

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TOPSOE, INC.,

Petitioner

v.

L'AIR LIQUIDE, SOCIÉTÉ ANONYME POUR L'ETUDE ET
L'EXPLOITATION DES PROCÉDÉS GEORGES CLAUDE,

Patent Owner

Case IPR2025-01173
Patent No 11,673,805

PATENT OWNER SUR-REPLY

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PATENT OWNER'S EXHIBIT LIST

Exhibit	Shorthand	Description
2001	Darde-US	U.S. Patent Application Pub. No. 2015/0321914
2002		File History of U.S. Patent Application Pub. No. 2015/0321914
2003	Reinertsen-PCT	PCT Publication WO 2021/175662
2004	Reinertsen FW	File History of U.S. Patent Application Pub. No. 2023/0119784
2005		Search Results of Subclasses from Google Patents available online at: https://patents.google.com/?q=(C01B3%2f40+OR+B01D53%2f047+OR+C01B3%2f48+OR+C01B2203%2f0233+OR+C01B2203%2f0244+OR+C01B2203%2f0405+OR+C01B2203%2f042+OR+C01B2203%2f046+OR+C01B2203%2f1058+OR+C01B2203%2f1241+OR+B01D53%2f002+OR+C01B32%2f50+OR+B01D53%2f22+OR+B01D2256%2f16+OR+B01D2257%2f504+OR+C01B2203%2f0283+OR+C01B2203%2f043+OR+C01B2203%2f0475+OR+C01B2203%2f147+OR+Y02C20%2f40+OR+Y02P20%2f151+OR+C01B3%2f56+OR+C01B3%2f38+OR+C01B3%2f503+OR+C01B3%2f506+OR+C01B2203%2f0261+OR+C01B2203%2f0811+OR+C01B2203%2f1235+OR+C01B3%2f382+OR+F25J3%2f067+OR+F25J3%2f08+OR+C01B2203%2f0833+OR+C01B2203%2f0838)&country=WO,US,EP,JP&before=filing:20221005
2006	Search Printout	Listing of Patent Families in Examiner's Search Printout from the '805 Patent File History
2007	Kresnvak	U.S. Patent Application Pub. No. 2015/0141535
2008	Family 1	Espacenet Listing of Patent Family for WO2006042986A1

Exhibit	Shorthand	Description
2009	Family 2	Espacenet Listing of Patent Family for WO2022178439A1
2010	Family 4	Espacenet Listing of Patent Family for WO2010022162A2
2011	Family 5	Espacenet Listing of Patent Family for WO2007123673A1
2012	Family 6	Espacenet Listing of Patent Family for WO2014005745A1
2013	Family 7	Espacenet Listing of Patent Family for CN113795460A
2014	Family 8	Espacenet Listing of Patent Family for WO2014091097A1
2015	Family 9	Espacenet Listing of Patent Family for JP5677659B2
2016	Family 10	Espacenet Listing of Patent Family for WO2014091098A1
2017	Family 11	Espacenet Listing of Patent Family for WO2015173290A1
2018	Family 14	Espacenet Listing of Patent Family for WO2019162236A1
2019	'805 Patent Family	Espacenet Listing of Patent Family for US11673805B2
2020	L'Air Liquide Publications	Espacenet Listing of Patent Family for US20210155478
2021	Smith	Declaration of Dr. Joseph Smith, Ph.D.
2022	Smith CV	CV of Dr. Joseph Smith, Ph.D.
2023	Klein Depo	Transcript of 4/2/2026 Deposition of Dr. Klein
2024	Klein Depo2	Transcript of 8/7/2026 Deposition of Dr. Harald Klein

I. Introduction

Petitioner's Reply confirms what the Petition could only obscure: no prior art reference discloses, and no combination of references renders obvious, the claimed sequence of pressure swing adsorption ("PSA") hydrogen separation *upstream of* cryogenic carbon dioxide separation. Rather than confront that gap, Petitioner asks the Board to overlook it—first by mischaracterizing an unsupported obviousness theory as one of anticipation, and then by defending obviousness combinations that no POSITA would have been motivated to make.

