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Blowing Agents and Foaming Processes 2002

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Emulsions, Foams and Thin Films
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Foam and Foam Films
Elsevier, 1998

Foams and Emulsions
Kluwer Academic Publishers, 1999

Foams: Theory, Measurements and Applications
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Handbook of Plastic Foams
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The Polymer Lexicon
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PCRS Plastics Industry Report, 2000

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Blowing Agents and Foaming Processes 2002

The fourth one-day conference dedicated to the critical role of blowing agents in foamed plastics and rubber

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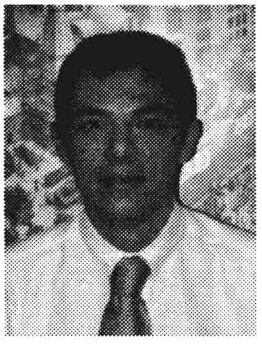
HYDROCARBON-BLOWN FORMULATIONS FOR APPLIANCES AND RIGID PANELS: AVAILABLE SOLUTIONS FOR SPECIFIC LOCAL REGULATIONS

Christian Cairati and Davide Lucca - Cannon Afros
Max Taverna - Cannon Group

BIOGRAPHIES



Christian Cairati – born in Milan, Italy, in 1970 – has a technical education in Information Technology, a specialisation in Plastics Processing Technologies and a master in ISO 9000 Standards and Quality System Management. He worked for more than ten years in processing companies as production manager and for three years as technical, quality and marketing consultant in the plastics sector in Italy and abroad. He joined Cannon Afros in 2001, as responsible of the Company Communication.

Davide Lucca - born in Como, Italy, in 1968 - graduated in Mechanical Engineering in 1994 at Politecnico of Milan. He joined Cannon Afros sales department in 1994. Today he is in charge as Area Manager of the Asian market.

Max Taverna - born in Buenos Aires, Argentina, in 1949 - has an education background in Industrial Chemistry. He worked five years for Upjohn's Polyurethanes Division in Italy, and joined Cannon Afros as European Sales Manager in 1982. Since 1986 he has co-ordinated all the Group's communications activities, and serves today as Cannon Communication's Director.

ABSTRACT

The increasing use of LBBA hydrocarbons as expanding agents for rigid foams requires a specific engineering of the equipment required for the storage, the distribution and the processing of the Polyurethane formulations containing these potentially hazardous materials. When approaching the markets, the experience grown in dealing with these chemicals must be completed with the respect of local regulations and manufacturing habitudes. This new paper describes practical experiences and suggestions to handle this delicate matter.

INTRODUCTION

Every country in the world is geared up to comply with the objectives of the Montreal Protocol, and its amendments, which provide for the gradual and progressive replacement of Ozone depleting Chlorofluorocarbons (CFC's). The deadlines for the phasing out of these harmful chemicals were set according to the economic and regional specific situation of each area. While many countries have just started the conversion from CFC's to mainly HCFC's, others are ready to take the next technological step.
The progressive substitution of CFC's with other blowing agents - less harmful for the Ozone's layer - has posed a new technological challenge to every PU processor. When the rules of an existing game change, it becomes fundamental investing in strategic researches for the development of alternative solutions. At the heart of this gamble is the ability to implement innovative processes with environmentally and sustainable chemicals and obtain results equal, if not better, to those obtained using conventional blowing agents.
The replacement of CFC's with hydrocarbons as expanding agent in rigid polyurethane foams for insulation applications – mostly for household and industrial refrigerators and freezers - is one of the most reliable alternatives available today.
The process has been used in many countries since April '93, this process has passed a lot of market tests easier: industrial feasibility production, safety, foam dimensional stability and insulation capacity. Its benefits have been widely demonstrated by million of refrigerators manufactured and sold worldwide.
Complying with the increasingly greater amount of energy-saving laws that are passed and the need to reduce the environmental impact, hydrocarbons-blown foams represent today the right and balanced solution in the next decade, also for this application (figure 1).

