X				
3M					X

Spray Foam Insulation Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (2.43), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.43

Company	Alternative Technology		
	HFC	Water Blown	Cyclopentane
Allhaboverken		X	
Association PUR		X	

1. Company:		**Case Study Category**	**2.4 Rigid Polyurethane Spray Foam Insulation**
Name	**Allhaboverken AB**		
Add.	Adolfsbergsvägen 3 S-70227 Örebro		
Coun.	Sweden	**2. Products**	Rigid PUR insulation foam, sprayed in situ.
Tel:	+46 19 209800		
Fax:	+46 19 273747		
Telex:	-		
Contact	Mr. Heinz Boldt		

3. New Technology Applied	CFC-11 was substituted by CO_2 in the conventional PUR foaming process (drop-in). The technology is fully implemented and are producing approximately 100 tons of raw materials a year.
4. End product quality **Operational implications**	The insulation capability of the new products is somewhat lower. The process temperature has changed. There are no other significant changes.
5. Safety and Environmental issues	-
6. Implementation, Operational and maintenance costs	-

1. Company:		**Case Study Category**	**2.4 Rigid Polyurethane Spray Foam Insulation**
Name	**Association PUR - Czech society for the application of polyurethane foam in the building industries**		
Add.	102 21 Prague 10, Prazská 16		
Coun.	Czech Republic	**2. Products**	Sprayed rigid polyurethane insulation foam for roofs.
Tel:	+42 2 752 641		
Fax:	+42 2 752 691		
Telex:			
Contact	Mr. Vladimír SVEC, Chairman of Trustees.		

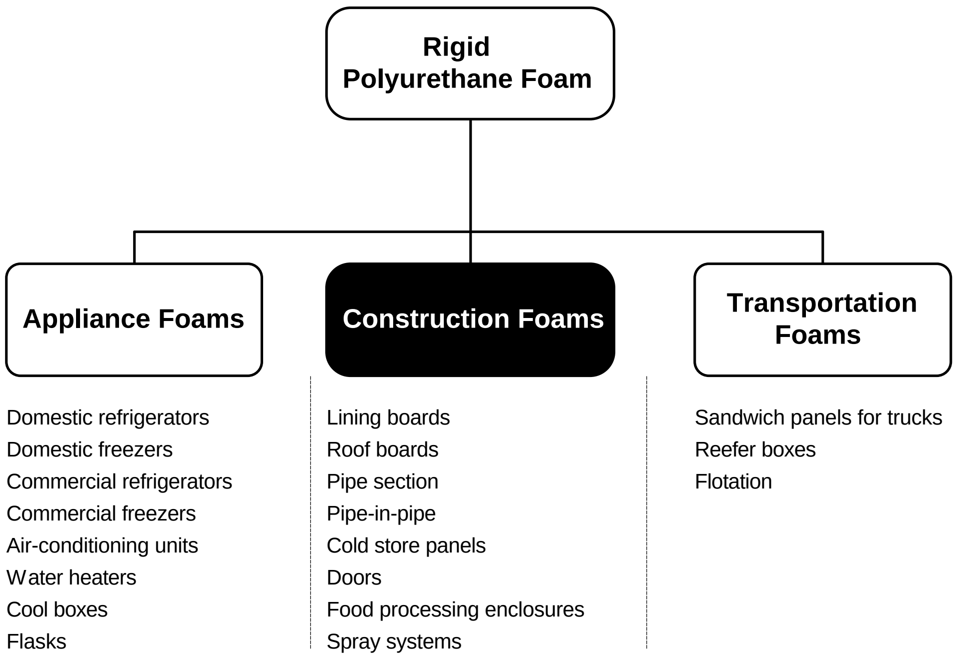
3. New Technology Applied	CFC-11 was substituted by CO_2 in a conventional high pressure foaming process. The ratio between the polyol and the isocyanate has also changed. The technology is fully implemented.
4. End product quality	The new CO_2 blown foam has a thermal conductivity approximately 16 per cent higher than the CFC blown foams.
Operational implications	Due to a changed mixing ratio between the polyol and the isocyanate, a larger capacity of the foaming equipment is needed. Increased reaction heat for the new process. The energy requirement is increased for the new process, due to a changed mixing ratio, use of larger equipment and increased viscosity of the mixture. Operating procedures and training requirements are more or less the same as for CFC blown foams.
5. Safety and Environmental issues	There are no changes regarding safety issues.
6. Implementation, Operational and maintenance costs	The cost of producing CO_2 blown foam is approximately 20% higher than with CFC-11.

2.5 Rigid Polyurethane Foam - Slabstock

Technical Options Overview

Description of Sector

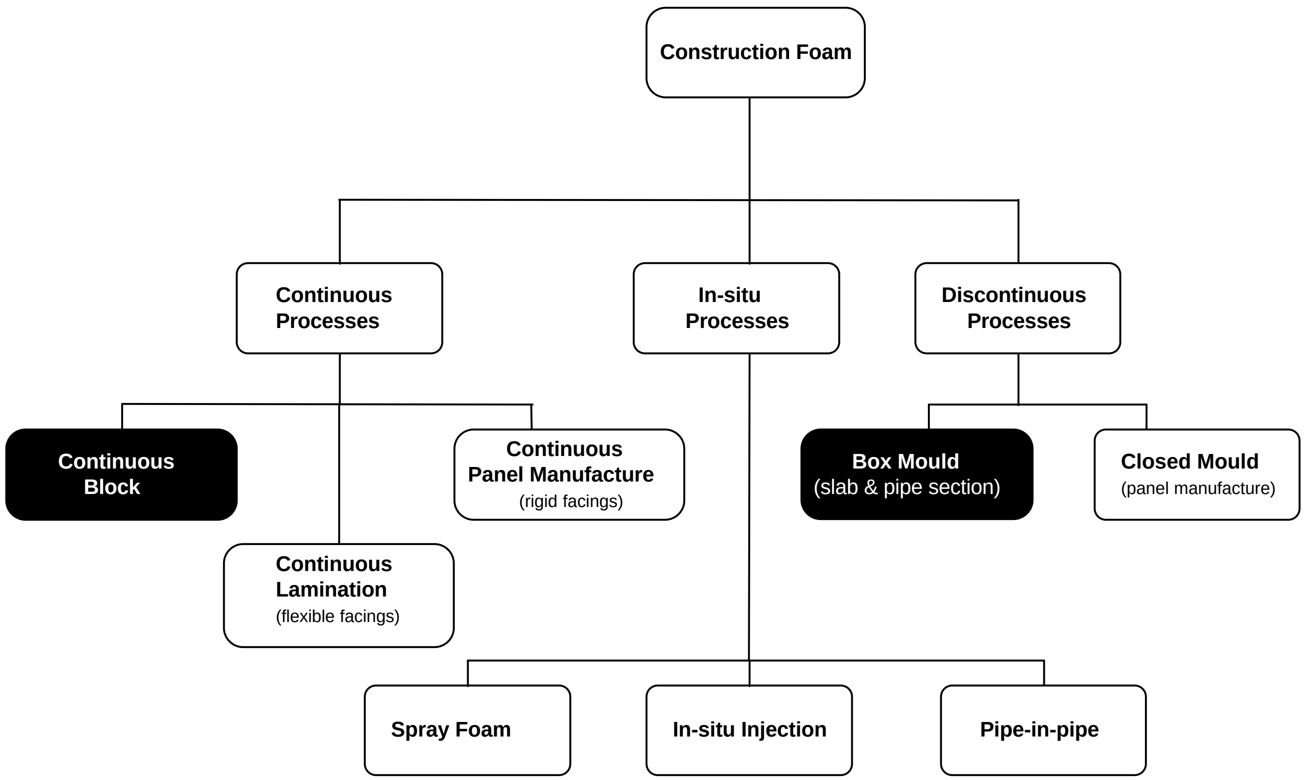
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

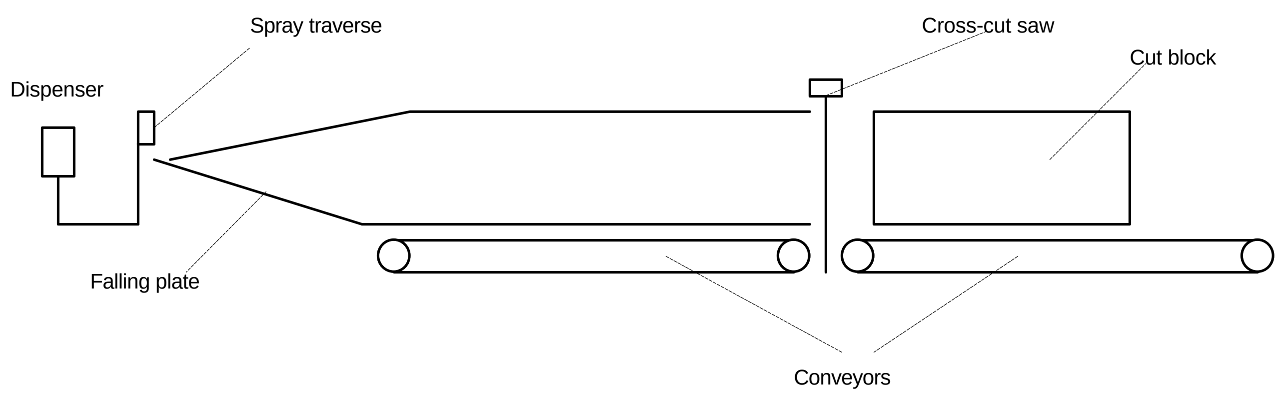
Construction Foams

There are a substantial number of products and processes involved in this sector. These are best summarised in the diagram overleaf:



Slabstock Foam & Pipe Sections

Slabstock foams, pipe sections and other profiles are fabricated from blocks of rigid polyurethane foam. These blocks can be made on a discontinuous basis using a box mould or more typically by a continuous process of the type illustrated below:



Summary of Available Technical Options

Although there are detailed formulation issues affecting each of the processes listed, the general options available to the slabstock sector are similar to those of other insulation foams. The general requirements of all foams are

- Low thermal conductivity
- Fire performance
- Strength/density ratio
- Ease of processing
- Ease of use and handling

The options can therefore be summarised as follows:

n- & iso-Pentane - Very little pentane is used in slabstock. Requires control of flammability issues in both processand product. Most formulations contain increased fire retardant levels to accommodate the change. Pentane is also a VOC and its emissions may need to be controlled in certain parts of the world.

Liquid HFCs - Similar comments as noted under the appliance section (Sec. 2.1.). Again the major problem for the industry is availability (around 2000) and the potential impact of local global warming legislation. Additionally, the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.

CO_2 (Water blown) - Useful in applications where insulation efficiency is less important. However, density increases are also evident and the technology, in its current form is not very attractive. Further developments are on-going.

Less Preferred Options (measurable ODP)

HCFCs (141b & 22/142b) - These are widely used for insulation applications since they provide the strongest combination of product characteristics available. Many companies are waiting for the arrival of liquid HFCs which should provide similar performance rather than switching to hydrocarbons. Nonetheless, HCFCs must be recognised as an interim solution by all using them.

Slabstock Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.51) summarises the detailed information for those companies ***which provided Data Sheets.*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the “Supplier Information - Data Sheets” at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.52) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in “Supplier Information - Contacts” at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.51 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology			
		HFC	HCFC	Hydro-carbons	Water-blown
Polyurethane Systems	Baxenden				X
	Bayer AG	X	X	X	X
	Busing & Fesch		X		X
	Elastogran	X	X	X	X
	ICI Polyurethanes	X	X	X	X
Blowing Agent	AlliedSignal	X			
	Exxon Chemicals			X	
	Solvay Fluor	X	X		
Flame Retardants	Albright & Wilson	X	X	X	X
Ancilliaries	Acmos Chemie.	X	X	X	X
	3M	X	X	X	
Machinery	Cannon				X
	Edulan				X
	Tectrade Kemi AS			X	X

Matrix 2.52 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albrecht Baumer KG		X			
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Beamech Group Ltd.		X			
Borsodchem Rt. PUR Plant	X				
Bomix Chemie GmhB					X
Busing & Fasch Gmbh & Co.	X				
Cannon-Afros		X			
Chem-Trend A/S					X
Courtaulds Chemicals				X	
Crecimiento Industrail Co. Ltd		X			
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPond de Nemours Int. S.A.			X		
Edulan	X	X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals			X		
Fecken Kirfel		X			
FMC Corp. UK Ltd.				X	
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
IFS Systems	X				
Isothane Ltd.	X				
Krauss-Maffei Kunstofftechnik GmbH		X			
La Roche Chemicals			X		
Maschinenfabrik Hennecke GmbH		X			
Mica Machinery (Sales) Ltd.		X			
Nitroil Europe Handels GmbH	X				
OMS Impianti Group		X			
Pelron/Ele	X			X	X
Perros		X			
Resina Chemie	X				
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Sunkist Chemical Machinery Ltd		X			
Tectrade Kemi AS					
TSE Industries					X
Th. Goldschmidt AG					X

Tosoh Corporation	X				
Unichema UK	X				
Wito Corporation	X				
Zaco PTI b.v.		X			
3M					X

Slabstock Foam Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully make the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix, locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.53

Company	Alternative Technology		
	HCFC	Water Blown	Cyclopentane
Efisol	X		
Kooltherm Insulation	X		
Tarec International	X		

1. Company: Name **EFISOL** Add. 5, Rue du Dôme 75116 Paris Coun. France Tel: + 33 4755 5341 Fax: + 33 4704 3543 Telex: 640 581 Contact -	**Case Study Category** **2.5 Rigid Polyurethane Slabstock** **2. Products** -

3. New Technology Applied	The original process was conventional polyurethane foaming on a continuous line with CFCs as blowing agents. CFC has been substituted by HCFC 141b. <u>The share of CFC-free production:</u> Less than 1% in 1992 Approximately 10% (assumption) in 1993 Approximately 50% (assumption) in 1994 The process is fully implemented.
4. End product quality	The end product has reduced insulation properties compared with the original product.
Operational implications	The costs of the end product is a little higher with the CFC-free technology. The production rate is lower with the new technology. The new process requires staff training.
5. Safety and Envrionmental Issues	-
6. Implementation, operational and maintenance costs	The investment costs are about US$ 1 m. for one plant. The maintenance costs are around 10% higher than before, due to the staff training.

1. Company:		**Case Study Category**	**2.5 Rigid Polyurethane Slabstock**
Name	**Kooltherm Insulation Products Ltd.**		
Add.	P.O. Box 3 Charlestown, Glossop, Derbyshire SK13 8LE		
Coun.	United Kingdom	**2. Products**	Rigid PU and polyisocyanurate block foam for slabstock, pipe sections etc.
Tel:	+ 44 1457 861611		
Fax:	+ 44 1457 852319		
Telex:	669867		
Contact	Mark S. Harris, Technical Manager		

3. New Technology Applied	The manufacturing process is continuous and was based on the use of CFCs as blowing agents. CFC-11 has been substituted with HCFC 141b and requires the use of alternative formulations, particularly in repect to polyols, catalysts and surfactants. The manufacture of rigid polyurethane and polyisocyanurate foam is in full scale commercial production. The plant is capable of producing up to 100m^3 of foam per hour.
4. End product quality	The use of HCFC 141b to replace CFC-11 produces a foam which is inherently 10-15% lower in compression strength. This problem has been significantly reduced by the use of alternative formulations. The insulation efficiency of HCFC 141b blown products is broadly similar to the CFC-11 products.
Operational implications	HCFC 141b, with its 8^{o}C higher boiling point than CFC-11, requires modified processing parameters.
5. Safety and Environmental Issues	There are no additional safety issues.
6. Implementation, operational and mainenance costs	No significant changes occur in this area as a result of the switch from CFC to HCFC.

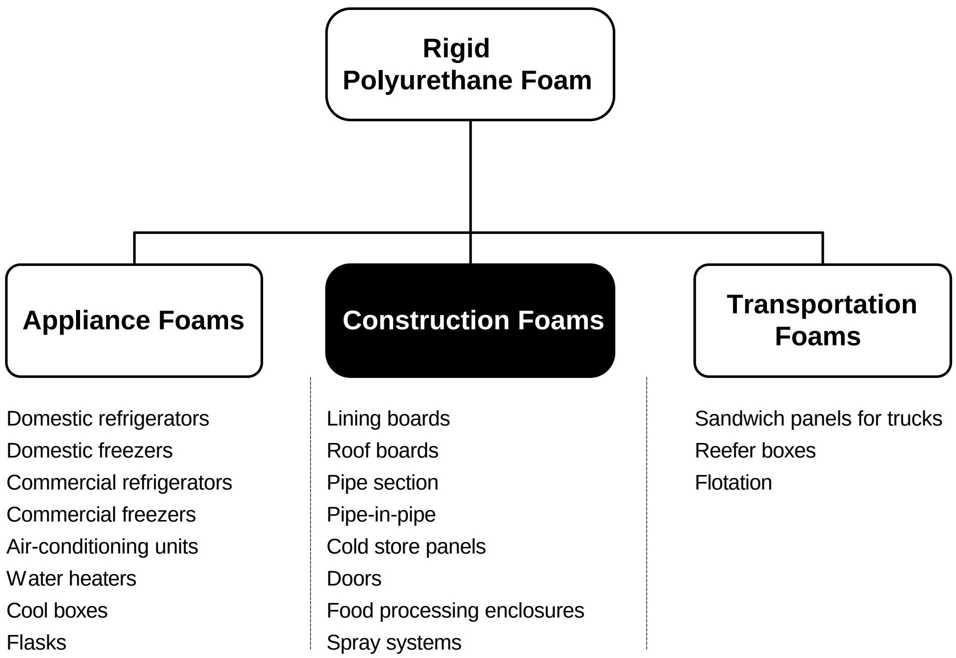
1. Company:	**Case Study** **2.5** **Category** **Rigid Polyurethane Slabstock**
Name **Tarec Insulation Divison of Recticel N.V.** Add. Visbeekstraat 24 2300 Turnhout Coun. Belgium Tel: + 32 1442 4271 Fax: + 32 1442 7221 Telex: 71003 Contact -	**2. Products** -
3. New Technology Applied	Since 1990, CFC-11 was substitued by HCFC in a conventional PUR foaming process. The composition of the foam has been modified. Full production has been reached with the new technology.
4. End product quality Operational implications	There has been no changes in the properties of the end-product quality. -
5. Safety and Environmental issues	There has been a few minor changes in the safety issues.
6. Implementation, Operational and maintenance costs	The operational costs have not been estimated. Investments costs have not been estimated.

2.6 Rigid Polyurethane Foam - Pipe-in-pipe/Preformed Pipe

Technical Options Overview

Description of Sector

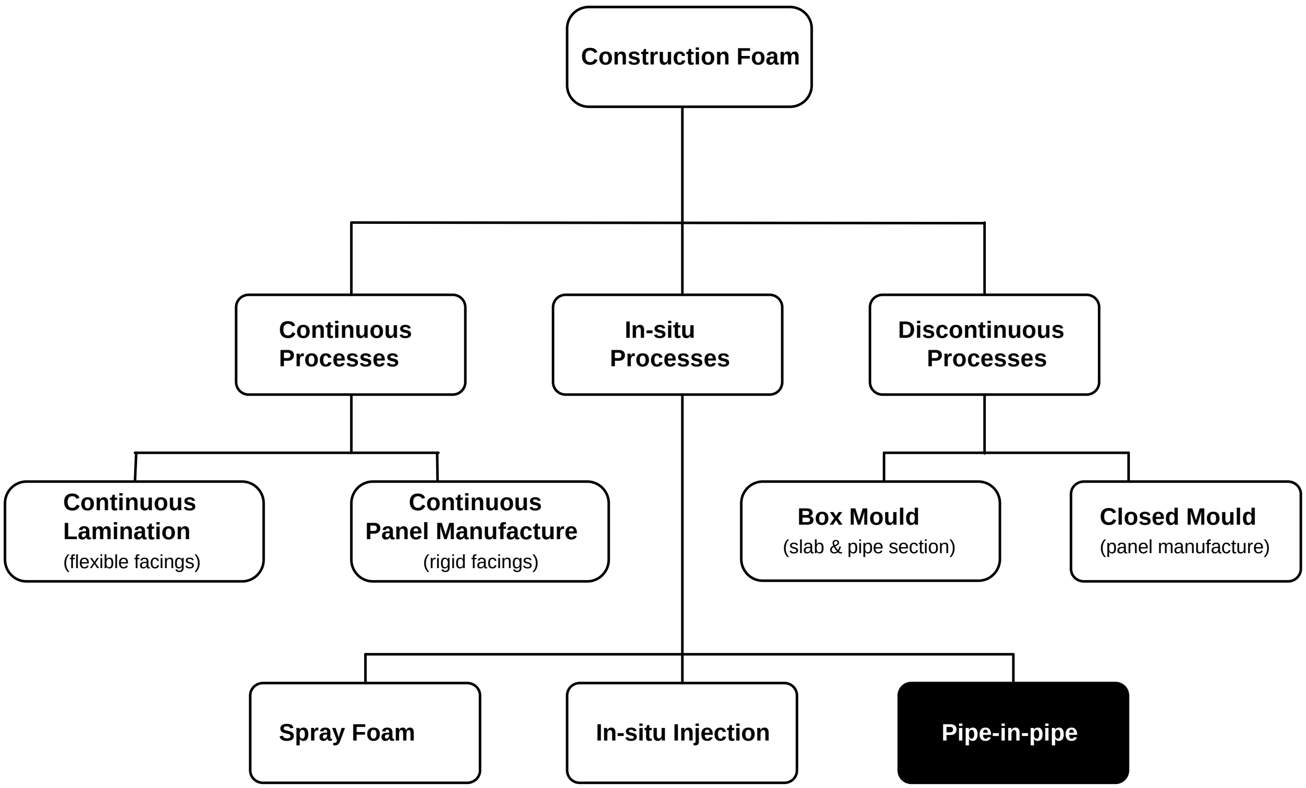
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

Construction Foams

There are a substantial number of products and processes involved in this sector. These are best summarised in the diagram overleaf:



Pipe-in-Pipe

This technique represents a specific form of in-situ injection but has the advantage of being factory based. It is primarily used to provide underground district heating, but is also being increasingly used in the process industries and other applications where moisture ingress is to be avoided.

Summary of Available Technical Options

Although there are detailed formulation issues affecting pipe systems of varying dimensions, the general requirements of all systems are

- Low thermal conductivity
- Good flow characteristics
- Strength/density ratio
- Good adhesion
- Ease of use and handling

The options can therefore be summarised as follows:

Cyclopentane - Requires control of flammability issues in both process and product. Most formulations contain increased fire retardant levels to accommodate the change. Pentane is also a VOC and its emissions may need to be controlled in certain parts of the world.

Liquid HFCs - Similar comments as noted under the appliance section (Sec. 2.1.). Again the major problem for the industry is availability (around 2000) and the potential impact of local global warming legislation. Additionally,

		the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.
CO_2 (Water blown)	-	Particularly useful in applications where insulation efficiency is less important and is proving to have widespread appeal.

Less Preferred Options (measurable ODP)

HCFCs (141b & 22/142b)	-	These are widely used for insulation applications since they provide the strongest combination of product characteristics available. Many companies are waiting for the arrival of liquid HFCs which should provide similar performance rather than switching to hydrocarbons. Nonetheless, HCFCs must be recognised as an interim solution by all using them.