On Ground 1, Petitioner cannot show that Reinertsen discloses the elements of claim 1 arranged as the claim requires. Reinertsen's embodiments either use Pd-membrane H₂ separation upstream of CO₂ separation, or use PSA H₂ separation only *downstream of* CO₂ separation—never PSA H₂ separation *upstream of* cryogenic CO₂ separation. To manufacture "anticipation," Petitioner must substitute PSA for the Pd-membrane in one embodiment and add a cooling step Reinertsen never discloses. Substitution and addition are hallmarks of obviousness, not anticipation, and Reinertsen supplies no instruction, express or inherent, for either modification. If anything, Reinertsen affirmatively discourages the very sequence Petitioner needs: it warns that placing PSA upstream of CO₂ separation would create a costly, low-pressure CO₂ stream requiring further compression and cooling, and it invariably resolves that concern by placing PSA downstream of CO₂ separation.

Grounds 2 and 3 fare no better. Petitioner's obviousness theories depend on modifying Reinertsen or Rytter with Darde, but Petitioner never identifies any improvement a POSITA would have reasonably sought to achieve via those modifications. That omission is fatal to Petitioner's grounds because Reinertsen's own data show that substituting PSA H₂ separation upstream of cryogenic CO₂ separation would sacrifice both hydrogen recovery and carbon capture relative to Reinertsen's configurations. The worst of both worlds is not a "suitable option."

Darde does not rescue Petitioner's obviousness theories: Darde adopted that inferior combination only in pursuit of other results—steam production and condensate capture—that are absent from Petitioner's proposed Reinertsen-Darde and Rytter-Darde combinations. Absent *any* corresponding benefit, a POSITA would not have been motivated to incorporate only drawbacks from Darde to thereby materially reduce Reinertsen's or Rytter's H₂ production and CO₂ capture.

Finally, Petitioner's attempt to discredit Dr. Smith's testimony by reducing it to a single, cherry-picked statement about hydrogen purity ignores that purity was Petitioner's own chosen metric, and ignores the substance of Dr. Smith's unrebutted analysis of Reinertsen's disclosed hydrogen-recovery and carbon-capture data. For these reasons, detailed below, Petitioner has not met its burden to prove any challenged claim unpatentable.

II. Ground 1: Reinertsen Does Not Anticipate Claim 1

Claim 1 requires “(e) separating hydrogen from the fourth synthesis gas stream by pressure swing adsorption . . .” and “(f) separating carbon dioxide from the first residual gas stream obtained in step (e) by cryogenic carbon dioxide separation” POR, 5; EX1001, 15:15-35. Claim 1 therefore requires not just any combination of PSA H₂ separation and cryogenic CO₂ separation, but a particular sequence of those steps, namely PSA H₂ separation *upstream of* cryogenic CO₂ separation. Reinertsen does not disclose that sequence.

At base, Petitioner contends that Reinertsen discloses the claimed sequence because (a) one of multiple disclosed embodiments includes Palladium membrane H₂ separation upstream of cryogenic CO₂ separation, and (b) there is a separate mention of PSA H₂ separation outside of the description of the FIG. 4 embodiment on which Petitioner relies. But Petitioner neglects Reinertsen’s actual disclosure.

To start, Reinertsen explicitly discourages placing PSA H₂ separation upstream of CO₂ separation. Early in its description, Reinertsen generically introduces PSA H₂ separation “[h]ydrogen may be separated from a hydrogen containing gas mixture by use of a pressure swing absorption/adsorption (PSA) processor.” EX1005, ¶[0056]. Reinertsen continues that the PSA reactor can be “a large and costly part of the hydrogen plant” and “may also result in CO₂ being released at low pressure, e.g. atmospheric pressure, and so there is a subsequent need

for compression and cooling.” EX1005, ¶[0056]. Even so, Reinertsen teases that “[s]till, it can be feasible to use PSA for some hydrogen production plants.” EX1005, ¶[0056]. The plain implication of that last sentence is that a POSITA would have expected the “subsequent need for compression and cooling” to undermine feasibility of using PSA for H₂ separation *upstream of* CO₂ separation.