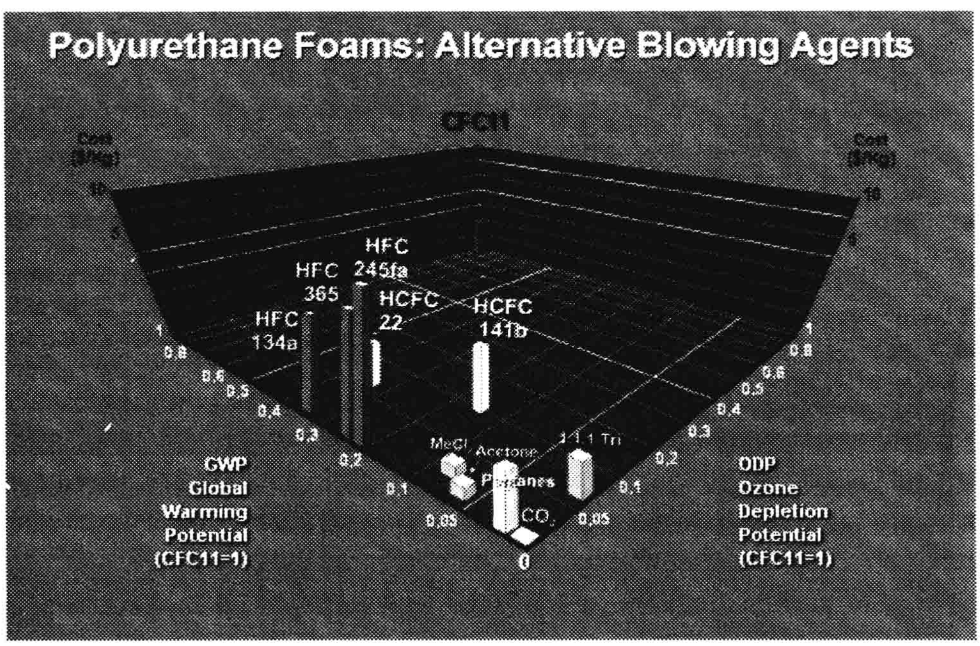


Figure 1 – Costs and environmental impacts comparison between CFC11 and the main alternative blowing agents industrially available on the market.

In the refrigerator industry, where polyurethane play both an insulating and the structural role, the replacement of CFC-11 with HCFC-141b, HFC-134a and pentanes initially caused slightly lowered insulation efficiency and dimensional stability problems which forced to increase foam densities from a typical 32-33 kg/m^3 to 36-38 kg/m^3. This over-packing resulted in higher foam costs, which added to the already increased cost of formulations, which were blown with components more expensive than CFC-11.
Today the situation has improved significantly: insulations factors and moulded densities are now very similar and close to those of the "old times" ones.
By far the most notable change in the refrigerator industry is its winning battle towards increasing efficiency. A recent report of a U.S. trade magazine focused on the appliances market showed that this trend will continue to grow in the coming years as a result of the recently passed U.S. legislation that will according to the Department of Energy (DOE) says, " result in reduced energy consumption, reduced consumer costs and reduced emission of air pollutants associated with electricity production".
According to the DOE, over the next 30 years the revised standards will help to save approximately 6.67 quads of primary energy and result in a 465 million-ton reduction in CO_2 and a 1,362 thousand-ton reduction

of No_x. The new standard, in force since July 2001, requires that refrigerators consume about 479 kW h/year, which means approximately 30% more efficiency than that offered by previous models and about 70% more than those used in 1976.

MARKET FOCUS

Europe - Local regulations restrict the use of HCFC's, which is why they will be shortly banned altogether. Today all European refrigerator manufacturers have converted their plants and are using Cyclopentane and hydrocarbon blends.
The conversion of existing plants and the installation of new ones started in 1993 and has concerned initially all major companies in Western Europe and immediately after those operating in the nowadays CSI countries, Poland, Hungary, in Slovakia and the Czech republic.
One of the key market player has already gone beyond, designing an innovative solution. In this new technological step ahead, a blowing agent blend is used where a portion of liquid Pentane (about 10%) is replaced with Isobutane, which makes it possible to increase insulating and structural properties, reducing the foam density. In other words, it ensures equal insulating capacity (with lower lambda), significant savings in raw materials and improvement in the quality of end products.

North-America – The Association of Home Appliance Manufacturers (AHAM) has announced that the U.S. refrigerator production has increased around 3% percent a year between 1998 and 2000. Here, the production of HCFC-141b will be definitely banned as of 1st January 2003, while others HCFC's with lower ozone depleting potential (ODP) are likely to be permitted until 2010. This is obviously the deadline for those companies that are already using formulations containing these blowing agents, while those about to start a new foaming business are required to adopt alternative solutions.
This is why in the last couple of years the hydrocarbons market has started to grow rapidly in North America as well. The demand to convert fast the HCFC-141b based plants increases day by day. Refrigerator manufacturers as well as many boiler makers have installed new Pentane lines or have decided to refurbish their old ones.
The excellent results achieved in Europe, in terms of performance and safety, have persuaded some local manufacturers to go along the same track. And that is why the future trend, at least for some specific applications, seems closely related to what happens on the European market.

South America - Due in part to the World Bank's effort to assist the developing countries in their programme to phase out CFC's and in part to the gradual unavailability of CFC-11 blown formulations, all major Latin American manufactures, including Argentine and Brazilian ones, have already turned to Cyclopentane.

Africa – In the past five years, with the help of multilateral funds aimed at providing economic and technical support, a lot of machines that use Cyclopentane have been installed in several African countries: Morocco, Algeria, Tunisia and Cameroon. Most of them were purchased by the local manufacturing centres of multinational companies which directly define the technical requirements of each plant.
This is what happened with a complex plant that Cannon has recently delivered to Daewoo in Egypt for the production of domestic refrigerators.

Oceania - In **Australia** and **New Zealand** the market is divided among three major suppliers which have already converted all their long-running production lines to Cyclopentane.

