

# Foaming Industry

## Introduction

Polymeric foams are produced from a broad range of different polymers. The first foams for industrial use were developed between 1910 and 1920 known as foam rubbers. These days a variety of applications have developed. They reach from soft foams in the automotive and furniture industry to rigid foams as insulation materials in the building construction industry or appliances like refrigerators and ice boxes. Today one can find industrial foam in almost all areas of daily life.



From the perspective of a gas detection system supplier the most interesting fields are concentrated around the production of polymer precursor components and the foaming process itself. A lot of very toxic and partially flammable gases and vapours are used in the foaming industry. Therefore a gas detection system is highly recommended in nearly all steps of production.

In January of 2003, US law will force a major change in most plastic foam-processing lines. Due to ozone depletion, environmental laws have banned all use of Hydrochloro-fluorocarbons (HCFCs) starting January 2003. A majority of USA and international foam manufacturers are scrambling to create a foaming process that uses no HCFC gasses. Some are substituting less efficient hydrocarbons such as pentanes and butanes; others are switching to expensive HFC's. According to an A. D. Little report of March 2002, "The major manufacturers in the boardstock industry have decided to convert to hydrocarbon blowing agents due to the higher costs of the HFC blowing agents."

## Market Segments and Development

Three major market segments can be distinguished around the production and use of industrial polymeric foams:

- Production of polymer components (chemical industry)
- System suppliers for foam processing
- Foam production and related products containing polymeric foams

U.S. Markets for Polymeric Foam by Resin Family, through 2006 (Million Lbs.)	2001	2006	AAGR % 2001-2006
Polyolefin	300	361	3.8
Polystyrene	1913	2031	1.2
Polyurethane	3961	4720	3.6
Polyvinyl Chloride	1156	132	2.6
Others	91	102	2.3
Total	7421	8529	2.8

## Description of the Challenge

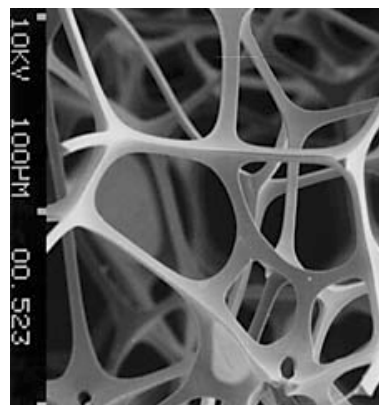
### 1. Production and Processing of Polymeric Foams

There are different industrial polymeric foams based on a wide range of polymers and foam production processes. When industrial foams are produced a gas can be generated during the formation of the polymer. An example for this process is polyurethane (PU) where carbon dioxide is produced in the polymerisation reaction itself. The gas bubbles are trapped in the stiffening polymer and produce a porous structure which builds the frame structure of a polymeric foam.

Because not all polymerisation reactions generate a gas as a by-product some are started from an already formed polymer. In these cases the foam is produced by mixing a blowing agent with the moulded polymer under high pressure. During the extrusion and the pressure release the expanding gas forms the foam structure.

As a blowing agent all gases which can be liquefied under pressure such as fluorinated hydrocarbons, carbon dioxide and nitrogen can be used. Also liquids with boiling points far below the process temperatures for the polymer melts like n-pentane, c-pentane and hexane are used as blowing agents. Due to their potential effect to the ozone layer fluorinated hydrocarbons are increasingly being replaced by pure hydrocarbons. While the environmental aspect of these new blowing agents is positive, the flammable nature of the replacements requires a risk analysis of the potential explosion hazard.

The extrusion process requires that the blowing agent is continuously supplied to the polymer melt. To guaranty a high and reproducibile production quality in the extrusion process the concentration and the amount of blowing agent in the polymer melt has to be controlled very precisely. Otherwise

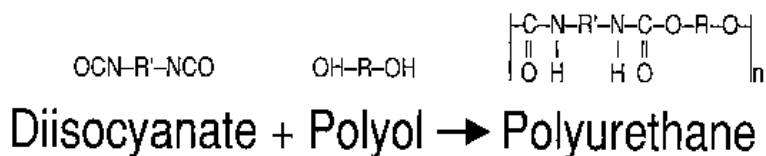


the volume of the polymer foam varies. This causes production losses and quality problems leading to a non profitable process.