Pipe-in-pipe/Preformed Pipe Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.61) summarises the detailed information for those companies which ***provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Rigid Polyurethane Foam chapter on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.62) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.61 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technology				
		HFC	HCFC	Hydro-carbons	Water-blown	Other
Polyurethane Systems	Baxenden				X	
	Bayer AG				X	
	Busing & Fasch		X		X	
	Elastogran	X	X	X	X	
	Hennecke			X		
	I.F.S. Chem					X
	ICI Polyurethanes	X	X		X	
	Tagos SRL				X	
Blowing Agent	AlliedSignal	X	X			
	Solvay Fluor	X	X			
	Exxon Chemicals			X		
Flame Retardants	Albright & Wilson	X	X	X	X	X
Ancilliaries	Acmos Chemie	X	X	X	X	X
	3M	X	X	X		
Machinery	Cannon				X	
	Edulan				X	
	Hennecke			X		

Matrix 2.62 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Acmos Chemie					X
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Beamech Group Ltd.		X			
Borsodchem Rt. PUR Plant	X				
Busing & Fasch Gmbh & Co.	X				
Cannon-Afros		X			
Courtaulds Chemicals				X	
Deltapur	X				
Dow Europe	X				
DuPond de Nemours Int. S.A.			X		
Edulan	X	X			
Elastogran GmbH	X				
EniChem SpA	X				
Elf Atochem SA			X		
Exxon Chemicals			X		
FMC Corp. UK Ltd.				X	
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
IFS Systems	X				
Isothane Ltd.	X				
Isotherm AG		X			
Krauss-Maffei Kunstofftechnik GmbH		X			
La Roche Chemicals			X		
Maschinenfabrik Hennecke GmbH		X			
Nitroil Europe Handels GmbH	X				
Oxid Inc.	X				
Pelron/Ele	X			X	X
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Tagos SRL	X				
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				
3M					X

Pipe-in-pipe/Preformed Pipe Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully make the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix, locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.63

Company	Alternative Technology		
	HCFC	Hydro-Carbons	Water-Blown
ABB District Heating		X	
KWH Tech Ltd	X		X
Powerpipe AB			X
Tarco Energy		X	

1. Company: Name **ABB District Heating** Add. Treldevej 191 DK 7000 Fredericia Coun. Denmark Tel: + 45 7592 6211 Fax: + 45 7592 2404 Telex: - Contact Hans Nørgaard Pedersen	**Case Study Category** **2.6 Rigid Polyurethane Pipe-in-pipe** **2. Products** District heating pipes insulated with rigid PUR foam
3. New Technology Applied	Until 1990 CFC-11 was used as blowing agent. The annual consumption was 550 tons. Since 1994 the company has used a special blowing agent, type DH4, with no impact on the ozone layer. The reduction in the use of ozone depleting substances has been obtained by process changes, alternative process equipment, product redesign and by substitution of chemicals used. The substitute blowing agents are inert gases and hydrocarbons including pentanes. The process change has involved a rebuilding of the production plants. The production of district heating pipes amounts to approx. 3000 km per year. The polyurethane consumption is approx. 6500 tons per year. 80% of this is produced in Scandinavia, the rest in Central Europe.
4. End product quality **Operational implications**	The mechanical properties are improved, and the insulation properties remain the same. The production rate is unchanged, and as the production waste contains no chlorine, the destruction of the waste is less complicated. The quantitative consumption of raw materials is unchanged. The new process does not require additional training of the staff. The energy consumption is unchanged.
5. Safety and Environmental issues	Hygiene limit values are higher for the new product. Rules must be observed.
6. Implementation, Operational and maintenance costs	-

1. Company: Name **KWH Tech Ltd. Thermopipe** Add. P.O.Box 383 SF 65101 Vasa Coun. Finland Tel: + 358 6132 65666 Fax: + 358 6132 65260 Telex: 74105 whvsa sf Contact Mr. Stefan Lindvall, Product Manager	**Case Study Category** **2.6** **Rigid Polyurethane Pipe-in-pipe** **2. Products** Preinsulated district heating pipes.
3. New Technology Applied	When producing preinsulated pipes with PUR rigid foam as insulation material, the foam liquids are injected at a high velocity into the space between carrier- and jacketpipe using a high pressure foaming machine.The injection can be done from one end or from the middle of the pipe element. CFC-11 was used as blowing agent until 1994, and was substituted thereafter by CO_2 and HCFC 141b. The share of CFC-free pipe production: CO_2-blown / HCFC-blown - 1990: 3 per cent of pipes / - - 1991: 5 per cent " / - - 1992: 20 per cent " / - - 1993: 10 per cent " / 20 per cent of pipes The technology is fully implemented.
4. End product quality	The new foams have a thermal conductivity, approx. 10-15 per cent higher for CO_2 blown foams and 5 per cent higher for HCFC blown foams. The new foams have higher mechanical strength values.
Operational implications	The new product requires new polyol types and increased isocyanate consumption. Operating procedures and training requirements are the same as for CFC blown foams. Due to the use of larger pumps and increased viscosity of the mixture an increased use of energy is necessary.
5. Safety and Environmental Issues	No changes in safety issues.
6. Implementation, operational and maintenance cost	The main investment cost is due to the extension of the foaming machinery. Approximate total cost including development of the foam, tests and the equipment is US$ 290,000 - 360,000.

1. Company:		**Case Study Category**	**2.6 Rigid Polyurethane Pipe-in-pipe**
Name	**Powerpipe AB**		
Add.	Box 44 S-425 02 HISINGS KÄRRA		
Coun.	Sweden	**2. Products**	Preinsulated pipes.
Tel:	+ 46 031 57 06 00		
Fax:	+ 46 031 57 51 41		
Telex:	-		
Contact	Göran Johansson, Technical Manager.		

3. New Technology Applied	Until 1989 CFC-11 was used as blowing agent. After 1989 Powerpipe AB changed to CO_2 as blowing agent. The process has been fully implemented since 1989, with an annual production of polyurethane approx. 1100 tons.
4. End product quality	The mechanical and ageing properties have improved. The thermal conductivity has increased by up to - 10 per cent.
Operational implications	No significant changes in the operation procedures have been necessary. The production rate, energy consumption and quantitative consumption or raw materials is unchanged. The cyanate/polyol ratio has been changed to 100/188. Training and skill requirements are unchanged.
5. Safety and Environmental Issues	No changes.
6. Implementation, operational and maintenance costs	No investment costs in foaming equipment. Small investment in mixing equipment.

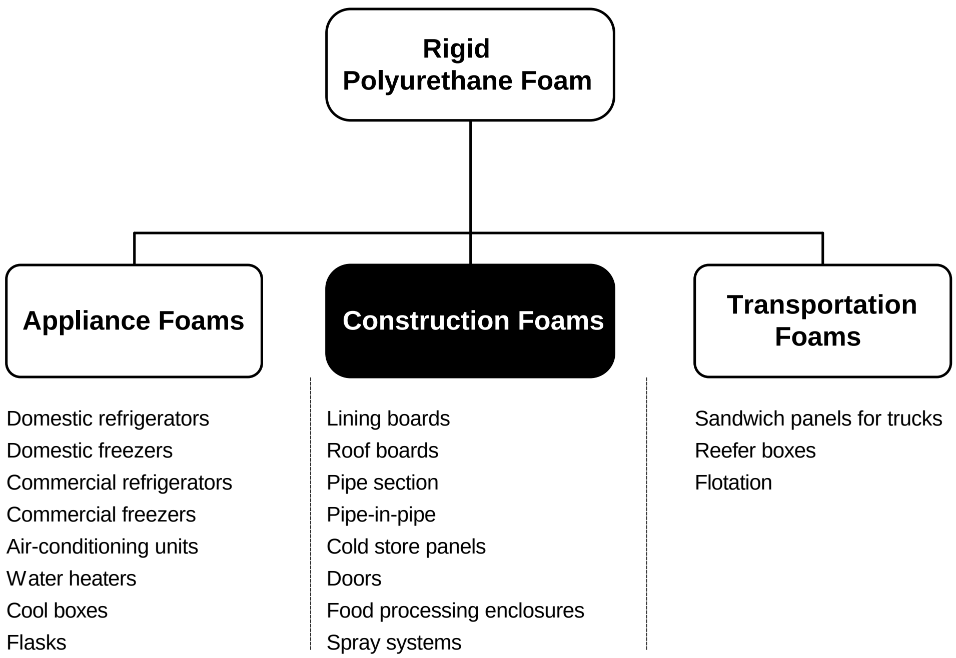
1. Company: Name **Tarco Energy A/S** Add. Erritsø Møllebanke 10 DK-7000 Fredericia Coun. Denmark Tel: + 45 7594 0222 Fax: + 45 7594 0168 Telex: - Contact Mr. Sverre K. Simonsen, Chemical Engineer.	**Case Study Category** **2.6 Rigid Polyurethane Pipe-in-pipe** **2. Products** Pre-insulated district heating pipes.
3. New Technology Applied	In 1992 CFC-11 was subsituted by HCFC-142b and CO_2 in a conventional PUR foaming process. As from 1994, Tarco Energy A/S has produced pre-insulated district heating pipes with the use of cyclopentane as blowing agent. CFCs and HCFC were subsituted by cyclopentane everywhere in the production. The foam is injected into the space between the carrier steel pipe and the casing pipe of polyethylene. The annual production of insulation foam is approx. 2,000 tons.
4. End product quality	The thermal conductivity of the new product is 0.0275 W/m/K. This constitutes an improvement compared to HCFC-142b blown foams.
Operational implications	Production rate equals that of the former process. The waste amount is unchanged. The excellent dilution properties of cyclopentane make it possible to use polyols with higher viscosity, which improve the mechanical properties of the foam. The flammability of cyclopentane makes it necessary to maintain a nitrogen pressure in the store tanks. Ventilation is necessary during the foaming process.
5. Safety and Environmental issues	Cyclopentane has a threshold limit value (TLV) of 300 ppm. The explosion limits in air are 1.1 per cent to 8.8 per cent volume. Nitrogen gas in all tanks and increased ventilation necessary.
6. Implementation, Operational and maintenance costs	The investment in new production machinery was approx. US$ 1 m. Development costs were approx. US$ 285,000. Operational and maintenance costs are the same as for the original process.

2.7 Rigid Polyurethane Foam - One-component Foam

Technical Options Overview

Description of Sector

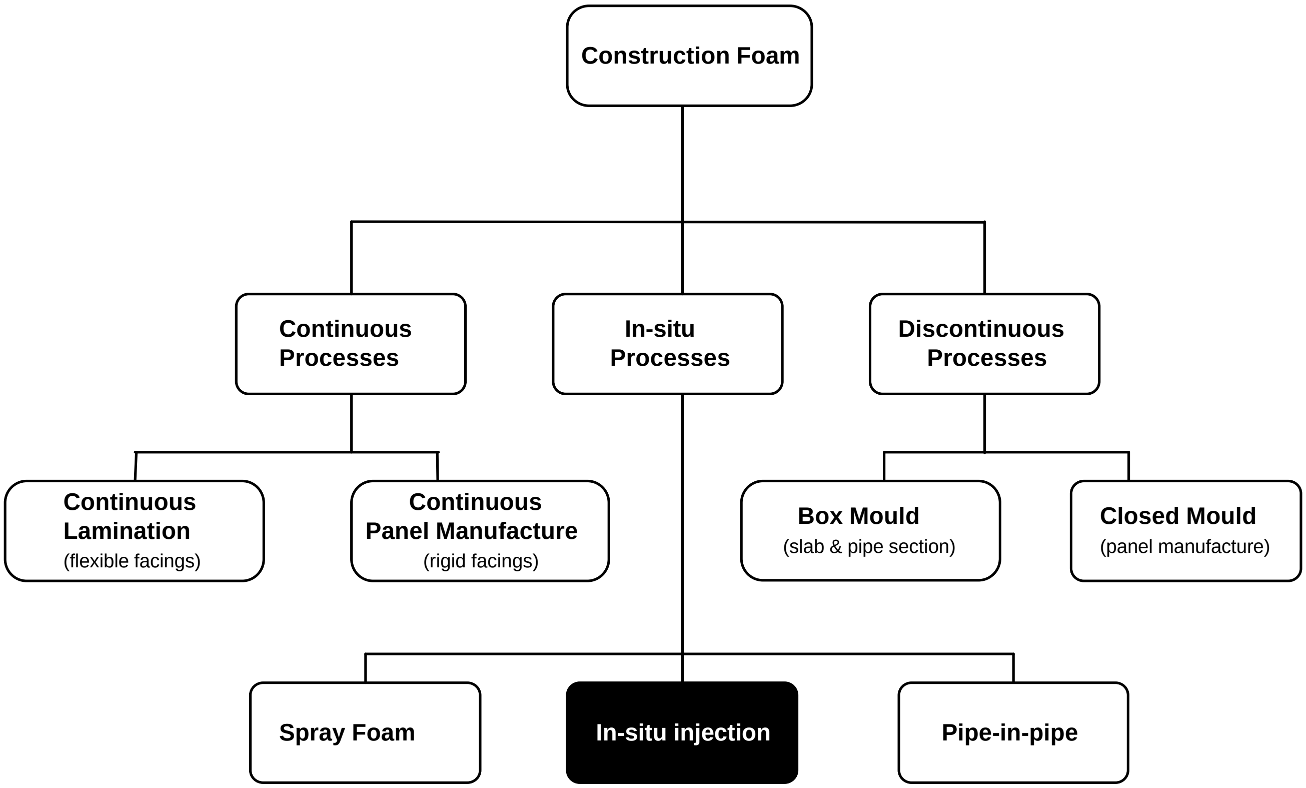
The rigid polyurethane foam industry can be characterised in several, equally valid, ways. However, for the sake of this treatment, it is probably simplest to divide by application and subsequently by product/process. Accordingly, the first diagram describes the three main end-use sectors served by rigid polyurethane foams:



These application areas are characterised by their requirement for high thermal efficiency, structural integrity and light weight.

Construction Foams

There are a substantial number of products and processes involved in this sector. These are best summarised in the diagram overleaf:



One Component Foams

One component foams are a specific sub-group of the in-situ injection sector. As their name implies, the technology provides a system which can be used without the need for mixing on site and it has therefore been possible to supply these systems in disposable cans. The market has therefore developed in the 'do-it-yourself' sector and as a utility filler for the building trade. The nature of the technology makes the technical options for CFC replacement much more specific.

Summary of Available Technical Options

The general requirements of all foams are

- Intermediate thermal conductivity
- Fire performance
- Strength/density ratio
- Versatility at a wide range of application temperatures
- Ease of use and handling

The options can therefore be summarised as follows:

Propane or butane	-	Requires control of flammability issues in both process and product. Most formulations contain increased fire retardant levels to accommodate the change. These hydrocarbons are also VOCs and their emissions may need to be controlled in certain parts of the world.
Dimethyl ether (DME)	-	Similar comments as noted above with respect to flammability.

HFC 134a	-	Already being used in significant quantities. It provides a non-flammable and zero-ODP option.
HFC 152a	-	Only in early stages of commercial development. Has required significant formulation changes but looks a valuable longer-term alternative.

<u>Less Preferred Options (measurable ODP)</u>

HCFCs (22 & 22/142b)	-	These are still widely used since they provide the closest parallel to CFC-12 at this stage in terms of product characteristics available. Nonetheless, HCFCs must be recognised as an interim solution by <u>all</u> using them.

One-component Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (2.71) summarises the detailed information for those companies which ***provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Rigid Polyurethane Foam chapter, on page 2-111. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (2.72) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end chapter 2. Contact the supplier to obtain detailed information.

Matrix 2.71 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	**Company**	**Alternative Technology**			
		HFC	**HCFC**	**Hydro-carbons**	**Water-blown**
Polyurethane Systems	Baxenden				X
	Bayer AG				X
	Busing & Fasch		X		X
	ICI Polyurethanes				X
Blowing Agent	AlliedSignal	X	X		
	Solvay Fluor	X	X		
	Exxon Chemicals			X	
Flame Retardants	Albright & Wilson	X	X	X	X
Ancilliaries	3M	X	X	X	
Machinery	Cannon				X
	Edulan				X

Matrix 2.72 *All known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	PU Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**	**Ancilliaries**
Air Products and Chemicals Inc.	X				X
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
BASF AG	X				
Baxenden	X	X			
Bayer AG	X				
Borsodchem Rt. PUR Plant	X				
Courtaulds Chemicals				X	
Deltapur	X				
Dow Europe	X				
DuPont Chemicals			X		
DuPont de Nemours Int. S.A.			X		
EniChem SpA	X				
Exxon Chemicals			X		
FMC Corp. UK Ltd.				X	
Hoescht AG				X	
Hoocker	X				
ICI Polyurethanes	X				
IFS Systems	X				
Isothane Ltd.	X				
Nitroil Europe Handels GmbH	X				
Oxid Inc.	X		X		
Pelron/Ele	X			X	X
SAIP		X			
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Th. Goldschmidt AG					X
Tosoh Corporation	X				
Unichema UK	X				
Witco Corporation	X		X		
3M					X

One-component Foam Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully make the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Rigid Polyurethane Foam chapter on page 2-111, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (2.73), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 2.73

Company	Alternative Technology		
	HFC	Water Blown	Cyclopentane
Soudal NV	X		

1. Company: Name **Soudal NV** Add. Everdongenlaan 18-20 2300 Turnhout Coun. Belgium Tel: + 32 1442 4231 Fax: + 32 1442 6514 Telex: 31626 Contact -	**Category** **2.7 Rigid Polyurethane One-Component Foam** **2. Products** One and two component foam in aerosols in cans for appliance insulation in situ. The manufaturer is fillling components for the appliance can. The components include polyol, MDI and propellant.
3. New Technology Applied	The new technology is based on chemical substitution and modifications of the process. The propellant (an ozone depleting substance) has been replaced by HFC. The substitution of propellant has resulted in a reformulation of the polyol part of the foam. Furthermore, the composition of the foam has changed: Composition of the <u>original product</u> <u>new product</u> Polyol 30 parts 30 parts MDI 35 parts 47 parts Propellant (HFC) 35 parts 23 parts The technology is fully implemented. 100% of the 8 million aerosol cans produced a year contain HFC as the propellant. The process flow is 5000m^3 per year.
4. End product quality **Operational implications**	- The production rates for the modified technology are the same as for the original technology. Increased amount of catalyst is needed for the new process. The waste streams are the same as before, apart from the propellant. The new technology has required equipment for gas detection. There are no technical constraints with the new technology.
5. Safety and Environmental issues	Explosiometers are necessary.
6. Implementation, Operational and maintenance costs	The costs for new raw materials are about 20 per cent higher than for the raw materials used in the original process.

2.8 Supplier Information

About the Supplier Information

This section includes all of the known suppliers of technology, equipment and chemicals for this sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in *Supplier Data Sheets.*

How to Use this Information

Part 1: Contacts provide a ***comprehensive contact list for all suppliers,*** including both those which contributed Data Sheets as well as those that did not. This section is organised sequentialy into PU systems, Machinery, Blowing Agents, Flame Retardants and Anxcilliaries and within these sections, alphabetically by company name. After locating a specific supplier, contact the company to obtain detailed information.

Part 2: Data Sheets contain ***detailed process information when provided by the supplier.*** These sheets contain data that can help you better evaluate a particular technical option. This section is organized sequentially into Foam manufactures, Polyurethane Chemicals, Blowing Agents, Flame Retardants, Release Agents and Machinery and within these sections, alphebetically by company name. After locating and reading the specific data sheet, contact the supplier to obtain additional information.

DISCLAIMER

Please note that the information contained in the Data Sheets is of a commercial nature and it is up to the reader to verify any claims about performance, safety, costs, etc. made by the company. UNEP IE in no way endorses or recommends any company, product, process or claims referred to in these Data Sheets, as they are provided for information purposes only.

PART 1 - CONTACTS

PU Systems

Air Products and Chemicals Inc.
Chemical Products Group
7201 Hamiltion Boulevard
Allentown, PA 18195-1501
United States
Tel. (1) 610-481-6799
Fax. (1) 610-481-4381
Main Products: Amine & tin catalysts, silicone & other surfactants, release agents etc.

BASF AG
Intermediates Marketing
67056 Ludwigshafen
Germany
Tel.
Fax. (49) 621-60-20805
Main Products: Amine catalysts, chain extenders

Bayer AG
51368 Leverkeusen
Germany
Tel. (49) 214-301
Fax. (49) 214-306-6411
Main Products: Polyurethane systems

Baxenden Chemicals Ltd.
Paragon Works
Baxenden
Accrington
Lancashire BB5 2SL
United Kingdom
Tel. (44) 1254-872278
Fax. (44) 1254-871247
Main Products: Polyurethane systems & Machinery

Borsodchem Rt. PUR Plant
H-3702 Kazincbarcika P.O.B. 208
Hungary
Tel. (36) 48-310-211
Fax. (36) 48-310-277
Main Products: Polyols & MDI

Busing & Fasch GmbH & Co.
Zum Damm 6
26180 Rastede
Germany
Tel. (49) 4402-1065
Fax. (49) 4402-1064
Main Products: Polyurethane systems

Deltapur
36065 Mussolente (VI)
Via Dante Alighieri, 27/B
Italy
Tel. (39) 424-579511
Fax. (39) 424-579500
Main Products: Polyurethane systems

Dow Europe
Bachtobelstrasse 3
CH-8810 Horgen
Switzerland
Tel. (41) 1 728-2818
Fax. (41) 1 728-2096
Main Products: Polyurethane systems

Edulan A/S
Jens Olsens Vej 3
DK-8200 Aarhus N
Denmark
Tel. (45) 86-10-90-90
Fax. (45) 86-10-92-88
Main Products: Polyurethane systems and equipment

Elastogran GmbH
Systems Division
Geiselbullach Factory
Industriestrasse 1
D - 82140 Olching
Germany
Tel. (49) 81-42-1780
Fax. (49) 81-42-178-213
Main Products: Flexible, spray & insulation systems

EniChem SpA Polyurethane
Via Taramelli, 26
20124
Milan
Italy
Tel. (39) 2-69771
Fax. (39) 2-6977-8183
Main Products: Polyurethane Systems

Hoocker (Synthesia Espanola)
62 Conde Borrell Street
08015 Barcelona
Spain
Tel. (34) 3-325-77-50
Fax. (34) 3-426-46-82
Main Products: Polyols & polyurethane systems

ICI Polyurethanes
Everslaan 45
3078 Everberg
Belgium
Tel. (32) 2-758-9211
Fax. (32) 2-759-5501
Main Products: Polyurethane systems

IFS Systems
Maple Road
Kings Lynn
Norfolk, PE34 3AH
United Kingdom
Tel. (44) 1553-764-229
Fax. (44) 1553-765-038
Main Products: Polyurethane systems

Isothane Limited
Newhouse Road
Huncoat Business Park
Accrington
Lancashire BB5 6NT
United Kingdom
Tel. (44) 1254-872555
Fax. (44) 1254-871522
Main Products: Polyurethane systems

Nitroil Europe Handels GmbH
Zippelhaus 1-2
D - 20457
Hamburg
Germany
Tel. (49) 40-325-6560
Fax. (49) 40-325-65616
Main Products: Amine catalysts

Oxid Inc.
4600 Post Oak Place
Suite 250
Houston
Texas 77027
United States
Tel. (1) 713-296-7504
Fax. (1) 713-296-7599
Main Products: Polyester polyols

Pelron/Ele Corporation
7847 West 47th Street
Lyons, 60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols, amine catalysts, flame retardants & silicones

Shell Chemicals Europe Ltd
Shell Centre
London
SE1 7NA
England
UK
Tel. (44) 171 9341234
Fax. (44) 171 9343359
Main Products: Polyurethane systems & hydrocarbon blowing agents

Tosoh Corporation
Fine Chemicals Division
PU Catalysts International Group
1-7-7, Akasaka, Minato-ku
Tokyo
Japan
Tel. (81) 3-3585-9891
Fax. (81) 3-3585-5556
Main Products: Amine catalysts

Unichema UK
Bebington
Wirral
Merseyside L62 4UF
England
UK
Tel. (44) 151 6452020
Fax. (44) 151 6459197
Main Products: Polyester Polyols

Witco Corporation
Polyester/Polyurethane Group
One America Lane
Greenwich
CT 06831-2559
United States
Tel. (1) 203-861-6277
Fax. (1) 203-861-6323
Main Products: Polyester Polyols, coating resins

Machinery

Albrecht Baumer KG
Asdorfer Strasse 96-106
D-57258 Freudenberg
Germany
Tel: (49) 2734-450
Fax: (49) 2734-3056
Main Products: Block handling and cutting equipment

Beamech Group Limited
Tenax Road
Trafford Park
Manchester, M17 ?UT
United Kingdom
Tel. (44) 161-848-0316
Fax. (44) 161-873-7718
Main Products: VPF and other PU and PF equipment

Cannon-Afros
Via Galileo Ferraris, 65
21042 Caronno Pertusella (Varese)
Italy
Tel. (39) 2-96531
Fax. (39) 2-9656897
Main Products: PU metering and mixing equipment

Cannon-Viking
Viking House, Unit 1
Parkway Trading Estate
Barton Dock Road, Stretford
Manchester, M32 OTL
Tel. (44) 161-866-9909
Fax. (44) 161-866-8808
Main Products: Slabstock and Lamination Plants

Crecimiento Industrial Co. Ltd.
Office No. 348
Chien Teh St.
40107 Taichung
Taiwan
Republic of China
Tel. (886) 4-2116453
Fax. (886) 4-2111543
Main Products: Post-applied facing laminators, PU Dispensers, Batch mixers, Cutting equipment

Fecken Kirfel
Goebbelgasse 1-15
Postfach 725
Aachen
D52008
Germany
Tel. (49) 2 41182020
Fax. (49) 2 411820213
Main Products: Machinery - cutting

Graco Inc.
4050 Olsen Memorial Highway
Minneapolis
Minnesota 55422
United States
Tel. (1) 612-623-6000
Fax. (1) 612-623-6884
Main Products: Spray foam equipment

Gusmer Inc.
One Gusmer Drive
Lakewood
New Jersey, 08701
United States
Tel. (1) 908-370-9000
Fax. (1) 908-905-8968
Main Products: Spray foam, panel & integral skin equipment

Isotherm AG
PUR-Anlagenbau
Aarestrasse 13,
CH-3627
Heimburg
Switzerland
Tel. (41) 33-379393
Fax. (41) 33-375019
Main Products: Spray and injection dispensers

Kauss-Maffei Kunstofftechnik GmbH
Krauss-Maffei-Strasse 2
80997 Munchen
Federal Republic of Germany
Tel. (49) 89-88-99-0
Fax. (49) 89-88-99-31-51
Main Products: PU - Panel, injection & spray machinery

Maschinenfabrik Hennecke GmbH
Birlinghovener Strasse 30
D-53754
Sankt Augustin-Birlinghoven
Germany
Tel. (49) 22-41-339-0
Fax. (49) 22-41-339-204
Main Products: Flexible & rigid PU foam equipment

Mica Machinery (Sales) Ltd
Mica House
Hyde Road
Denton
Manchester M34 3AJ
United Kingdom
Tel: (44) 161-320-3356
Fax: (44) 161-320-3356
Main products: cutting and granulating machinery