Asia –There are three major market centres in this area: China, Japan and Korea. Through their local subsidiaries, they influence the way of working in the rest of the Asian countries, transplanting here their technologies. What makes that possible is the lack of national manufacturers in the other countries leaving the door open to scores of Chinese, Japanese and Korean companies.
In **Korea**, manufacturers such as Samsung and LG have already converted all their plants to Cyclopentane and extended this standard to all their production centres in the world. Another big player such as Daewoo, has announced its intention to complete a full conversion to pentane of all its Korean plants by the end of 2002. The company has begun using pentane technology also in its production sites abroad and started up a refrigerator foaming line in Egypt supplied by the Cannon Group.
In **Japan**, as of 1st January 2002 all products manufactured and sold on the domestic market are required by law to be made with alternative blowing agents. Manufacturers may continue to produce parts with HCFC-141b as long as they are exported. The same restriction has been applied to Japanese production sites abroad. The sites that make products for Japanese domestic market will be converted to Cyclopentane straightaway.
In **China**, with the help of the World Bank, the major refrigerator manufacturers, Haier and Kelon, have retrofitted all of their existing units to use Cyclopentane since 1994.

Like Electrolux in Europe, Zonghy has started foaming with a blowing agent blend composed by Cyclopentane and Isobutane.
According to the latest published statistics, between 1998 and 2000, China registered a 15,4% increase in refrigerator production, followed by Turkey up to 10%.
The Chinese insulation panel market is huge and divided in small and medium sized manufacturers. The law grants an extension of the deadline for the units' conversion. Today, it is still unclear how long this transitional period will be. What is certain is that, in the next few years, the panel maker's scenario will be characterized by important mergers and buy-outs to create larger companies with higher production efficiency and investment capabilities. Many firms have already established current negotiations to retrofit their existing units.

TECHNICAL BACKGROUND

As we have seen in this market survey, the situation varies considerably from one region to another. Yet the trend in act is clearer now then it was five years ago.
The CFC's substitution program has been rapidly implemented everywhere and in the last decade Cyclopentane has confirmed its role as one of the most successful and reliable alternative technologies available.
Through experiences gained worldwide, it has been shown how innovative applications can be designed and realised. Submitted to a complete and accurate risks analysis, hydrocarbons-blown systems can be considered safe and pose no danger to the operators involved in the process or to the surrounding environment.
As a matter of fact, the successful installation of over 200 plants by the Cannon Group alone has confirmed that our solutions were at the same time technically correct and economically affordable by the market.
The safety measures adopted since the early stages of this technology were appropriate and correct. The use of specific storage tanks, pre-blending stations, metering machines, foaming fixtures and related ventilation equipment, gas monitoring networks and electric safety features have prevented explosions and accidents. A proper use of ventilation, which is advisable for all polyurethane plants, reduces the risk of accumulation of hydrocarbon gas in those areas (e.g. pre-mixing and polymerisation) where small quantities of gas are regularly emitted.
Tests conducted to measure the evaporation level of blends made from variable percentages of Cyclopentane (e.g. 15%) and conventional polyols, show that the evaporation rate is 80 g/m^2 per hour as against 4.610 g/m^2 an hour when the chemical is used pure. This means that the evaporation rate of pure Cyclopentane is 50 times higher than that of a typical blend. Also important is that its potential capacity to saturate the surrounding atmosphere does not depend on the chemical's volume but on the surface of the wet area: the smaller size of the surface, the lower evaporation rate.
There are important requirements to be satisfied to ensure proper safe working conditions. All equipment and devices involved in the processing of pure Cyclopentane must be placed outside the factory in dedicated external room (pre-mix unit) and special storage areas (above or below ground). Inside the production plant, safety boxes and drain trays must be placed around and under the equipment, where there might be leakages. This is of particular importance because by reducing the presence of possible wet surfaces, the evaporation value decreases along with the number of classified areas and their hazards.
Proper ventilation is another key factor for the areas classification, for allowing access to them and for designing equipment. With a view to providing good air re-circulation, Cannon has developed a consistent, active ventilation system based on two back-up connected fans. This solution guarantees excellent flexibility and safety:

- in normal working conditions, only one fan is turned on guaranteeing that all ventilation safety standard are satisfied;
- in case of planned or unplanned maintenance to one fan, the other can be used without stopping the ventilation inside the box
- In case of emergency, the additional fan can be used to double the ventilation capacity.

The electrical components fitted on the equipment are selected according to the classification of each area and must be feature by special electric barriers to prevent electric arcs and from causing an explosion.
Two other key factors should be considered when implementing safety features: the density of Cyclopentane vapours and their explosive limit. The vapours are heavier than air and if released, they would remain at ground floor. Moreover, if the concentration of Cyclopentane in the air is kept below 1,4%, the chemical is not explosive at all. By the same way, it would possible to guarantee safe working conditions by keeping the concentration of vapours above 8,7% (figure 2).

