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**D E C I S I O N**  
**of 26 March 2003**

**Case Number:** T 0051/00 - 3.3.3

**Application Number:** 90916868.4

**Publication Number:** 0502871

**IPC:** C08J 9/12

**Language of the proceedings:** EN

**Title of invention:**

Use of liquid carbon dioxide as a blowing agent in the production of flexible, open-cell polyurethane foam

**Patentee:**

DOYLE, Earl N., et al

**Former Opponent:**

Foaming Technologies CarDio B.V.

**Headword:**

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**Relevant legal provisions:**

EPC Art. 54, 56

**Keyword:**

"Novelty (yes)"  
"Inventive step (yes) - problem and solution"

**Decisions cited:**

T 0789/89, T 0642/97, T 0616/98

**Catchword:**

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Case Number: T 0051/00 - 3.3.3

**D E C I S I O N**  
**of the Technical Board of Appeal 3.3.3**  
**of 26 March 2003**

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**Decision under appeal:** Decision of the Opposition Division of the  
European Patent Office dated 30 September 1999  
and issued in writing on 5 November 1999 revoking  
European patent No. 0 502 871 pursuant to  
Article 102(1) EPC.

**Composition of the Board:**

**Chairman:** R. Young  
**Members:** A. Däweritz  
U. Tronser

## Summary of Facts and Submissions

- I. The grant of European patent No. 0 502 871 in respect of European patent application No. 90 916 868.4, based on International patent application No. PCT/US90/06485, filed on 13 November 1990 and claiming priority of 29 November 1989 of an earlier application in the United States of America (442645), was announced on 7 May 1997 (Bulletin 1997/19) on the basis of 21 claims.

Claims 1 and 13 as granted read as follows:

- "1. A process for the production of a flexible, open-cell polyurethane foam, the process comprising:
- a) mixing the following components at ambient temperatures in a mixing zone:
    - i) a diisocyanate having a functionality of 2.0 to 2.7,
    - ii) at least one hydrogen donor having a functionality of 2 to 4 and which is at least one polyol having a molecular weight of 2000 to 6500,
    - iii) at least one surfactant which is effective in forming an open-cell polyurethane foam,
    - iv) at least one catalyst, and
    - v) a blowing agent comprising a gas having a boiling point below approximately -73°C (-100°F) at atmospheric pressure, the mixture being subjected to a pressure in the mixing zone which is sufficient to maintain the blowing agent in the liquid state at ambient temperatures;

b) ejecting the mixture from the mixing zone to atmospheric pressure; and  
c) curing the resultant foam at ambient temperatures."

"13. The process of any preceding claim, wherein the polyurethane foam has a density of 12 to 192 kg/m<sup>3</sup> (0.75 to 12 pounds per cubic feet)."

The remaining dependent claims related to specific embodiments of this process.

II. On 6 February 1998, a Notice of Opposition was filed in which revocation of the patent in its entirety was requested on the grounds of lack of novelty within the meaning of Articles 54(1) and (2) EPC and of inventive step within the meaning of Article 56 EPC. In order to support these objections, the Opponent relied on nine documents.

III. In a decision announced on 30 September 1999 and issued in writing on 5 November 1999, the Opposition Division acknowledged novelty of the claimed subject-matter over

D1: CA-A-0 647 294 and

D3: US-A-3 184 419, respectively,

but held that the subject-matter of the patent in suit as granted lacked an inventive step in view of the above two documents, irrespective of whether D1 or D3 was taken as the closest state of the art. This finding was held to apply also to the auxiliary request, wherein the feature of Claim 13 (above) had been added at the end of the above wording of Claim 1.

- (i) In particular, the Opposition Division took the position that the subject-matter of the claims as granted differed from D1 by curing step (c), ie curing at ambient temperatures, and from D3 by feature (a)(v), ie the requirement that the reaction mixture be subjected to a pressure in the mixing zone which is sufficient to maintain the blowing agent in the liquid state at ambient temperatures.
  