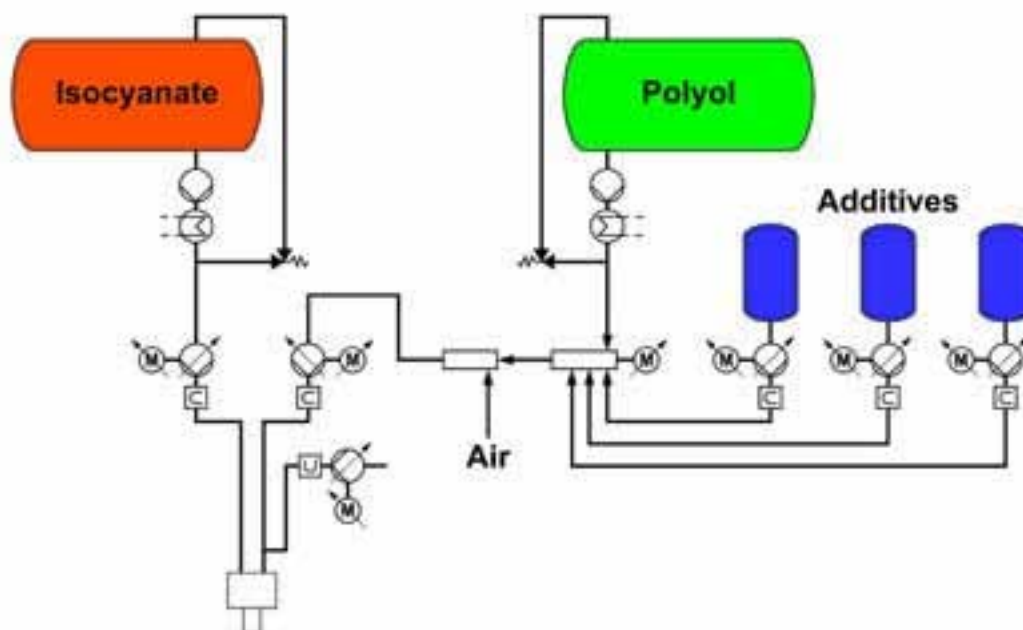
Very good temperature control is necessary, especially with CO<sub>2</sub> (water) technology as a blowing agent because of the high exothermic reaction. For low rejection rates positive control with heating and cooling is required. This is normally based on water circulation. The second best option is to have mould heating (ovens) facilities for the start-up of production and then to rely on the foam exothermic reaction to maintain the required temperature.

## 2. Production of Polymer Components in the Foaming Industry

The most prominent representative among the polymeric foams is based on the polymer Polyurethane (PU). The annual world wide production of PU soft foams alone exceeds 1400 million t. The PU production is based on the polymerisation reaction of two components:



Diisocyanates are extremely toxic substances with TLV values down to the ppb range.



Flow Chart of a Polyurethane Production Facility

## Solution from Dräger

As described above there are different measuring tasks around the production and usage of polymeric foams. Gas Detection systems cover different stages in the foam production process. Starting from detection system for the storage areas of base chemicals like Ethylene Oxide (EO), Propylene Oxide (PO) and liquid hydrocarbons they are also used in control loops of the foam processing.

### **1. LEL Measurement of Hexane and Pentane used as blowing agent**

The preferred method of Hexane and Pentane detection in the foam industry is the use of infrared gas detection transmitters. Catalytic bead sensors should not be used because one can expect polymerising substances in the environment which can heavily affect the sensor. The experience of customers has shown that catalytic bead sensors are poisoned after a very short time period.

Polytron IR Ex is the first choice when the customer is looking for low detection limits. This is requested in case an early warning for leak detection is required. The lowest measuring range is 0..3000 ppm. Warning levels of 300 ppm for A1 (first alarm level) and 1000 ppm for A2 (second alarm level) can be realised with good results. The maintenance intervals can be set to 6 .. 12 month due to the high stability and the self check functions of the instrument according to directive T023 of the "Employment Accident Insurance Fund for the Chemical Industry in Germany" (BG Chemie).