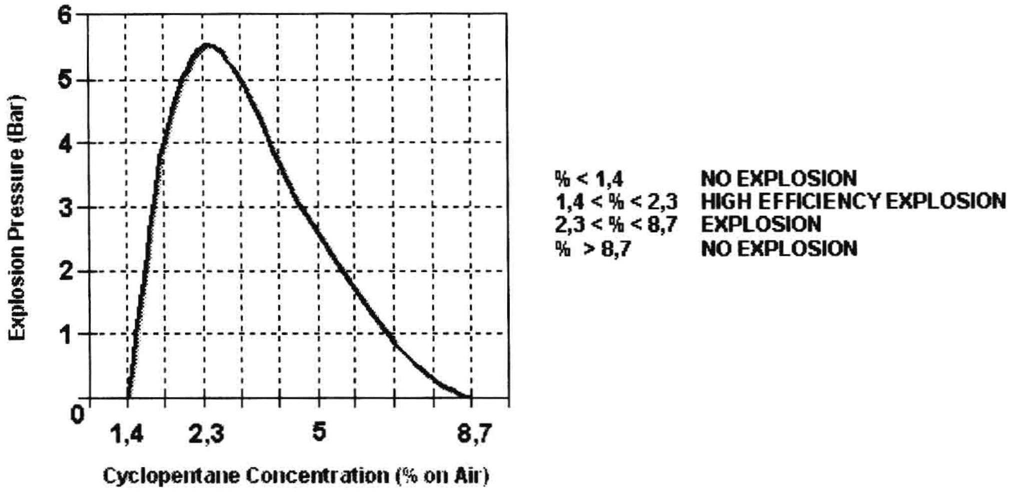


Figure 2 – The diagram shows how Cyclopentane concentrations could influence the safety of the working conditions.

Therefore, a gas sensor system must be put in place to monitor the atmosphere and measure the concentration of Cyclopentane vapours in the classified areas. Certainly, the ideal position for the sensors would be at ground level but it would be advisable to install sensors at the top of the ventilated boxes as well, because Cyclopentane vapours may go up as a result of high temperature.
The repeatability of the process is proven. Special equipment has been designed to mix hydrocarbons with polyols in desired, programmable percentages.
Foam performance is improving: compared to early formulations significant steps forward have been made. Foam flowability has reached satisfactory levels owing, among other things, to the optimisation of liquid lay-down and filling patterns. The insulation factor, as measured in real-life conditions by calculating the level of energy consumption of various models, equals that of freon-less formulations.
Dimensional stability is within acceptable limits, partially helped by a slight increase in moulded density and over-packing to optimise foam's isotropy. Industrial refrigerators have gone from a traditional 32-33 kg/m^3 density in CFC-11 blown foams to 36-37 kg/m^3 in Cyclopentane-blown ones. This increase has had no influence on the design of polymerisation jigs, which are made to withstand even higher pressures. The next chapter provides an overview of the recent developments.
De-moulding time depends on the foam's dimensional stability, its moulded density and over-packing ratio, and is also affected by the market demand for thicker walls. All the rates of the a.m. parameters worsened in the early days and Cyclopentane-blown foams needed longer de-moulding times. It has been recently reported that formulation adjustments have brought back times to 3.5 minutes for 50-60 mm thick freezers and to 7 minutes for 100 mm thick ones. Shorter de-moulding times seem to be more realistic now.

NEW TECHNOLOGICAL REQUIREMENTS

Today foaming processes that use hydrocarbons as blowing agents represent the most reliable and economical alternative to CFC's. This is the reason why we are here to talk about hydrocarbon technology.
Furthermore, some manufacturers have already taken it a step ahead by adding around 10% of N-Pentanes, and more recently Isobutane, to the mixture of the whole blowing agents loaded. This blend has the same thermal conductivity as a full Cyclopentane mixture but its products are characterized by better insulation performances and improved structural properties. In the meantime, foam densities are reduced by 10% as well, closing to a typical value of freon-blown formulations.
This technology offers significant benefits to the manufacturers and a wide range of applications especially in the refrigerators and insulated panel industry. It has great potential for its expansion.
A recent market study conducted in co-operation with some manufacturers has shown that by using hydrocarbon-blown formulations rather than HCFC-141b for, say, an annual foaming production of 1.000 tons of PU foam, one can achieve savings in raw materials of 120 to 150.000 U.S. dollars.
This means that the investment needed to purchase a new hydrocarbon-using plant, (or to convert an existing one), can be entirely paid back in 2 to 3 years with the additional benefit that production facilities are enriched with an innovative and sustainable technology.
The introduction of hydrocarbons in polyurethane foams modified some habits in the manufacture of refrigerators and panel. Equipment for storing and pre-mixing chemicals had to be added while metering equipment and foaming fixtures had to be adapted or replaced. And not all manufacturers have the same problems: different products, different manufacturing habits and local regulations deeply influence the choice of production equipment.

PENTANE PLANT VIEW

Each case requires a specific approach and has a technical solution. All Cannon equipment and machines working with hydrocarbon-blown formulations are designed to European safety standards:

- CEI-EN 60079-10, specifies the criteria for a proper classification of hazardous areas;
- CEI-IEC 79-14, according to the previous one, specifies how to select the appropriate electric devices for each areas.

Up to now Cannon have supplied more than 100 customers from the four corners of the world and, with more than 200 high pressure dosing units installed, can be rightly considered the largest supplier of hydrocarbon foaming equipment.

Cannon has satisfied a wide range of customer requirements: from a simple polyol/Cyclopentane blending unit to a complete plant. Let us now review the solutions that are available to solve the different problems seen before. The following examples are all taken from real supplied plants.

1) Pentane Storage

In case of pilot plants or small production lines, storage containers can be installed immediately outside the production building in a naturally ventilated area protected from sunlight by a cabinet. This aboveground application is easy to inspect and maintain (figure 3).