Nevertheless, Petitioner proffers the “can be feasible” sentence as a suggestion that PSA H₂ separation *upstream of* CO₂ separation might be feasible. *See* Reply, 11, 12, 16-17 (citing EX1005, ¶[0056]). But that sentence conspicuously does not mention downstream CO₂ separation of any sort, much less cryogenic CO₂ separation. *See* EX1005, ¶[0056]. In fact, Dr. Klein’s testimony confirmed that instead placing PSA H₂ separation *downstream of* CO₂ separation avoids the issue altogether: “If you install an amine-based CO₂ removal system downstream of a water gas shift reactor and your target is to remove all CO₂, then there is no CO₂ going to the PSA” and “[t]herefore, there is no CO₂ released in the residual gas of the PSA.” EX2024, 25:23-26:11. By no coincidence, in addition to multiple embodiments using Pd-membrane H₂ separation *upstream of* CO₂ separation, Reinertsen discloses several embodiments using PSA H₂ separation *downstream of* CO₂ separation. But embodiments with PSA H₂ separation *upstream of* CO₂ separation (of any sort)? Reinertsen does not disclose a single one.

A. Reinertsen does not disclose PSA H₂ separation *upstream of* cryogenic CO₂ separation

Reinertsen focuses on the use of membranes, especially Pd membranes, for H₂ separation. See EX1005, ¶¶[0011], [0062], [0108], [0149], Embodiment Examples 1-7, FIGs. 10-12; POR, 6-9. To that end, most of Reinertsen's disclosed embodiments involve Pd-membrane H₂ separation upstream of CO₂ separation. See e.g., EX1005, Embodiment Example 1 (¶¶[0105]-[0107], FIG. 3), Embodiment Example 2 (¶¶[0109]-[0110], FIG. 4), Embodiment Example 3 (¶¶[0111]-[0113], FIG. 5), Embodiment Example 4 (¶¶[0114]-[0116], FIG. 6), Embodiment Examples 5-7 (¶¶[0122]-[0125], FIG. 7), Embodiment Example 8 (¶[0128], FIG. 8), Embodiment Example 9 (¶[0129], FIG. 9); POR, 6-9; EX2023, 68:10-69:8 ("His examples, besides the comparative example, *all include palladium membrane, yes.*"¹), EX2023, 69:2-8 (Dr. Klein confirming that in each of embodiment examples 1 through 5 with the palladium membrane, either the amine separation or the cryogenic separation *can follow* the palladium membrane); see also EX1005 ¶[0108] ("Advantageously, the use of a Pd-membrane separator for separating hydrogen as the subsequent process to the WGS process allows the hydrogen separation process to be performed particularly efficiently and effectively."). But Reinertsen also discloses several embodiments involving PSA H₂ separation, all of

¹ All emphasis added except where otherwise noted.

which put PSA *downstream of* CO₂ separation. *See, e.g.*, EX1005, ¶[0056] (“PSA processes may also result in CO₂ being released at low pressure ... so there is a subsequent need for compression and cooling. Still, it can be feasible to use PSA for some hydrogen production plants [such as Figure 2 in which CO₂ is separated *before* PSA hydrogen separation].”), ¶[0085] (disclosing membrane CO₂ separation followed by PSA hydrogen separation); EX2024, 16:9-21 (Dr. Klein confirming that Reinertsen’s paragraph [0085] describes membrane CO₂ separation followed by PSA H₂ separation); *see also* POR, 7-9.

1. Petitioner mischaracterizes its argument as one of anticipation rather than obviousness

“Because the hallmark of anticipation is prior invention, the prior art reference—in order to anticipate under 35 U.S.C. § 102—must not only disclose all elements of the claim within the four corners of the document, but must also disclose those elements ‘*arranged as in the claim.*’” *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008) (quoting *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983)).