OMS Impianti Group
via Sabbionetta 4
20050 Verano Brianza
Milano
Italy
Tel. (39) 362-983-1
Fax. (39) 362-900581
Main Products: Flexible & rigid PU foam equipment

Perros
Strada per Cassinettam6
20081 Abbiategrasso
Milano
Italy
Tel. (39) 2 9241121
Fax. (39) 2 9420678
Main Products: Polyurethane metering and mixing machines

SAIP
Via Bressanella, 3
22044 Romano Di Inverigo
Como.
Italy
Tel. (39) 31 605762
Fax. (39) 31 606934
MainProducts: Polyurethane dispensing equipment

Sunkist Chemical Machinery Ltd.
10th Floor, 200 Kingshan S. Road, Sec 2
Taipei
Taiwan
Tel. (886) 2-395-56686
Fax. (886) 2-321-7266
Main Products: Flexible foam equipment, cutting & laminating

Zaco PTI b.v.
Zuidkerkenlaan 20
1906 AC Limmen
The Netherlands
Tel. (31) 72-505-3184
Fax. (31) 72-505-3669
Main Products: Polyurethane machinery and Phenolic systems/machinery

Blowing agents

Allied Signal
20 Peabody Street
Buffalo
New York, 14210
United States
Tel. (1) 716-827-1407
Fax. (1) 716-827-6275
Main Products:HCFC-141b, HFC-245a

Elf Atochem SA
4 Cours Michelet-Cedex 42-92091
Paris
La Defense 10
France
Tel. (33) 1 49007425
Fax. (33) 1 49007021
Main Products: Blowing Agents-HCFC 141b, 142b, 22, HFC 134a

Exxon Chemical Belgium
Hermeslaan 2
B-1831 Machelen
Belgium
Tel. (32) 2-722-2171
Fax. (32) 2-722-2193
Main Products: Cyclopentane & other hydrocarbons

DuPont Chemicals
Customer Service Centre
B-15305
Wilmington
DE 19898
United States
Tel. (1) 302-774-2099
Fax. (1) 302-774-2370
Main Products: Blowing Agents - HFC 134a, HCFC141b

DuPont de Nemours Int. S.A.
2 Chemin du Pavillion
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel. (41) 22-717-5111
Fax.
Main Products: Blowing Agents - HFC 134a, HCFC141b

ICI Klea
P.O. Box 13
The Heath
Runcorn
Cheshire, WA7 4QF
United Kingdom
Tel. (44) 928-513-213
Fax. (44) 929-511-418
Main Products: HFC-134a

La Roche Chemicals
P.O. Box 1031
Baton Rouge
Louisiana 70821
United States
Tel. (1) 800-248-6336
Fax. (1) 504-652-9945
Main Products: HCFC-141b

Shell Chemicals Europe Ltd
Shell Centre
London
SE1 7NA
England
UK
Tel. (44) 171 9341234
Fax. (44) 171 9343359
Main Products: Polyurethane systems & hydrocarbon blowing agents

Solvay Fluor und Derivate
Hans-Bockler-Allee 20
D-30173 Hannover
Germany
Tel. (49) 511-8570
Fax. (49) 511-817338
Main Products: HCFC-141b, HCFC-142b, liquid HFC development

Flame Retardants

Albright & Wilson UK Ltd.
210-222 Hagley Road West
Oldbury
Warley
West Midlands B68 0NN
United Kingdom
Tel. (44) 121 420 5117
Fax. (44) 121 420 5545
Main Products: A & W Amgard range for PU foam

Akzo Chemicals B.V.
Stationsplein 4
P.O. Box 247
3800 AE Amersfoort
The Netherlands
Tel. (31) 676-767
Fax. (31) 676-150
Main Products: Phosphorus-based flame retardants

Courtaulds Chemicals
Water Soluble Polymers
PO Box 5
Spondon
Derby, DE21 7BP
United Kingdom
Tel. (44) 332-661422
Fax. (44) 332-280610
Main Products: Phosphate-based fire retardants

FMC Corporation UK Ltd.
Process Additives Division
Tanex Road
Trafford Park
Manchester M17 1WT
Tel: (44) 161 872 2323
Fax: (44) 161 873 7271
Main Products: Phosphate-based flame retardants

Hoescht AG
Business Unit Additives
Marketing Flame Retardants &
Performance Chemicals
D-65926
Frankfurt
Germany
Tel. (49) 69-305-2317
Fax. (49) 69-305-15671
Main Products: Phosphate-based flame retardants

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols,amine catalysts, flame retardants & silicones

Ancilliaries

Air Products and Chemicals Inc.
Chemical Products Group
7201 Hamiltion Boulevard
Allentown
PA 18195-1501
United States
Tel. (1) 610-481-6799
Fax. (1) 610-481-4381
Main Products: Amine & tin catalysts, silicone & other surfactants, release agents etc.

Chem-Trend A/S
Smedeland 14
DK 2600
Glostrup
Denmark
Tel. (45) 42-45-67-11
Fax. (45) 43-63-03-50
Main Products: Mould release agents

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: Polyols, amine catalysts, flame retardants & silicones

Th. Goldschmidt AG
Goldschmidtstrasse 100
D-45127 Essen
Germany
Tel. (49) 201 173 01
Fax. (49) 201 173 2691
Main Products: Range of silicone release agents, amine & tin catalysts, foam stabilisers, colour pastes

3M
Canadastraat,11
B-2070 Zwijndrect
Belgium
Tel: (32) 3250 7867
Fax: (32) 3250 7847
Main Products: Additives for Rigid PU systems

PART 2 - DATA SHEETS

1. Company:	**Data Sheet Category** **2.8 Rigid Polyurethane Spray Foam Insulation Foam Manufacturer**
Name **Icynene Inc.** Add. 376 Watline Avenue Mississauga, Ontario L4Z 1X2 Coun. Canada Tel:. + 1 905 890 7325 Fax: + 1 905 890 7784 Telex: - Contact Graeme G. Kirkland, President.	2. Products — Polyicynene™ water blown foam for a range of construction industry applications.

3. Original process	In the original process CFC/HCFC were used.
4. Reduction/elimination method	In the new technology CFC/HCFC is replaced by water and air. The composition of the original and the new plastic foams are not disclosed.
5. Implications of the new technology	
End product quality	The technology allows a given thermal resistance to be achieved without CFC/HCFC and with lower cost and lower raw material usage. 50 per cent higher application thickness is necessary to obtain the same thermal resistance.
Operational implications	Only minor changes are required in operating procedures. Factory training is required for applicators. Energy consumption is unchanged.
6. Scale of operation	Small scale operation is economic.
7. Technical constraints	-
8. Restrictions of technology	The technology is privately held by Icynene Inc.
9. Stage of technology	-
10. Level of commercialization	The technology is commercially available in U.S.A., Canada, and Korea. Implementation in other countries may require compliance with local testing and approval regulations. The technology has been used successfully in the construction industry since 1987.
11. Investment costs	No capital costs are involved in switching.

12. Operational and maintenance costs	No significant additional operational and maintenance costs.
13. Safety issues	The technology requires no additional safety precautions.
14. Development of technology	The technology is developed in-house.
15. Other	-

1. Company:		**Data Sheet** **Category**	**2.8** **Suppliers of PU Systems**
Name	**Baxenden Scandinavia A/S**		
Add.	Fuldbyvej 4 Pedersborg DK-4180 Sorø		
Coun.	Denmark	**2. Products**	PUR, machinery, component system
Tel:	+45 53 63 33 33		
Fax:	+45 53 63 49 66		
Telex:	40 101 Isoform		
Contact	H Nygaard		

3. Original process	The foam was blown with CFC-11 and CFC-12.
4. Reduction/elimination method	The use of CFC-11 and CFC-12 was reduced by product redesign, process modification, and substitution of chemical components. The content of CFC-11 and CFC-12 has been eliminated.
5. Implications of the new technology	
End product quality	The quality of the new and the old product does not differ significantly.
Operational implications	The production rate as well as the quality are unchanged. Operating procedures have been changed, but the new operating procedures are considered trade secrets. There are no additional requirements for staff training. Energy consumption is unchanged.
6. Scale of operation	-
7. Technical constraints	None.
8. Restrictions of technology	The technology is not patented.
9. Stage of technology	The technology is fully implemented.
10. Level of commercialization	The technology is commercially available.
11. Investment costs	The investment costs are considered trade secrets.
12. Operational and maintenance costs	These costs are considered trade secrets.
13. Safety issues	The new products might have lower hygienic limits and contain flammable constituents.
14. Development of technology	The technology is developed independently by Baxenden Scandinavia A/S.
15. Other	-

1. Company: Name **Bayer AG** Add. 51368 Leverkusen Coun. Germany Tel: +49 0214/30-1 Fax: +49 0214 30-66411 Telex: 85101-0 by d Contact local Bayer AG sales offices.	**Data Sheet 2.8** **Category Suppliers of PU Systems** **2. Products** Raw materials for polyurethane foams, foaming component systems and foaming machinery. Bayer AG is a supplier of a wide range of systems specific for each application: - Flexible PUR foams - Integral PUR foams - Rigid foams
3. Original process	The original systems were based on CFCs.
4. Reduction/elimination method	The elimination methods are based on a number of solutions specific for each application. The new technologies are based on alternative process equipment, redesign of the products, substitution of chemicals, process modification, etc. The most important systems are: <u>Foam system</u> — <u>Alternative blowing/insulation agent</u> Flexible PUR foams — CO_2 Integral PUR foams — CO_2, HCFCs, pentane Rigid foams — CO_2, HCFCs, HFCs, pentane, cyclopentane Where no drop-in solution has been possible, modified or new equipment for processing has been developed. Except for HCFC-141b, which offers a "drop in solution" most other alternatives require modification of existing equipment/installations. In general, there is no change in isocyanates, whereas polyol formulations are adapted to the blowing agent. Except for CO_2 the quantity and ratio of the main components equal CFC-technologies.
5. Implications of the new technology	This depends on the choice of CFC-free foam system.
End product quality	-

	Operational implications	-
6.	**Scale of operation**	-
7.	**Technical constraints**	This depends on the choice of CFC-free foam system.
8.	**Restrictions of technology**	-
9.	**Stage of technology**	The technologies are fully implemented.
10.	**Level of commercialization**	Raw materials and machinery are commercially available. Raw materials and machinery are being widely used by the industry.
11.	**Investment costs**	This depends on the choice of CFC-free foam system.
12.	**Operational and maintenance costs**	This depends on the choice of CFC-free foam system.
13.	**Safety issues**	Pentanes are flammable and require appropriate safety precautions.
14.	**Development of technology**	Bayer AG is one of the major producers of raw materials for polyurethane foams and have intensively been engaged in the development of alternative blowing agents and appropriate foam systems for each application.
15.	**Other**	-

1. Company:		**Data Sheet** **Category**	**2.8** **Suppliers of PU Systems**
Name	**Büsing & Fasch GmbH & Co.**		
Add.	Zum Damm 6, 26180 Rastede		
Mail	Postfach 1504, 26173 Rastede		
Coun.	Germany	**2. Products**	Chemicals for polyurethane foam systems: Rigid polyurethane insulation foams, flexible moulded foams and integral skin foams used for insulation, in the motor industry, in the furniture industry etc.
Tel:	+49 04402/1065		
Fax	+49 04402/1064		
Telex			
Contact	Dipl. Ing. Lutz Ohmstede.		

3. Original process	Büsing and Fasch GmbH & Co. is a supplier of polyurethane systems, selling systems on the base of polyols. Isocyanates are exclusively sales products. Chemicals are purchased, and polyurethane systems are produced by mixing the polyols and additives. The composition of the polyurethane systems depends on the final use and function of the product, and each system has a special formula.
4. Reduction/elimination method	The new blowing agents are pentane and HFC 134a. New polyether polyols are used.
5. Implications of the new technology	
End product quality	The end product quality depends on the specific application.
Operational implications	The waste stream generation and composition has not changed.
6. Scale of operation	-
7. Technical constraints	-
8. Restrictions of technology	There are no restrictions.
9. Stage of technology	-
10. Level of commercialization	The technology is commercially available.
11. Investment costs	Basic equipment for pentane: approx. US$ 330,000 Basic equipment for HFC-134a: approx.: US$ 330,000-660,000
12. Operational and maintenance costs	Unknown

13. Safety issues	There is a risk with hydrocarbons (pentane) so safety devices must be considered. No risks from HFC-134a.
14. Development of technology	The technology has been developed in cooperation with Bayer AG and other producers of foaming systems.
15. Other	-
16. Additional information	Other producers: Bayer AG and Bereich PUR.

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of PU Systems**
Name **Elastogran (BASF)** Add. Geschäftsbereich Halbzeug und Bauteile Werk Lemförde Postfach 1160 D-2844 Lemförde	
Coun. Germany Tel: +49 5443/120 Fax: +49 5443/12456 Telex: - Contact -	**2. Products** Foaming components systems, and foaming machinery. Systems for: Flexible moulded foam, semi rigid foam, packaging foam, rigid foam for appliances, sandwich panels, district heating pipes, spray foam, slabstock, and insulating panels. Flexible integral skin foam, shoe soles.

3. Original process	In the original process CFC-11 was used as a blowing agent.
4. Composition of plastic foam	The new blowing agents in place of CFC-11 are HCFC-22, HCFC-22/142b mixture, HCFC-141b, HFC-134a, n-pentane, isopentane, cyclopentane, water, or combination of two or more of these blowing agents. The other ingredients include polyether or polyester polyols, cross linkers, silicone surfactants, flame retardants, catalysts, and pigments. The isocyanate component may be polymeric MDI or a pre-polymer of monomeric MDI or a mixture of both. The other ingredients are the same as used previously, although different grades are required to achieve properties as close to the original material as possible.
5. Implications of the new technology **End product quality** **Operational implications**	In general some deterioration in most properties including insulation, compression strength, compression set, skin formation and flame retardancy is expected. Changes in production rates are not expected. Waste generation and composition, and energy requirements are not expected to be changed, but an increase in consumption of isocyanates and flame retardants is expected. Special procedures to add gaseous and flammable blowing agents is needed, and continuous training of personnel is required.
6. Scale of operation	Batch-production of 200 kg - 20 tons.

7.	**Technical constraints**	Many of the CFC-free formulations have tighter processing parameters than their CFC-containing predecessors.
8.	**Restrictions of technology**	Regarded highly confidential, but no patents.
9.	**Stage of technology**	The processes are fully implemented, but are still under further planning and developing.
10.	**Level of commercialization**	Most of the technology is commercially available (some in limited quantities, e.g. up to 1 ton batches). Much of the technology is being applied already, though some users maintain the old CFC-technology as long as possible.
11.	**Investment costs**	Confidential information.
12.	**Operational and maintenance costs**	Confidential information.
13.	**Safety issues**	Flammable blowing agents (e.g. pentanes) pose serious risks.
14.	**Development of technology**	Technology development in co-operation between members of the BASF/ELASTOGRAN Group.
15.	**Other**	-

<table>
<tr><td>1. Company:

ICI Polyurethanes
Add. Everslaan 45
3078 Everberg
Coun. Belgium

Tel:. +32 2 758 9211
Fax: +32 2 759 5501
Telex: 26151 ICIEVB B
Contact Dr. Mike Jeffs, Belgium, or local sales offices.</td><td>Data Sheet 2.8
Category Suppliers of PU Systems

2. Products Raw materials for foaming systems.
ICI is a supplier of chemicals for a wide range of CFC-free foams and foaming systems:
- Rigid PUR, appliance insulation, sprayed, slabstock, poured-in-place
- Rigid laminated polyisocyanurate foam
- Flexible PUR slabstock, moulded
- Integral skin foams</td></tr>
<tr><td>3. Original process</td><td>ICI Polyurethanes previously supplied a range of systems using CFC-11 for rigid PUR, e.g. appliance insulation, sprayed, slabstock, poured-in-place, rigid laminated polyisocyanurate foam and flexible moulded PUR. Systems were also supplied for integral skin foams.

ICI Polyurethanes did not supply chemicals or systems for flexible slabstock foam.</td></tr>
<tr><td>4. Reduction/elimination method</td><td>Elimination of CFC was obtained by product redesign, substitution, and alternative use pattern. The substitution methods within the foam sectors were as follows:

<u>Rigid polyurethane foams:</u> Substitution of CFC and system optimization with HCFC and HFC, pentane, or CO_2 (water-isocyanate reaction).

<u>Flexible slabstock:</u> Proprietary Waterlily technology (water-blown).

<u>Integral skin foam:</u> Water, HCFC, or hydrocarbon blown.

<u>Moulded flexible foams</u>: Water (CO_2)

Proprietary isocyanates and polyols are used.
Rigid foam systems for use with HCFC-141b, HCFC-22/HCFC-142b, HFC-134a, isopentane, n-pentane, and cyclopentane.
Integral skin foam systems use HCFC-141b or isopentane. The other foam systems are water blown (CO_2).</td></tr>
<tr><td>5. Implications of the new technology</td><td></td></tr>
</table>

	End product quality	For rigid foams the insulation capacity is retained with HCFC-141b and cyclopentane as the blowing agent. HFC-134a causes up to ten per cent increase in thermal conductivity. The insulation values for the other agents are intermediate.
	Operational implications	The Waterlily technology gives a new and better level of comfort. The production rate resulting from the new technologies has not been changed significantly. The new technologies have not given rise to any changes in the waste streams with the exception that the waterlilly technology gives the possibility of recycling. The new systems have not caused significant changes in the raw material consumption rates except increased isocyanate usage in rigid foams through increased water co-blowing. New safe procedures are essential when hydrocarbons are used. Training of the staff is required and can be provided by ICI Polyurethanes. The new technologies do not cause changes in energy consumption.
6.	**Scale of operation**	World scale chemical production units.
7.	**Technical constraints**	There are no technical constraints.
8.	**Restrictions of technology**	Waterlily flexible slabstock technology is proprietary. ICI holds numerous other patents.
9.	**Stage of technology**	The technologies are fully commercially available.
10.	**Level of commercialization**	All the technologies are either in production or in advanced pre-production trial stage.
11.	**Investment costs**	For gaseous blowing agents, equipment modifications on scale of US$ 50,000 are necessary. Safe precautions for implementation with hydrocarbons may cost more than US$ 1 m. depending on factory size.
12.	**Operational and maintenance costs**	Only minor changes in operational and maintenance costs. More information about that can be obtained from contact names.
13.	**Safety issues**	No significant changes are necessary regarding toxicity. Precautions necessary due to flammability of hydrocarbons. Full safety information is available from ICI Polyurethanes.
14.	**Development of technology**	The technologies have been developed in-house by ICI Polyurethanes.
15.	**Other**	-

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of PU Systems**
Name **I.F.S Chemicals LTD** Add. Maple Road Kings Lynn Norfolk, PE34 3AH Coun. The United Kingdom Tel: +44 553 - 764 229 Fax: +44 553 - 765 038 Telex: - Contact Dr. Barrie G. Colvin, Managing Director. Mr. Ian J Widdowson, Sales Director	**2. Products** Polyurethane chemicals

3. Original process	In the former process the blending operation took place in an open vessel (each batch 10-20 tonnes). CFC-11 was added as the blowing agent. The original foams contained 8-20 per cent CFC-11.
4. Reduction/elimination method	The elimination was obtained by drop-in substitution of chemical. The CFC-11 was substituted by a proprietory mixture of blowing agents all with an ozone depleting potential (ODP) of zero. Resin component is fully formulated and is non-hazardous. The blowing agent is designated "Pental" and is a blend of five zero (ODP) blowing agents.
5. Implications of the new technology	
End product quality	The thermal conductivity of the end product is increased 10 per cent.
Operational implications	The production rate is unchanged The waste streams are unchanged. No change in raw materials except the exclusion of CFC-11 and introduction of "Pental". The energy consumption is unchanged as are the operating procedures. No special training of staff is required.
6. Scale of operation	3,000 tonnes of PU chemicals are produced annually.
7. Technical constraints	None.
8. Restrictions of technology	The technology is in the public domain.
9. Stage of technology	The technology is fully implemented.

10. Level of commercialization	The technology has been commercially available since 1989.
11. Investment costs	The technology has been applied successfully in a wide range of industries.
12. Operational and maintenance costs	The implementation of the technology has not implied capital costs as the technology has been developed as a true drop-in substitution. No changes in maintenance costs.
13. Safety issues	No changes necessary.
14. Development of technology	The technology has been developed in-house.
15. Other	-

1. Company: Name **Tagos SRL** Add. Via A. Colombo, 29 21040 Sumirago VA Partita IVA 00215400128 Coun. Italy Tel: +39 331 909 110 Fax: +39 331 908 420 Telex: - Contact Mr. Marco Monzeglio	**Data Sheet** **2.8** **Category** **Suppliers of PU Systems** **2. Products** Systems for polyurethane rigid foams, spray, poured-in-place injection etc.

3. Original process	The original foaming systems are based on polyol blends with use of CFC-11 as blowing agent. 100% water blowing covers about 40% of our polyol production.
4. Reduction/elimination method	The new method is based on substitution of chemicals and modifications of the foaming systems. CFC-11 is substituted with HCFC-141b as blowing agent. The formulations and the foaming technology have been re-studied. Water-blown foams have been developed where possible.
5. Implications of the new technology	
End product quality	The thermal conductivity of the foams has increased.
Operational implications	The production rates of the new technology are the same as previous. The energy consumption is the same as for the previous process. The consumption of MDI has increased.
6. Scale of operation	100% of polyol blends are water/HCFC 141b or water blown.
7. Technical constraints	-
8. Restrictions of technology	No patents
9. Stage of technology	The technology is fully implemented, but it is considered as a transitional solution.
10. Level of commercialization	We operate only on the national market.
11. Investment costs	-
12. Operational and maintenance costs	-
13. Safety issues	There are no safety drawbacks or merits associated with the new technology.
14. Development of technology	The technology is developed on site.
15. Other	-

16. Additional information	Mr. Marco Monzeglio - email:tagos@mercury.tread.it

1. Company:		**Data Sheet Category**	**2.8** **Suppliers of Blowing Agents**
Name	**AlliedSignal**		
Add.	20 Peabody Street Buffalo, New York, 14210		
Coun.	United States	**2. Products**	HFC-245fa
Tel:	+ 1 716 8271407		
Fax:	+ 1 716 827 6275		
Telex:	-		
Contact	Mr. David J. Williams, Technical Service & Development Manager		

3. Original process	The original process was the use of CFC-11 or HCFC 141b as a blowing agent for both rigid and flexible polyurethane and polyisocyanurate foams.
4. Reduction/elimination method	The elimination method is a chemical substitution by HFC 245fa of CFC-11 or HCFC 141b with some process and formulation modifications. For rigid foams, surfactant changes may be needed to optimise performance. The technology has not yet been fully explored in flexible foams, so modifications that may be required are not identified as yet.
5. Implications of the new technology	
End product quality	Although this technology is still at a relatively early stage of development, initial results show end product quality equal to that of CFC-11 or HCFC 141b containing rigid foams. No data is available on flexible foam end product quality.
Operational implications	Cooler component temperatures may be required with this technology.
6. Scale of operation	The technology is currently in development. Small quantities are being produced for toxicity testing ad initial sampling.
7. Technical constraints	None.
8. Restrictions of technology	The use of HFC 245fa as a foam blowing agent is covered in many countries by patents issued to Bayer. AlliedSignal is a licensee of these patents and therefore is free to develop this technology globally.
9. Stage of technology	The toxicity of this material is currently being studied to comply with global regulations. Results to date are encouraging. Limited sampling is anticipated in 1996, resulting in better development of the technology.
10. Level of commercialization	This technology is currently in the developmental stage. Global implementation of this technology is anticipated.
11. Investment costs	The typical investment costs are not yet fully defined. However, data available to date suggests that factories designed to use CFC-11 or HCFC 141b should be able to convert to HFC 245fa

	with minimal capital investment.
12. Operational and maintenance costs	The use of HFC 245fa may require cooler component temperatures, thereby increasing energy costs. The magnitude of these costs is yet undefined.
13. Safety issues	HFC 245fa is non-flammable. HFC 245fa has a boiling point slightly lower than CFC-11 and thereby will have a higher vapour pressure at any given temperature. Pressure relief valves and similar devices may need to be resized upon implementing this technology.
14. Development of technology	-
15. Other	-

1. Company: Name **Exxon Chemical Europe** Add. Vorstiaan 280 B-1160 Brussels Coun. Belgium Tel: +32 2674 4401 Fax: +32 2674 4406 Telex: 22364 Contact -	**Data Sheet Category** **2.8 Suppliers of Blowing Agents** **2. Products** Hydrocarbons

3. Original process	Rigid polyurethane insulation foams have historically relied upon CFCs and more recently HCFCs as blowing agents. The polyurethane industry has been able to switch to zero ozone depleting technology by using pentane as a blowing agent in rigid polyurethane foams to replace them. Polystyrene foams are also able to use pentane as a blowing agent.
4. Reduction/elimination method	Isomers of pentane (cyclopentane, normal pentane, isopentane) have completely replaced the use of CFCs. Tailer-made blends are also available to meet the needs of both process and specific foam properties.
5. Implications of the new technology	
End product quality	Exxol CyclopentaneΘ, Exxsol® Isopentane T, and Norpar® 5T are not classified as stratospheric ozone depletors and are therefore not subject to regulation under the Montreal Protocol. Their very short atmospheric lifetime is also synonymous with a very low GWP. The absence of reactive molecules and bonds ensure that these high purity hydrocarbons demonstrate very low chemical reactivity. This inert chemical characteristic, combned with appropriate physical properties of volatility and viscosity, has ensured that Exxon Chemical pentanes have been recogniesed as excellent foam blowing agents for a number of polymer technologies. Their low thermal conductivity makes them particularly suitable today for use in demanding polurethane insulating foam application inpanels for refrigerators, freezers, constuction and refrigerated transport plus other end-uses such as insitu pipe insulation.
Operational implications	Pentanes are flammable prducts and all necessary precautions must be taken in equipment design and operations. Our knowledge and years of experience in the handling of hydrocarbons allow us to provide expert advice in the areas of safety and VOC control.
6. Scale of operation	Full commercial use in may countries.
7. Technical constraints	see 5.
8. Restrictions of technology	Manufacture and sale of pentanes is not restricted.