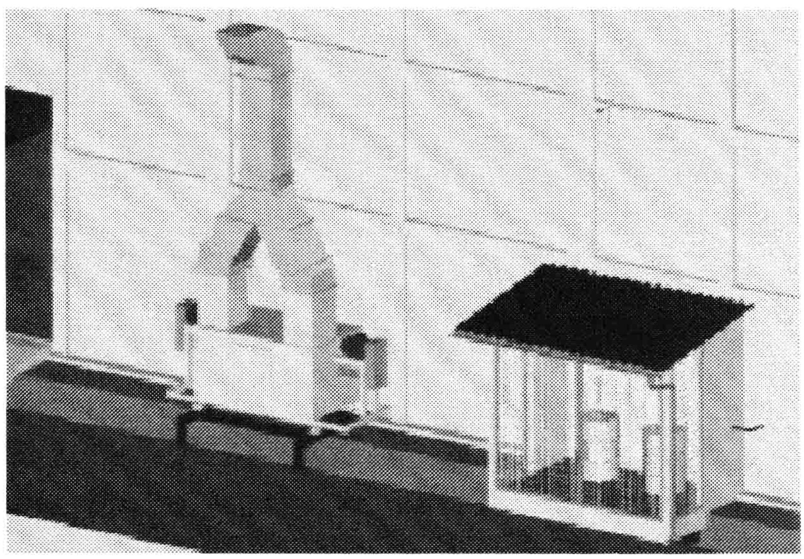


Figure 3 – Outside foaming plant view. Aboveground Cyclopentane storage application with external drums. On the left, a detail of the ventilation system.

The underground storage solution is normally preferred by customers, and more in general advised by Cannon, who have considerable production volumes and need to process large amounts of chemicals everyday. There are region where the raw material supplies are subject to all sorts of problems: external unsafe conditions, shortage of chemicals, transportation delays, bad weather with temperature well below 0°C, etc.. under these circumstances, an underground tank with a capacity of 20 to 30 m^3 is probably the safest and most appropriate solution.

The underground alternative enables the tanks to be fill by way of gravity loading from road-tankers, with or without a special pumping system. In this case, it is not mandatory to use Nitrogen blanketing: just one flush before starting to work the first time is enough.

More attention must be paid to the transfer of hydrocarbons from the underground tank to the pre-mix device in the foaming plant. Here, maintenance and inspection are slightly more complex.

So far Cannon has supplied - according to the request of each customer - either the engineering design of a proper storage station or some specific equipment excluding the tank, or a full installation. Today the underground solution seems to be favoured by the market: almost ¾ of Cannon's customers have requested the installation of this kind of tanks (figure 4).

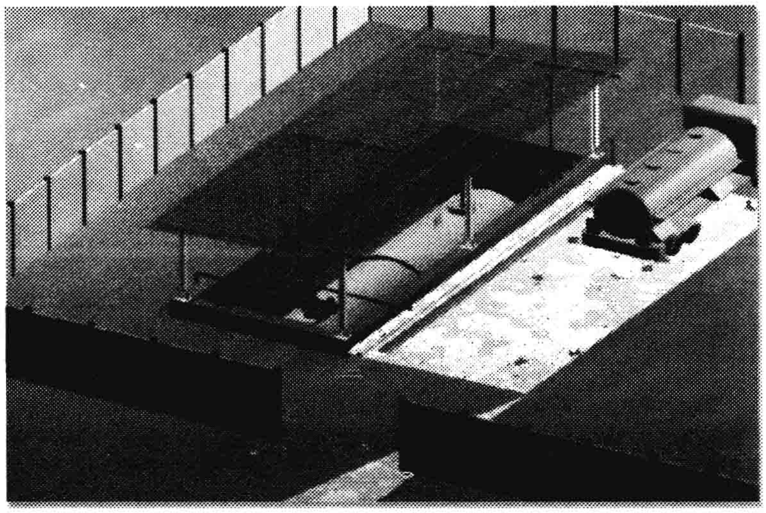


Figure 4 – Sample of Cyclopentane underground storage tank with a capacity of 30 m^3

2) Pre-mix

Penta EasyFroth™ is a closed-loop high pressure pre-blending unit, specially designed for hydrocarbons and other liquid blowing agents (figure 5). The closed-loop control system is extremely important to keep a constant ratio of polyol and Cyclopentane, guaranteeing better foam quality. How does the control system work? The required ratio for the specific formulation is set and stored in the PLC. During the foaming process, the system constantly keeps reading the outputs of both Cyclopentane (A) and polyol (B) through special flow transducers. The system calculates the actual ratio of A and B and, in case of deviation from the set value, it automatically adjusts the frequency of the inverter of the polyol pump motor to bring back the actual ratio to the nominal one.

Penta EasyFroth is composed of three main frames: a polyol pumping group, a double acting cylinder dosing group for hydrocarbons with a static mixer placed in a ventilated box and a control cabinet positioned far away from the safety area.

Figure 5 – EasyFroth unit can easily be interfaced with existing metering machines

The equipment is also available in such a form that can be installed in two separate rooms. The metering unit is connected to the part of the pre-mix device that comes in contact with hydrocarbons and it is also placed in a ventilated box.