Because of the excellent stability and the very low cost of ownership Polytron 2 IR will be the choice for detection of explosion hazards in the foaming industry. The gas table stored in the Polytron IR holds currently 30 gases and allows a flexible and accurate detection of hexane and pentane in the 0..100% LEL range. A response time of less than 5 s even with a splash guard installed guarantees a reliable and fast warning. Since October 2004 all Polytron IR transmitters allow lower full scale detection values. Therefore lower measuring ranges and detection limits are available depending on the selected measuring gas. Please see also our product descriptions for more detailed information.

The infra-red technology allows also a continuous gassing of the transmitters in the high LEL range without ageing or poisoning effects as they are known from catalytic bead sensors.

### **2. Measurement of Ethylene Oxide and Propylene Oxide in the PU Production**

The base chemicals EO and PO used in the Polyurethane production can be measured in the range of 0..20 ppm using the electrochemical OV Sensor. The transmitters which are recommended in this case are Polytron 7000 and Polytron 2 XP. Reasonable warning levels can be set-up as 10 ppm for A1 and 15 ppm for A2.

Further on leak detection in storage areas of EO and PO can be performed using Polytron IR Ex. Due to the very low measuring range of 0..5000 ppm a fast response time can be realised. Reasonable warning levels can be set-up as 1000 ppm for A1 and 4000..5000 ppm for A2.

Ex-detection in the range of 0..100% LEL should be done using Polytron 2 IR transmitters. An intricate cross calibration can be evaded because both gases are stored in the standard data set of the P 2 IR. The calibration can be performed using common calibration gases like Methane or Propane which can be selected in the menu. When the unit is switched back into the measuring mode the cross calculation to EO and PO will be done automatically. The response time of less than 5 s and calibration intervals up to 2 years fulfil all customer needs in this applications.

### 3. Tox Measurement of Carbon Dioxide and Hydrochlorofluorocarbons (HCFC)

Due to the ozone layer damaging nature of the HCFC R134a, R141b or R142b they will have a limited use in the future. But nevertheless some older equipment is based on this technology. The detection of these substances is possible with Polytron IR Ex in the range of about 2 Vol% depending on the listed HCFC.

When CO<sub>2</sub> is used as a blowing agent in the foam production the Polytron IR CO<sub>2</sub> can be used. Measuring ranges are available from 0..2000 ppm up to 0..30 Vol%. As discussed before all arguments why an infrared transmitter should be used in the foaming industry are also valid for this product.

### 4. Tox-Measurement in the PU Production Process

Regarding the possibilities of diisocyanates detection with the Dräger IMS 5000 please see the application note directly referencing this problem.

For detailed description of the technical features of all Dräger gas detection transmitters visit our homepage under [www.draeger.com/gds](http://www.draeger.com/gds).

### Advantages of the Dräger Solution

- constant sensitivity over time (cat ex has a decreasing sensitivity over time)
- no poisoning
- theoretical unlimited lifetime
- Low cost of ownership, 1 calibration per year or per 2 years. No consumables.
- Not sensitive to air-flow
- Fast response time
- 5 years warranty for Polytron IR Ex and 3 years for Polytron 2 IR
- microprocessor technology with self-test routines
- Low measuring range for the Polytron IR Ex and Polytron 2 IR
- 100% FAILSAFE

### Restrictions

#### Tox-Measurement in the PU Production Process

Currently there is no stationary detection equipment available to measure all diisocyanates in the TLV range. The only possibility to offer a product will be to suggest a Dräger Tube. The IMS (ion mobility spectrometer) instrument will give us some opportunities for TDI and Phenyl-diisocyanate. Further tests and developments have to be performed to verify the possibilities of this instrument. See also the application note directly referencing this problem.

The TLV value of ethylene oxide (1.0 ppm) and propylene oxide (2.5 ppm) can not be monitored using the OV-electrochemical sensor. Due to the instability of the zero reading and the very wide cross sensitivity spectrum the detection limit of this sensor is not good enough to reach the requested performance for the TLV monitoring.