- (ii) Starting from D1, which related to the production of soft, low density polyurethane foams using liquid carbon dioxide as blowing agent in order to improve the flexibility of polyurethane foams and to reduce the amount of polyisocyanate used in the NCO-H<sub>2</sub>O-reaction to generate CO<sub>2</sub> as blowing agent, the technical problem, which had been solved by the above distinguishing feature, was seen in a reduction of time and, hence, an increase in productivity to obtain the final product. The solution found, ie faster curing at higher temperatures, was considered obvious to the skilled person, eg. in view of D3, according to which it was known to cure a foam either by standing at room temperature or by warming the mould (column 4, lines 30 to 34). Both options were considered in D3 and therefore their use was at the discretion of the skilled person.
  
- (iii) Since the Proprietors had submitted that, in their opinion, D3 was a more adequate closest prior art, a second approach starting from D3 was considered in the decision under appeal. The distinguishing feature to D3 was to be the

liquid state of the blowing agent in the mixing chamber. However, D1 suggested the use of liquid CO<sub>2</sub> as the blowing agent, the use of which was therefore obvious. Moreover, the Proprietor had failed to show that the use of liquid CO<sub>2</sub> in the mixing chamber was related to any unexpected technical effect which was not hinted at by either D1 or D3.

- (iv) Claim 1 of the auxiliary request contained a further distinguishing feature due to the inclusion of the density range of the product. However, this claim also lacked an inventive step for the same reasons as outlined for the main request.

Consequently, the patent was revoked for lack of inventive step.

- IV. On 22 December 1999, a Notice of Appeal was lodged by the Proprietors (Appellants) against this decision with simultaneous payment of the prescribed fee. The Statement of Grounds of Appeal was received on 3 March 2000 and included Claim 1 of an auxiliary request identical to Claim 1 of the auxiliary request before the Opposition Division.

The Appellants agreed with the fact that novelty had been acknowledged in the decision under appeal, but did not concur with the reasons given therefor.

- (i) Thus, it was argued that D1 neither related to the preparation of an open-cell foam, nor to the

use of carbon dioxide in the liquid state at any point of the process, nor to curing the foam at ambient temperature.

Whilst it was accepted that document D3 related to the preparation of an open-cell foam, it was denied that this had been the result of the foaming process, because D3 included a crushing of the foam to open the cells. The silicone oil used in D3 would not act as a surfactant in the foaming step of that process but it would rather prevent - as a bubble breaker - the formation of bubbles in the prepolymer.

- (ii) Starting from D3 as the closest state of the art, the technical problem was seen in the preparation of a flexible open-cell polyurethane foam without having to crush the resulting foam to break open the cells. Additionally, the argument in the decision under appeal was supported that, in the mixing zone of D3, the carbon dioxide was not maintained in liquid state. Moreover, D3 would lead the skilled person away from selecting the approach taken in the patent in suit by teaching him to operate at relatively low pressures, as demonstrated in the Example of D3.

Since Document D1 aimed at closed-cell foams in tyres, for this reason alone, D1 could not be taken as closest state of the art, nor could it provide any information which would lead the skilled person to modify the teaching of D3 so as to arrive at something within the scope of the claims under consideration.

(iii) In addition to the eight documents listed in the decision under appeal, the Appellants referred to five additional documents and publications to support their arguments, including

D13: EP-A-0 645 226.

V. In its counterstatement dated 12 September 2000, the Respondent reiterated its novelty objections based on D1 and D3, but supported the findings as to inventive step of the decision under appeal. Additionally, a further objection as to lack of inventive step was raised on the basis of

D4: US-A-4 337 318,

which had already been cited in the Notice of Opposition, in combination with common general knowledge.

VI. In a letter dated 26 February 2003, the Appellants disputed the arguments of the Respondent. Thus, it was argued that D4 concerned only rigid closed-cell foam.

VII. By letter of 24 March 2003, the opposition was withdrawn by the Respondent, who additionally stated that it had changed its opinion regarding the alleged invalidity of the patent in suit and, consequently, no longer challenged the validity of the patent. It informed the Board that it would not attend the oral proceedings arranged for 26 March 2003.



VIII. The oral proceedings were held as scheduled in the presence of the Appellants.

(i) In these oral proceedings, the following issues were discussed in detail:

(a) Having regard to Claim 1 of D4, which refers to the preparation of low density polyurethane foam from (i) a polymeric diisocyanate having a functionality within a range of approximately 2.2 to 2.9, (ii) a blend of polyols, surfactant and catalyst and (iii) the same blowing agent as in the patent in suit which seemed to be treated and reacted with each other in quite the same way as in Claim 1 of the patent in suit, it did not appear to be explicitly evident that, according to the Appellants, D4 would relate to a rigid closed-cell structure.