Penta EasyFroth offers a number of significant advantages: it is a flexible system capable of mixing and metering a wide range of blowing agents, such as LBBA, liquid carbon dioxide, Cyclopentane and blends (Cyclopentane plus Isobutane). Its excellent mixing efficiency is confirmed by the high percentage of expanding agent dissolving rapidly into the polyols.
The closed-loop control ensures a constant mixing ratio in each foaming sequence. The very small overall size of the machinery makes the installation easy everywhere (figure 6).
In case of large production lines it is better to use a centralised pre-mix unit that serves several foaming stations. In this respect, to save costs, it would be advisable to have a dedicated, properly controlled and ventilated area where all pre-mix equipment are installed.

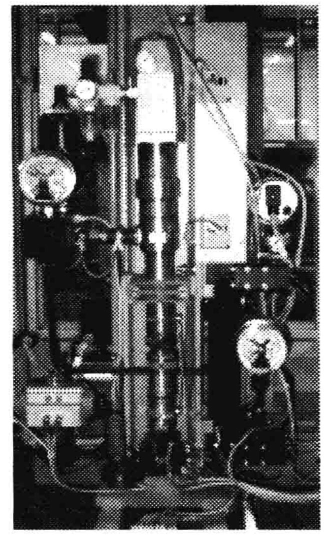


Figure 6
The electrical components and instruments installed inside the ventilated box are explosion proof and so, intrinsically safe also thanks to the earthing of all metal parts.

3) Dosing Unit

"A-System Penta Twin" is a complete high pressure metering machine containing an integrated polyol/hydrocarbons blending unit under the same section hood. The range consists in four models with 40-100-200-350 kg/min of output capacity. The complete polyol group – tank and metering unit - is placed over a drip pan welded to and integrated in the ventilated box frame and it has been designed to obtain a high degree of ventilation and respect strict safety requirements.
The modular design offers the highest machine flexibility and reduces production costs while meeting the safety standard set by international and local authorities (figure 7).
The unit has been split in two independent parts, one for the polyol circulating system and the other for Isocyanate, each with a special and proper structure.
This means restricting the use of safety devices only to the polyol unit. Explosion-proof devices can be mounted exactly where they are needed, which takes it possible to avoid buying extra safety features for components that are not supposed to be placed in a dangerous area. The number of gas detectors is reduced, the ventilation is optimised and the installation of electric components and the earthing of all metal parts are simplified.
Two different types of gas sensors can be installed: catalytic or infrared, remembering that they must be connected to a power back-up system (either battery or power generator) to eliminate the risk of a potential power-cut. Catalytic sensors are cheaper, easy to mount and test but require more maintenance (every month) and are easily affected by chemical agents such as freon, isocyanates, silicones and silicates. On the other side, infrared sensors are not prone to contaminations and require less maintenance (every month only in the areas where vapours are expected to be released continuously and every three in the others), but they are significantly much more expensive.
Specific construction details have been adopted to reduce the risk of hydrocarbon vapours accumulation.

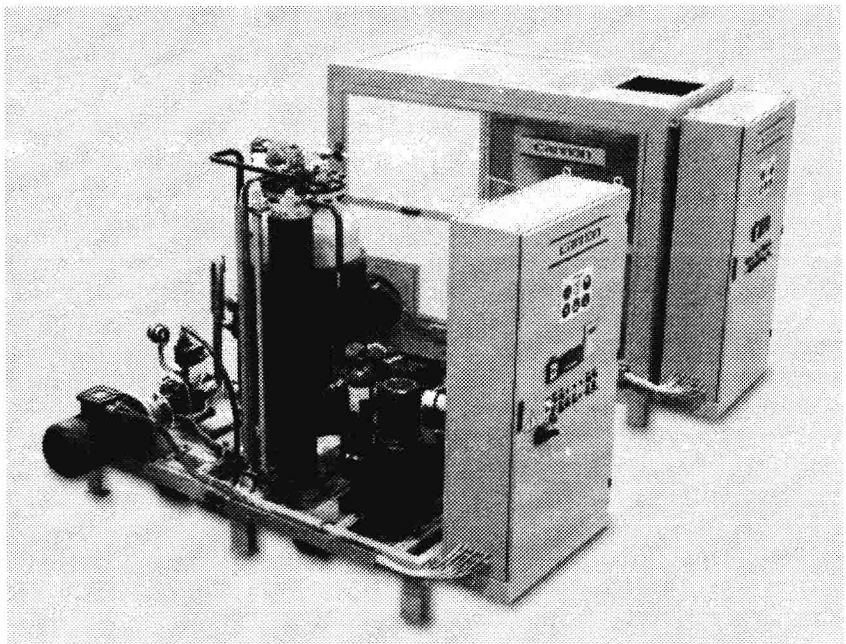


Figure 7 – A-System Penta Twin, a complete and dedicated high pressure metering machine develops and manufactures considering safety measures required working with Pentanes.

A RETROFITTING SOLUTION

Today's Cannon approach to a retrofitting job can rely on the experience that the Group has gained in this specific application of polyurethane technology by converting dozens of existing plants in many countries in the world.

The use of Cyclopentane requires significant parts of the existing plant to be modified and new equipment installed (e.g. premix systems, storage system, dosing units, etc.)