9. Stage of technology	Technology in using pentanes as blowing agents is fully commercialised. The polyurethane industry and users continue to optimise their systems.
10. Level of commercialization	Products are fully commercialised and available worldwide.
11. Investment costs	Plants should be modified to ensure adequate safe storage and handling of pentane.
12. Operational and maintenance costs	Plants should be modified to ensure safe storage and handling of pentane.
13. Safety issues	Pentanes are flammable and all necessary precautions must be taken in equipment design and operation. For further details, please consult our material safety data and product specification sheets available on request.
14. Development of technology	Technology has been developed with the involvement of pentane manufacturers, polymer and additive producers, system houses, equipment suppliers and users.
15. Other	Exxon Chemical supply the full range of pentane grades worldwide. We manufacture all three isomers: cyclopentane, isopentane and normal pentane; our modern blending factilities offer the flexibility to meet your requirements for mixtures thereof. Products sheets available on request.
Additional Information	Sales offices and regional Head Quaters are listed in Appendix

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of Blowing Agents**
Name **Solvay Fluor und Derivate Gmbh** Add. P. O. box 220 D-30002 Hannover Coun. Germany Tel +49 511/857* 2653 Fax: +49 511/857*-2166 Telex: - Contact P. Roumegoux, Marketing (*2721) L. Zipfel Technical Service (*2583)	**2. Products** Blowing agents HFC-134a, HFC-152a. Further blowing agents under development

3. Original process	-
4. Reduction/elimination method	Research and development to produce HCFCs/HFCs as a substitute for CFCs. E.g. 141b as "drop in" for R11 in PU. Technical service to help customers to switch from CFCs to HCFCs.
5. Implications of the new technology	-
End product quality	Nearly as good end products as with CFCs. Better properties than other alternative blowing agents.
Operational implications	It is easier to implement and safer to use than other alternatives (e.g. hydrocarbons).
6. Scale of operation	HCFCs: 22, 141b, 142b full production HFCs: 134a, 152a full production 245fa, 365mfc R&D
7. Technical constraints	None.
8. Restrictions of technology	HCFCs: transitional products.
9. Stage of technology	R&D on 3rd generation blowing agents (HFCs) for PU Introduction of 134a, 152a as blowing agents for PS
10. Level of commercialization	see below

Market blowing agents (kt/yr)	HCFC	HFC
Europe	50	3
USA	15	1
Japan	15	1
Rest of World	20	1

11. Typical investment costs	Costs are incurred by foamers, but very low required for the plant.
12. Operational and maintenance costs	-
13. Safety issues	None, as far as non-flammable blowing agents are concerned.
14. Development of technology	Blowing agent manufacturers, system houses and toxicological R&D programmes have been involved in the development.
15. Other	-

1. Company:		**Data Sheet Category**	**2.8** **Suppliers of Flame Retardants**
Name	**Albright & Wilson UK Ltd.**		
Add.	210-222 Hagley Road West Oldbury, Warley West Midlands B68 0NN		
Coun.	United Kingdom	**2. Products**	Flame retardants for polyurethane foam systems.
Tel:	+44 121 4205117		
Fax:	+44 121 4205545		
Telex:	336291 Albriw G		
Contact	-		

3. Original process	For use in rigid foams, standard flame retardants such as Tris Mono Chloroisopropyl Phosphate (TMCP) were effective where CFCs were the blowing agents. CFCs are inherently flame retardant and also act as viscosity suppressors. High efficiency, viscosity reducing flame retardants were not normally used as standard. In the flexible foam industry, CFCs not only acted as blowing agents but also had a cooling effect on the urethane reaction in the centre of the block. The elimination of CFCs has resulted in a new emphasis on foam quality, such as discolouration (scorch) and automotive standards.
4. Reduction/elimination method	For use in rigid foams, Albright & Wilson have developed a range of higher efficiency flame retardants to meet the new challenges of non-CFC blown faoms. The AMGARD V490 range (V490, V485, V475, V4000) is a group of products which can be used in water, 141b or pentane blown systems to meet a range of standards such as BIN4102 B2 & B3. LOIs of 22.4% to 2.8% can also be achieved. The products are halogen free, efficient and 2K system stable. In addition they all posses a degree of viscosity suppression which is vital due to the widespread use of highly viscous polyester polyols. In the flexible foam industry, Albright & Wilson have developed a range of flame retardants specifically designed to meet the new challenges of non-CFC blown systems. Our range includes those which meet international and automotive standards, low fogging products and products where low scorch is important.
5. Implications of the new technology	
End product quality	The new generation of flame retardants, such as the AMGARD V490 range have enabled foam manufacturers to continue to supply the rigid foam industry and to meet the flammability standards demanded by the customer. The AMGARD range of flame retardants fo flexible foams have enabled foamers to produce foams of better quality then previously.
Operational implications	The viscocity suppression properties of the AMGARD V490 range have aided the use of more inherently flame retardant, high

	viscocity polyester polyols in rigid foams.
6. Scale of operation	All products offered for both rigid and flexible foams are in full commercial production.
7. Technical constraints	None.
8. Restrictions of technology	AMGARD V490 is covered by the Australian Convention. To sample or supply countries who are not members of the Convention, Albright & Wilson has to apply for an Export Licence. For countries who are members of the Convention, Albright & Wilson require an end-user statement before sampling or supply of the product.
9. Stage of technology	Albright & Wilson are committed tocontinuing the development of new, halogen free products for both the flexible and rigid foam industries. These new developments will be designed to meet more severe standards in rigid foam and improve efficiency, scorch performance and fogging in flexible foam. In all cases the impact on the environment, both in terms of the raw material and also recycling of the finished foam is considered.
10. Level of commercialization	Our products are sold throughout Europe, Asia and North America.
11. Investment costs	None required.
12. Operational and maintenance costs	Slight increases in total formulation costs may be seen. However, due to the increased efficiency of the new flame retardants, and care choice of other additives in the formulation, then these costs can be kept to a minimum. In the flexible foam industry there may be some slight increases in overall formulation costs. However, this does mean that our customers can meet flammability and functional standards demanded.
13. Safety issues	Please apply to Albright & Wilson for a copy of the relevant Health & Safety datasheet.
14. Development of technology	Development is inhouse: Albright & Wilson Polyurethane Flame Retardants Technical Service and Albright & Wilson International Technical Centre.
15. Other	We offer a comprehensive range of flame retardants for use in both rigid and flexible polyurethane foams. The range includes 8 products for rigid foams and 13 products for flexible. Of the latter, there are three low fogging additives and one antistatic. We also offer two plasticisers in the AMGARD range namely AMGARD TBEP and TOF.
Additional Information	Please see our list of worldwide offices and production sites.

1. Company:		**Data Sheet Category**	**1.4** **Suppliers of Ancilliaries**
Name	**Acmos Chemie GMBH & CO.**		
Add.	P.O. Box 10 10 69 28010 Bremen		
Coun.	Germany	**2. Products**	Release agents for polyurethane foam systems
Tel:	+ 42 151890		
Fax:	+ 42 1511415		
Telex:	245116 acoms d		
Contact	-		

3. Original process	In former times the carrier medium used in relase agents was alternatively freon R11 or 1,1,1-trichloroethane. For the demoulding of polyurethane foam systems a release agent has to be applied to avoid the tearing or breaking of moulded parts when taken out of the mould. The ideal release agent uses a carrier medium which is neutral in smell, non-flammable and has a very high volatility to flash-off quickly. R11 and 1,1,1-trichloroethane (with exception to smell) were ideal solvents for the purpose of release agents.
4. Reduction/elimination method	1. Substitution of R11 or 1,1,1-trichloroethane by highly volatile hydrocarbons for example hexan. Disadvantage: extremely flammable with a flash-point below 0^{o}C. 2. Substitution of R11 or 1,1,1-trichloroethane by methylene chloride or a blend of methylene chloride with hydrocarbons. Disadvantages: odour, human health risks, and restrictions of 50ppm in the workplace in many countries. 3. Introduction of high solids eliminating the carrier medium and dissolving the active substances in a low volatile hydrocarbon with a flash-point of more than 60^{o}C and therefore with almost no risk of flammable vapours. The amount applied to the moulds are reduced by upto 90%. The results are achieved with a cheap air assisted spraygun witha 0.3 mm nozzle (spraygun approx. US$ 300,000). 4. Waterbased products: substitution of R11 and 1,1,1-trichloroethane as carrier medium by water. Spraying method has to be adapted.
5. Implications of the new technology	
End product quality	Normally the end product quality is higher or at least equivalent.
Operational implications	The process parameters have more restricted tolerances. The sprayguns have to be adapted.
6. Scale of operation	The process is proved to be cost neutral and introduced in several plants worldwide including underdeveloped countries.
7. Technical constraints	In applying the release agent, certain care has to be taken. Training in the operation of the spraygun is therefore needed. The

	technology and the products are available at ACMOS or ACMOS representatives worldwide.
8. Restrictions of technology	None.
9. Stage of technology	Fine tuning of the technology is carried out whenever the client has specific requirements.
10. Level of commercialization	The technology is available worldwide. In Germany, ozone depleting solvents are banned in the use of release agents.
11. Investment costs	Approx. US$ 300,00 per spray unit. Depending on the pumps and valves, another US$ 1,000 might need to be invested to adjust the pumps and the valves to the restricted process parameters.
12. Operational and maintenance costs	No specific maintenance costs is required. In the beginning, the operational costs might be higher. After a week or two, productivity has no restrictions in terms of speed.
13. Safety issues	There is a risk of flammability with the use of low volatile hydrocarbons thus safety measures have to be considered. In the case of using methylene chloride the maximum concentration allowable in the workplace must be appropriate to local regulations.
14. Development of technology	Development was carried out between ACMOS and some key clients.
15. Other	-

1. Company:		**Data Sheet Category**	**2.8 Suppliers of Ancillliaries**
Name	**3M**		
Add.	Canadastraat, 11 B-2070 Zwijndrect		
Coun.	Belgium	**2. Products**	Additives for Rigid Polyurethane Systems.
Tel:	+32 3250 7867		
Fax:	+32 3250 7847		
Telex:	-		
Contact	Mr. R. Van San, Technical Service Engineer.		

3. Original process	The original process was PU manufacturing with CFCs as blowing agent. This was replaced by hydrocarbon blowing agents such as pentane or cylcopentane, or by HCFCs. This resulted in foams with lower insulation properties.
4. Reduction/elimination method	The thermal conductivity of the foam can be reduced by using the additive perfluoro-N-methymorfoline (PF-5052) up to 1% of the total foam weight. The additive must be emulsified in the polyol. It can be used with all of the alternative blowing agents. The additive should not be mixed with the blowing agent.
5. Implications of the new technology	
End product quality	If the perfluoro-N-methylmorfoline (PE-5052) is properly emulsified in the polyol in a concentration of up to 1% of total foam weight, the final thermal conductivity of the foam will be reduced up to 15% depending on the blowing agent used.
Operational implications	A mico-emuulsion of the additive in the polyol is essential to obtain the fine cells needed for thermal conductivity reduction.
6. Scale of operation	This technology is currently being used at production scale by several foam manufacturers.
7. Technical constraints	None.
8. Restrictions of technology	None.
9. Stage of technology	The technology is implemented, and detailed literature is available.
10. Level of commercialization	The perfluoro-N-methylmorfoline (PE-5052) additive is fully commercailly available.
11. Investment costs	Limited investment. The additive technology only requires some emulsification equipment, as also needed for using hydrocarbon blowing agents.
12. Operational and maintenance costs	Cost of the new technolgy is primarily due to the cost of the additive. This increased cost is off-set by improvement in translation performance.

13. Safety issues	None. PF-5052 is non-flammable and essentially non-toxic. Material safety data sheets on the additive are available.
14. Development of technology	3M (see 16)
15. Other	References: 1. US Patent 5,162,384 (Nov 10.1992) "Making Foamed Plastic Containing Perfluorinated Heterocyclic Blowing Agent" 2. Urethanes Technology, Oct/Nov. 1992, K. Focquet, "3M Materials Give Microcellular Foams: Better Foam Insulation Follows."

1. Company: Name **Cannon Group** Add. Via Colombo 49 20090 Trezzano S/N -Milan Coun. Italy Tel +39 2 484 00 765 Fax: +39 2 445 65 08 Telex: 352662 Contact -	**Data Sheet** **2.8** **Category** **Suppliers of Foam Machinery** **2. Products** Polyurethane foaming equipment

3. Original process	-
4. Reduction/elimination method	Substitution of CFC-11 with - Cyclopentane (or normal-pentane or iso-pentane) - HCFC-22 + HCFC-142b or HFC-134a
5. Implications of the new technology	
End product quality	Slightly worse insulation factor (5-8%?)
Operational implications	Improve equipment safety. For cyclopentane: Protect equipment against explosion
6. Scale of operation	Industrial
7. Technical constraints	Changing of some foaming equipment necessary
8. Restrictions of technology	Insulation factor not as good as with CFCs, no other negative effects.
9. Stage of technology	Fully industrial stage
10. Level of commercialization	Fully available, several solutions for new and/or retrofitted
11. Investment costs	30% higher than conventional machines
12. Operational and maintenance costs	Higher energy, required by the ventilation/extraction fans
13. Safety issues	Explosion protection: Gas sensors + alarm system required all around.
14. Development of technology	Well developed already
15. Other	-
16. Additional information	Manufactured by Cannon Afros, Cannon Crios and Cannon USA Distributed by the network of Cannon offices

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of Foam Machinery**
Name **Cannon Group-Afros SpA** Add. Via G. Ferraris 65 21042-Garonno Pertusella (VA) Coun. Italy Tel +39 2 96531 Fax: +39 2 9656897 Telex: 333063 Contact General Manager	**2. Products** Polyurethane foaming equipment Cannoxide
3. Original process	Expansion of polyurethane foams have used CFCs for years. Cannon - Afros Division, has developed a technology to substituted CFC in the discontinuous process (moulding) replacing them with injected liquid CO_2.
4. Reduction/elimination method	Blowing effect of CFC has been replaced with a combination of 1) Liquid of CO_2 that provides initial pre-expansion. 2) Addition of small percentages of water to the formulation to complete the foam expansion.
5. Implications of the new technology	
End product quality	Better flexible foams (specially the softer grades) Better rigid foam (mechanically stronger) Cheaper foams in all applications
Operational implications	Adapt existing equipment with new CO_2 storage, metering, blending and mixing devices, or use new dedicated equipment for this application.
6. Scale of operation	Industrial evaluation at some European customers. 100 of pilot and laboratory trials successfully made in 1994 and 1995.
7. Technical constraints	Adapt equipment with new hardware.
8. Restrictions of technology	Metering pump, blending system, mixing head are 3 patented items. No license involved.
9. Stage of technology	This technology is in constant evolution: developments include rigid applications (refrigeration panel) and automotive industry (seats).
10. Level of commercialization	Some equipment supplied in late 1995 in Europe. For the first quarter of 1996, delivery in Europe and USA. Expected full industrial production in 1996.
11. Investment costs	One new metering machine equipped with liquid CO_2 metering kit costs around US$ 200,000.
12. Operational and maintenance costs	No significant increase in maintenance costs. Very significant saving when comparing the cost of CO_2 with CFCs and

	alternatives.
13. Safety issues	Less risk than before: CO_2 is a safe chemical.
14. Development of technology	Cannon has developed the equipment. Major raw material suppliers (e.g. Dow, BASF) has also contributed along with manufacturers of furniture, automotive parts, refrigeration and panels.
15. Other	This technology is derived from the CarDio™ Technology, developed by Cannon to expand continuous foams (slabstock), now in operation at 11 plants in Europe and the USA.

1. Company:		**Data Sheet** **Category**	**2.8** **Suppliers of Foam Machinery**
Name	**Edulan AS**	**2. Products**	Foam mixture systems and equipment for the manufacture of rigid PUR foam products
Add.	Jens Olsens Vej 3 DK-8200 Aarhus N		
Coun.	Denmark		
Tel:	+45 86 10 90 90		
Fax:	+45 86 10 92 88		
Telex:	7805032 tlxau dk		
Contact	Mr. Hans Jørgen Østergaard, Director.		

3. Original process	The classic rigid PUR foam systems were blown mainly with CFC-11 or CFC-113. The typical content of CFC in the polyol component was 20-30 per cent.
4. Reduction/elimination method	New chemical composition of all the foam system components: First a new blowing agent containing 1,1,1 trichloroethane, HCFC-22 and pentane was introduced. Later the PUR system was modified to be blown with HCFC-141b, while other systems were developed to be solely water-blown (CO_2). Now a new blowing agent with no ozone depleting effect has been developed using conventional foam systems.
5. Implications of the new technology	
End product quality	The latest development shows almost same insulation properties as with CFC-11 blown foam.
Operational implications	No changes of production rates or raw material consumption. No changes in quantity of waste, but the composition of the new waste makes disposal less difficult. No changes in energy consumption.
6. Scale of operation	No limits in quantity. Production capacity will be expanded according to demand.
7. Technical constraints	-
8. Restrictions of technology	The technology is patented by Edulan AS.
9. Stage of technology	The technology is fully implemented at Edulan AS.
10. Level of commercialization	The chemicals and the equipment are commercially available and full scale production implemented.
11. Investment costs	The investment in research and development plus the pilot plant operations total approx. US$ 450,000.
12. Operational and maintenance	No changes

costs	
13. Safety issues	No changes anticipated, but applications are being prepared.
14. Development of technology	The technology has been developed solely by Edulan AS.
15. Other	-

1. Company:		**Data Sheet** **Category**	**2.8** **Suppliers of Foam Machinery**
Name	**Gusmer Corp.**		
Add.	One Gusmer Drive Lakewood, New Jersey 08701		
Coun.	United States	**2. Products**	Machinery Manufacturer: High pressure meter, mix and dispensing machinery. Featuring mechanical, solventless, self cleaning dispensing heads, auxiliary inert gas nucleation equipment and heaters.
Tel:	+1 908 370 9000		
Fax:	+1 908 905 8968		
Telex:	-		
Contact			

3. Original process	-
4. Reduction/elimination method	Improved equipment design offers Automatic Temperature Control and higher operating/dispense pressures to ensure thorough mixing of CFC-free plastic foams.
5. Implications of the new technology	
End product quality	Meets material suppliers specification for CFC-free plastic foam.
Operational implications	
6. Scale of operation	Full production.
7. Technical constraints	Minimum bulk storage and field substrate temperatures, recommendations must be respected.
8. Restrictions of technology	Proprietary.
9. Stage of technology	Final
10. Level of commercialization	The machinery is commercially available.
11. Investment costs	Dependent upon specific application/equipment requirements.
12. Operational and maintenance costs	See 11
13. Safety issues	Compliance with manufacturers and system suppliers recommendations.
14. Development of technology	-
15. Other	-

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of Foam Machinery**
Name **Krauss-Maffei** Kunstofftechnik GmbH Add. P. O. Box 50 03 40 80973 Munchen Coun. Germany Tel: +49 89 8899-2168 Fax: +49 89 8899-4000 Telex: 523163-22 Contact Mr. A. Bauer (KT 2) Mr.W. Dausch (KT 21)	**2. Products** Mixing metering machines clamping units, plant systems premixing stations for white appliances, automotive, construction, furniture and technical parts.

3. Original process	Plant and machine manufacturers of polyurethane foam system dispensing machinery in conjunction with CFC-11 and CFC-12 in the past.
4. Reduction/elimination method	Redesigned plant and machinery for processing CFC-free systems: e.g. water-blown flexible foams or cyclopentanes for insulating foams. Other CFC-free blowing agents catered for are: HCFC: 141b, 134a, R22 & 142b blend.
5. Implications of the new technology	
End product quality	The product quality is the same.
Operational implications	In the case of pentane, X-protected structural units are required additional to original, redesigned plant.
6. Scale of operation	Full production on 50 machines worldwide since the change-over.
7. Technical constraints	Where pentane is used, safety precautions applicable to that country must be observed.
8. Restrictions of technology	We sell machines and plants, plus the ‘know-how’. Authorisation is part and parcel of sales.
9. Stage of technology	Our machinery is continuously updated to suit new blowing agents.
10. Level of commercialization	Worldwide.
11. Investment costs	Costs are subject to the type of blowing agent and the size of the plant.
12. Operational and maintenance costs	These vary form factory to factory. We are not involved as suppliers.
13. Safety issues	Our machinery conforms to the statutory health and safety regulations laid down by the European Union.
14. Development of technology	Co-operation with raw material manufacturers.

15. Other	Information on the technology is available from all renowned raw material manufacturers.

1. Company:		**Data Sheet** **Category**	**2.8** **Suppliers of Foam Machinery**
Name	**Maschinenfabrik Hennecke GmbH**		
Add.	Birlinghovener StraBe 30 D-53754 Sankt Austin-Birlinghoven		
Coun.	Germany	**2. Products**	Machinery and chemicals for the production of - Refrigerators, freezers, and other parts made of PU rigid foam - Long-distance heating pipes - Sandwich panels
Tel:	+49 2241 339-0		
Fax:	+49 2241 339204		
Telex:	889410		
Contact	-		

3. Original process	CFC (R11) as blowing agent in the Polyurethane rigid foam for insulating refrigerators and freezers.
4. Reduction/elimination method	The Ozone-reducing CFC is replaced by the inoffensive Pentane.
5. Implications of the new technology	No depletion of the Ozone layer - ODP = 0 negligible global warming effect - GWP = 0.001
End product quality	Same insulation effect as before.
Operational implications	In contrast to CFC, Pentane is flammable.
6. Scale of operation	The production equipment has to be suitable for preventing explosions at any state of operation and even in case of human failure.
7. Technical constraints	All devices carrying Pentane (tank storage facility, pipelines, PENTAMAT™ premixing station, HK metering machines, mixhead lines and mixhead) have to be absolutely tight and equipped with additional leakage monitoring systems. Pentane-containing gases generated during the foaming process have to be exhausted. When the technical requirements (adaptation of the production lines) have been met, there are no further general restrictions. The production lines are subject to approval by the Authorities.
8. Restrictions of technology	-
9. Stage of technology	The entire technology is well-proven in practice.
10. Level of commercialization	In the industrial states, most plants have already been converted to Pentane processing.
11. Investment costs	Depending on the existing equipment, between US$ 190,000 and US$ 1,900,000 are required.
12. Operational and maintenance	Only slightly more expensive than for the CFC-blown foams.

costs	
13. Safety issues	Pentane is flammable, and appropriate fire precautions must be taken.
14. Development of technology	Completed.
15. Other	-

1. Company:	**Data Sheet** **2.8** **Category** **Suppliers of Foam Machinery**
Name **IMPIANTI OMS Spa** Add. Via Sabblonetta 20050 VERANO BRIANZA Coun. ITALIA Tel +39 362 - 9831 Fax: +39 362 - 900581 Telex: 335340 OMSVER I	**2. Products** Equipment for: PENTANE, CO_2, HCFC-141B, HFC-134a, HCFC -22. Household and Industrial refrigerators Insulated panels, steering wheels, armrests, car seats, blocks. Phenolic foam.

3. Original process	High pressure units (machines) with premixing (Ecoblend - Pentablend) according to blowing agents type.
4. Reduction/elimination method	CFC is substituted by pentane and C-Pentane™. Use of high pressure units self-cleaning heads and pre-mixing systems. Specific models Ecoblend/Pentablend™.
5. Implications of the new technology	Specific plants for use of alternative blowing agents.
End product quality	Same features obtained as with CFC blown foams
Operational implications	Modification to plants adopting devices, safeties and side protection according to used blowing agents.
6. Scale of operation	Full production.
7. Technical constraints	No limitation
8. Restrictions of technology	There is no disadvantage compared to HCFC technology
9. Stage of technology	
10. Level of commercialization	Very high level; mainly on white appliances sector (refrigerators), panels, automotive.
11. Investment costs	From US$ 200,000 to US$ 300,000, according to type of machine standard, turn key plants US$ 1 m.
12. Operational and maintenance costs	Similar to the costs for presently used machines;
13. Safety issues	High level of safety for use of pentane is necessary
14. Development of technology	Continuous research with raw material suppliers.
15. Other	-
16. Additional information	Our technical department is at your disposal for any information on C-Pentane.