Petitioner cannot show that Reinertsen discloses all elements “arranged as in the claim”. Instead, Petitioner’s Reply relies heavily on Reinertsen paragraph [0085]’s mention of pressure swing adsorption (PSA) as a way in which certain embodiments can separate hydrogen (H₂). Reply, 6, 8, 11. Taking a bit of creative license, Petitioner then interprets “embodiments” to mean *any* embodiment, and

concludes that, obviously, Reinertsen must have intended PSA H₂ separation as a substitute for Pd-membrane H₂ separation *in the particular embodiment* of FIG. 4 described three headings and 34 paragraphs later. *Compare* EX1005, ¶[0085] *with id.*, ¶[0109] (under the heading “Embodiment Example 2”); Reply, 6. Not so.

Petitioner’s theory relies on a substitution in Reinertsen’s FIG. 4 embodiment of PSA H₂ separation for Pd-membrane H₂ separation. *See* Reply, 6 (“PSA is thus a direct substitute for Pd-membrane at the same position (Unit 12 of Figures 3-7).”). And Dr. Klein further conceded that it would also require further modification, namely the cooling of shifted gas before it could be fed to a PSA H₂ separation unit. EX2024, 40:1-4. Reinertsen discloses neither modification, so cannot anticipate.

2. Reinertsen’s paragraph [0085] only describes PSA H₂ separation following membrane CO₂ separation

Despite Petitioner’s efforts to characterize its mention of PSA as broadly applicable to any of Reinertsen’s disclosed embodiments, Reinertsen’s paragraph [0085] instead mentions PSA H₂ separation only *after* membrane CO₂ separation. EX1005, ¶[0085]; EX2024, 16:9-17 (“This is separation of CO₂ with a membrane ... Reinertsen starts in 85, paragraph 85, with embodiments may alternatively use a combination of solid membranes. ... That’s the first part of paragraph 85. ... the remaining two-thirds of paragraph 85 is describing the [PSA]”). That is, Dr. Klein himself admitted that Reinertsen’s paragraph [0085] first discloses embodiments using membranes for CO₂ separation, and—in that context of

membrane CO₂ separation—mentions that some such “embodiments” can use PSA for H₂ separation. EX2024, 16:18-21 (“So my understanding of that paragraph [85] is it’s really alternatively to, let’s say, the main parts of -- in his patent where it describes CO₂ separation.”), 16:9-17:17. Thus, Reinertsen’s paragraph [0085] discloses PSA H₂ separation only after membrane CO₂ separation.

Nevertheless, Petitioner argues that paragraph [0085]’s mention of the “use PSA to separate hydrogen *from the gas output from the WGS reactor*” means the PSA must be *upstream* of CO₂ separation. Reply, 6; EX1005, ¶[0085]. Petitioner’s position is belied both by paragraph [0085] itself (which *first* describes CO₂ separation), and by Reinertsen’s discussions elsewhere of gas output from the WGS reactor. For example, Reinertsen’s claim 1 recites “performing a hydrogen separation process *and* a carbon dioxide separation process *on the shifted gas*.” EX1005, Cl. 1. Despite one necessarily preceding the other, the plain language says both are performed “on the shifted gas,” meaning “on the shifted gas” does not denote gas received directly from a WGS reactor. *See* EX2024, 10:6-11:3 (confirming “the shifted gas” is the “shifted gas coming from the water gas shift reactor”), 11:13-12:5 (confirming that claim 1’s recitation of performing separation functions “on the shifted gas” includes CO₂ separation upstream of H₂ separation, such as in Reinertsen FIG. 2’s embodiment with amine CO₂ separation upstream of PSA H₂ separation). Thus, by Dr. Klein’s own admission, paragraph [0085]’s use

of the phrase “gas output from the WGS reactor” does **not** inherently suggest—much less necessitate—that hydrogen separation would occur before CO₂ separation.