Obviously, retrofitting an existing foaming plant represents a complex engineering task. Expert Cannon staff analyse the conditions and consequently suggest the type of conversion that is necessary based on local safety rules so that permission to work is granted by the local authorities.

A retrofitting job poses more limitations than supplying a new plant:

- many existing technical features must be taken into account;
- a detailed technical survey is necessary to make an accurate price-estimate;
- the installation must not interfere too much with the production schedule (week-ends and holidays are the best times for this kind of jobs).

The final cost is lower than that of a new plant but expected savings can be lost with the wrong approach. The supplier must ensure a competent and numerically sufficient staff for all each stages of the job (price estimate, engineering, manufacturing, installation, start-up).

As a supplier of polyurethane processing equipment working through local offices, Cannon has tremendously benefited from the interaction with its local engineers, who can speak the same language as its customers, making communication easy in these complex retrofitting jobs.

When a customer needs to convert an existing plant to hydrocarbons, the modular design of Cannon Penta Twin is the safest and most appropriate solution. In the light of the market evolution Cannon has developed a system based on flexibility to help those PU processors who have already invested in CFC's and HCFC's technologies and prefer, for justified economical reasons, to modify their units instead of replacing them.

All the components in these dedicated Cannon machines have been specially designed and realised for hydrocarbons foaming processes. The key benefit is the system's modularity: the unit is the sum of independent modules assembled together.

Cannon's retrofitting solution consists of attaching a **Pentamodule** to the existing customer line. In other words, a complete metering polyol side with all the required safety features is added to the line replacing all the old polyol fixtures. The areas, where Cyclopentane vapours are expected to be released continuously or for long periods of time, are closed in a monitored and ventilated box so as to minimise the presence of hazardous surfaces.

Special attention is devoted to the ventilation of foaming jigs. What we have learnt over the years is that it is enough to install suction ducts with aspiration grills directly under the walls of each foaming fixture to remove all the vapours released during the foam rising and polymerisation stages.

That helps to avoid the costly and time-consuming task of building a complete box around the jigs. Obviously, energy wise, it would be more cost-effective and technically easier to suck air through ventilation ducts with limited dimensional section, rather than guaranteeing the continuous replacement of the large volume of air contained in the sealed boxes.
The speed of the air at the ventilation intakes must not be below 2 m/sec and this value must be increased to 7-9 m/sec in the collecting pipes that convey the air through the factory roof. Generally, a ventilation system for a dosing machine that works with four foaming jigs must guarantee a suction rate of 2500 m^3 an hour.
Typically, customers need to retrofit an existing line which features electrically heated fixtures that make the area be classified as potentially explosive zone. In early projects, Cannon recommended a jigs conversion to a water conditioning system that made it possible to remove electric resistances from a dangerous area and use water also as a coolant. Today Cannon offers additional solutions that take into account even more complex retrofitting jobs.
The priority is to prevent the risk of explosion that may derive from the contact between Cyclopentane vapours and electrical components that have been switched on. To do that, it is sometimes better to switch off the jigs for a reasonable time (usually around 90 seconds) right after the foam has been injected. This solution can be applied when the cost of converting the fixtures from electrical to water based heated system is much higher than the potential risk.

INDUSTRIAL APPLICATIONS
Here are two projects that Cannon has recently worked on. The first one is a retrofitting job on a line for refrigerating displays for food and drinks commissioned in 2001. The Customer produced refrigerating units for soft drinks makers like Coca Cola, which are very environmentally conscious. These companies are rated environmentally friendly and insist that their sub-contractors too apply environmentally sound operating practices. For this reason, foaming equipment and production line had to be retrofitted because the refrigerating units were required to be insulated with Cyclopentane pulyurethane foam.
Four years ago the same Customer purchased one of Cannon's A-System 100 Standard machines where the moulds, the cabinet and the door are arranged in a semi-circle in front of the machine (figure 8).

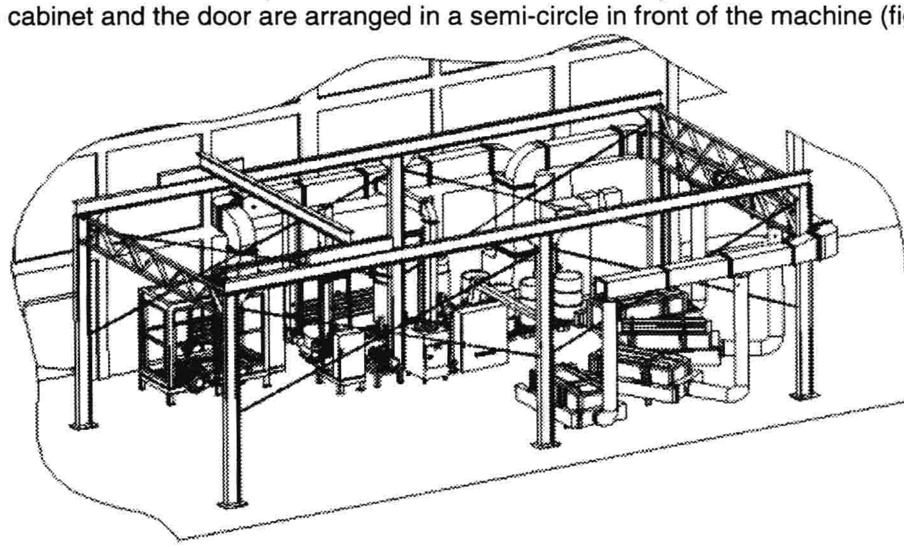


Figure 8 – Customer plant: layout of the refrigerator's doors and cabinets foaming area.