1. Company:		**Data Sheet Category**	**2.8 Suppliers of Foam Machinery**
Name	**Perros Industriale SpA**		
Add.	Strada per Cassinetta, 6 20081 Abbiategrasso (Mi)		
Coun.	Italy	**2. Products**	Domestic/commercial/industrial refrigerators
Tel:	+39 2 9421121		
Fax:	+39 2 942 10678		
Telex:	334604 PerrosI		
Contact	Mr D.Torchiana, Sales Manager		

3. Original process	Insulation of domestic/commercial/industrial refrigerators produced using a standard polyurethane system. 35/40 parts by weight of CFC-11 in the polyol was used as the blowing agent.
4. Reduction/elimination method	CFC-11 has been substituted by cyclopentane, HCFC 141b and/or 134a. Perros has developed the necessary machinery/equipment for these new blowing agents. Particular focus is on cyclopentane - safety devices and controls (international standard) due to flammability of the hydrocarbon.
5. Implications of the new technology	
End product quality	The major problem is that the product has to pass very tight international energy consumption controls (insulation factor) along with the requirement to avoid any change in the design.
Operational implications	Modification/implementation of existing equipment with necessary safety devices and control to international safety level standards.
6. Scale of operation	Cyclopentane is used all over Europe, South Korea, Japan and now in developing countries.
7. Technical constraints	Safety conditions and regulations are the major problems which must be considered when using cyclopentane.
8. Restrictions of technology	No restrictions in licensing and transfer of technology.
9. Stage of technology	The chemical suppliers, especially in the USA are trying to find other possible blowing agents for polyurethane foam in order to avoid the dangers of cyclopentane.
10. Level of commercialization	Companies world wide are using cyclopentane, including developing countries like China, India, Central/North Africa.
11. Investment costs	Production capacity of the plants and equipment used will effect the level of financial investment.
12. Operational and maintenance costs	The additional costs are related to maintenance of safety devices and controls.
13. Safety issues	Cyclopentane is flammable and appropriate measures must be taken to avoid explosions and fires.
14. Development of technology	Major chemical suppliers are trying to find other substitutes to

	cyclopentane due to safety issues.
15. Other	-

1. Company:		**Data Sheet** **2.8** **Category** **Suppliers of Foam Machinery**
Name	**Tectrade Kemi As**	
Add.	Linde Alle 3 DK - 2850 Naerum	
Coun.	Denmark	**2. Products**
Tel:	+ 45 4280 5288	
Fax:	+ 45 4280 6188	
Telex:	19487 nortecdk	
Contact	Kim Klausen, Erik Larsen	

3. Original process	-
4. Reduction/elimination method	The new process introduces pentane (as a co blowing agent) directly into the mixing head of a low or high pressure foam machine. This process enables an open cell fully water blown foam of very low density (20-30 g/lt) without causing shrinkage. This makes the conversion from ozone depleting substances to pentane simple and cheap.
5. Implications of the new technology	
End product quality	Pentane blown foams posses the same quality found with CFC blown foam.
Operational implications	-
6. Scale of operation	Fully commercialized and fully implemented
7. Technical constraints	-
8. Restrictions of technology	None
9. Stage of technology	-
10. Level of commercialization	More than 10 factories have converted to the new solution.
11. Investment costs	-
12. Operational and maintenance costs	-
13. Safety issues	When supervising the technology update, no safety issues or health problems have arisen.
14. Development of technology	Tectrade A/S, Cannon Spa
15. Other	-

Phenolic Foam

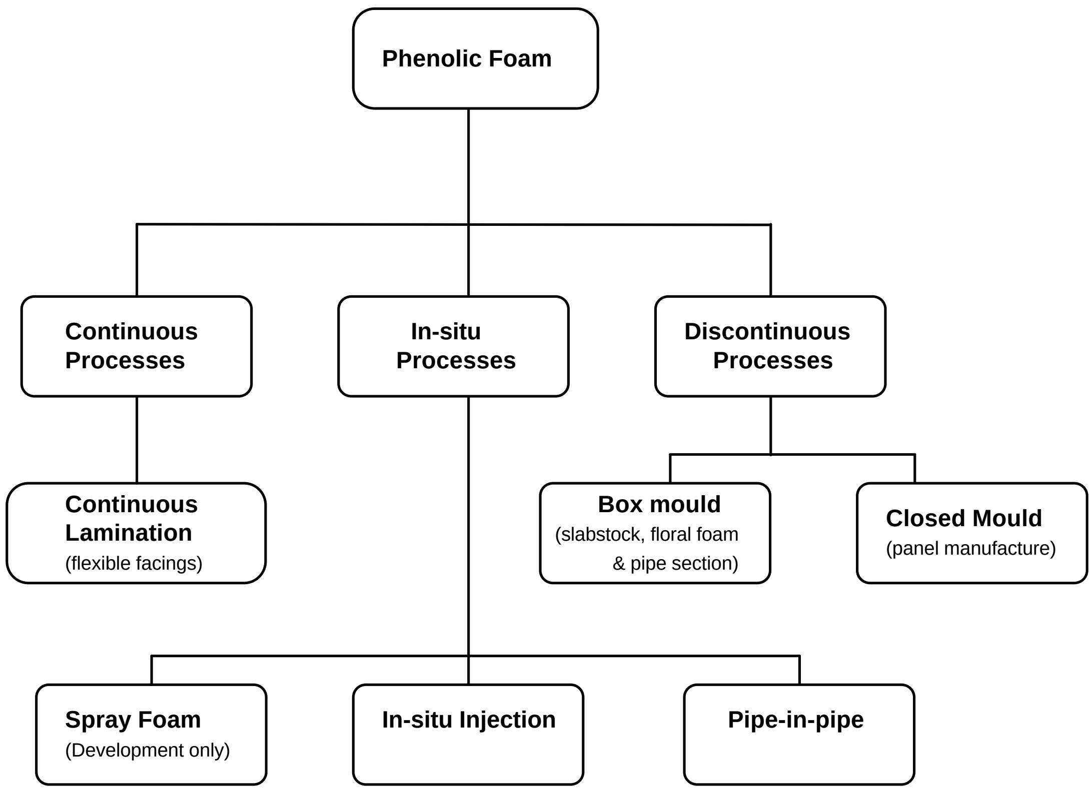
3 Phenolic Foam

3.1 Phenolic Foam

Technical Options Overview

<u>Description of Sector</u>

Phenolic foams can potentially serve the same range of application areas as rigid polyurethane construction foams and hence the list of products shown under the construction heading of Section 2 gives a good indication of what might be achieved with these foams. Phenolic materials, however, are generally more difficult to process than polyurethanes and hence the product range is slightly limited by the full development of commercial processes. The current status can be summarised as follows:



<u>Summary of Available Technical Options</u>

With the obvious exception of floral foams, the key reason for using phenolic materials is their excellent fire, smoke and toxicity performance which is an inherent property of the polymer itself. Historically, the low toxicity has been attributable to the fact that there has been no need for additional fire retardants in the formulation. A move to flammable blowing agents such as hydrocarbons introduces a problem for phenolic materials in that halogenated and/or nitrogen based compounds may need to be introduced for the first time (CFCs have not presented a problem in the past because of their stability). These considerations have led to a slightly different emphasis on alternatives than that set out for insulating polyurethane foams. The options can be summarised as follows:

Liquid HFCs - Similar comments as noted under the polyurethane section (Sections 2.1 & 2.2.). Again the major problem for the industry is availability (around 2000) and the potential impact of local

		global warming legislation. Additionally, the cost sensitivity of the construction sector makes the price of eventual liquid HFCs an important factor.
n- & iso-Pentane	-	Only really usable for open-celled foams such as those sold to the floral foam sector. Incorporation in closed cell foams requires the use of fire retardants.

Less Preferred Options (measurable ODP)

HCFCs (mostly HCFC-141b)	-	Widely used in the phenolic foam sector at present for the reasons given previously. The availability of liquid HFCs is a critical aspect of the HCFC phase-out in this sector.

Phenolic Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (3.11) summarises the detailed information for those companies which ***provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Phenolic Foam chapter on page 3-15. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (3.12) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 3. Contact the supplier to obtain detailed information.

Matrix 3.11 Suppliers which have provided detailed data sheets

Category of Technology, Equipemnt or Chemicals	**Company**	**Alternative Technology**		
		HFC	**HCFC**	**Hydro-carbons**
Foam Manufacturer	Kooltherm		X	
Systems	BP Chemicals	X	X	X
Ancilliaries	3M	X	X	X
Machinery	Beamech	X	X	X
	Impianti OMS	X	X	X
	Zaco	X	X	X

Matrix 3.12 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals			
	Phenolic Systems	**Machinery**	**Ancilliaries**	**Blowing Agent**
Albrecht Baumer KG		X		
AlliedSignal				X
Beamech Group Ltd		X		
Baxenden Chemicals		X		
BP Chemicals	X			
Cannon-Afros		X		
Cray Valley Total	X			
Crecimiento Industrial Co. Ltd		X		
DuPont Chemicals				x
DuPont de Nemours Int. S.A.				X
Elf Atochem SA				X
Exxon Chemicals Belgium				X
Fecken Kirfel		X		
Impianti OMS		X		
ICI Klea		X		
La Roche Chemicals				X
Maschinenfabrik Hennecke GmbH		X		
Mica Machinery (Sales) Ltd		X		
Occidental Chemical Europe	X			
Solvay Fluor und Derivate				X
Sunkisk Chemical Machinery		X		
3M			X	
Zaco		X		

3.2 Supplier Information

About the Supplier Information

This section includes all of the known suppliers of technology, equipment and chemicals for this sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in *Supplier Data Sheets.*

How to Use this Information

Part 1: Contacts provide a ***comprehensive contact list for all suppliers,*** including both those which contributed Data Sheets as well as those that did not. This section is organised sequentialy into Phenolic systems, Machinery, Blowing Agents, and Anxcillary and within these sections, alphabetically by company name. After locating a specific supplier, contact the company to obtain detailed information.

Part 2: Data Sheets contain ***detailed process information when provided by the supplier.*** These sheets contain data that can help you better evaluate a particular technical option. This section is organized sequentially into Foam manufactures, Phenolic systems, and Machinery and within these sections, alphebetically by company name. After locating and reading the specific data sheet, contact the supplier to obtain additional information.

DISCLAIMER

Please note that the information contained in the Data Sheets is of a commercial nature and it is up to the reader to verify any claims about performance, safety, costs, etc. made by the company. UNEP IE in no way endorses or recommends any company, product, process or claims referred to in these Data Sheets, as they are provided for information purposes only.

PART 1 - CONTACTS

Phenolic Systems

BP Chemicals Ltd
Sully
South Glamorgan
CF64 5YU
United Kingdom
Tel: (44) 1446-731255
Fax: (44) 1446-731385
Main Products: Phenolic Systems

Cray Valley
Immeuble le Diamont
16 Rue de Republique
92800 Puteaux
France
Tel: (33) 1 4135 6888
Fax: (33) 1 4135 6136
Main Products: Phenolic Systems

Occidental Chemical Europe n.v.
Henry Fordlaan
B-3600 Genk
Belgium
Tel: (32) 89 354935
Fax: (32) 89 363202
Main Products: Phenolic Systems

Machinery

Albrecht Baumer KG
Asdorfer Strasse 96-106
D-57258 Freudenberg
Germany
Tel. (49) 2734-450
Fax. (49) 2734-3056
Main Products: Block handling and cutting equipment

Baxenden Chemicals Ltd.
Paragon Works
Baxenden
Accrington
Lancashire BB5 2SL
United Kingdom
Tel. (44) 1254-872278
Fax. (44) 1254-871247
Main Products:Polyurethane systems & machinery

Beamech Group Limited
Tenax Road
Trafford Park
Manchester, M17 ?UT
United Kingdom
Tel. (44) 161-848-0316
Fax. (44) 161-873-7718
Main Products: VPF and other PU and PF equipment

Crecimiento Industrial Co. Ltd.
Office No. 348
Chien Teh St.
40107 Taichung
Taiwan
Republic of China
Tel. (886) 4-2116453
Fax. (886) 4-2111543
Main Products: Post-applied facing laminators, PU Dispensers, Batch mixers, Cutting equipment

Cannon-Afros
Via Galileo Ferraris, 65
21042 Caronno Pertusella (Varese)
Italy
Tel. (39) 2-96531
Fax. (39) 2-9656897
Main Products: PU metering and mixing equipment

Fecken Kirfel
Goebbelgasse 1-15
Postfach 725
Aachen
D52008
Germany
Tel. (49) 2 41182020
Fax. (49) 2 411820213
Main Products: Machinery - cutting

Maschinenfabrik Hennecke GmbH
Birlinghovener Strasse 30
D-53754
Sankt Augustin-Birlinghoven
Germany
Tel. (49) 22-41-339-0
Fax. (49) 22-41-339-204
Main Products: Flexible & rigid PU foam equipment

Mica Machinery (Sales) Ltd.
Mica House
Hyde Road
Denton
Manchester, M34 3AJ
United Kingdom
Tel. (44) 161-320-3356
Fax. (44) 161-320-3345
Main Products: Cutting and granulating equipment

Sunkist Chemical Machinery Ltd.
10th Floor, 200 Kingshan S. Road, Sec 2
Taipei
Taiwan
Tel. (886) 2-395-56686
Fax. (886) 2-321-7266
Main Products: Flexible foam equipment, cutting & laminating

Blowing Agents

Allied Signal
20 Peabody Street
Buffalo
New York, 14210
United States
Tel. (1) 716-827-1407
Fax. (1) 716-827-6275
Main Products: HCFC-141b, HFC-245a

DuPont Chemicals
Customer Service Centre
B-15305
Wilmington
DE 19898
United States
Tel. (1) 302-774-2099
Fax. (1) 302-774-2370
Main Products: Blowing Agents - HFC 134a, HCFC141b

DuPont de Nemours Int. S.A.
2 Chemin du Pavillion
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel. (41) 22-717-5111
Main Products: Blowing Agents - HFC 134a, HCFC141b

Elf Atochem SA
4 Cours Michelet-Cedex 42-92091
Paris
La Defense 10
France
Tel. (33) 1 49007425
Fax. (33) 1 49007021
Main Products: Blowing Agents-HCFC 141b, 142b, 22, HFC 134a

Exxon Chemical Belgium
Hermeslaan 2
B-1831 Machelen
Belgium
Tel. (32) 2-722-2171
Fax. (32) 2-722-2193
Main Products: Cyclopentane & other hydrocarbons

ICI Klea
P.O. Box 13
The Heath
Runcorn
Cheshire, WA7 4QF
United Kingdom
Tel. (44) 928-513-213
Fax. (44) 929-511-418
Main Products: HFC-134a

La Roche Chemicals
P.O. Box 1031
Baton Rouge
Louisiana 70821
United States
Tel. (1) 800-248-6336
Fax. (1) 504-652-9945
Main Products: HCFC-141b

Solvay Fluor und Derivate
Hans-Bockler-Allee 20
D-30173 Hannover
Germany
Tel. (49) 511-8570
Fax. (49) 511-817338
Main Products: HCFC-141b, HCFC-142b, liquid HFC development

PART 2 - DATA SHEETS

1. Company: Name **Kooltherm Insulation Products Ltd.** Add. P.O. Box 3 Charlestown, Glossop, Derbyshire SK13 8LE Coun. United Kingdom Tel: + 44 1457 861611 Fax: + 44 1457 852319 Telex: 669867 Contact Mr. Mark S. Harris, Technical Manager.	**Data Sheet Category** **3.2 Phenolic Foam** **2. Products** Laminate and block phenolic closed cell foams
3. Original process	The original manufacturing process of both closed cell laminate phenolic foam and closed cell discontinuous block phenolic foam was based on CFCs as blowing agents.
4. Reduction/elimination method	The elimination of CFCs has been achieved by process changes and chemical substitution. Technology has been developed to enable the original blowing agents (CFC11/113/114) to be substituted by either HCFC-141b or pentane.
5. Implications of the new technology	
End Product Quality:	Utilising HCFC 141b as a blowing agent results in a product of virtual identical physical properties to the original CFC blown foams. Use of pentane results in a product which has an approx. 10% inferior thermal conductivity performance. As fire performance of the product is also affected, local test/regulations should be taken into consideration.
Operating Implications:	In both block and laminate closed cell phenolic foam processes, the use of HCFC 141b requires the use of improved process technology to ensure optimum product quality. In the case of pentane blown block and laminate closed cell foams, the implications with regard to flammability of pentane needs to be given careful consideration. This can involve significant expenditure.
6. Scale of operation	The technology for the manufacture of HCFC 141b blown block and laminated closed cell phenolic foams is in full operation. The technology with regard to pentane blown foams has been fully developed and full scale production trials have taken place. However, the technology is not currently in commercial production.
7. Technical constraints	Processing technology and product performance are fully

	understood and defined.
8. Restrictions of technology	Kooltherm holds rights to a series of patents with respect to phenolic foam technology. Kooltherm's policy is to actively seek the licensing of technology worldwide and would be happy to discuss the situation with parties who have an interest.
9. Stage of technology	The technology is fully commercialised. Work is ongoing to develop HFC blown foams as and when these materials become available. It is anticipated that HFC blown foams will be availble around the turn of the century.
10. Level of commercialization	Phenolic foam, manufactured by Kooltherm and its licensees is used world-wide. Particularly in the Far East, South Africa and the USA.
11. Investment costs	Kooltherm would welcome discussing investment costs with parties interested in becoming licensees.
12. Operational and maintenance costs	Operational and maintenance costs resulting from the change to HCFC blown foams are minimal. It is not the case with pentane blown products as significant plant modifications are required to allow safe use of this flammable material.
13. Safety issues	Phenolic foams are not toxic, but dust masks are recommended in areas where high levels of dust are generated. Appropriate handling instructions and procedures are needed for pentane.
14. Development of technology	The technology has been developed by Kooltherm and British Petroleum.
15. Other	Phenolic foams are recognised for their excellent thermal insulation properties, which can lead to space saving benefits. Closed cell phenolic foams have the best insulation efficiency of all commonly manufactured insulation material. A particular benefit to phenolic foams is its excellent fire performance and low smoke emission. Phenolic foams unique combination of properties makes it ideal insulation material for residencial, industrial and commercial building applications including pipework, ducting, walls, floors, roofs and ceilings.

1. Company: Name **BP Chemicals Ltd.** Add. Barry Business Group Sully South Glamorgan, CF64 5YU Coun. United Kingdom Tel +44 6731 364 Fax: +44 6731 385 Telex: - Contact David Jennings	**Data Sheet** **3.2** **Category** **Suppliers of Foam Chemicals** **2. Products** Chemicals and systems and technology for phenolic foam, discontinuous and continuous boards, insulated panels, pipe insulation and insitu applications.

3. Original process	In the original process, CFC was used as the blowing agent
4. Reduction/elimination method	Non-CFC developments of the process have been demonstrated on a pilot scale for board and panel production. Resin systems and process equipment are available for alternative blowing agents <u>Original process</u>: Resol phenolic resin; Surfactants; CFC blowing agent; Catalyst <u>New process</u>: Resol phenolic resin; Surfactant; Blowing agent (including HCFC, Pentane isomers, methylene chloride); Cell modifying agent; Catalyst
5. Implications of the new technology	
End product quality	The foam structure and mechanical properties are comparable with or better than their CFC predecessors. Initial and aged K-value is dependent on the choice of blowing agent.
Operational implications	In the new process the blowing agent may be directly metered into the mixing head or preblended with the resin component. Alternative blowing agents such as HCFC and pentane isomers are more efficient and are therefore used at a lower addition rate. Operating procedures are as for the CFC process. Appropriate operational precautions should be taken for the use of pentane. Injection of the new systems is slightly easier than the CFC systems as they have better flow characteristics.
6. Scale of operation	Commercial scale.

7. Technical constraints	There are no technical constraints .
8. Restrictions of technology	Closed cell technology is covered by a patent and by pre-existing commercial arrangements. It is available through a license arrangement. Open cell technology is freely available.
9. Stage of technology	The technology has been proven on a pilot scale and in a number of applications subsequently commercialized.
10. Level of commercialization	Full commercial scale in a range of applications.
11. Investment costs	As for CFC predecessors
12. Operational and maintenance costs	As for CFC predecessors
13. Safety issues	No additional safety considerations beyond the need to make allowance for flammability in the case of pentane as a blowing agent.
14. Development of technology	The technology has been developed by BP chemicals.
15. Other	-

1. Company:		**Data Sheet Category**	**3.2 Suppliers of Foam Chemicals**
Name	**3M**		
Add.	Canadastraat, 11 B-2070 Zwijndrect		
Coun.	Belgium	**2. Products**	Additives for Phenolic foam systems
Tel:	+32 3250 7867		
Fax:	+32 3250 7847		
Telex:	-		
Contact	Mr. R. Van San, Technical Service Engineer.		

3. Original process	The original process was manufacturing with CFCs as blowing agent. This was replaced by HCFCs. This resulted in foams with lower insulation properties.
4. Reduction/elimination method	The thermal conductivity of the foam can be reduced by using the additive perfluoro-N-methymorfoline (PE-5052) up to 1% of the total foam weight. The additive must be emulsified in the polyol. It can be used with all of the alternative blowing agents e.g.HFCs. The additive should not be mixed with the blowing agent.
5. Implications of the new technology	
End product quality	If the perfluoro-N-methylmorfoline (PE-5052) is properly emulsified in the polyol in a concentration of up to 1% of total foam weight, the final thermal conductivity of the foam will be reduced up to 15% depending on the blowing agent used.
Operational implications	A mico-emuulsion of the additive in the polyol is essential to obtain the fine cells needed for thermal conductivity reduction.
6. Scale of operation	This technology is currently being used at production scale by several foam manufacturers.
7. Technical constraints	None.
8. Restrictions of technology	None.
9. Stage of technology	The technology is implemented, and detailed literature is available.
10. Level of commercialization	The perfluoro-N-methylmorfoline (PE-5052) additive is fully commercailly available.
11. Investment costs	Limited investment. The additive technology only requires some emulsification equipment, as also needed for using HCFC blowing agents.
12. Operational and maintenance costs	Cost of the new technolgy is primarily due to the cost of the additive. This increased cost is off-set by improvement in translation performance.
13. Safety issues	None. PE-5052 is non-flammable and essentially non-toxic. Material safety data sheets on the additive are available.

14. Development of technology	-
15. Other	References: 1. US Patent 5,162,384 (Nov 10.1992) “Making Foamed Plastic Containing Perfluorinated Heterocyclic Blowing Agent” 2. Urethanes Technology, Oct/Nov. 1992, K. Focquet, “3M Materials Give Microcellular Foams: Better Foam Insulation Follows.”

1. Company:		**Data Sheet Category**	**3.2** **Suppliers of Foam Machinery**
Name	**Beamech Group Ltd**		
Add.	Tenax Road, Trafford Park Manchester M17 1JT		
Coun.	United Kingdom	**2. Products**	Equipment for phenolic foam
Tel:	+44 161 8480316		
Fax:	+44 161 8737718		
Telex:	-		
Contact	-		

3. Original process	Continuous phenolic foam lamination equipment using CFC or other auxillary blowing agents.
4. Reduction/elimination method	CFC and other replaced by ISO/N pentane in the formualtion to make foams with low lambda value.
5. Implications of the new technology	
End Product Quality:	Full range of excellent foams with good physical properties including lambda values.
Operating Implications:	The use of pentane includes special storage, metering, blending and conveying equipment.
6. Scale of operation	In full production.
7. Technical constraints	None.
8. Restrictions of technology	None.
9. Stage of technology	Fully developed and used commercially.
10. Level of commercialization	Mainly Europe
11. Investment costs	Depends upon the type of and layout of existing equipment in the factory.
12. Operational and maintenance costs	Slightly higher costs because of care required for pentane handling, but lower than HCFC alternatives.
13. Safety issues	As a flammable material, pentane must be handled according to defined standards. Storage of pentane and suitable pentane detection systems must be incorporated to ensure that the pentane and foam production areas are kept well below the lower explosion limit.
14. Development of technology	Pentane suppliers and hazard assessment companies involved.
15. Other	-

1. Company: Name **IMPIANTI OMS Spa** Add. Via Sabblonetta 20050 VERANO BRIANZA Coun. ITALIA Tel (39) 362 - 9831 Fax: (39) 362 - 900581 Telex: 335340 OMSVER I	**Data Sheet Category** **3.2 Suppliers of Foam Machinery** **2. Products** Equipment for: PENTANE, CO_2, HCFC-141B, HFC-134a, HCFC -22. Household and Industrial refrigerators Insulated panels, steering wheels, armrests, car seats, blocks. Phenolic foam.

3. Original process	High pressure units (machines) with premixing (Ecoblend - Pentablend) according to blowing agents type.
4. Reduction/elimination method	CFC is substituted by pentane and C-Pentane^{TM}. Use of high pressure units self-cleaning heads and pre-mixing systems. Specific models Ecoblend/Pentablend^{TM}.
5. Implications of the new technology	Specific plants for use of alternative blowing agents.
End product quality	Same features obtained as with CFC blown foams
Operational implications	Modification to plants adopting devices, safeties and side protection according to used blowing agents.
6. Scale of operation	Full production.
7. Technical constraints	No limitation
8. Restrictions of technology	There is no disadvantage compared to HCFC technology
9. Stage of technology	
10. Level of commercialization	Very high level; mainly on white appliances sector (refrigerators), panels, automotive.
11. Investment costs	From US$ 200,000 to US$ 300,000, according to type of machine standard, turn key plants US$ 1 m.
12. Operational and maintenance costs	Similar to the costs for presently used machines;
13. Safety issues	High level of safety for use of pentane is necessary
14. Development of technology	Continuous research with raw material suppliers.
15. Other	-
16. Additional information	Our technical department is at your disposal for any information on C-Pentane.