(b) Furthermore, having regard to the disclosure of D3, it was discussed whether the blowing agent was maintained in liquid state in the mixing chamber or not, since both D3 and the US equivalent of the patent in suit as mentioned in D13 (page 2, line 57 to page 3, line 2) referred to by the Appellants, appeared to indicate that the skilled reader would have understood that, in those two documents, the blowing agent was maintained in the liquid state during the mixing of the components.

- (c) In the latter connection, it was to be established whether a clear distinction had to be made between the blowing agent being maintained in liquid state, as defined in step (a) of the process of Claim 1, and the blowing agent being comprised in the liquid phase.
  
- (ii) The point of view taken by the Appellants during the oral proceedings can be summarised as follows:
  - (a-i) Emphasis was put on the argument that the field of polyurethane foam production was divided in two distinct major parts, ie concerning soft (flexible) products, on the one hand, and rigid products, on the other. In both these parts, the recipes for making foams were based on "six or seven" principal components, ie polyisocyanate, polyol, water, surfactant, catalyst (amine- and/or metal-based) and blowing agents (for "pre-" and/or "post-expansion"). If a skilled person were asked to prepare a foam from a composition of starting materials taken from a list of generic compounds, as defined in Claim 1 of D4 (above), he would in reply pose the question of which type of foam (soft or rigid) was required, and further, whether the foam should be closed- or open-cellular. This was because the individual constituents would have to be selected from the

conventional materials known for each of the above generic components, accordingly.

- (a-ii) In every case of preparing a polyurethane foam, the product was initially closed-cellular. To provide an open-cell foam, some means had to be provided to get the closed cells to open. In practice, whether the final product would have an open-cell or a closed-cell structure depended, in particular, on the specific choices of catalyst and surfactant. The latter was necessary to bring the reactants together in an appropriate way. In support of this argument, the Appellants referred to Appendix III filed with their letter of 19 August 1999, which included copies of a number of data sheets of commercial catalysts and silicone surfactants. Before such surfactants were available, soft open-cell polyurethane foams could not be made.

The Appellants emphasised in this connection that rigid closed-cell, soft (flexible) open-cell and soft closed-cell foams were also known.

- (a-iii) In summary, specific measures (by choosing an appropriate surfactant or by squeezing the foam as in D3) had to be carried out in order to obtain a foam

having an open-cell structure. In other words, silence in this context in a disclosure meant closed cells.

(a-iv) The absence of any reference to such measures in D4 alone meant that this document referred to this latter type of foam. Consequently, it could not serve as the closest state of the art in the assessment of inventive step.

(b-i) In D3, liquid carbon dioxide was not metered into the mixing chamber, but admixed with one of the reactants (the prepolymer) before this reactant was fed to the mixing zone. Consequently, the blowing agent was dissolved therein, but not retained in liquid state. This had been confirmed by a deposition testimony of a technical expert witness relied upon by the former Respondent in respect of legal proceedings concerning the US equivalent of the patent in suit (Appendix II to the letter of 19 August 1999), according to which "- it is clear that liquid CO<sub>2</sub> as liquid CO<sub>2</sub> would not reach the mixer in liquid form". However, the presence of gaseous CO<sub>2</sub> in excess of its solubility limit in the reaction mixture caused "blow holes" (big bubbles) in the resulting foam.

(b-ii) The Appellants stated that the dwell time in the mixer under the conditions given (large quantities of reactants in

a small volume of the mixing chamber) were not such that CO<sub>2</sub> could be liquefied again. Furthermore, they argued that it was specifically indicated in D3 that pressures lower than those necessary to maintain the blowing agent in liquid state were applied in the mixture of CO<sub>2</sub> and the prepolymer (column 3, lines 47 to 54 and column 1, lines 36 to 39).

(b-iii) D13 was drafted after publication, ie in knowledge of both D3 and the US-equivalent of the patent in suit, so that the opinion expressed there should be disregarded.