The equipment is characterized by a medium production rate with around 300 pieces a day (80,000 pa). The machine was still relatively new, therefore it was not appropriate to scrap it. That is why Cannon proposed to supply a A-System 100 Pentamodule in order to convert the polyol stream alone to Cyclopentane. The module came complete with an electrical panel that housed the power and auxiliary supplies for the running of the pump and equipment. It also featured all the terminals ready to be interfaced with the existing machine that acted only as an Isocyanate module.
The consumption of Cyclopentane was about 120-150 kg a day, which is less than a standard 200 litres drum. We therefore supply a single pumping system to work directly on the drum. without interfering with the safety measure.
Cyclopentane and polyol were mixed through our proprietary PEF pre-mix unit which ensures a consistent ratio of Cyclopentane and polyol by means of open-loop control of the pump output. The blend was loaded directly into the machine day tank.
Due to their big size, refrigerating displays require a lot of workers to be manufactured and particularly to place the metal shell in the foaming fixtures. The foaming jigs are designed accordingly, so that they are able

to hold the refrigerators frames. Today more automation is used to minimize the amount of manpower needed: nevertheless, this is a sector where a higher amount of manual work is required.
The long cycle time does not economically justified the cost of a system with one mixing head fixed on the polymerisation jigs. That is why the foam is injected manually by using a single head mounted on a pivoting boom. The four fixtures are placed in front of the foaming device in a radial layout.
The safety system applied to this hydrocarbon installation consists of a right-sized network of suction ducts positioned under each foaming fixture. These U-shaped suction ducts are all connected to a common ventilation system that sucks the air out of the factory through the wall behind the foaming area (figure 9).

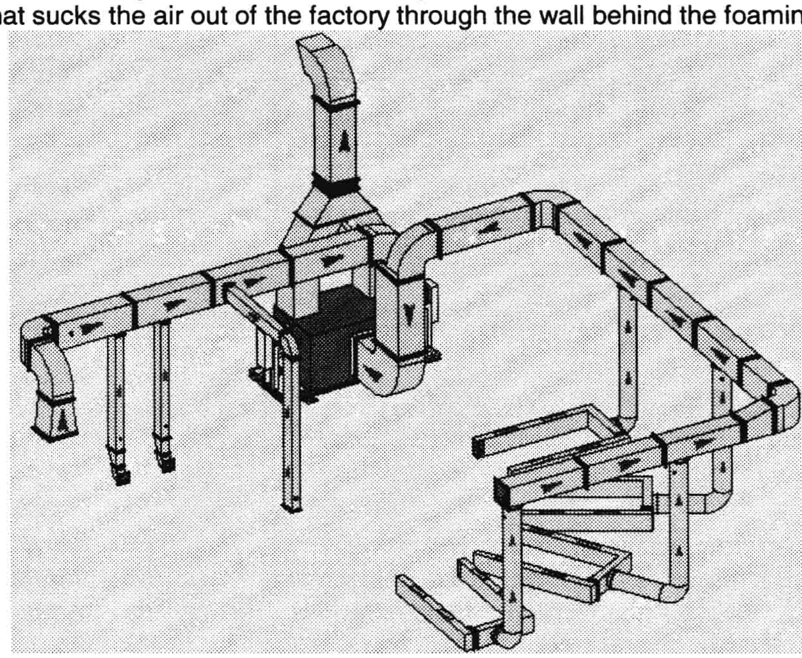


Figure 9 – Customer plant: detail of the foaming area's ventilation system.

The forced ventilation system ensures that Cyclopentane's vapours are removed, while the combustible monitoring system keeps constantly checking and displaying their concentration. If the presence of vapours exceeds 15%, the control system will trigger off a standby fan to double the ventilation. If the situation worsens and the concentration of Cyclopentane's vapours increases over 30%, the control system will cut off the power to the foaming machine and all the other production line equipment, leaving just the ventilation on.
The safety control system features a separate power supply independent from that of the production line. Moreover it is equipped with a UPS which lasts for at least 30 minutes.
A new earthing system was developed to connect all the equipment associated with the production line in order to equalize the potential and prevent the creation of static charge.

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The second project Cannon has worked on is a new plant for the production of home refrigerators, commissioned by one of the bigger sector's player worldwide with a total annual production of over 3,000,000 refrigerators that means 5,000 units per working shift.
For the development of new projects this Customer carefully considered a number of vendors of machines and technologies and finally opted for 2 internationally renowned machine suppliers: Cannon being one of them.
The customer wanted to achieve a high production rate, so it decided to set up a new dedicated factory for the production of refrigerators up to 800 litres. In March 2001 it asked Cannon to supply the necessary foaming equipment.
The line was equipped with an A-System 200 Penta Twin with a double dosing unit that features proprietary FPL24 mixing heads, which provide a streamline flow at high output (figure 10).