1. Company: Name **Zaco (PTI) BV** Add. Zuidkerkenlaan 20 Limmen 1906 AC Coun. The Netherlands Tel: +31 725 053184 Fax: +31 7250 53669 Telex: - Contact Mr. Frans Voorwalt	**Data Sheet 3.2** **Category Suppliers of Foam Machinery** **2. Products**

3. Original process	The original process used CFC-11 as blowing agent in continuous block foam.
4. Reduction/elimination method	CFC-11 is substituted with HCFC 141b and pentane.
5. Implications of the new technology **End product quality** **Operational implications**	-
6. Scale of operation	The technology is fully commercialised.
7. Technical constraints	Hydrocarbons (pentane) are flammable and safety precautions applicable to that country must be observed.
8. Restrictions of technology	No restrictions.
9. Stage of technology	No further developments.
10. Level of commercialization	The technology is used in plants throughout the world.
11. Investment costs	Investment costs required introduce the new technology into an existing factory is approx. US$ 600,000-700,000
12. Operational and maintenance costs	Same.
13. Safety issues	Ventilation is required for health & safety.
14. Development of technology	none.
15. Other	-

Polystyrene Foam

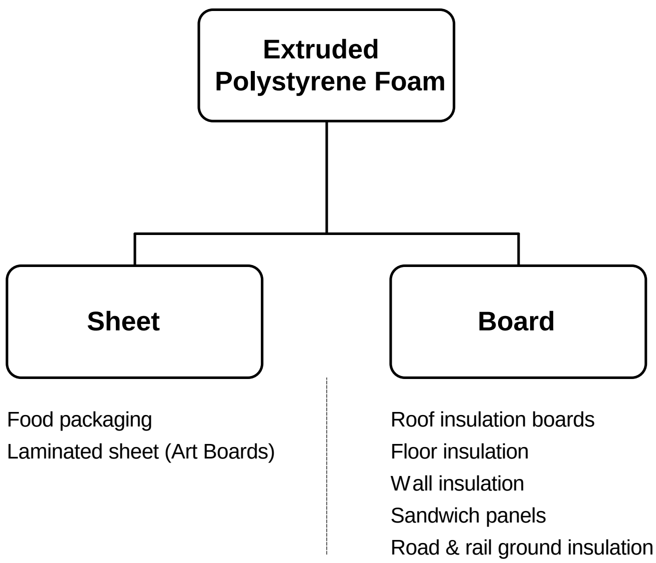
4.1 Polystyrene Foam - Extruded Polystyrene Sheet

Technical Options Overview

Description of Sector

Polystyrene foams are manufactured in two forms, ‘expanded’ and ‘extruded’. The expansion process, as the name implies is a closed mould technique in which polystyrene beads containing blowing agent are expanded by application of heat. This technology has never used CFCs (pentane is standard) and hence the process will not be considered further here.

Extruded foams, however, are manufactured on a continuous basis by the injection of blowing agent at high pressure into molten polystyrene. There are two types of extruded polystyrene: board and sheet. The distinction comes in the thickness of the product and implicitly its end-use, as shown below:



Extruded Polystyrene Sheet

Extruded sheet is thermoformable and hence can be moulded into articles such as fast-food containers. In fact this application represents over 80% of the consumption of extruded sheet The insulating performance of these products does not have to be exceptional and therefore blowing agent retention is not a pre-requisite. This heavily influences the choice of alternative technology and has opened the way for hydrocarbons, as is noted below.

Summary of Available Technical Options

The options available for extruded sheet product are as follows:

hydrocarbons - N-pentane, butane, isopentane and isobutane are all readily available hydrocarbons which are currently being used as replacements for CFCs. The only complication in their use (other than flammability) arises from areas where VOC legislation could be prohibitive. In such cases investment costs climb as high as US$ 1 million to ensure that emissions are restricted.

HFC 134a	-	HFC-134a is valuable in that both flammability and VOC concerns are negated. However, cost is a critical issue. Additionally, difficulties exist with processing and food contact approval
HFC 152a		HFC-152a has food contact approval and is easier to process than HFC-134a. However, HFC-152a is flammable. It is only used in air quality non-attainment areas as price is still substantially higher than for hydrocarbons.
CO_2, water and nitrogen	-	All of these provide processing difficulties at present although 100% CO_2 is being used commercially in some markets. The difficulty with the technology is the sensitivity of the system to blowing agent levels.

Less Preferred Options (measurable ODP)

HCFC-22	-	HCFC-22 has been used as an interim solution whilst other alternatives were researched but its use is now on the decline.

Extruded Sheet Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (4.11) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the “Supplier Information - Data Sheets” at the end of the Polystyrene Foam chapter on page 4-23. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (4.12) lists all known suppliers; these are companies for ***which detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in “Supplier Information - Contacts” at the end of chapter 4. Contact the supplier to obtain detailed information.

Matrix 4.11 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	**Company**	**Alternative Technology**			
		HFC	**HCFC**	**Carbon Dioxide**	**Hydro-carbons**
Foam Manufacturer	Dow Plastics			X	
Machinery	Battenfeld	X	X	X	X

Matrix 4.12 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals			
	Polymer Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**
Albright & Wilson				X
Akzo Chemicals B. V.				X
BASF	X			
Battenfeld GmbH		X		
Battenfled Gloucester		X		
Crecimiento Industrial Co. Ltd		X		
Dow Chemicals	X			
Dow Europe	X			
DuPont de Nemours Int. S.A.			X	
Elf Atochem			X	
Exxon Chemicals			X	
Fecken Kirfel		X		
Hoescht AG				X
La Roche Chemicals			X	
Pelron/Ele Corporation				X
Solvay Fluor und Derivate			X	
Sunkisk Chemical Machinery		X		
Tramaco GmbH			X	X

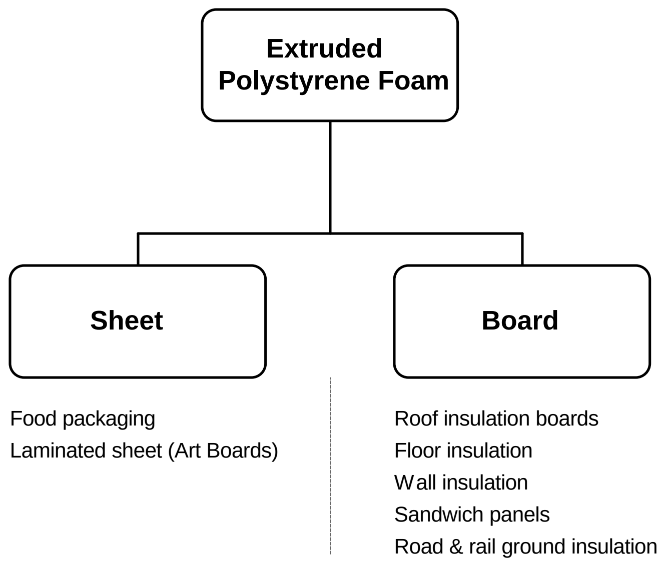
4.2 Polystyrene Foam - Extruded Polystyrene Board

Technical Options Overview

Description of Sector

Polystyrene foams are manufactured in two forms, ‘expanded’ and ‘extruded’. The expansion process, as the name implies is a closed mould technique in which polystyrene beads containing blowing agent are expanded by application of heat. This technology has never used CFCs (pentane is standard) and hence the process will not be considered further here.

Extruded foams, however, are manufactured on a continuous basis by the injection of blowing agent at high pressure into molten polystyrene. There are two types of extruded polystyrene: board and sheet. The distinction comes in the thickness of the product and implicitly its end-use, as shown below:



Extruded Board Foam

Extruded board, in contrast with extruded sheet, is manufactured with a view to retaining the blowing agent for insulating purposes. High insulation performance is obtained by the retention of a ‘heavy’ gas (previously CFC-12) within the foam cells (see ‘Guidance for selecting non-ODS alternatives’). Some blowing agents have no value in this context since the polystyrene matrix is permeable to them. Accordingly, there are significant differences in view within the industry about the most appropriate blowing agent choice for extruded board. The situation is summarised below:

Summary of Available Technical Options

Currently, in all of the non-Article 5 countries where XPS is produced, the CFC-12 has been replaced with HCFC-142b, either in combination with HCFC-22 or alone.

As explained in the ‘Guidance for selecting non-ODS alternatives’ section, using the example of polyurethane foam, substitution of the ‘heavy’ gas by another blowing agent which is not retained in the cells of the foam but which permeates through the cell walls and diffuses out into the atmosphere, leads to a clear drop in thermal insulation resistance.

The zero ozone depleting options open to the extruded polystyrene board industry range from CO_2 alone, or in combination with a secondary agent like ethanol, to HFCs - specifically those commercially available (e.g.HFC-134a and HFC-152a):

HFC-134a	-	makes a commercially acceptable product with an overall thermal insulation performance some 10-15% worse than the value obtained with ODSs, but processing is more difficult.
HFC-152a	-	alone HFC-152a is not really an option since it diffuses readily out of the foam and is flammable. Could be used in conjunction with other blowing agents. Processes easily.
CO_2	-	with and without secondary blowing agent, patented technology. Processing difficult!

Less Preferred Options (measurable ODP)

HCFCs (22 and 142b)	-	Still widely used because of the lack of attractive alternatives. They are generally used as co-blowing agents because the HCFC-22 is relatively permeable through the cell walls.

Final selection will be based on meeting the properties needed for individual end-use applications.

Hydrocarbons can produce a physically good foam product. They are retained in the cells but do not really contribute to insulation performance. They should not be used alone since their presence can critically influence the fire behaviour of this thermoplastic foam.

Extruded Polystyrene Board Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (4.21) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Polystyrene Foam chapter on page 4-23. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (4.22) lists all known suppliers; these are companies for ***which detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end chapter 4. Contact the supplier to obtain detailed information.

Matrix 4.21 Suppliers which have provided detailed data sheets

Category of Technology,, Equipment or Chemicals	**Company**	**Alternative Technologies**		
		HFC	**HCFC**	**Carbon Dioxide**
Foam Manufacturer	Rockwool Ecoprim	X		
Machinery	Battenfeld	X	X	X

Matrix 4.22 *All Known Suppliers*

Company	Category of Technology, Equipment or Chemicals				
	Polymer Systems	Machinery	Blowing Agent	Flame Retardants	Ancilliaries
Albright & Wilson				X	
Akzo Chemicals B. V.				X	
BASF	X				
Battenfeld GmbH		X			
Crecimiento Industrial Co. Ltd		X			
Deltapur	X				
Dow Chemicals	X				
Dow Europe	X				
Exxon Chemicals			X		
Hoescht AG				X	
Pelron/Ele	X			X	X
Shell Chemicals Europe Ltd	X		X		
Solvay Fluor und Derivate			X		
Sunkisk Chemical Machinery		X			
Tramaco GmbH			X	X	

Extruded Polystyrene Board Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Polystyrene Foam chapter on page 4-23, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (4.23), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 4.23

Company	Alternative Technologies		
	HCFC	Carbon Dioxide	Other
Finnfoam-Eristeet OY			X

1. Company:		**Case Study Category**	**4.2 Extruded Polystyrene Board**
Name	**Finnfoam-Eristeet OY**		
Add.	Joensuunkatu 2 SF 24100 Salo		
Coun.	Finland	**2. Products**	Extruded polystyrene insulation boards.
Tel:	+ 358 24 31 8551		
Fax:	+ 358 2473 19924		
Telex:	-		
Contact	Mr. Seppo Paasi		

3. New Technology Applied	In the ordinary poystyrene extrusion process used, CFC-12 has been substituted with other blowing agents, although the identity of the blowing agent is undisclosed. The technology is fully implemented though considered to be a transitional solution.
4. End product quality	No significant changes of the product quality.
Operational implications	No waste problems. Consumption of raw materials and energy is approximately the same. Additional personnel training is required.
5. Safety and Environmental issues	No significant safety changes.
6. Implementation, Operational and maintenance costs	The operation cost has increased a little.

4.3 Supplier Information

About the Supplier Information

This section includes all of the known suppliers of technology, equipment and chemicals for this sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in *Supplier Data Sheets.*

How to Use this Information

Part 1: Contacts provide a ***comprehensive contact list for all suppliers,*** including both those which contributed Data Sheets as well as those that did not. This section is organised sequentialy into Polystyrene systems, Machinery, Blowing Agents, Flame Retardants and Anxcillary and within these sections, alphabetically by company name. After locating a specific supplier, contact the company to obtain detailed information.

Part 2: Data Sheets contain ***detailed process information when provided by the supplier.*** These sheets contain data that can help you better evaluate a particular technical option. This section is organized sequentially into Foam manufactures, Polymers, and Machinery and within these sections, alphebetically by company name. After locating and reading the specific data sheet, contact the supplier to obtain additional information.

DISCLAIMER

Please note that the information contained in the Data Sheets is of a commercial nature and it is up to the reader to verify any claims about performance, safety, costs, etc. made by the company. UNEP IE in no way endorses or recommends any company, product, process or claims referred to in these Data Sheets, as they are provided for information purposes only.

PART 1 - CONTACTS

Polystyrene Systems

BASF AG
Karl Bosch Strasse 38
D 67056 Ludwigshafen
Germany
Tel: (49) 621 601
Fax: (49) 621 60 45618
Main Products: *Polystyrene systems*

Dow Chemical
Midland
Michigan 48667
United States
Tel. (1) 517-636-2806
Fax. (1) 517-636-0592
Main Products: *Polystyrene systems*

Dow Europe
Bachtobelstrasse 3
CH-8810 Horgen
Switzerland
Tel. (41) 1 728-2708
Fax. (41) 1 728-2965
Main Products: *Polystyrene systems*

Machinery

Battenfeld Gloucester Engineering Co. Inc.
Blackburn Industrial Park,
P.O. Box 900
Gloucester
Massachusetts 01930
Tel: (1) 508 281 1800
Fax: (1) 508 283 9206
Main Products: machinery for polystyrene and polyolefin

Battenfeld GmbH
Scherl 10
58540 Meinxhagen
Germany
Tel. (49) 2354-720
Fax. (49) 2454-72503
Main Products: *Injection moulding machines*

Crecimiento Industrial Co. Ltd.
Office No. 348
Chien Teh St.
40107 Taichung
Taiwan
Republic of China
Tel. (886) 4-2116453
Fax. (886) 4-2111543
Main Products: *Post-applied facing laminators,*
PU Dispensers Batch mixers,
Cutting equipment

Fecken Kirfel
Goebbelgasse 1-15
Postfach 725
Aachen
D52008
Germany
Tel. (49) 2 41182020
Fax. (49) 2 411820213
Main Products: *Machinery - cutting*

Sunkist Chemical Machinery Ltd.
10th Floor, 200 Kingshan S. Road, Sec 2
Taipei
Taiwan
Tel. (886) 2-395-56686
Fax. (886) 2-321-7266
Main Products: *Flexible foam equipment, cutting*
& laminating

Blowing Agents

Elf Atochem SA
4 Cours Michelet-Cedex 42-92091
Paris
La Defense 10
France
Tel. (33) 1 49007425
Fax. (33) 1 49007021
Main Products: *Blowing Agents-HCFC 141b, 142b, 22, HFC 134a*

Exxon Chemical Belgium
Hermeslaan 2
B-1831 Machelen
Belgium
Tel. (32) 2-722-2171
Fax. (32) 2-722-2193
Main Products: *Cyclopentane & other hydrocarbons*

DuPont de Nemours Int. S.A.
2 Chemin du Pavillion
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel. (41) 22-717-5111
Fax.
Main Products: *Blowing Agents - HFC 134a, HCFC141b*

La Roche Chemicals
P.O. Box 1031
Baton Rouge
Louisiana 70821
United States
Tel. (1) 800-248-6336
Fax. (1) 504-652-9945
Main Products: *HCFC-141b*

Solvay Fluor und Derivate
Hans-Bockler-Allee 20
D-30173 Hannover
Germany
Tel. (49) 511-8570
Fax. (49) 511-817338
Main Products: *HCFC-141b, HCFC-142b, liquid HFC development*

Tramaco GmbH
Siemensstrasse 1-3
25421 Pinneberg
Germany
Tel. (49) 4101-70602
Fax. (49) 4101-706200
Main Products: *Chemical blowing agents and Flame retardants*

Flame Retardants

Flame retardants

Albright & Wilson UK Ltd.
210-222 Hagley Road West
Oldbury
Warley
West Midlands B68 0NN
United Kingdom
Tel. (44) 121 420 5117
Fax. (44) 121 420 5545
Main Products: *A & W Amgard range for PU & PS foam*

Akzo Chemicals B.V.
Stationsplein 4
P.O. Box 247
3800 AE Amersfoort
The Netherlands
Tel. (31) 676-767
Fax. (31) 676-150
Main Products: *Phosphorus-based flame retardants*

Hoescht AG
Business Unit Additives
Marketing Flame Retardants & Performance Chemicals
D-65926
Frankfurt
Germany
Tel. (49) 69-305-2317
Fax. (49) 69-305-15671
Main Products: *Phosphate-based flame retardants*

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: *Polyols, amine catalysts, flame retardants & silicones*

Tramaco GmbH
Siemensstrasse 1-3
25421 Pinneberg
Germany
Tel. (49) 4101-70602
Fax. (49) 4101-706200
Main Products: *Chemical blowing agents and*

PART 2- DATA SHEETS

1. Company: Name **Rockwool Ecoprim AB** Add. S 541 86 Skövde Coun. Sweden Tel: + 46 500 469200 Fax: + 46 500 469261 Telex: - Contact Mr Andrew Gunnarsson, Managing Director.	**Data Sheet Category** **4.3 Polystyrene foam Board** Foam Manufacturer **2. Products** Rigid XPS boards for insulation and other purposes.

3. Original process	Extruding of PS for foam boards with CFC-12 as blowing agent.
4. Reduction/elimination method	New production machinery: new system for blowing agent distribution and feeding. Alternative blowing agents: mixture of HFCs and CO_2.
5. Implications of the new technology	
End product quality	No change.
Operational implications	Lower production rate due to lower solubility of blowing agent. No changes of process management except the change of recipe. The increase in density of the product has resulted in a similar increase of energy cost for melting and cooling.
6. Scale of operation	Annual production is approx. 3,000 tonnes of rigid XPS boards annually.
7. Technical constraints	Blowing agent is more flammable and less soluable. This creates different types of production constraints.
8. Restrictions of technology	There are numbers of patents and patent applications around in the field of blowing agents, additives and resins. It is very likely that most replacement recipes will interfere somewhere.
9. Stage of technology	The technology is fully implemented.
10. Level of commercialization	The producers are commercially available since Swedish regulation requires zero ODP blowing agents from 1st January 1997.
11. Investment costs	Increased costs for blowing agent.
12. Operational and maintenance costs	Increased blowing agent costs: US$ 562,500 /y Increased raw material costs: US$ 262,500 /y Increased energy costs: US$ 12,500 /y Increased insurance rate: US$ 37,500 /y

	Total: US$ 875,000 /y
13. Safety issues	HFCs are flammable.
14. Development of technology	All development and implementation of HFC based blowing agents are carried out by Rockwool Ecoprim AB.
15. Other	-

1. Company:		**Data Sheet Category**	**4.3 Extruded Polystyrene Sheet** Foam Manufacturer
Name	**Dow Plastics North America**		
Add.	Midland Michigan 48667		
Coun.	United States	**2. Products**	Packaging applications, typically for food packaging such as meat trays, plates, bowls and fast food containers.
Tel	+1 517 6362806		
Fax:	+1 517 6360592		
Telex:	-		
Contact	Gary Welsh		

3. Original process	Foam sheets has historically been made using CFC-12 as a blowing agent. Subsequent changes to HCFC-22 were made. Hydrocarbon blowing agents are also used. CFCs and HCFCs are associated with stratospheric ozone depletion and hydrocarbons are associated with the tropospheric ozone formation (smog).
4. Reduction/elimination method	Carbon dioxide (CO_2) has been substituted as the blowing agent.
5. Implications of the new technology	Zero ozone depletion potential. Because commercially available CO_2 from existing sources is used, the net global warming impact of the blowing agent is zero.
End product quality	Product performance is similar to CFC, HCFC and hydrocarbon blown foams. CO_2 blown foams have better physical properties over time vs. CFC, HCFC and hydrocarbon blown foams.
Operational implications	CO_2 is non-flammable.
6. Scale of operation	Dow had licensed 100% CO_2 technology to 8 commercial foam sheet converters globally.
7. Technical constraints	Utilization of 100% CO_2 as a blowing agent requires retrofit of existing extrusion process and knowledge of new process parameters.
8. Restrictions of technology	None known.
9. Stage of technology	Continuous refinements of process and resin technology.
10. Level of commercialization	8 licensees in Europe, USA, Pacific and Latin America.
11. Investment costs	Costs can vary as a function of a new vs existing extrusion process. If an existing process, costs are relative to the design and age of the process and equipment.
12. Operational and maintenance costs	This can vary depending on specific extrusion equipment used, products made and location.
13. Safety issues	No specific concerns for this product. Safey aspects of handling CO_2 are described in licensed technology package.
14. Development of technology	Dow developed the technology. License includes both patent and know-how.

15. Other	-

1. Company: Name **Dow Chemical** Add. Midland, Michigan 48667 Coun. USA Tel: +1 517 636 2806 Fax: +1 517 636 0592 Telex: - Contact -	**Data Sheet Category** **4.3 Suppliers of Foam Polymers** **2. Products** Chemicals for thermoformed packaging articles typically for food packaging such as meat trays, plates, bowls and fast food containers.

3. Original process	The original blowing agents were CFCs and HCFCs.
4. Reduction/elimination method	The technology uses 100% CO_2 as a blowing agent to replace CFC, HCFC and hydrocarbon blowing agents in the production of polystyrene foam sheet. The technology is typically retrofitted into an existing tandem foam sheet extrusion process.
5. Implications of the new technology	
End product quality	Equivalent to existing products.
Operational implications	-
6. Scale of operation	Commercial scale tandem extrusion lines, 4-½ x 5" operation at extrusion rates of 550-800 lb/hr.
7. Technical constraints	-
8. Restrictions of technology	-
9. Stage of technology	-
10. Level of commercialization	-
11. Investment costs	-
12. Operational and maintenance costs	-
13. Safety issues	-
14. Development of technology	-
15. Other	-

1. Company:		**Data Sheet** **Category**	**4.3** **Suppliers of Machinery**
Name	**Battenfeld Gloucester Engineering**		
Add.	Blackburn Industrial Park, P.O. Box 900, Gloucester, Massachusetts 01930		
Coun.	United States	**2. Products**	Machinery for polystyrene and polyolefin
Tel:	+ 1 508 281 1800		
Fax:	+ 1 508 283 9206		
Telex:	-		
Contact	Mr Al Hall, Senior Product Manager		

3. Original process	The original process consisted of high pressure injection systems using CFC/HCFC as blowing agent.
4. Reduction/elimination method	CFC/HCFC is substituted by pentane or with other hydrocarbons, and in mixtures with CO_2.
5. Implications of the new technology	
End product quality	With appropriate process optimization, the end product quality is similar.
Operational implications	Changes in operating conditions are required, along with additional safety equipment for flammable materials.
6. Scale of operation	Commercial production.
7. Technical constraints	none.
8. Restrictions of technology	none.
9. Stage of technology	Process optimization, further development of inert gas usage.
10. Level of commercialization	Widespread usage in packaging foams.
11. Investment costs	US$ 50-100,000 per production line for new high pressure metering units.
12. Operational and maintenance costs	No significant change.
13. Safety issues	Enhanced safety procedures required for any hydrocarbon.
14. Development of technology	Mostly inhouse and jointly with customers.
15. Other	Battenfeld Gloucester Engineering supplies complete processing lines for production of polystyrene and polyolefin foams.