Prepared by: Dr. Robert Kessel

## References (internal, external)

Country	CUSTOMER	Branch	ENGINEERING COMP./ CONTRACTOR	GAS 1	GAS 2	GAS 3	GAS 4	QTY-GAS1	QTY-GAS2	QTY-GAS3	QTY-GAS4	Year
Belgium	Electrolux	17		IR Ex								
Belgium	Huntsmann Europe Everberg	17		Polytron IR Type 334	Polytron IR Ex IL	Polytron IR Ex	Polytron 2 O2 LS	8	4	2	1	
Belgium	Huntsmann Europe Everberg	17		Polytron 2 OV	Polytron IR Ex			1	5			
Belgium	Recitel	17		Polytron IR Type 334	Polytron IR Ex IL	Polytron 2 H2	Polytron IR Ex	3	3	2	3	
Belgium	Soudal Turnhout	17		Polytron IR Ex				3				
Belgium	Tarec Turnhout	17		Polytron IR Type 334				4				
Belgium	Trost St Truiden	17		Polytron IR Ex				3				
China	BYS, Chuzhou	17	Bosch	Polytron IR Ex				53				
China	Changling, Baoji	17	Leyboldt, D	Polytron IR Ex				12				
China	Changzhu Fridge Co., Changzhu	17	Leyboldt, D	Polytron IR Ex				7				
China	Haier, Quindao	17	Liebherr, D	Polytron IR Ex				17				
China	Kelong, Chendu	17	Leyboldt, D	Polytron IR Ex				12				
China	Kelong, Shunde	17	Leyboldt, D	Polytron IR Ex				25				
China	Kelong, Yangkou	17	Leyboldt, D	Polytron IR Ex				12				
China	Xinfei Electric Co.Ltd., Xinxiang	17	Hennecke, D	Polytron IR Ex				37				1996
Czech Republic	Linde Frigera Beroun	17		Polytron IR Ex				8				
Finland	Electrolux Oy	17		Polytron SE Ex				30				1993
Germany	AEG Hausgeräte GmbH, Kassel	17		Polytron IR Ex	Polytron Ex/SE Ex	Polytron SE Ex		13	5	1		
Germany	Bosch GmbH, Reutlingen	17		Polytron IR Ex				13				1998
Germany	Bosch-Siemens Hausgeraete GmbH, Giegen	17		Polytron SE Ex	Polytron IR Ex			45	56			1996-97



