SNAP CODE: **060303**
060304

SOURCE ACTIVITY TITLE: **CHEMICALS PRODUCTS MANUFACTURING OR PROCESSING**
Polyurethane Foam Processing
Polystyrene Foam Processing

NOSE CODE: **107.03.03**
107.03.04

NFR CODE: **3 C**

1 ACTIVITIES INCLUDED

This chapter deals with the application and subsequent discharge of organic compounds as blowing agents for creating plastic foams (Polyurethane and Polystyrene). These blowing agents need to be liquids which are characterised by a low boiling point. By application of external heat (polystyrene) or due to the reaction heat (polyurethane) the liquid evaporates and helps create the foam, without actually taking part in the reaction. Liquids used are CFC's (like F11, F12, F22), now being replaced by pentane and butane. Emissions are from the release of these blowing agents during foaming, or subsequently by the long-term release over several years, and are strictly evaporative. The production of the raw materials is included in SNAP code 040500 covering bulk chemical production.

Polyurethane (PUR) and polystyrene (EPS) are used in building construction, for heat insulation, and for packaging material. Characteristic is a high proportion of on-site foaming, i.e. only the production takes place in well defined production plants, the foaming (EPS) and the actual formation (PUR) directly at the site needed, which leads to direct emissions without foreseeable control.

2 CONTRIBUTIONS TO TOTAL EMISSIONS

	PUR	**EPS**	**source**
Baden-Württemberg (Germany)	0.1 %*	1.3 %	(Rentz et al, 1993)
Austria	0.5 %	0.2 %	(Orthofer et al, 1989)

*) long-term emissions not considered

3 GENERAL

3.1 Description

a) Polyurethane
Polyurethane is produced by the exothermic reaction of iso-cyanates with alcohols. About 80 % of the world production is foams (Stoeckhert et al, 1993), which are created by adding blowing agents. For soft polyurethane foams water may be used, which binds with iso-cyanate to form CO_2. Hard polyurethane foams utilise organic liquids as blowing agents (CFC's, now being replaced by alkanes), which evaporate due to the heat formation of the reaction. Hard foam is known for its good sealing and insulation properties. This also determines its use in refrigeration equipment as well as in the building and construction industry. While prefabricated compounds can be attributed to production sites directly, a considerable proportion of polyurethane foam is produced and applied directly, for example at a construction site. Figures for Germany (Greenpeace, 1991) indicate that this "direct production" is almost as large as prefabrication (7000t CFC's used, vs. 9500t).

Another aspect of the sealing properties is, that the blowing agent is included into the cells of the structure, and only eventually released. According to German estimation (Rentz et al, 1990), only about 15 - 25 % of the blowing agent applied is released immediately, the rest is stored inside the cells of the foam and released eventually. Again, estimations are available for Germany (Plehn, 1990). The total amount of stored F11 (70000 t) is about 5 times the annual usage of CFC's for hard foam polyurethane.

b) Polystyrene
Polystyrene foams are primarily used for insulation material and for packaging material. EPS raw beads contain about 6 % pentane which is evaporated in the expansion stages and emitted during pre-expansion and moulding as well as during transport and storage (Achermann, 1992). Moulding is frequently performed in relatively small units (by heating EPS-beads with steam), and therefore relatively difficult to control. For Baden-Württemberg (Rentz et al, 1993), the emissions from EPS foam processing are about 10 times the emissions from polyurethane processing (without long-term emissions).

3.2 Definitions

Blowing agent:	usually liquid substance which evaporates during the process (or releases gas) in order to expend the volume of the substrate ("blow") into a foam.
PUR:	polyurethane
EPS:	expandable polystyrene

3.3 Techniques

see 3.1.

3.4 Emissions

Emissions are due to evaporation of blowing agents and consist of CFC's or alkanes (pentane, butane), respectively. All blowing agent used will be emitted eventually into the atmosphere, unless there exists some kind of capturing device. However, it may take years until all of the blowing agent is released from the cells of a PUR foam.

3.5 Controls

Replacement of CFC's by pentane and butane is reducing CFC emissions at the cost of increasing alkane emissions

Control / combustion of pentane, wherever defined production units are available

Reduction of long-term emissions by controlled destruction of used foam material (like the insulation of refrigerators).

Replacement of plastic foams as packaging materials.

4 SIMPLER METHODOLOGY

Emissions are derived from the production of PUR-foams and EPS foams times blowing agent content (see section 8). Assuming all of the blowing agent is eventually emitted, and constant annual production figures, the annual emissions are equal to the amount of blowing agent applied. In this case, the long-term emissions from foams produced in previous years are simply assumed to be equal to the amount of blowing agent retained in the foam produced in the current year.