Polyolefin Foam

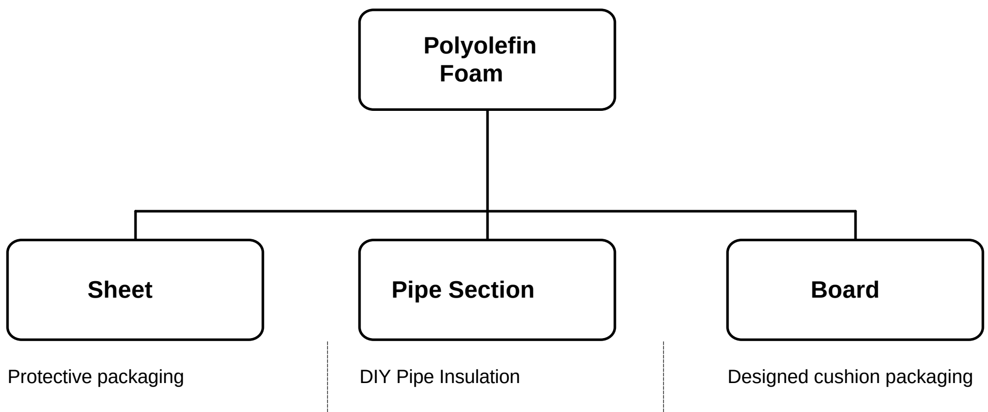
5 Polyolefin Foam

5.1 Polyolefin Foam Technical Options

Technical Options Overview

Description of Sector

Polyolefin foams separate into sheet and board products in a similar fashion to polystyrene foams. However, the increased flexibility of polyolefin foams gives the sheet product more of a role in the packaging of delicate equipment. An additional application for polyethylene foam is for self-wrap thermal insulation for pipe. These uses are shown below:



The process used for manufacture is very similar to that used for extruded polystyrene foams. The products are typically closed cell foams but with permeable cell walls. Hence blowing agents are lost within 1-4 weeks of manufacture. Diffusion rates are important since, if these are more rapid than air ingress, shrinkage will result.

Summary of Available Technical Options

Alternative blowing agent options can be summarised as follows:

Hydrocarbons (e.g. iso-butane)	-	Flammability of hydrocarbons can cause a problem in both process and product. It is important that diffusion is complete before despatch to avoid increased product flammability problems. VOC considerations may also be an issue.
HFCs (134a & 152a)	-	These products are difficult to process, particularly in thick section. However, HFC-152a (though flammable) has been used in situations where VOC legislation constrains the use of hydrocarbons.
CO_2, or nitrogen	-	These have low solubility in the polymer and the increase in mix viscosity may be too great for many extruders. Carbon dioxide diffusion rates are also too fast to avoid massive shrinkage at present. Enabling technology is required to offset this effect.

Less Preferred Options (measurable ODP)

HCFCs (22 & 142b)	-	Widely used separately or in combination (the blend is non flammable). HCFC142b is preferred in thicker sections. As the blowing agent is lost there is no long-term insulation benefit from using HCFCs.

5.1 Polyolefin Foam Technology Matrices

About the Matrices

The matrices below indicate the known suppliers of technology, equipment and chemicals for this foam sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook Some, but not all, of the suppliers have provided this detailed information, which is contained in the Supplier Data Sheets.

How to Use the Matrices

The ***first matrix*** (5.11) summarises the detailed information for those companies ***which provided Data Sheets***. Once you have identified a technology, equipment or chemical of interest, locate the corresponding company in the "Supplier Information - Data Sheets" at the end of the Polyolefin Foam chapter 5 on page 5-17. If you require more information after you have read the Data Sheet, contact the supplier at the address listed in the Data Sheet.

The ***second matrix*** (5.12) lists all known suppliers; these are companies for which ***detailed information about their products is not available*** as well as those companies ***which provided Data Sheets (in bold italics).*** Once you have identified a technology, equipment or chemical of interest, locate the corresponding company under contact in "Supplier Information - Contacts" at the end of chapter 5. Contact the supplier to obtain detailed information.

Matrix 5.11 Suppliers which have provided detailed data sheets

Category of Technology, Equipment or Chemicals	Company	Alternative Technologies			
		HFC	HCFC	Hydro-carbons	Carbon Dioxide
Machinery	Battenfeld	X	X	X	X

Matrix 5.12 *All Known Suppliers*

Company	**Category of Technology, Equipment or Chemicals**				
	PU Systems	**Machinery**	**Blowing Agent**	**Flame Retardants**	**Ancilliaries**
Albrecht Baumer KG		X			
Albright & Wilson				X	
AlliedSignal			X		
Akzo Chemicals B. V.				X	
Battenfeld GmbH		X			
Crecimiento Industrial Co. Ltd		X			
DuPont Chemicals				X	
DuPont de Nemours Int. S.A.				X	
Elf Atochem SA			X		
Exxon Chemicals			X		
Fecken Kirfel		X			
FMC Corp. UK Ltd				X	
Hoescht AG				X	
La Roche Chemicals			X		
Pelron/Ele				X	
Solvay Fluor und Derivate			X		
Sunkisk Chemical Machinery		X			
Tramaco GmbH			X	X	

5.1 Polyolefin Foam Technology Case Study Matrix

About the Case Studies

These case studies describe examples of the successful conversion to non-ODS technologies, equipment and/or chemicals by companies that produce products in this foam sector.

The purpose of these case studies is to illustrate that companies similar to yours have successfully made the transition to “ozone friendly” alternatives while maintaining the product quality, operational conditions, workplace safety and financial aspects required to be competitive in the marketplace.

Details about the alternatives referred to in the case studies can be found in the Data Sheets at the end of the Polyolefin Foam chapter on page 5-17, or by contacting the suppliers directly. Additionally, the companies described in the case studies may be willing to discuss their experience with you directly.

How to Use this Information

The case studies that follow immediately after the matrix are organized alphabetically by company name. After identifying a specific company within the matrix (5.13), locate and read the case study. You may wish to contact the company to see if additional information about their experience with the alternative technology is available.

Matrix 5.13

Company	Alternative Technology			
	HCFC	**Hydro-carbons**	**Carbon Dioxide**	**Other**
Scriptoria N.V. Div.		X		

1. Company: Name **Scriptoria N.V. Div. Sentinel** Add. Bodemstraat 11 B-3830 Wellen Coun. Belgium Tel: + 32 11 370 111 Fax: + 32 11 370 290 Telex: - Contact Mr. M. Fiddelaers, Plant Manager. Mrs. E. Gaerts	**Case Study Category** **5.1 Polyolefin Foam** **2. Products** Polyethylene and polypropylene foam in sheets and blocks
3. New Technology Applied	The original manufacturing process was based on directly gassed extruders using CFCs as a blowing agent. The blowing agents CFC-12 and CFC-114 have been substituted by butane. The reduction method was also based on process change, alternative process equipment and engineering controls. With the technology fully implemented, the use of polyethylene is approx. 15,000 tons per year and the use of butane approx. 1,000 tons per year.] Since 1993, 6 plants have been in operation.
4. End product quality **Operational implications**	The end product quality is unchanged. The operation procedures and the personnel training requirements has changed significantly as a result of the change of the use of an inert freon gas to an explosive butane gas as a blowing agent. The energy consumption has increased as a result of the incineration process. A project to eliminate this negative effect is ongoing. The waste streams are unchanged. Gas waste streams are now treated with energy recovery. Technical constraints have not been realised.
5. Safety and Environmental issues	The end product contains a certain amount of butane. The latter could cause problems under extreme storage conditions with lack of ventilation combined with extreme temperatures. As a result of this switch, all equipment and buildings have been changed to meet explosion proof standards. Process air is treated through incineration.
6. Implementation, Operational and maintenance costs	The investments costs were US$ 15,000,000 in 1991. There are no changes in maintenance costs. Personnel costs, however, have increased significantly with a total of US$ 1,000,000 per year.

5.2 Supplier Information

About the Supplier Information

This section includes all of the known suppliers of technology, equipment and chemicals for this sector, all of which have been contacted to solicit detailed information about their products for inclusion in this Sourcebook. Some, but not all, of the suppliers have provided this detailed information, which is contained in *Supplier Data Sheets.*

How to Use this Information

Part 1: Contacts provide a ***comprehensive contact list for all suppliers,*** including both those which contributed Data Sheets as well as those that did not. This section is organised sequentialy into Polyolefin systems, Machinery, Blowing Agents, Flame Retardants and Anxcillary and within these sections, alphabetically by company name. After locating a specific supplier, contact the company to obtain detailed information.

Part 2: Data Sheets contain ***detailed process information when provided by the supplier.*** These sheets contain data that can help you better evaluate a particular technical option. This section is organized sequentially into Foam manufactures, Polyolefin Chemicals, Blowing Agents, Flame Retardants, Release Agents and Machinery and within these sections, alphebetically by company name. After locating and reading the specific data sheet, contact the supplier to obtain additional information.

DISCLAIMER

Please note that the information contained in the Data Sheets is of a commercial nature and it is up to the reader to verify any claims about performance, safety, costs, etc. made by the company. UNEP IE in no way endorses or recommends any company, product, process or claims referred to in these Data Sheets, as they are provided for information purposes only.

PART 1 - CONTACTS

Machinery

Albrecht Baumer KG
Asdorfer Strasse 96-106
D-57258 Freudenberg
Germany
Tel. (49) 2734-450
Fax. (49) 2734-3056
Main Products: *Block handling and cutting equipment*

Battenfeld GmbH
Scherl 10
58540 Meinxhagen
Germany
Tel. (49) 2354-720
Fax. (49) 2454-72503
Main Products: *Injection moulding machines*

Battenfeld Gloucester Engineering Co. Inc.
Blackburn Industrial Park
P.O. Box 900
Gloucester
Massachusetts 01930
Tel: (1) 508 281 1800
Fax: (1) 508 283 9206
Main products: Machinery for Polystyrene and Polyolefin

Crecimiento Industrial Co. Ltd.
Office No. 348
Chien Teh St.
40107 Taichung
Taiwan
Republic of China
Tel. (886) 4-2116453
Fax. (886) 4-2111543
Main Products: *Post-applied facing laminators, PU Dispensers Batch mixers, Cutting equipment*

Fecken Kirfel
Goebbelgasse 1-15
Postfach 725
Aachen
D52008
Germany
Tel. (49) 2 41182020
Fax. (49) 2 411820213
Main Products: *Machinery - cutting*

Sunkist Chemical Machinery Ltd.
10th Floor, 200 Kingshan S. Road, Sec 2
Taipei
Taiwan
Tel. (886) 2-395-56686
Fax. (886) 2-321-7266
Main Products: *Flexible foam equipment, cutting & laminating*

Blowing Agents

Allied Signal
20 Peabody Street
Buffalo
New York, 14210
United States
Tel. (1) 716-827-1407
Fax. (1) 716-827-6275
Main Products: *HCFC-141b, HFC-245a*

Elf Atochem SA
4 Cours Michelet-Cedex 42-92091
Paris
La Defense 10
France
Tel. (33) 1 49007425
Fax. (33) 1 49007021
Main Products: *Blowing Agents-HCFC 141b, 142b, 22, HFC 134a*

Exxon Chemical Belgium
Hermeslaan 2
B-1831 Machelen
Belgium
Tel. (32) 2-722-2171
Fax. (32) 2-722-2193
Main Products: *Cyclopentane & other hydrocarbons*

DuPont Chemicals
Customer Service Centre
B-15305
Wilmington
DE 19898
United States
Tel. (1) 302-774-2099
Fax. (1) 302-774-2370
Main Products: *Blowing Agents - HFC 134a, HCFC141b*

DuPont de Nemours Int. S.A.
2 Chemin du Pavillion
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva
Switzerland
Tel. (41) 22-717-5111
Fax.
Main Products: *Blowing Agents - HFC 134a, HCFC141b*

La Roche Chemicals
P.O. Box 1031
Baton Rouge
Louisiana 70821
United States
Tel. (1) 800-248-6336
Fax. (1) 504-652-9945
Main Products: *HCFC-141b*

Solvay Fluor und Derivate
Hans-Bockler-Allee 20
D-30173 Hannover
Germany
Tel. (49) 511-8570
Fax. (49) 511-817338
Main Products: *HCFC-141b, HCFC-142b, liquid HFC development*

Tramaco GmbH
Siemensstrasse 1-3
25421 Pinneberg
Germany
Tel. (49) 4101-70602
Fax. (49) 4101-706200
Main Products: *Chemical blowing agents and Flame retardants*

Flame Retardants

Akzo Chemicals B.V.
Stationsplein 4
P.O. Box 247
3800 AE Amersfoort
The Netherlands
Tel. (31) 676-767
Fax. (31) 676-150
Main Products: *Phosphorus-based flame retardants*

Albright & Wilson UK Ltd.
210-222 Hagley Road West
Oldbury
Warley
West Midlands B68 0NN
United Kingdom
Tel. (44) 121 420 5117
Fax. (44) 121 420 5545
Main Products: *A & W Amgard range for foams*

FMC Corporation UK Ltd
Process Additives Division
Tanex Road
Trafford Park
Manchester M17 1WT
Tel: (44) 161 872 2323
Fax: (44) 161 873 7271
Main Products: Phosphate-based flame retardants

Hoescht AG
Business Unit Additives
Marketing Flame Retardants & Performance Chemicals
D-65926
Frankfurt
Germany
Tel. (49) 69-305-2317
Fax. (49) 69-305-15671
Main Products: *Phosphate-based flame retardants*

Pelron/Ele Corporation
7847 West 47th Street
Lyons
60534 Illinois
United States
Tel. (1) 708-442-9100
Fax. (1) 708-442-0213
Main Products: *Polyols, amine catalysts, flame retardants & silicones*

Tramaco GmbH
Siemensstrasse 1-3
25421 Pinneberg
Germany
Tel. (49) 4101-70602
Fax. (49) 4101-706200
Main Products: *Chemical blowing agents and Flame retardants*

PART 2 - DATA SHEETS

1. Company:	**Data Sheet Category** — **4.3 Suppliers of Machinery**
Name: **Battenfeld Gloucester Engineering Co. Inc.**	
Add.: Blackburn Industrial Park, P.O. Box 900, Gloucester, Massachusetts 01930	
Coun.: United States	**2. Products** — Machinery for polystyrene and polyolefin
Tel: + 1 508 281 1800	
Fax: + 1 508 283 9206	
Telex: -	
Contact: Mr Al Hall, Senior Product Manager	

3. Original process	The original process consisted of high pressure injection systems using CFC/HCFC as blowing agent.
4. Reduction/elimination method	CFC/HCFC is substituted by pentane or with other hydrocarbons, and in mixtures with CO_2.
5. Implications of the new technology	
End product quality	With appropriate process optimization, the end product quality is similar.
Operational implications	Changes in operating conditions are required, along with additional safety equipment for flammable materials.
6. Scale of operation	Commercial production.
7. Technical constraints	none.
8. Restrictions of technology	none.
9. Stage of technology	Process optimization, further development of inert gas usage.
10. Level of commercialization	Widespread usage in packaging foams.
11. Investment costs	US$ 50-100,000 per production line for new high pressure metering units.
12. Operational and maintenance costs	No significant change.
13. Safety issues	Enhanced safety procedures required for any hydrocarbon.
14. Development of technology	Mostly inhouse and jointly with customers.
15. Other	Battenfeld Gloucester Engineering supplies complete processing lines for production of polystyrene and polyolefin foams.

Annexes

Annex A - About UNEP IE's OzonAction Programme under the Multilateral Fund of the Montreal Protocol on Substances that Deplete the Ozone Layer

Do you need answers to any of these questions?

What are CFCs, halons & other ozone depleting substances (ODS)?

- Why are they being phased out globally?
- When will they be phased out?
- Will I still be able to buy them?
- Can they be replaced?
- What are the alternative technologies, equipment, and substitutes?
- How do I contact the experts?
- Do not-in-kind alternatives exist?
- How do I obtain them?
- What are governments doing?
- What can industry do?
- What can my company do?
- What can I do?
- What kind of assistance is available to me in order to facilitate the switchover?
- How/where can I get information?
- How can I get training?
- What is happening in my country and in my region?
- Who is responsible for ODS phase-out issues in my country?

The OzonAction Programme can provide answers to these questions and many others relating to ozone depletion. You have the right to benefit from the research and experience that has been gathered over the past few years. All it takes to make a start is a letter, a fax, or a phone call.

The OzonAction Information Clearinghouse

The OzonAction Information Clearinghouse (OAIC) is an integrated information exchange service designed to eet the needs of developing countries through various communication media. The OAIC provides technical, policy and scientific information on a wide range of ODS phase-out issues including:

- descriptions of alternative technologies and product listings for each industrial use sector;
- an international directory of experts and consultants;
- technical literature abstracts, and information for ordering documents;
- descriptions of national and corporate policies and programmes to phase out ODS;
- listings of workshops, conferences and meetings concerning ozone depletion issues; and
- bulletins containing news on phase-out initiatives.

There is no charge for using the OAIC query response service; simply phone, fax, email or write us with your question.

Why do we need the Ozonaction Programme?

Scientists agree that emissions of manmade chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, methyl bromide and other substances are responsible for depletion of the ozone layer.

Millions of ozone molecules are being destroyed every minute and this is increasing the amount of harmful

ultraviolet radiation that reaches the Earth's surface. People, animals and plants are being exposed to this radiation, which threatens to cause skin cancer and eye cataracts, reduce agricultural productivity and severely damage the marine food chain.

The world community has understood the gravity and urgency of this situation, and has acted decisively.

Nations throughout the world have committed themselves to phasing out the use and production of these ODS through an international treaty: the Montreal Protocol. They recently decided that the threat is now so acute that the phase-out should be accelerated.

The Multilateral Fund was established by Parties to the Protocol in January 1991 to provide financial and technical assistance to developing countries that are Party to the Protocol to enable them to phase-out ODS. Four organizations serve as the Fund's implementing agencies: the UN Development Programme (UNDP), the UN Environment Programme (UNEP), the UN Industrial Development Organization (UNIDO) and the World Bank.

UNEP was given responsibility for gathering information, holding workshops, training courses, networking, conducting country programmes and acting as an information clearinghouse.

The OzonAction Programme is UNEP's response to this mandate.

The Programme also receives the support of the Finnish International Development Agency (FINNIDA) and the Swedish International Development Authority (SIDA) .

How can the Ozonaction Programme help?

The OzonAction Programme is designed to ease developing countries' transition to the use of chemicals that do not deplete the ozone layer.

We can help by providing information, organizing training and assisting countries in the preparation of their national programmes for phasing out ODS.

<u>Information exchange</u>

Information about technical and policy issues is available through our OzonAction Information Clearinghouse (OAIC). The information exchange on how to reduce ODS use takes place through mail, fax and phone, as well as through electronic, (i.e. on-line and diskette databases), the OzonAction newsletter and technical publications prepared in close liaison with the UNEP Assessment Panels and their Technical and Economic Options Committees as well as in partnership with government, industry and NGOs.

<u>Training</u>

The OzonAction Programme helps by:

- organizing training and networking workshops to provide government and industry decision-makers with information on ODS control policies, strategies, and replacement technologies and products;
- organizing regional and national "train the trainer" courses which include information and skills on servicing, maintenance, and recovery and recycling; and
- advising on national information campaigns to raise public awareness on the importance of ozone protection, and publishing documents and training.

<u>Country Programmes</u>

The OzonAction Programme helps developing countries that consume small quantities of ODS to assess their

current production and consumption and to develop their own national phase-out action plans. The cost of developing these programmes is met by the Multilateral Fund. Other implementing agencies can also collaborate to assist with country programmes and identify investment projects.

Helping you to help our planet

Our goal is to help you obtain the information you need to make the right decisions.

Become a partner in the global OzonAction network and join the thousands of people who have decided to act in order to preserve the fragile ozone shield.

- to get the OzonAction Newsletter
- to get Technical Brochures/Sourcebooks
- to get answers to your technical and policy questions
- to get the contact data of your National Ozone Unit.

Write, phone, fax, email or telex us now to:

UNEP Industry & Environment
OzonAction Programme
39-43, Quai André Citroën
75739 Paris Cedex 15
France
Email: ozonaction@unep.fr
Tel: 33 (1) 44 37 14 50
Fax: 33 (1) 44 37 14 74
Telex: 204 997 F
Cable: UNITERRA PARIS

Or for *ASIA and the PACIFIC*:

UNEP Regional Office for Asia & the Pacific (ROAP)
UN Building, Radjamnern Avenue
10200 Bangkok, Thailand
Tel: (66 2) 280 60 88
Fax: (66 2) 280 38 29

Or for *LATIN AMERICA and the CARIBBEAN*:

UNEP Regional Office for Latin America & the Caribbean
(ROLAC)
155, Boulevard de los Virreyes Col Lomas
Virreyes - 11000 Mexico DF
Tel: (52 5) 202 4841
Fax: (52 5) 202 0950

About UNEP Industry and Environment

It is now widely accepted that sustainable development and a sound environment go hand - in - hand. UNEP recognized this as early as 1975 when it established its Industry and Environment center (IE), located in Paris. UNEP IE functions as a catalyst to bring industry, government and non-governmental organizations together to work towards environmentally sound forms of industrial development. UNEP IE seeks to:

- define and encourage the incorporation of environmental criteria in industrial development;
- help formulate policies, strategies and management tools for sustainable industrial development and build the capacity for their implementation.
- promote preventative environmental protection through cleaner, safer production as well as other pro-active approaches;

and

- stimulate the exchange of information on environmentally sound technologies and forms of industrial development.

To promote the transfer of information and the sharing of knowledge and experience, UNEP IE has developed three complementary tools: a *Technical Report Series*; the quarterly *Industry and Environment* review; and a *Query-Response Service*.

Annex B - Glossary of Acronyms and Significant Terms

AB technology	Process by which formic acid reacts with an isocyanate to produce CO_2 and carbon monoxide for the expansion of flexible polyurethane foam.
Acetone	An organic solvent which has zero ODP, CH_3COCH_3.
ABA	Auxiliary blowing agents
Blowing agent	A gas, a volatile liquid, or a chemical that during the foaming process generates gas. The gas creates bubbles or cells in the plastic structure of a foam.
Butane	A gaseous hydrocarbon of the alkane series, C_4H_{10}.
Carbon dioxide	A gaseous compound formed by for example combustion of carbon. Carbon dioxide causes the greenhouse effect, see *greenhouse effect*. The chemical formula for carbon dioxide is CO_2.
CO_2	The chemical formula for carbon dioxide.
Carbon tetrachloride	A chlorocarbon solvent with an ODP of approximately 1.1. It is considered toxic and a probable human carcinogen as classified by the International Agency for Research on Cancer. Its use is strictly regulated in most countries and it is used primarily as a feedstock material for the production of other chemicals.
CFC	See *chlorofluorocarbon.*
Chlorofluorocarbon	An organic substance composed of chlorine, fluorine, and carbon atoms, usually characterized by high stability contributing to a high ODP.
Climate Change	The effect on the climates of the world induced by global warming.
Cyclopentane	A cyclic hydrocarbon, C_5H_{10}
Dimethyl ether	Molecule formed by elimination of water from two molecules of methyl alcohol, CH_3OCH_3.
Fluorinated ethers	Ether in which one or more hydrogen atoms have been replaced by fluorine.
Greenhouse effect	A thermodynamic effect whereby energy absorbed at the earth´s surface and normally radiated back out to space in the form of long wave infrared radiation, is retained due to gases in the atmosphere, causing a rise in global temperature. See also *global warming* and *global warming potential*.
Global warming	Global warming is an increase in the natural greenhouse effect. CFCs can cause greenhouse gases effect.
GWP	Global warming potential, i.e. the potential relative impact to the global warming. GWP can be determined relative to the effect of carbon dioxide or another gas giving rise to global warming. Carbon dioxide based GWPs enable

chemical emissions to be converted to their equivalent emission of carbon dioxide. This constitutes a common basis for comparing impacts.

Halons — Substances used as fire extinguishing agents. Halons have high ODPs.

HCFC — See *hydrochlorofluorocarbon*.

HFC — See *hydrofluorocarbon*.

Hydrocarbon — An organic substance composed only of hydrogen and carbon. Gaseous or volatilized hydrocarbons are flammable.

Hydrochlorofluorocarbon — An organic substance composed of hydrogen, chlorine, fluorine, and carbon atoms. These chemicals are less stable than CFCs, thereby having generally lower ODPs. Usually abbreviated as HCFC.

Hydrofluorocarbon — An organic substance composed of hydrogen, fluorine, and carbon. These chemicals have no ODP and are likely to be widely used as refrigerants. Usually abbreviated as HFC.

Isocyanates — Chemicals used in polyurethane foam production. Isocyanates contain the isocyanate group -NCO. The majority of polyurethanes are produced from the two isocyanates, toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI).

MDI — See *Isocyanates*

Methyl bromide — A colourless, odorless, highly toxic gas used as a broad spectrum fumigant in commodity, structural, and soil fumigation. Methyl bromide has an ODP of approximately 0.6.

Methylene chloride — Alternative blowing agent CH_2Cl_2.

Methyl chloroform — A common name for 1,1,1, -trichloroethane. Methyl chloroform is used as alternative blowing agent.

ODP — See o*zone depletion potential.*

ODS — Ozone Depleting Substance

Ozone — A gas formed when oxygen is ionised. Ozone partially filters certain wavelengths of UV light from earth. Ozone is a desirable gas in the stratosphere, but it is toxic to living organisms at ground level. See *volatile organic compound*.

Ozone depletion — Accelerated chemical destruction of the stratospheric ozone layer. Chlorine and bromine free radicals liberated from relatively stable chlorinated and brominated products by ultraviolet radiation in the ozone layer are the most depleting species.

