

Air Products and Chemicals, Inc. (Petitioner)
v.
Evonik Operations GMBH and Evonik Corporation (Patent Owner)

Petitioner's Demonstratives

Case No. IPR2024-00611
U.S. Patent No. 10,471,380 B2

Before Jo-Anne M. Kokoski, Avelyn M. Ross, Alyssa A. Finamore
Administrative Patent Judges



DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

Introduction

Ungerank's Comparative Example 1

COMPARATIVE EXAMPLE 1

Separation of a Mixture of Methane and Carbon Dioxide with a Mixing Ratio of 50 to 50 with a Moderately Selective Polyimide Membrane

The FIG. 11 shown connection arrangement was used. Each stage consisted of a hollow fiber membrane module consisting of hollow polyimide fibers from UBE (NM B01 A

based on the amount of gas to be separated supplied. Pure product streams are obtained with a relatively high double compression rate. The membranes used exhibit a moderate

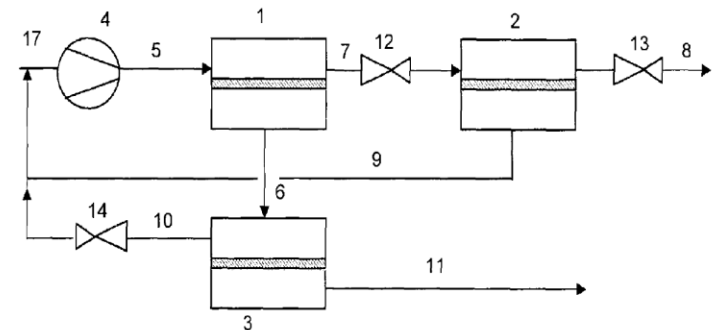
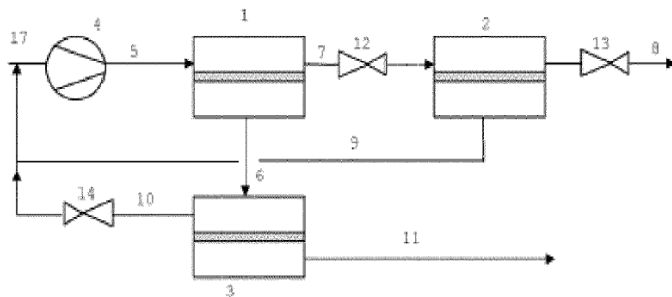


Fig. 11: Illustrative connection arrangement of several membrane modules according to invention

AP-1006 at 10:17-25, 10:64-65, Figure 11; AP-1038 at [0072]-[0074], Figure 11; Corrected Petition at 12-14

Priske '380 Patent

Priske's cover page



Illustrative connection arrangement of several membrane modules according to invention

Ungerank's Figure 11

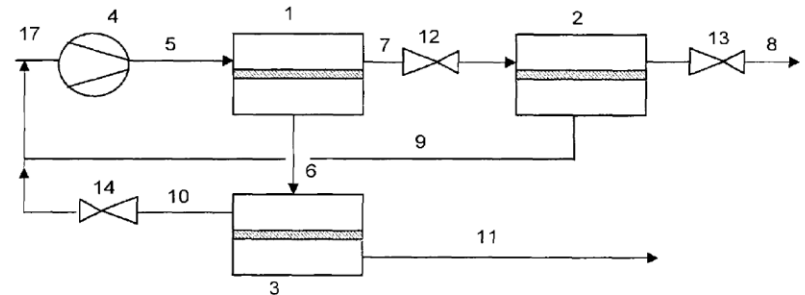


Fig. 11: Illustrative connection arrangement of several membrane modules according to invention

Priske on “lower selectivity” membranes and “high purity products”

The inventors further found out, that the inventive processes and apparatuses could produce high purity products even with membranes with a lower selectivity. The energy-optimized process of WO 2012/00727 requires higher selec-

AP-1001 at cover page, 2:43-45; AP-1006 at Figure 11; AP-1038 at Figure 11; Corrected Petition at 8, 12-13; Reply at 1

Priske '380 – Independent Claim 1

1. A method for separating gases from a crude gas stream comprising at least two components, wherein in an apparatus comprising a feed stream separation stage, a retentate separation stage and a permeate separation stage, each stage being a membrane separation stage with gas separation membranes,