(c-i) As regards the question of CO<sub>2</sub> in liquid state or in liquid phase, the Appellant argued that the solubility of carbon dioxide in the reaction mixture was only limited and not sufficient to achieve the desired low densities of the foam, which was corroborated by the very high density of the foam in the Example of D3 ("0.4 g/cm<sup>3</sup>"). It had been found by the Appellants, in accordance with the patent in suit, that, when feeding carbon dioxide in liquid state directly to the mixing zone and maintaining it there in that state, a much higher proportion of the blowing agent could be brought into the liquid mixture which allowed to obtain the desired low density product.

(c-ii) With respect to the explanation of the pressure (21 to 345 bar or 300 to 5000 psi) at ambient temperature (ie 21 to 38°C or 70 to 100°F) required to maintain the blowing agent in liquid state (patent in suit: column 5, lines 43 to 46), which appeared to be inconsistent with

D14: Temperature-Entropy Diagram for Carbon Dioxide, Liquid Carbonic, Scarborough 1974 (initially submitted as D9),

the Appellants stated that the diagram gave the data for pure CO<sub>2</sub>. In mixtures, less stringent conditions were required.

(iii) A new auxiliary request was submitted which was based on the wording of Claim 1 of the previous auxiliary request and Claims 2 to 12 and 14 to 21 as granted. The latter dependent claims were renumbered in accordance with Rule 29(5) EPC. In Claim 16 (renumbered "15"), the reference was amended accordingly.

IX. The Appellants requested that the decision under appeal be set aside and that the patent be maintained as granted or, alternatively, on the basis of Claims 1 to 20 filed as auxiliary request at the oral proceedings.

## Reasons for the Decision

1. The appeal is admissible.
2. *Procedural matters*

With the withdrawal of the opposition during the appeal proceedings, the Respondent ceased to be a party to these proceedings in respect of the substantive issues (T 789/89, OJ EPO 1994, 482, cf. the headnote; T 616/98 of 1 February 2001, section 2.1 of the reasons; T 642/97 of 15 February 2001, Section 2 of the reasons). Moreover, the clear and express statements of the former Respondent, that it had changed its opinion as to the invalidity of the patent in suit and no longer challenged the validity of the patent in suit, can only be understood to mean the withdrawal of its arguments raised against the case as presented by the Appellants and its acceptance of the arguments of the Appellants.

### *Main Request*

3. *Problem and Solution*
  - 3.1 The patent in suit concerns the use of liquid carbon dioxide as a blowing agent in a process for the production of flexible, open-cell polyurethane foam (cf. the title).

3.2 Documents D1, D3 and D4 were suggested as starting points for objections to patentability of the patent in suit. Therefore, the Board has, first of all, examined which of these documents is to be considered as representing the closest state of the art.

3.2.1 In document D1, a process is disclosed for preparing cellular polyurethane compositions having hysteresis properties approximating those of foamed natural rubber, thus allowing to fill a conventional rubber tyre with foam to eliminate the need for an inner tube. In that process, a liquid reactive hydrogen-containing polymer is reacted with an organic polyisocyanate to give a polyurethane elastomer, at least in part, in the presence of an appreciable imposed pressure of carbon dioxide and then releasing the pressure of the carbon dioxide to effect foaming of the reaction product (Claim 1). Preferably, at least one of the reactants is cooled to a temperature sufficiently low to substantially enhance the solubility of CO<sub>2</sub> in the components. Normally, temperatures around 15°C or below are adequate at 200 to 1000 psi (13.8 to 68.9 bar) of CO<sub>2</sub> pressure (or at higher pressures without previous cooling) to dissolve sufficient carbon dioxide in the reactants to achieve foaming upon the release of the CO<sub>2</sub> pressure (page 2, lines 14 to 27). In the known process, organic emulsifying agents, eg. water-soluble organic silicones such as a water-soluble polyoxyalkylene polydimethyl siloxane block copolymer, could be used to facilitate the mixing and increase the compatibility of the components of the reaction mixture (page 3, lines 10 to 21).



In Example 1, a prepolymer of ethylene glycol adipate and tolylene diisocyanate ("**TDI**") was, after dissipation of the reaction heat, subjected in a pressure vessel to a CO<sub>2</sub> pressure of 600 psi (41.4 bar) and then, simultaneously with a mixture of ethylene glycol adipate, water and activator, prepared in another pressure vessel under a similar CO<sub>2</sub> pressure, metered to a mixing head. As the materials reacted in the mixing head and attained a consistency sufficient to produce a stable foam, the foam was withdrawn from the mixing head into moulds and the pressure was released. Upon the release of the pressure, the product expanded and was then cured in an oven for two hours. The product was described as a very soft foam, the density of which could be varied from 64.1 to 16.0 kg/m<sup>3</sup> (about 4 to about 1 lbs/cu.ft.) depending on the pressure of carbon dioxide and rate of pressure release.