Ozone-depletion potential — A relative index of ability of a substance to cause ozone depletion. The reference level of 1.0 is assigned as an index to CFC-11 and CFC-12. If a product has an ozone-depleting potential of 0.5, a given weight of the product in the atmosphere would, in time, deplete half the ozone that the same weight of CFC-11 or CFC-12 would deplete. Ozone-depletion potentials are calculated

	from mathematical models which take into account factors such as the stability of the product, the rate of diffusion, the quantity of depleting atoms per molecule, and the effect of ultraviolet light and other radiation on the molecules.
Ozone layer	A layer in the stratosphere, at an altitude of approximately 10-50 km, where a relatively high concentration of ozone filters harmful ultraviolet radiation from the earth.
Pentane	A low-boiling hydrocarbon of the alkane series, C_5H_{12}. There are five pentane isomers.
Perfluoralkanes	Member of alkane series in which a pair of hydrogen atoms has been replaced by fluorine.
Polyethylene	A polymer of ethylene, C_2H_4.
Polyisocyanurate	A polymer containing isocyanurate groups.
Polyolefin	A polymer of a hydrocarbon that contains a double bond.
Polypropylene	Polymerized propylene, a plastic with similar properties to polyethylene.
Polystyrene	A thermoplastic polymer of styrene.
Polyurethane	Any polymer containing the urethane group.
Propane	A gaseous hydrocarbon of the alkane series. C_3H_8.
Propellant	The component of an aerosol spray that acts as a forcing agent to expel the product from the aerosol canister.
Propylene	C_3H_6, a member of the ethylene series.
PU	See Polyurethane
PS	See Polystyrene
Reduced CFC-11 technology	Technology featuring a high-water formulation that generates carbon dioxide from a water-isocyanate reaction.
Softening agent	Additive which lowers foam hardness and reduces the need for a blowing agent.
Stratosphere	The portion of the atmosphere approximately 10-50 kilometers above the earth´s surface where the bulk of atmospheric ozone resides.
TDI	See *Isocyanates*
TEWI	Total Equivalent Warming Impact, TEWI, is the sum of the direct emission (of chemicals) and indirect emission (energy related, primarily CO_2) of greenhouse gasses from operation of a product, such as a domestic refrigerator.
Thermoplastic	Becomes plastic on heating and hardens on cooling, and can repeat these processes.

Thermosetting	Sets permanently when heated.
1,1,1-trichloroethane	A hydrochlorocarbon solvent with an estimated ODP of 0.11 relative to CFC-11. Also known as methyl chloroform.
TMCP	Tris Mono Chloroisopropyl Phosphate
Troposphere	The portion of the atmosphere approximately 0-12 kilometers above the earth´s surface, in which convection plays a large role in the general circulation.
VOC	See *volatile organic compound*
Volatile organic compound	Chemicals that evaporate at their temperature of use and which, by a photochemical reaction under favorable climatic conditions, cause atmospheric oxygen to be converted into potentially smog-promoting tropospheric ozone.
VPF	Variable pressure foaming

Annex C - Contacts for Additional Information and Assistance

This annex contains contact addresses of organizations in different countries. It primarily contains national industry associations, but some international organizations are also included.

The addresses are organized sequentially by Implementing Agencies, Industry Associations, Standards Organizations, Technical Assistance and Research Organizations and Government Organizations. Within each section, companies are listed alphabetically.

The addresses might be helpful for you if you require additional information before you select or implement a non-ODS alternative.

You should also be aware of the assistance you can obtain from the environmental protection agency, the ministry of the environment, or similar authority in your country.

Secretariat and Implementing Agencies of the Multilateral Fund, and UNEP Ozone Secretariat

Multilateral Fund for the Implementation of the Montreal Protocol
Attn: Dr. Omar El-Arini
27th fl., Montreal Trust Building,
1800 MC Gill College,
Av. Montreal, Québec,
Canada H3A 3J6
Tel: (1) 514 - 282 1122
Fax: (1) 514 - 282 0068
Email: oelarini@unmfs.org

The Secretariat for the Vienna Convention and the Montreal Protocol
Attn: Mr .K.M Sarma, Executive Secretary
P.O. Box 30552
Nairobi
Kenya
Tel: (254-2) 62-1234/62-3851
Fax: (254-2)52-1930
Email: madhava.sarma@unep.org
Internet:
http://www.unep.org/unep/secretar.ozone/home.htm

United Nations Development Programme (UNDP)
Attn: Mr. Frank Pinto
1 United Nations Plaza
New York
NY 10017 USA
Tel: (1) 212 906 5042
Fax: (1) 212 906 6947
Email: frank.pinto@undp.org

United Nations Environment Programme Industry and Environment (UNEP IE)
Attn: Mr. Rajendra M. Shende
Tour Mirabeau
39-43, quai André Citroén
75739 Paris Cedex 15
France
Tel: (33) 1 44 37 14 50
Fax: (33) 1 44 37 14 74
Email: ozonaction@unep.fr

United Nations Industrial Development Organization (UNIDO)
Attn: Mrs. A. Tcheknavorian
PO Box 300
A-1400 Vienna
Austria
Tel: (43) 1 211 310
Fax: (43) 1 2307 449
Email: mwathie@unido.org

World Bank
Attn: Mr. Ken Newcombe
1818 H. Street NW,
Washington, DC 20433
USA
Tel: (1) 202 477 1234
Fax: (1) 202 676 0483
Email: knewcombe@worldbank.org

Industrial Associations

Abimao
Av. Jabaquara, 2925
04045-902 São Paulo-SP
Brazil
Tel: Not Available
Fax: Not Available

Abioum
R. Santo Antonio, 184-17&18 and
01314-000 São Paulo-SP
Brazil
Tel: Not Available
Fax: Not Available

Abiplast
Av. Paulista, 2439-8 and
01311-936 Sâo Paulo-SP
Brazil
Tel: Not Available
Fax: Not Available

Association Technique du Polyurethanne Projeté
A.T.P.P.
16, avenue Hoche
75008 Paris
France
Tel: (33) 1 - 45 63 73 07
Fax: Not Available

All India Plastic Manufacturers' Association
Jehangir Building, 3rd Floor
133 Mahatma Gandhi Road

Bombay - 400 003
India
Tel: Not Available
Fax: Not Available

Apindo
Asosiasi Industri Plastik Indonesia
Att.: Ir. A. Sarbini, Chairman
C/O PT Made Wikri Tunggal
Jl. Kesatrian I/25, Jakarta Timur 13150
Indonesia
Tel: Not Available
Fax: Not Available

Arbeitsgemeinschaft Verstärkte Kunststoffe e.V.
Am Hauptbahnhof 10
6000 Frankfurt 1
Germany
Tel: (49) 69 - 25 09 20
Fax: (49) 69 - 25 09 19

Association of Greek Producers of Plastics
66, Michalakopoulou Str.
115 28 Athens
Greece
Tel: (30) 1 - 77 94 818
Fax: Not Available

Asociación Nacional de Industrias del Plástico A.C.
Dr. Vértiz No. 546
Col. Vértiz Narvarte
03600 México D.F.
Mexico
Tel: Not Available
Fax: Not Available

Asociación Espanola de Industriales de Plásticos (Anaip)
C/ Raimundo Fdez. Villaverde no. 57
2003 - Madrid
Spain
Tel: Not Available
Fax: Not Available

Asociación de industriales de manteriales aislantes (Andima)
C/ Hermosilla no. 31
28001 - MADRID
Spain
Tel: (34) 1 - 575 0800/575 5426
Fax: (34) 1 - 575 0800

Associacão Portuguesa da Indústria de Plásticos
R.D. Estefânia, 32-2
1000 Lisboa
Portugal
Tel: Not Available
Fax: Not Available

British Plastics Federation (BFC)
Att: D.R. Jones, Dir.
6, Bath Place
London
EC2A 3JE
United Kingdom
Tel: (44) 171 - 457 5000
Fax: (44) 171 - 457 5045

British Rigid Urethane Foam Manufacturers' Association Ltd. (BRUFMA)
Att: Mr. G.W. Ball
3rd Floor, Central Buildings
11 Peter Street
Manchester M2 5QR
United Kingdom
Tel: (44) 161 - 835 1031
Fax: (44) 161 - 839 7495

British Urethane Foam Contractors Association Ltd. (BUFCA)
Att.: Ms. Eve Skidmore, sec.
26, Warwick Row
Coventry
West Midlands CV1 1EY
United Kingdom
Tel: Not Available
Fax: Not Available

British Rubber Manufacturers Association (BRMA)
90/91 Tottenham Court Road
London WIP 0BR
United Kingdom
Tel: (44) 71 580 2794
Fax: (44) 71 631 5471

Canadian Urethane Manufacturers Association
Att.: Manager R. D. Davis
32 Baleberry Cr.
Weston, Ontario M9P 3L2
Canada
Tel: Not Available
Fax: Not Available

Chambre Syndicale des Emballage en Matière Plastique
6, rue Jadin
75017 Paris
France

Tel: (33) 1 46 22 33 66
Fax: (33) 1 46 22 02 35

Canacintra
Consejo Industrias Quimica y Paraquimica
Paseo de la Reforma 403-1204
Co. Cuahtémoc
06500 México D.F.
Mexico
Tel: Not Available
Fax: Not Available

Chamber of Environmental Engineers
Selanik Cad. No: 19/1
Kizilay 06650 Ankara
Turkey
Tel & Fax: Not Available

Centro Español de Plasticos
Att.: Presidente sr. José Lloria
Enric Granados, 101
E-08008 Barcelona
Spain
Tel: Not Available
Fax: Not Available

European Phenolic Foam Association
Att.: Mr John Fairley, Secretary
Association House
235 Ash Road
Aldershot
Hants GU12 4DD
United Kingdom
Tel: (44) 1252 336318
Fax: (44) 1252 333901

Fédération de la Plasturgie
65 rue de Prony
75854 Paris
France
Tel: (33) 1 47 63 12 59
Fax: (33) 1 47 64 11 25

Fédération des Industries des Equipements pour Véhicules
F.I.E.V.
79, Rue J.-J. Rousseau
92158 Suresnes Cedex
France
Tel: (33) 1 46 25 02 30
Fax: (33) 1 46 97 00 80

Fabrimetal- Fédération des Entreprises de l´Industrie
des Fabrications Metalliques, Mecaniques, Electriques,
Electroniques et de la Transformation des Matières Plastiques A.S.B.L.
Rue de Drapiers 21
B-1050 Bruxelles
Belgium
Tel: (32) 2 - 510 23 11
Fax: (32) 2 - 510 23 01

Fédération des Industries Chimiques de BelgiqueSquare Marie-Loise 49
B-1040 Bruxelles
Belgium
Tel: (32) 2 - 238 97 11
Fax: (32) 2 - 231 13 01

Fachverband, Bau, Möbel- und Industrie Halbzeuge aus Kunststoff
Am Hauptbahnhof 12
6000 Frankfurt 1
Germany
Tel: (49) 69 - 25 33 51
Fax: (49) 69 - 23 98 37
Tlx: 411 122

Fachverband Kunststoff Konsumwaren
Am Hauptbahnhof 12
6000 Frankfurt 1
Germany
Tel: (49) 69 - 2 71 05 31
Fax: (49) 69 - 23 98 38
Tlx: 411 122

Fachverband Schaumkunststoffe e.V.
Am Hauptbahnhof 12
6000 Frankfurt
Germany
Tel: (49) 69 - 2 71 05 37
Fax: (49) 69 - 23 27 99
Tlx: 411 122

Gesamtverband Kunststoffverarbeitenede Industrie e.V.
Am Hauptbahnhof 12
6000 Frankfurt 1
Germany
Tel: (49) 69 - 2 71 05 0
Fax: (49) 69 - 23 27 99
Tlx: 411 122

Groupement des Industries Francaises des Appareils d'Equipements Ménagers
G.I.F.A.M.
39, avenue d'Iéna
75783 Paris Cedex 16
France
Tel: (33) 1 53 23 06 53
Fax: (33) 1 47 20 20 73

Hong Kong Plastic Material Suppliers Association Ltd. I/F
11 Lai Yip. St.
Kwun Tong, Kln.
Hong Kong
Tel & Fax : Not Available

Hong Kong Plastic Industry Council
Federation of Hong Kong Industries
4/F Hankow Centre
5-15 Hankow Road
TST, Kowloon
Hong Kong
Tel: Not Available
Fax: Not Available

Hong Kong Plastics Manufacturers Assoc. Ltd.
Rm. 302, Red A Central Bldg.
37 Wellington St.
Hong Kong
Tel: Not Available
Fax: Not Available

Industrieverband Verpackung und Follen Aus Kunststoff e.V.
Fellnerstrasse 5
6000 Frankfurt 1
Germany
Tel: (49) 69 - 55 08 19
Fax: (49) 69 - 59 57 12

Industrial Association for Environmental Quality
Ormat Turbines Ltd.
P.O.B. 68
Yavne 70650
Israel
Tel: (972) 3 - 375063
Fax: (972) 3 - 377695

Industrieverband Hartschaum e.V.
Kurpfalzring 100 a
Postfach 10 30 06
6900 Heidelberg
Germany
Tel: Not Available
Fax: Not Available

Industrieverband Polyurethan-Hartschaum e.V.
Kriegerstrasse 17
7000 Stuttgart 1
Germany
Tel: (49) 711 - 29 17 16
Fax: (49) 711 - 29 49 02

Industrial Estate Authority of Thailand
618 Nikhom Makkasan Rd. Ratchathewi
Bangkok 10400
Thailand
Tel: (66) 2 - 530561
Fax: (66) 2 - 532965 / 534086

Korea Plastic Industry Cooperative
Att.: President Kook-No Lee
146-2, Ssangnim-dong
Chung-ku
Seoul 100-400
Republic of Korea
Tel: Not Available
Fax: Not Available

Kunststoff-Verband der Schweiz (KVS)
Schachenallee 29
5000 Aarau
Switzerland
Tel: (41) 64 - 23 08 63
Fax: (41) 64 - 23 07 62

Multicentro Macaracuay
Ave. San Francisco
Piso 7, Oficina 7 & 9
Caracas 1070
Venezuela
Tel: (58) 2 - 256 2867
Fax: (58) 2 - 256 4192

Malaysian Plastics Manufacturers´ Association
37 (Ground Floor), Jalan 20/14
Paramount Garden
46300 Petaling Jaya
Malaysia
Tel: (60) 3 - 776 3027
Fax: (60) 3 - 776 8352

National Consortium Replastic
via Tomacelli 132
00186 Roma
Italy
Tel: Not Available
Fax: Not Available

National Plastic Industry Association (APIP)
Rua De Estefania, 32, 2.
1000 Lisboa
Portugal
Tel: Not Available
Fax: Not Available

NFK, Dutch Plastic Federation
P.O.Box 420
2260 AK Leidschendam
The Netherlands
Tel: (31) 70 - 3175490
Fax: (31) 70 - 3177408

Oficape
Oficina de Calidad de Poliuretanos Espanoles
C/ Agastia no. 73
28027 - MADRID
SPAIN
Tel: (34) 1 - 4169081
Fax: (34) 1 - 4133480

Office of Plastics & Leather´Industry,
Association of Light Industry
China Plastics Processing Industry Association
Att: Mme. Cheng Hao-ming, senior engineer
22B Fuwai Dajie
Beiing, 100035
China
Tel: (86) 1 - 5122056
Fax: (86) 1 - 8322976

Plastic Pipe and Fittings Association
Att.: Exec.Dir. Richard W. Church
Bldg. C, Ste. 20
800 Roosevelt, Rd.
Glen Ellyn, IL 60137
USA
Tel: (1) 708 - 858 6540
Fax: Not Available

Polyisocyanurate Insulation Manufacturers Association
Att.: President Jared O. Blum
1001 Pennsylvania Avenue, N.W.;
Washington D.C. 20004
Tel: (1) 202 - 624 2709
Fax: (1) 202 - 628 3856
Email: joblum@pima.org

Polyurethane Division, Society of the Plastic Industry
Att.: Exec.Dir. Fran W. Lichtenberg
355 Lexington Ave.
New York, NY 10017
United States
Tel: (1) 212 - 351 5425
Fax: (1) 212 - 697 0409

Polyurethane Foam Association
Att.: Exec.Dir. Louis H. Peters
PO Box 1459
Wayne, NJ 07470
United States
Tel: (1) 201 - 633 9044
Fax: (1) 201 - 628 8986

Polyurethane Manufacturers Association
Att.: Exec.Dir. Richard W. Church
Bldg. C. Ste. 20
800 Roosevelt Rd.
Glen Ellyn, IL 60137
Tel: (1) 708 - 858 2670
Fax: Not Available

Polystyrene Moulders Association
Att: Derek Maynard, Secretary
Confederation of Irish Industry
Confederation House
Kildare St.
Dublin 2
Eire
Tel: (353) 1 - 6779801
Fax: (353) 1 - 6777823

Plastic Industry Association
2nd Floor, 41-43 Exhibition St.
Melbourne Vic 3000
Australia
Tel: Not Available
Fax: Not Available

Polyethylene Foam Insulation Association
Att: Mr.J.G. Fairley, sec.
Association House
235 Ash Road
Aldershot
Hampshire GU12 4DD
United Kingdom
Tel: (44) 1252 336318
Fax: (44) 1252 333901

Plastics Institute of New Zealand
4th Floor Enterprise House
3-9 Church Street
Wellington
New Zealand

Tel: Not Available
Fax: Not Available

Siresp
Av. Paulista, 1313-8 and
01311-923 Sâo Paulo-SP
Brazil
Tel: Not Available
Fax: Not Available

Society of the Plastics Industry of Canada
Att.: President E.R. Evason Canada
1262 Don Mills Road, Suite 104
Don Mills, Ontario M3B 2W7
Canada
Tel & Fax: Not Available
Syndicat National de l'Isolation
S.N.I.
10, rue du Débarcadère
75852 Paris Cedex 17
France
Tel: (33) 1 40 55 13 70
Fax: (33) 1 40 55 13 69

Syndicat National des Extrudeurs de Profilés Plastiques
65, Rue de Prony
75854 Paris Cedex 17
France
Tel: Not Available
Fax: (33) 1 47 54 01 92

Syndicat National des Plastiques Alvéolaires
15, Avenue du Recteur Poincaré
75016 Paris
France
Tel: (33) 1 45 20 42 68
Fax: (33) 1 42 24 59 02

Syndicat National du Moulage et de la Transformation de Feuilles et Films Plastiques
65, Rue de Prony
75854 Paris Cedex 17
France
Tel: Not Available
Fax: (33) 1 47 54 01 92

Schweizer Polyurethan Verband (SPUV)
Schachenallee 29
5000 Aarau
Switzerland
Tel: (42) 64 - 23 09 71
Fax: (42) 64 - 23 07 62

Singapore Plastic Industry Association
#03-02 Chinese Chamber of Commerce & Industry Building
47 Hill Street
Singapore 0617
Singapore
Tel: (65) 3377686/33811739
Fax: (65) 3376971

Society of Israel Plastics Industries
The Manufacturers Association of Israel
29, Hamered St.
P.O.B. 50022
Tel Aviv 61500
Israel
Tel: (972) 3 - 5128846
Fax: (972) 3 - 662026

Society of the Plastics Industry
Att.: Larry L. Thomas
1275 K. St. NW. Ste. 400
Washington, DC 20005
Tel: (1) 202 - 371 5200
Fax: (1) 202 - 371 1022

The Society of the Plastic Industry, Inc.
Polyurethane Division
355 Lexington Avenue
New York 10017
United States
Tel: (1) 212 351 5424
Fax: (1) 212 351 5424

The Associaciation of the Hungarian Plastic Industry
Erzsébet Kit. útja 1/C
1146 Budapest
Hungary
Tel: (36) 1 - 1428 920
Fax: (36) 1 - 1420 980

The Chiu Chau Plastic Manufacturers Association co. Ltd.
Rm. 603 Fu Hing Bldg
9-11 Jubilee St.
Hong Kong
Tel: Not Available
Fax: Not Available

The Japan Plastic Industry Fereration
Tokyo Club Bldg.
2-6, Kasumigaseki 3-chome
Chiyoda-ku
Tokyo 100
Japan
Tel: Not Available
Fax: Not Available

The Industry Council for Packaging & The Environment
Tremier House
10, Greycoat Place
London
SW1P 1SB
United Kingdom
Tel: Not Available
Fax: Not Available

The Industry Council for the Packaging and the Environment
Att: Mr. Peter Davis
Tenterden House,
3 Tenderten Street
London W1R 9AH
United Kingdom
Tel: (44) 71 - 409 0949
Fax: (44) 71 - 409 0161

Tube and Pipe Fabricators Association, International
Att.: Exec. Dir. John Nandzik
5411 E. State St.
Rockford, IL 61108
United States
Tel: (1) 815 - 399 8700
Fax: (1) 815 - 399 7279

Ucaplast (Union des Industries et de la Distribution des Plastiques et du Caoutchouc)
1, Square la Bruyére
750009 Paris
France
Tel: (33) 1 42 80 10 22
Fax: (33) 1 42 80 55 45

Union of Producers of Plastics
Att.: Ing. Vladimir Michálek
Mikulandská 7
113 61 Praha 1
Czech Republic
Tel: Not Available
Fax: Not Available

Verband Kunststofferzeugende Industrie e.V.
Karlstrasse 21
6000 Frankfurt 1
Germany
Tel: (49) 69 - 25 56 3 10/13 03
Fax: Not Available
Tlx: 411 372

Verband der Polyurethan-Weichschaum Industrie e.V.
Postfach 90 10 60
Zeppelinallee 69
60487 Frankfurt
Germany
Tel: Not Available
Fax: Not Available

Standards Organizations

American Society for Testing and Materials (ASTM)
100 Barr Harbour Drive
West Conshohocken, Pennsylvania 19428-2959
Tel: (1) 610-832-9585
Fax: (1) 610-832-9555
Email: service@local.astm.org
Internet: http://www.astm.org

British Standard Institute
389 Chiswick High Road
London
W4 4AL
United Kingdom
Tel: (44) 71-629-9000
Fax: (44) 71-629-0506
Telex: 266933

Bureau of Indian Standards (BIS)
9 Bahadur Shah Zafar Marg
New Delhi 110 002
India
Tel: (91) 11-3317991
Fax: (91) 11-3314062

National Fire Protection Association (NFPA)
1 Batterymarch Park
PO Box 9101
Quincy, MA 02269-9101
Tel: (1) 617-770-3000
Tel: (1) 617-984-7700 (en espanol)
Fax: (1) 617-984-7777 (en espanol)
Email: Custserv@NFPA.org
Internet: http://www.wpi.edu/Academics/Depts.Fire.Nfpa.nfpa-home.html

International Standards Organization (ISO)
1, rue de Varembe
Case postale 56
CH-1211 Geneve 20
Switzerland

Tel: (44) 22-749-0111
Fax: (44) 22-733-3430
Telex: 41 22 05 iso ch
Telegram: isorganiz
Email: cetral@isocs.iso.ch
Internet: http//www.iso.ch/welcome.html

The American National Standards Institute (ANSI)
11 West 42 Nd Street
New York 136
United States
Tel: (1) 212-642-4900
(1) 212-398-0023
Email: mgonzale@ansi.org
Internet: http://www.ansi.org

Technical Assistance and Research Organizations

AFEAS Program Office,
The West Tower- Suite 400,
1333 H Street NW,
Washington, DC 20005 USA
Tel: (1) 202 - 898 0906
Fax: (1) 202 - 789 1206

Center for Emissions Control (CEC)
2001 L Street, NW
Suite 506A
Washington, DC 20036
United States
Tel: (1) 202-785-4374
Fax: (1) 202-833-0381
Email: cec@sysnet.net
Internet:
http://www.sysnet.net/paintstrip/thecent.html

The Programme for Alternative Fluorocarbon Toxicity Testing, (PAFT)
P.O. Box 13,
Runcorn.
Cheshire WA7 4 QF.
United Kingdom
Tel: (44) 928 - 511 418
Fax: (44) 928 - 511 418

Government Organizations

Occupational Safety and Health Administration (OSHA)
200 Constitution Ave., N.W
Washington, D.C. 20210
United States
Tel: (1) 202 219 8148
Fax: (1) 202 219 5986
Email: webmaster@osha-slc.gov
Internet: http://gabby.osha-slc.gov

To obtain lists of National Ozone Units in developing countries, or stratospheric ozone protection focal points in developed countries, please contact UNEP IE OzonAction Programme.

Annex D - References and Further Reading

References

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Klempner, D. and Frisch, K.C. (1991): Handbook of Polymeric Foams and Foam Technology. *Hanser Publishers, Munich. ISBN 3-446-15097-8.*

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Annex E - Information Submission Form

The catalogues are "living" documents that will be updated on a regular basis to reflect technological advancement, new products, and changing control measures. Information is welcome both on alternatives to uses covered in the catalogue as well as on alternatives not discussed. UNEP request that companies or individuals with such information complete the form on the next page and forward it to:

Mr Rajendra Shende, Co-ordinator, UNEP IE OzoneAction Programme
Tour Mirabeau
39-43, Quai André Citroën
75739 Paris Cedex 15
France
Tel: (33) 1 44 37 14 50
Fax: (33) 1 44 37 14 74

FOAM SOURCEBOOK INFORMATION SUBMISSION FORM

1. Company: Name Add. Coun. Tel Fax: Telex: Contact:	**Category** **2. Products**
3. Original process	
4. Reduction/elimination method	
5. Implications of the new technology **End product quality** **Operational implications**	
6. Scale of operation	
7. Technical constraints	
8. Restrictions of technology	
9. Stage of technology	
10. Level of commercialization	
11. Investment costs	
12. Operational and maintenance costs	
13. Safety issues	
14. Development of technology	
15. Other	
16. Additional information	