Application Note

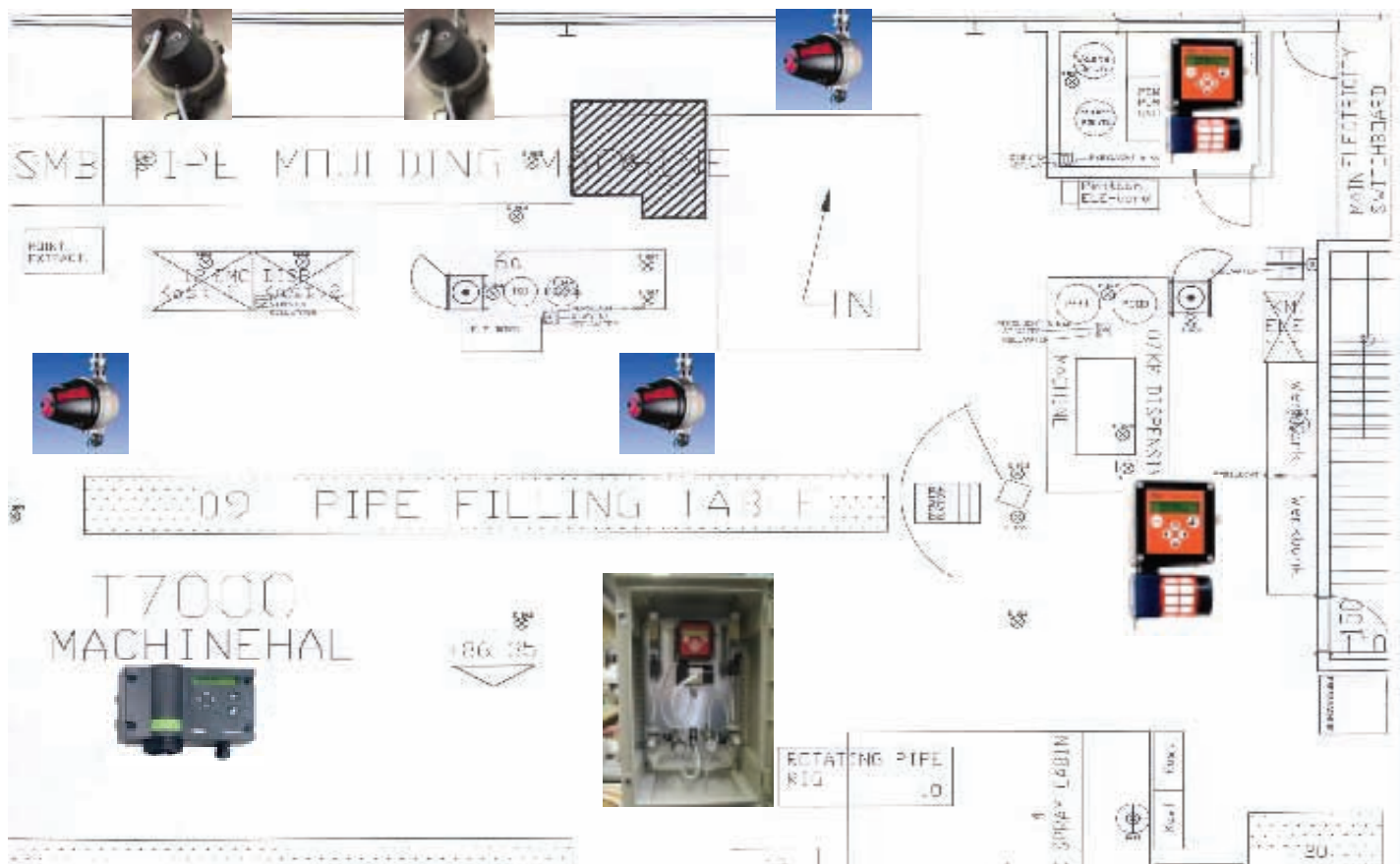
Germany	Gramkow-Werk Offenbach GmbH	17		Polytron IR Ex	Polytron SE Ex	77	6	
Germany	Hennecke GmbH, St. Augustin	22		Polytron IR Ex	Polytron Ex/SE Ex	197	10	
Germany	Indeplastic	17		Polytron IR Ex		20		1996
Germany	Krauss-Maffei	22		Polytron IR Ex		103		
Germany	Lätzsch GmbH Kunststoffverab.	17		Polytron IR Ex		15		1994
Germany	Liebherr Hausgeräte GmbH, Ochsenh.	17		Polytron IR Ex	Polytron SE Ex	10	99	1993-95
Germany	Peguform GmbH, Bötzingen	17		Polytron SE Ex		19		1997
Great Britain	Electrolux	18		Polytron SE Ex		60		1996
Great Britain	Norfröst	17		Polytron IR Ex		13		1996
India	Allwyn Voltas Ltd., Hyderabad	17	Plasttechnik Greiz GmbH, D	Polytron IR Ex		6		1996
Italy	Ocean	17		Polytron IR Ex		20		1994
Italy	Stimamiglio	17		Polytron IR Ex		20		1994
Italy	Whirlpool, Siena	17		Polytron IR Ex		10		1994
Italy	Whirlpool, Trento	17		Polytron IR Ex		22		
Slovenia	Gorenje Velenje	22	Hennecke	Polytron Ex/SE Ex		8		
Sweden	Electrolux, Mariestad	3		Polytron SE Ex		12		
USA	Hennecke Machinery / Miles	17		Polytron IR Ex		7		1994

**Appendix** (application pictures supplied by our Belgium team)









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