5 DETAILED METHODOLOGY

Basically, emissions are determined the same way as for the simpler methodology. A number of parameters need to be taken into account, however:

Release of trapped blowing agents - According to figures presented by Rentz et al, 1993, about 30 % of the emissions due to hard PUR foam take place in the year of its formation, and 20 % in the years thereafter. In case of drastic changes of production, the production statistics of 4 years before the base year of the inventory need to be taken into account for the long-term releases.

Control measures (section 3.5) need to be taken into account for primary production. For EPS foaming, especially the abatement technology used in storage, pre-expansion and moulding has to be assessed (see section 8).

The blowing agent applied needs to be determined.

6 RELEVANT ACTIVITY STATISTICS

Industry statistics (production of PUR and EPS foams).

7 POINT SOURCE CRITERIA

No point sources are to be expected from this sector. Some large chemical plants may, however, include activities described here.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

Emissions are equal to the amount of blowing agent applied. Production figures are taken from the respective production statistics, the content of the blowing agent is listed in table 2.

Table 2: Content of blowing agent (%) in material before expansion

	Polyurethane (Rentz et al, 1993)	EPS (Achermann, 1992)
blowing agent content:	12 % (D) *	6 % ©

* figure derived for CFC's used as a blowing agent. No data are available for pentane as a replacement. Applying the same emission factor, the quality code has to be downgraded to (E).

8.1 Detailed methodology

For EPS foam processing, the application of controls needs to be considered. While no explicit emission factors can be given, a split of the emissions during different parts of the process may help attributing the efficiency of an abatement device (table 3).

Table 3: Relative emissions during different stages of EPS foam processing [6]

Transport/storage of raw beads	8 %
pre - expansion	27 %
Storage	17 %
Moulding	25 %
Final product*	23 %

* Diffuse emissions during use

9 SPECIES PROFILES

Depending on the blowing agent, emissions are F11, F12, F22, butane and pentane. The dominant agent will be pentane in the foreseeable future.

10 UNCERTAINTY ESTIMATES

As the production figures as well as the content of blowing agent can be found quite straightforwardly, the uncertainty is not too high and may be in the range of +/- 30% (see also Rentz et al, 1993), where uncertainty is estimated at +/- 20 %).

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

No information is available on the amount of blowing agent being transferred to other media (soil, water) than air.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Much of the emissions are associated with final distribution of goods (packaging) or building industry (insulation). These emissions are most appropriately attributed to population. Thus disaggregation of emissions should be performed according to population.

13 TEMPORAL DISAGGREGATION CRITERIA

Depending on the specific situation, about half of the emissions may be considered continuous, the other half process - orientated, concentrated on regular working times.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

16 VERIFICATION PROCEDURES

The total emissions from the solvent sector (SNAP group 6) may be assessed applying a solvent balance (Import - Export + Production - Destruction) for a country. In many countries good statistics can be obtained which may be more reliable than the data available for individual source activities.

17 REFERENCES

B. Achermann. VOC Newsletter 7, p.5. Projectbureau KWS 2000, Den Haag, February 1992

Greenpeace, e.V. (ed.) Der verzögerte Ausstieg. Der FCKW-Verbrauch der bundesdeutschen Industrie; 1990/91. Greenpeace report, Hamburg, 1991. (as cited in Rentz et al).

R. Orthofer, G. Urban. Abschätzung der Emissionen von flüchtigen organischen Verbindungen in Österreich. OeFZS report 4497, Seibersdorf (Austria), February 1989

W. Plehn, Kunststoffe 80 (4), p. 470-477 (1990) as cited in Rentz et al).

O. Rentz, et al. Konzeptionen zur Minderung der VOC-Emissionen in Baden-Württemberg. Bericht der VOC-Landeskommission. Umweltministerium Baden-Württemberg, Luft-Boden-Abfall Heft 21, Stuttgart, 1993.

K. Stoeckhert, W. Woebcken (eds.). Kunststoff-Lexikon, 8th ed., Carl Hanser Verlag, Munich, 1992.

18 BIBLIOGRAPHY

19 RELEASE VERSION, DATE AND SOURCE

Version: 1.1

Date: 29 March 1995

Source: W. Winiwarter
Austrian Research Centre
Austria

20 POINT OF ENQUIRY

Any comments on this chapter or enquiries should be directed to:

Wilfried Winiwarter

Austrian Research Centre Seibersdorf
A-2444 Seibersdorf
Austria

Tel: +43 2254 780 3868
Fax: +43 2254 780 3888
Email: winiwarter@arcs.ac.at