- a) a feed stream is separated in the feed stream separation stage into a first permeate stream and a first retentate stream,
- b) the first retentate stream is separated in the retentate separation stage into a second permeate stream and a second retentate stream,
- c) the first permeate stream is separated in the permeate separation stage into a third retentate stream and a third permeate stream,
- d) the second retentate stream is removed as a first product,
- e) the third permeate stream is removed as a second product, and
- f) the second permeate stream and the third retentate stream are combined with the crude gas stream to give the feed stream, and wherein
 - i) the combined gas volume of the second permeate stream and the third retentate stream is from 60 to 100% of the volume of the crude gas stream,
 - ii) the total capacity of the gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description, and
 - iii) the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 0.5 to 8.

AP-1001 at claim 1; Corrected
Petition at 25-32; Reply at 6-9,
11-25

The Capacity Limitation In Priske's Claim 1

Priske '380 – The Claim 1 “Capacity” Limitation

Membrane capacity as used in the present invention is defined as the product of the membrane surface and the permeance of the membrane at operating temperature that is determined for nitrogen (Grade 4.8) under standard conditions. Standard conditions are described in detail in section measurement methods below. Membrane surface respectively membrane area is the external surface of the membrane as macroscopically visible. For its determination it is

Claim 1, element f.ii.

ii) the total capacity of the gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description, and

154. As the '380 patent explains, capacity is the product of permeance and surface area, and measuring capacity at standard conditions is the result of and depends on measuring permeance at those conditions. AP-1001, 14:55-15:18.

AP-1001 at 2:53-60, claim1; Corrected Petition at 10, 18, 29-31; Reply at 6-9; AP-1003 at ¶154

All The Prior Art And Priske Examples Are Simulations

Patent Owner's Response at 56

Moreover, Comparative Example 1 and the Figure 7(a) and 7(b) embodiments in Scholz are based on the results of simulation software

Priske

EXAMPLES

In all examples and reference examples the membrane capacity relates to nitrogen (Grade 4.8) and were measured under the standard conditions described above.

General Description of the Simulation:

The simulation is based on the following assumptions:

Steady state

Ideal gas

Ideal separator membrane in the permeation model

Response at 56; AP-1001 at 15:28-35; Reply at 4; AP-1041 at ¶¶8-9, 12, 16-19

The Prior Art's Capacity Ratios Equal Their Surface Area Ratios

39. When membranes have identical properties (aside from their surface areas), the membranes' permeances, measured at any set of conditions (i.e., as long as the conditions are the same), are necessarily identical.

40. In Scholz's Figure 7 and in Ungerank's Comparative Example 1, since all those systems have identical membrane properties in each system (except for their surface areas), the membranes' permeances in each system, measured "for nitrogen Grade 4.8 under standard conditions as defined in the description," are necessarily identical.

41. As a result, in Scholz's Figure 7 and in Ungerank's Comparative Example 1, the capacity ratio of the membranes in any two stages is equal to the surface area ratio in those two stages, because the equal permeances cancel each other out:

$$\frac{Capacity2}{Capacity1} = \frac{area2}{area1} * \frac{permeance}{permeance}$$

AP-1041 at ¶¶39-41;
Corrected
Petition at 18-
19, 29-30;
Reply at 6-9;
AP-1003 at ¶¶154-158

The Relative Sizes Of The Stage 1 And Stage 2 Membranes In Ungerank's Comparative Example 1

Dr. Baker's First Declaration (AP-1003)

93. This limitation is in many ways a restatement of the “recycle” limitation in different words. As described earlier, the relative size of the membranes depends on the target performance required by the application and the selectivity of the membranes used. As I described above, for typical biogas separations, obtaining high purity methane in the second stage retentate stream generally means that the first separation stage is processing a higher concentration CO₂ gas and is almost always relatively small compared to the second separation step which is processing a lower concentration gas.

94. In other words, having a capacity in step 2 that is greater than in step 1 is largely a result of common design criteria for biogas separations—i.e., the composition of the crude stream and requiring relatively high purity methane in the retentate in the second stage. In my opinion, a POSITA would have understood this in December 2014.