In Example 2, a prepolymer prepared from diethylene glycol adipate and a commercial TDI isomeric mixture was cooled to 45°F (7°C) and then added to a mixture comprising hexanetriol, hydroxylated vegetable oil and N-ethylmorpholine in a Votator type mixer whilst the prepolymer was held under a pressure of 27.6 bar (400 lbs/cu.ft.) of CO<sub>2</sub>. After one minute in the mixer, the product was withdrawn therefrom into moulds and allowed to foam to form buns. The foamed product was cured in an oven and sliced to obtain test specimens.

Both examples are silent with respect to the presence of a surfactant.

3.2.2 Consequently, and contrary to the finding in the decision under appeal, the Board finds that the silence of D1 as to any measures designed to open the cells of the foam produced, and as to any component such as a surfactant inherently capable of opening such cells, must be interpreted as meaning that D1 fails to disclose an open-celled foam.

3.2.3 Nor is any mention made in D1 that the blowing agent is to be added as a liquid or to be maintained in liquid state before the expansion. D1 refers only to the achievement of sufficient solubility of the gas in the reactants.

Whilst it has not been disputed that the pressure range of 200 to 1000 psi (at around 15°C) disclosed in the general description of D1 (page 2, lines 19 to 21) may overlap with the range referred to in the description of the patent in suit (300 to 5000 psi or 21 to 345 bar; column 5, lines 43/44), the Appellants emphasised that it was not sufficient to simply have the appropriate temperatures and pressures prevailing in order to liquefy carbon dioxide gas, but that a significant dwell time was also required for the liquefaction to occur. Moreover, upon condensation significant amounts of heat are freed which have to be removed. No mention is made of such a measure. On the contrary, a Votator mixer is used in Example 2 which generates further heat in the mixture. In summary, D1 neither contains any reference to the addition of liquid CO<sub>2</sub>, nor any teaching or suggestion about the need for or use of such a dwell time in order to liquefy the gas (Statement of Grounds of Appeal, the paragraph bridging pages 19 and 20).

These arguments have neither been disputed by the former Respondent (cf. its letter of 12 September 2000), nor was any evidence provided for the presence of liquid CO<sub>2</sub> in the process of D1 by this former party on which the onus of proof had been to prove its case.

Consequently, the Board finds that the disclosure of D1 also fails to make available a blowing agent comprising a gas having a boiling point below approximately -73°C (-100°F) at atmospheric pressure, the mixture being subjected to a pressure in the mixing zone which is sufficient to maintain the blowing agent in the liquid state at ambient temperatures (feature a)v) of Claim 1).

3.2.4 Moreover, in neither of the two examples in D1, does the pressure correspond to or exceed the above pressure and temperature conditions (750 psi/51.7 bar at 15°C/59°F; see section 3.2.1, above), which were referred to in the decision under appeal to show that feature a) v) of Claim 1 had been met by D1, as could be taken from a triple point diagram (D 14; page 6, penultimate paragraph of the decision under appeal).

Finally, the only disclosure referring to a curing of the resultant foam is to be found in the examples. In both of these examples, the products were cured in an oven. Hence, it cannot be derived from this disclosure in a clear and unambiguous way that this step had been carried out at ambient temperature (see section 3.2.1, above).

3.2.5 In summary, D1 neither relates to the preparation of an open-cell foam, nor to the use of carbon dioxide in the liquid state at any point of the process, nor to curing the foam at ambient temperature. In particular, the document does not relate to open-cell foams.

3.3 As regards D4, for the reasons given under VIII.ii) a-i) to a-iv), which are not disputed by the former Respondent, the absence of any reference to a relevant measure for opening the cells of the foams formed in D4 means that this document also does not relate to open-cell foams.

3.4 Document D3 describes a process of making a polyurethane foamed material, requiring only a simple form of apparatus which can be operated at relatively low pressures (column 1, lines 36 to 39).