Moreover, when asked about the residual gas from the PSA unit, Dr. Klein admitted that Reinertsen’s paragraph [0085] does not address what happens to the adsorbed components downstream of the PSA. EX2024, 24:12-15 (Q: “Paragraph 85 doesn’t address what happens to those adsorbed components downstream of the PSA, does it?” A: “No. Correct.”). Stated another way, Dr. Klein conceded that paragraph [0085] starts by describing embodiments with membrane CO₂ separation, and—after mentioning the possibility of using PSA H₂ separation in such embodiments—does **not** describe any downstream CO₂ separation (much less cryogenic CO₂ separation).

3. *Petitioner misconstrues Dr. Smith’s testimony*

Reinertsen plainly undermines Petitioner’s characterization of Dr. Smith’s testimony. For example, Petitioner points to Dr. Smith’s general mention of “best practices” as a starting point, and attempts to paint Dr. Smith’s agreement that Reinertsen discloses cryogenic CO₂ separation downstream of Pd-membrane H₂ separation as a concession that H₂ must always be downstream. Reply, 5-6. But Dr. Smith “admitted” only that Reinertsen’s examples show what Reinertsen describes them as showing: *Pd-membrane* H₂ separation followed by CO₂ separation.

Indeed, read in context, the cited passages directly undercut Petitioner's contention. Rather than disclosing the claimed sequence, Reinertsen expressly discourages use of PSA for H₂ separation upstream of CO₂ separation. EX1005, ¶[0056] (lamenting size, cost, and need for downstream CO₂ compression when using PSA for H₂ separation upstream of CO₂ separation); EX2024, 25:23-26:11. And, when thereafter addressing the possibility of PSA for H₂ separation, Reinertsen places that PSA H₂ separation *downstream of* CO₂ separation. EX1005, FIG. 2, ¶¶[0103] and [0085]; EX2024, 16:9-17.

4. Reinertsen does not anticipate

In sum, Petitioner relies primarily on the embodiment of Reinertsen's Figure 4, but seeks to *modify* that embodiment with Reinertsen's paragraph [0085] *and* by introducing cooling of shifted gas between the WGS reactor and the purportedly added PSA H₂ separation. Absent an express or inherent instruction to make those particular modifications, which Reinertsen lacks, Petitioner's theory is one of obviousness rather than anticipation.

Petitioner argues for an inherent instruction to at least substitute PSA H₂ separation but, as explained above, Reinertsen says otherwise. After lamenting the size, cost, and need for downstream CO₂ compression if performing PSA H₂ separation upstream of CO₂ separation, Reinertsen notes that PSA can still be viable. EX1005, ¶[0056]. How so? Reinertsen answers repeatedly with examples using

PSA H₂ separation only *after* CO₂ separation. EX1005, ¶¶[0085], [0103], FIG. 2.

Thus, Reinertsen does not disclose, even implicitly, the sequence of claim 1.

B. Claim 11: Reinertsen does *not* disclose cryogenic CO₂ separation subjecting the first residual gas stream to a compression step

Petitioner's theory of anticipation for claim 11 suffers the same flaws as its theory for claim 1, addressed above. And that theory is even more faulty for claim 11. In particular, Dr. Klein previously conceded that CO₂ compression would not be necessary in Reinertsen's embodiment of FIG. 4 when the process gas exits the Pd-membrane H₂ separation at sufficient pressure. *See, e.g.*, EX2023, 104:2-11; *see also* POR, 10-12. Dr. Klein also conceded that, for its FIG. 4 embodiment, "Reinertsen does *not* disclose a compressor between [its] palladium membrane at 12 and the CO₂ capture unit at 13." EX2023, 99:6-9. Thus, Petitioner's "anticipation" theory rests on multiple modifications of Reinertsen's FIG. 4: (1) replacing the Pd-membrane H₂ separation with PSA H₂ separation, and (2) adding a compressor between PSA H₂ separation and its CO₂ separation. Reinertsen does not anticipate.