AP-1003 at ¶¶93-94; Corrected Petition at 9-10

Dr. Baker's Supplemental Declaration (AP-1041)

28. In my deposition, I discussed how a POSITA “might have already figured out” that in Ungerank’s Comparative Example 1, stage 2’s membrane surface area was larger than stage 1’s membrane surface area. For a fixed feed gas flow rate across the membrane surface, as the membrane becomes larger, more of the permeable component (CO_2) passes through the membrane. This depletes the feed gas of the permeable component (CO_2) and enriches it in the retained component (CH_4). Thus, as the membrane becomes larger, a disproportionate amount of the retained component (CH_4) begins to pass through the membrane. The net effect is that a larger membrane area results in lower concentrations of the permeable component (CO_2) in the permeate stream. Conversely, smaller membranes result in higher concentrations of the permeable component (CO_2) in the permeate stream. In terms of Ungerank’s Comparative Example 1, that means that a smaller membrane in stage 1 would result in a higher concentration of CO_2 in the first permeate stream (6).

29. A POSITA would have understood that in Ungerank’s Comparative Example 1, to achieve the relatively high concentration of CO_2 (99.0%) in the third permeate stream (11), a relatively large driving force would be needed in stage 3, meaning there must be a relatively high concentration of CO_2 in the first permeate stream (6). A POSITA would therefore have understood that stage 1’s membrane must be relatively small.

30. For stage 2, the same principle applies. However, the second permeate stream (9) is recycled. In other words, a POSITA would have understood that in Ungerank’s Comparative Example 1, to achieve the relatively high concentration of methane (98.5%) in the second retentate stream (8), a relatively large membrane would be needed in stage 2 to allow much of the permeable component (CO_2) to pass through it. A relatively large membrane in stage 2 would also allow a relatively large amount of methane to pass through stage 2’s membrane into the second permeate stream (9), but that stream, including the methane therein, is recycled and combined with the crude gas stream (17) so that it processed again.

AP-1041 at ¶¶28-30; Reply at 19, 25

Patent Owner's Incorrect Response Argument (p. 41)

Patent Owner's incorrect argument in its Response was based solely on the membrane "modules" in Ungerank's Comparative Example 1

Ungerank Comparative

Example 1 provides specific make and model information, and states that a module was used in each of its separation stages and, therefore, that the area ratios are 1:1. Specifically, for Comparative Example 1, Ungerank states that "each stage consisted of a hollow fiber membrane module consisting of hollow polyimide fibers from UBE (NM B01 A type)." AP1006-Ungerank, 10:24-27.

Response at 41; Reply at 4-5; AP-1041 at ¶¶20-23

Patent Owner's New, Incorrect Sur-Reply Argument (p. 8)

Patent Owner's argument in its Sur-Reply is newly raised, and legally and factually flawed

As Priske-'380 itself expressly states, the

retentate and feed stream stage membranes in UCE1 have the *identical* capacities.

See AP1001-Priske-'380, 6:22-29 (In “WO 2012/000727 [i.e., the Ungerank application], ... all separation stages have identical membrane capacities.”); *id.*,

AP1001-Priske-'380, 16:28-32 (“The Comparative-Example of WO 2012/000727

A1 was reproduced. Characteristics of this ex

capacities in all three separation stages”). On cross examination, Dr. Baker

Sur-Reply at 8

Motivation To Combine

In 2014, There Were Well Known Trade Offs Between Higher Selectivity And Lower Selectivity Membranes

Scholz at p. 4

have to be provided to take advantage of high membrane selectivities [23]. The trade-off between permeability and selectivity is well known [12]. In terms of process design low selectivities increase the amount of the retained gas species which permeates through the membrane resulting in increased compression duty. For high selectivity, permeance drops which increases the required membrane area remarkably. As a consequence higher investment costs and membrane replacement costs reduce the profitability of the upgrading process.

AP-1007 at 4; Corrected Petition at 20;
Reply at 11-13; AP-1003 ¶¶120-123.