3.4.1 In the process, polyurethane forming reactants comprising (1) a hydroxy terminated polyalkylene ether glycol having a molecular weight of at least 500, (2) an organic compound of the class consisting of polyisocyanates and polyisothiocyanates in an amount in excess of that required to react with the hydroxyl end groups of the polyol (glycol) and (3) water are mixed and reacted to form a cellular polyurethane. In a first step, a prepolymer having iso(thio)cyanato end groups and a viscosity of from 10 000 to 30 000 cP at 20°C is prepared from components (1) and (2). This prepolymer and the water are then continuously fed "into a chamber together with liquefied carbon dioxide as substantially the sole inert added foaming agent in an amount of at least one percent by weight of the prepolymer, said carbon dioxide being under pressure in the liquefied state and at a temperature below that at which

substantial reaction between the said prepolymer and the water takes place, stirring the resultant liquid mixture in the chamber, foaming the liquid mixture by releasing it from the chamber and thereby reducing the pressure in the liquid mixture and allowing the temperature of the foamed mixture to rise to convert it into an elastomer before substantial breakdown of the foam takes place" (Claim 1). In column 3, lines 24 to 31, possible crosslinking agents other than water are only referred to as "a polyol or other polyfunctional compound capable of reacting with the end groups".

The gas is preferably cooled before it is injected into the prepolymer, eg through a suitable high pressure nozzle, to facilitate pumping and metering of the liquid gas and to assist cooling the prepolymer and thus increasing the solubility of the gas therein. Otherwise difficulty may be experienced in pumping the gas or the pumping may even become impossible. However, since the gas used is soluble in the prepolymer, the pressure need only be in the order of that corresponding to the partial pressure of the dissolved gas and can therefore be considerably lower than that of the gas immediately prior to injection (column 3, lines 46 to 59).

After expansion, the foam is removed from the mould and preferably compressed by passing through rollers in order to burst any closed cells and finally matured by storing at room temperature or at an elevated temperature (column 4, lines 34 to 38).

- 3.4.2 In the sole example, a prepolymer was prepared from polypropylene glycol having a molecular weight of 2000, trimethylol propane and TDI at elevated temperature

with stirring. Then, before cooling, silicone oil was added and admixed. The resulting prepolymer was matured for two days at room temperature. Thereafter it was pumped at 25°C at constant rate to the mixing chamber of a specific foaming apparatus. Liquid CO<sub>2</sub> of about 0°C was injected at a constant rate into the prepolymer flow through an atomising nozzle set to open at 150 atmospheres. Two amine catalyts, one of them in the form of an aqueous solution, were metered as separate feed streams into the mixing chamber wherein the pressure was held constant at 300 psi (21 bar) by manual adjustment of the valve controlling the flow of the emergent mixture. The material expanded on leaving the nozzle to a foam which was allowed to run into an open mould. After the setting of the foam, the product was removed, repeatedly compressed by passing through rollers and finally matured by heating for 30 min at 70 to 80°C. The soft resilient foam had a high density of about 0.4 g/cm<sup>3</sup> (400 kg/m<sup>3</sup>) (column 5, line 50 to column 6, line 28).

3.5 Thus, in contrast to D1 and D4, D3 relates to a process which is intended to produce an open-cell flexible foam. In contrast to D1, it achieves this using a process wherein the carbon dioxide blowing agent is injected in liquid form. It therefore qualifies, in the Board's view, as a closer state of the art than D1 or D4 and indeed, in accordance with the view of the Appellants, as the closest state of the art.

3.6 In line with the patent specification, the technical problem underlying the patent in suit may be seen as the definition of a process which enables, in a simple way, without need to use environmentally hazardous blowing agents or mechanical bursting of closed cells,

to prepare a soft open-cell polyurethane foam having a very low density (patent in suit: column 1, line 5 to column 2, line 19 and column 3, lines 18 to 20 and Statement of Grounds of Appeal, page 32, point 6.2).

- 3.7 According to the patent in suit, this problem is solved by (a) mixing the following components at ambient temperatures in a mixing zone: (i) a diisocyanate having a functionality of 2.0 to 2.7, (ii) at least one hydrogen donor having a functionality of 2 to 4 and which is at least one polyol having a molecular weight of 2000 to 6500, (iii) at least one surfactant which is effective in forming an open-cell polyurethane foam, (iv) at least one catalyst, and (v) a blowing agent comprising a gas having a boiling point below approximately  $-73^{\circ}\text{EC}$  ( $-100^{\circ}\text{EF}$ ) at atmospheric pressure, whereby the mixture is subjected to a pressure in the mixing zone which is sufficient to maintain the blowing agent in the liquid state at ambient temperatures; (b) ejecting the mixture from the mixing zone to atmospheric pressure; and (c) curing the resultant foam at ambient temperatures.