III. Grounds 2 and 3: Reinertsen-Darde and Rytter-Darde Do Not Render Obvious Claim 1

On Reply, Petitioner fails to identify or defend any improvement to Reinertsen or Rytter that would have motivated a POSITA to make the alleged modifications. Instead, Petitioner defends its failure to identify any such improvement. At base, Petitioner skims past the art's suitable options for H₂ and CO₂ separation from

shifted gas—namely CO₂ separation upstream of PSA H₂ separation or Pd-membrane H₂ separation upstream of CO₂ separation—to instead parse the art more finely than a POSITA would have done. In particular, Petitioner attempts to isolate H₂ separation methods and CO₂ separation methods independently of the order in which a POSITA would have performed them. But Petitioner can only do so by neglecting the teachings of the very evidence on which the Petition relies.

Petitioner attempts to characterize its obviousness theories as merely choosing from among known “suitable options.” Reply, 10-11. What Petitioner actually does, however, is (i) dissect the processes disclosed by Reinertsen and Rytter, (ii) abstract and reassemble certain elements in the manner needed to challenge claim 1, and (iii) seek confirmation in Darde’s configuration, which a POSITA would have viewed as distinctly unsuitable for Reinertsen or Rytter’s stated goal of producing hydrogen. That a POSITA would *not* have been motivated to make the alleged modifications is laid bare by Petitioner’s failure to dispute that PSA would capture significantly less (86%) hydrogen than would Pd-membrane (93%).

A. Obviousness turns on what would have been understood by and desirable to a POSITA; not on how finely Petitioner parses the art

Obviousness concerns not only whether POSITA “*could* have made” the proposed combination, but whether they “*would have been motivated to [do so].*” *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) (emphasis in

original). *KSR* and *Intel* are entirely consistent. *Intel*, for example, recognizes that a solution need not be “best,” but must—at a minimum—be “suitable.” *Intel Corp. v. PACT XPP Schweiz AG*, 61 F.4th 1373, 1380 (Fed. Cir. 2023). Likewise, *KSR* contemplates choosing from among a “finite number of *identified*, predictable solutions.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

Neither *KSR* nor *Intel* relieve Petitioner of its burden to show that there would have been some expectation of *improvement* to motivate a POSITA to modify Reinertsen or Rytter with Darde. For example, *Intel* quotes *KSR* for the proposition that “[t]here is a motivation to combine when a known technique ‘has been used to *improve* one device, and a person of ordinary skill in the art would recognize that it would *improve* similar devices in the same way.’” *Intel*, 61 F.4th at 1380-81 (quoting *KSR*, 550 U.S. at 417). On Reply, rather than point to or defend motivating expectations for improvement, Petitioner instead tries to defend its lack thereof.

That difference is telling. First, Petitioner contends that obviousness does not require a motivation *per se*, suggesting even a Hobson’s choice would do. Reply, 10-11. Petitioner next attempts to cast Reinertsen’s explicit *discouragement* of PSA H₂ separation upstream of CO₂ separation as merely an alternative option. Reply, 11-13. Petitioner then brushes aside Reinertsen’s explicit disclosure that PSA recovers only 86% of hydrogen—significantly less than the 93% recovered by Reinertsen’s Pd-membrane—to focus instead on how almost-as-good PSA’s 99%

purity is relative to Pd-membrane’s “often greater than 99.9%” purity. Reply, 13-16; *see* EX1005, ¶[0062], FIG. 11. Finally, Petitioner attempts to minimize the utterly-unnecessary compression of CO₂ as acceptable because H₂ compression is more difficult (Reply, 16-18), but conspicuously neglects the fact that Reinertsen’s PSA H₂ embodiments still require *at least tenfold H₂ compression*. *See, e.g.*, EX1005, ¶[0103]; EX2024, 40:13-42:7. Ultimately, even on Reply, Petitioner does not once identify any *improvement* a POSITA might have reasonably sought by modifying Reinertsen or Rytter.

B. Reinertsen teaches away by expressly discouraging the use of PSA H₂ separation *upstream of* CO₂ separation

As explained above in Section II.A, Reinertsen explicitly *discourages* the use of PSA H₂ separation upstream of CO₂ separation. *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004) (teaching away requires prior art disclosure to “criticize, discredit, or otherwise discourage the solution claimed”). Rather than take Reinertsen’s discouragement head-on, Petitioner attempts to recast the issue as whether Reinertsen discloses PSA H₂ separation in the abstract. But that is not what the Federal Circuit requires.