Physically Combining Prior Art Is Not Required

“Etter’s assertions that Azure cannot be incorporated in Ambrosio are basically irrelevant, the criterion being not whether the references could be physically combined but whether the claimed inventions are rendered obvious by the teachings of the prior art as a whole”

In re Etter, 756 F.2d 852, 859 (Fed. Cir. 1985) (en banc) (emphasis added)

“Contrary to Allied’s position, it is not necessary that Caterpillar and Ogawa be physically combinable to render obvious the '489 patent ... The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference”

Allied Erecting & Dismantling Co. v. Genesis Attachments, LLC, 825 F.3d 1373, 1381 (Fed. Cir. 2016) (cleaned up) (emphasis added)

“a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle. ... A person of ordinary skill is also a person of ordinary creativity, not an automaton”

KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 420–21 (2007) (emphasis added)

Market Needs For Lower Selectivity Membranes

Design Pressures To Use Lower Selectivity Membranes

125. For the reasons explained above, it would have been obvious to a POSITA in December 2014 to use lower-selectivity, higher permeance (and therefore smaller area and less costly) membranes in that situation. For example, I described in my book *Membrane Technology and Applications* how membrane systems had been installed on offshore platforms, where small footprint and low weight are important. AP-1013, 363. On offshore platforms, low-cost energy is usually available, for example, hydrocarbon gases that otherwise might be flared.

128. For these reasons, before 2014 and since, some operators sought to minimize their initial investment costs (with the consequence that they would incur higher operating costs later). This is reason that would have led POSITAs to use lower-selectivity membranes.

45. A paper I co-authored that was published in mid 2014, *Pressure ratio and its impact on membrane gas separation processes*, explains an additional reason a POSITA would have used lower-selectivity membranes. AP-1046. As explained in the paper, some applications cannot be economically operated with high feed-to-permeate pressure ratios, and in those situations, the “limited pressure ratio means that the optimum membrane may not be the one with the highest selectivity; rather, a membrane with lower selectivity, but tailored to the pressure ratio, may result in a more economical process.”

46. A paper I co-authored that was published in 2008, *Natural Gas Processing with Membranes: An Overview*, explains an additional reason a POSITA would have used high permeance, smaller, lower selectivity membranes. AP-1047. As explained in the paper, “High skid costs arise because of the many pressure vessels, pipes, flanges, and valves that are required. One way to reduce membrane skid cost is to increase the permeance of the membranes, allowing a smaller membrane area to be used to treat the same volume of gas. All membrane manufacturers pursue this approach. Increasing the feed gas pressure also reduces

The Alleged “New Problem” In Priske

The Alleged “New Problem” In Priske ’380

“In determining whether the subject matter of a patent claim is obvious, neither the particular motivation nor the avowed purpose of the patentee controls. What matters is the objective reach of the claim. ... The first error of the Court of Appeals in this case was ... holding that courts and patent examiners should look only to the problem the patentee was trying to solve. ... Under the correct analysis, any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

The second error of the Court of Appeals lay in its assumption that a person of ordinary skill attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem.”

KSR Int’l Co. v. Teleflex Inc., 550 U.S. 398, 419–20 (2007) (emphasis added)

“we have repeatedly held that the motivation to modify a prior art reference to arrive at the claimed invention need not be the same motivation that the patentee had ... Requiring the motivation to modify to be the same motivation as that of the patent inventor has no basis in obviousness doctrine. *KSR* directs precisely the opposite ...”

Honeywell Int’l Inc. v. 3G Licensing, S.A., 124 F.4th 1345, 1353–54 (Fed. Cir. 2025)
(emphasis added)

Corrected Petition at 20-21; Reply at 14-15

Priske '380 Dependent Claims 9, 12 and 17

Priske '380 Dependent Claims 9, 12 And 17

9. The method of claim 1, wherein the combined gas volume recycled with the second permeate stream and the third retentate stream is from 65 to 85% of the volume of the crude gas stream.

12. The method of claim 11, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO_2/CH_4 of from 20 to 100.

17. The method of claim 2, wherein the compressor is a multistage compressor and the second permeate stream, the third retentate stream, or both are introduced into the compressor between two compression stages.

AP-1001 at claims 9, 12, 17; Corrected Petition at 34-36, 40; Reply at 26-27; Sur-Reply at 21-23

Patent Owner's Sur-Reply (p. 22) – Claim 12

Patent Owner incorrectly argues Petitioner relies on AP-1048 and AP-1049 as “teach[ing] this limitation”

Instead, Petitioner now argues, for the first time, that two references not previously identified—Bhatti (AP1048) and Staudt-Bickel (AP1049)—teach this limitation. These references were not cited in the original Petition, and their introduction at this stage constitutes an improper attempt to remedy deficiencies in the Petition's prima facie case. *See supra* Section III.B.1 (citing, among other things, 37 C.F.R. § 42.23(b) and *Intelligent Bio-Systems*, 821 F.3d at 1369).