In the absence of any argument or evidence from the former Respondent to the contrary, on whom the burden of proof lay, that, in accordance with the features of the claim, and, in particular, the examples of the patent in suit, the desired foams would not be obtained, the Board has no doubts that this problem is effectively solved by the process as defined in Claim 1.

4. *Novelty*

In view of the above facts and findings with respect to the documents D1, D3 and D4, the Board sees no reason to reconsider the question of novelty, which had been decided by the Opposition Division in favour of the Appellant.

Consequently, the subject-matter of Claim 1 is novel.

5. *Inventive step*

It remains to be decided whether the solution to the technical problem provided according to Claim 1 was obvious to a person skilled in the art having regard to the state of the art relied upon by the former Respondent.

5.1 It is evident from the above considerations that in the process in D3 the blowing agent is *not in the liquid state* when entering the mixing chamber.

Moreover, the document neither discloses nor suggests to meter into the mixing chamber a polyol having a functionality of 2 to 4 and a molecular weight of 2000 to 6500. It rather refers to a crosslinking agent or chain extender such as water and requires the temperature to be maintained in the mixer in a range at which no reaction between the reactive components can take place. Thus, the reaction is only possible after release of the reaction mixture to atmospheric pressure. As a consequence thereof, care has to be taken at this stage to avoid "substantial breakdown of the foam".



This danger is due to two facts: first, the reaction being started only after expansion of the carbon dioxide in the mixture and, secondly, the absence of an appropriate surfactant. According to the Appellant and undisputed by the former Respondent, the silicone oil (polydimethyl siloxane) added in the example of D3 only at the end of the preparation of the prepolymer, after polypropylene glycol and TDI have reacted, is not such a surfactant, but rather acts as a defoamer for the prepolymer. As pointed out by the Appellant (section VIII.ii) a-ii), above), a surfactant serves to bring the reactants together in an appropriate way. In view of the well-known hydrophobicity of such oils, this property cannot be attributed to the above silicone oil when water is used as the crosslinking agent. In fact, D3 is completely silent about the use of a surfactant.

In summary, D3 does not contain any hint to modify its process, let alone in order to further simplify it and to give further improved results such as a reduction of the density of the foam by a factor of more than two. Therefore, this document, by itself, provides no incentive to solve the above relevant technical problem (section 3.6), let alone in a manner such as to arrive at something within the ambit of Claim 1 under consideration.

- 5.2 Since, furthermore, D1 refers neither to the use of a blowing agent in liquid state nor to the preparation of open-cell foams, nor even to a surfactant (section 3.2.1, above), it cannot provide any hint either, which might have led the skilled person to modify the process of D3 to overcome the above technical problem so as to arrive at something within the scope of Claim 1.

5.3 Although no objection had been raised on a combination of D3 and D4, the Board has also examined whether a combination of the teachings of these documents would be conceivable and would make the claimed process obvious.

As already mentioned (section 3.3, above), Document D4 neither relates to flexible open-cell foams nor deals with the above relevant technical problem. Therefore, Board sees no reason not to accept the argument of the Appellants that this document cannot be considered relevant to the preparation of flexible open-cell foams.

Consequently, D4 cannot provide any incentive to modify the process of D3 so as to arrive at something falling within the ambit of Claim 1.

5.4 It follows that the process according to Claim 1 would not be obvious to a person skilled in the art. Consequently, the subject-matter of this claim involves an inventive step.

6. By the same token, Claims 2 to 21, which relate to particular embodiments of Claim 1, are directed to subject-matter which involves an inventive step.

7. It follows from the above considerations that the main request must be allowed.

8. *Auxiliary request*

Since the main request has been successful, it is not necessary for the Board further to consider the auxiliary request.

**Order**

**For these reasons it is decided that:**

1. The decision under appeal is set aside.
2. The patent is maintained as granted.

The Registrar:

The Chairman:

E. Görgmaier

R. Young