Moreover, Petitioner has not provided any motivation for a skilled artisan to combine the teachings of Bhatti and/or Staudt-Bickel with Ungerank. Nor do these references provide the necessary correlation between mixed-gas and pure-gas selectivity for the specific conditions of UCE1.

Patent Owner's Expert

Priske '380 Pertains To Biogas

In a next specific object, a process/apparatus usable with maximum universality is to be provided for any desired gas mixtures. More particularly, it should be possible to separate gas streams which are obtained in the production of biogas

The process according to the invention/the inventive apparatus have the particular advantages that there is no need for any additional purification of the permeate and/or retentate streams (11) or (8) for many applications. For example, in the case of purification of biogas or natural

The method/apparatus of the present invention can be used to produce, at one and the same time, a pure retentate stream (8) and a pure permeate stream (11) in biogas and natural gas purification. CO₂ can therefore be released into

The inventive apparatus or the process according to the invention can especially be used for separation of biogas or natural gases or air or other gas mixtures comprising: carbon

A crude gas mixture of 50 Vol. % methane and 50 Vol. % carbon dioxide, which corresponds approximately to a biogas mixture, was introduced into a mixing chamber (not shown in FIG. 1), fed via stream (17) to compressor (4) and

AP-1001 at 1:64-67, 12:50-54,
12:64-66, 13:24-25, 16:52-54,
claim 23; Reply at 2

23. The method of claim 1, wherein the crude gas stream is selected from the group consisting of biogas, natural gas, air, a gas mixture comprising carbon dioxide and methane,

The Parties Agree That Persons Of Ordinary Skill In The Art Must Have Biogas Experience

V. Level Of Ordinary Skill In The Art

For the purposes of this Patent Owner Response, Patent Owner utilizes Petitioner's proposed level of skill in the art: an individual with "a Master of Science degree in physical chemistry, chemistry, chemical engineering, or a related field, and at least three years of work experience in membrane gas-separation systems, **including but not limited to biogas membrane separations.**" Cor.Pet., 11; *see also* AP1003-Baker Decl., ¶¶56–60.

Response at 26-27; Corrected Petition at 12; AP-1003 at ¶58

Dr. Geise Has No Biogas Experience

3 We talked about before how you had not done any work
4 on membrane gas separation apparatuses for biogas,
5 right?

6 A That's correct.

3 A So I've engaged in other work related to
4 issues of gas transport or gas separations in
5 polymers, but not specifically in the space of
6 biogas.

20 A The group does not work on gas separations
21 explicitly. We do -- we do have a project that's

19 A The research that my group does in the
20 laboratory and the types of characterization that we
21 do are generally all focused on liquid phase
22 separations.

AP-1039 at 225:1-6, 76:25-77:12, 70:17-23, 63:19-22; Reply at 2-3

Dr. Geise's Opinions Should Be Accorded Little Weight

“To offer expert testimony from the perspective of a skilled artisan in a patent case - like for claim construction, validity, or infringement - a witness must at least have ordinary skill in the art. Without that skill, the witness' opinions are neither relevant nor reliable. The opinions would not be based on any specialized knowledge, training, or experience that would be helpful to the factfinder.

Kyocera Senco Indus. Tools Inc. v. Int'l Trade Comm'n, 22 F.4th 1369, 1376–77 (Fed. Cir. 2022) (emphasis added).

Reply at 3

Dr. Geise And Dr. Baker Have Many Differing Opinions

67. I disagree with Dr. Baker at paragraphs 153 through 161, that Scholz teaches “the total capacity of gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description.” This claim requirement is

84. I disagree with Dr. Baker’s opinion (paragraphs 119-136) that person of ordinary skill in the art would have been motivated to combine the teachings of the Ungerank patent and Scholz, for several reasons.

89. I disagree with Dr. Baker’s analysis concerning which elements a person of ordinary skill would take from the Ungerank patent’s CE1 and the processes of Scholz. The analysis from Dr. Baker on this topic appears to be

105. I disagree with Dr. Baker’s declaration at paragraphs 173 through 176, that Ungerank’s Comparative Example 1 renders obvious “wherein the combined gas volume recycled with the second permeate stream and the third retentate stream is from 65 to 85% of the volume of the crude gas stream.”

78. Therefore, I disagree with Dr. Baker’s assertion that there was a recognized need in the references to design a membrane gas separation plant focused on scenarios with low energy cost.

79. In fact, there was no market pressure or “need” for “lower-selectivity, lower-cost membranes” in 2014 as Dr. Baker suggests. Membrane gas separation

85. *First*, I disagree with Dr. Baker’s assertion that a person of ordinary skill would look to Scholz because “Ungerank’s Comparative Example 1 does not

95. I disagree with Dr. Baker’s opinion (paragraphs 137-142) that a person of ordinary skill in the art would have had a reasonable expectation of success combining the disparate teachings of the Ungerank patent with those of Scholz and achieving the claimed invention.

100.” AP1001-Priske-’380, cl. 12. Dr. Baker asserts that the Ungerank patent’s disclosure of a mixed-gas selectivity of 20 in Comparative Example 1 would translate to a pure gas selectivity that is “not ... more than 500% higher”—i.e., no more than 100. AP1003-Baker Decl., ¶178. This position is unsupported.

EX2008 at ¶¶67, 78, 79, 84, 85, 89, 95, 100, 105; Response at 22, 31, 38, 42, 52

The Agreed-Upon Qualifications Require Biogas Experience

The parties' agreed-upon definition:

V. Level Of Ordinary Skill In The Art

For the purposes of this Patent Owner Response, Patent Owner utilizes Petitioner's proposed level of skill in the art: an individual with "a Master of Science degree in physical chemistry, chemistry, chemical engineering, or a related field, and at least three years of work experience in membrane gas-separation systems, **including but not limited to biogas membrane separations.**" Cor.Pet., 11; *see also* AP1003-Baker Decl., ¶¶56–60.

Patent Owner's sur-reply (p. 24):

Petitioner's primary criticism of Dr. Geise's expertise is that he has not done any research specifically on "biogas membrane separations." Rep., 2-3. But Petitioner's own proposed (and agreed) definition of a POSITA requires three years of work experience in membrane gas-separation systems "**not limited to[] biogas separation.**" In addition, as Dr. Baker agreed, Priske-'380 "is more general than just biogas," and independent claim 1 is "not limited to biogas." EX2018-Baker-May-Dep., 57:6-24. In other words, Petitioner's complaint is that Dr. Geise does not have experience that Petitioner elected **not** to require and that does not correspond to any

Response at 26-27; Sur-Reply at 24; Corrected Petition at 12; AP-1003 at ¶58

Ungerank Is Prior Art

The Corrected Petition

The portions of U.S. Patent No. 8,999,038 (AP-1006), cited by column and line numbers herein and in AP-1003, are prior art under §102(a)(1), as they were published on April 25, 2013 in U.S. Patent App. Pub. No. 2013/0098242 (AP-1038) (“Ungerank”). The publication’s specification and figures are identical to the patent. *Compare* AP-1006 to AP-1038. Ungerank issued under §151, names

AP-1038

U.S. Patent App. Pub. No. 2013/0098242 (“Ungerank”)

Corrected Petition at v, 3

Exhibit 3001

Dear Honorable Board:

Last Friday, February 23rd, Air Products and Chemicals Inc. filed a petition for *inter partes* review of U.S. Patent No. 10,471,380 (IPR 2024-00611).

Earlier this week, Petitioner's counsel noticed an error in the petition. The error is that the petition cites to U.S. Patent No. 8,999,038 (Ungerank) (AP-1006) as prior art instead of the earlier patent application publication for that patent (U.S. Publ. No. 2013/0098242A1). The specification and figures in the patent and the application publication are identical, except for formatting. In other words, the petition cites to the correct teachings of Ungerank, but references the wrong document.

Exhibit 3001

Exhibit 3001; Reply at 9-10

Exhibit 3001

From the Board -

In view of the absence of opposition from the Patent Owner, Petitioner's request to file a corrected Petition is granted. If Patent Owner seeks an extension of time to file its Preliminary Response, it should inform the Board of the basis and duration of such request within three business days.

Regards,

Esther Goldschlager
Supervisory Paralegal Specialist
Patent Trial & Appeal Board
U.S. Patent & Trademark Office

Exhibit 3001; Reply at 9-10