The key issue is whether Reinertsen “discourage[s] the solution *claimed*”—i.e., PSA H₂ separation upstream of cryogenic CO₂ separation. *Id.* Reinertsen plainly does so by lamenting the need for CO₂ compression, and implicitly

acknowledging that that need could render PSA infeasible for hydrogen production. EX1005, ¶[0056] (“Still, it can be feasible to use PSA for some hydrogen production plants.”). And, as further discussed in Section II.A, Reinertsen goes on to describe the types of hydrogen production plants in which PSA can “still” be feasible—i.e., those in which CO₂ is separated before PSA H₂ separation. EX1005, FIG. 2, ¶¶[0103] and [0085]; EX2024, 16:9-17.

Under the proper standard, Reinertsen plainly discourages PSA H₂ separation *upstream of* CO₂ separation, and thereby teaches away from the claimed solution.

C. Petitioner does not dispute that its PSA modifications would significantly reduce the amount of hydrogen produced relative to Pd-membrane separation

As explained in the Patent Owner Response, Reinertsen’s FIG. 4 system already exhibits an *H₂ capture rate of 93%* (EX1005, FIG. 11 (Embodiment Example 2)), and directly indicates that PSA H₂ separation significantly reduces that H₂ capture rate to just 86% (*id.* (Comparative Example)). POR, 13, 16. As such, a POSITA would have understood and expected from this that PSA hydrogen separation would have a materially lower H₂ capture rate than Reinertsen’s Pd-membrane separation. POR, 16-18; EX2021, ¶¶60-61. Petitioner does not dispute that its PSA modification would materially harm the hydrogen-production performance relative to the Pd-membrane. *See* Reply, 13.

Instead, Petitioner dismisses (incorrectly) the 93% figure as a mere assumption for a “technology that had never operated beyond pilot scale.” Reply, 13. When deposed, Dr. Klein conceded that EX1018 not only supports Reinertsen’s significantly higher recovery rate for Pd-membrane H₂ separation, but confirms that membrane H₂ separation had already been deployed at scale. First, EX1018—which shows “technologies that Air Liquide can provide to customers” as of 2015—discloses, for PSA, a “H₂ recovery rate” of just “60-90%” and, for membrane separation, “hydrogen recovery” of “>98%”. Compare EX1018, 38/108 (“(PSA) Hydrogen Purification”) with 42/108 (“Hydrogen Separation Membranes”); EX2024, 49:22-50:5, 51:8-19. Thus, EX1018—which Petitioner and Dr. Klein themselves cite for commercial expectations (e.g., Reply, 14)—demonstrates that Reinertsen’s 93% “assumption” is actually *conservative* given EX1018’s disclosed hydrogen recovery of *greater than 98%* for membrane separation. EX1018, 42/108.

Moreover, rather than membrane H₂ separation being a mere pilot technology, Dr. Klein conceded that EX1018’s discussion of a “Largest system referenced” indicates both that there is an *actual* system with 124 membrane cartridges, and that it is only one of multiple *actual* systems. EX2024, 51:20-52:11.

Thus, documentary evidence introduced and relied upon by Petitioner itself confirms that membrane separation was available for hydrogen, and that a POSITA would have expected using PSA instead to materially reduce hydrogen capture.

D. Reinertsen discloses “suitable options” for hydrogen production with CO₂ capture

Reinertsen’s core purpose is hydrogen production, with a secondary function of carbon capture. *See, e.g.*, EX1005, Abstract, ¶[0005]; EX2024, 35:6-36:5. As set forth in Section II.A above, Reinertsen’s system uses either (1) membrane hydrogen separation upstream of cryogenic CO₂ separation or (2) amine or membrane CO₂ separation upstream of PSA hydrogen separation. Importantly, Reinertsen’s embodiments using Pd-membrane hydrogen separation *upstream of* cryogenic CO₂ separation achieve H₂ recovery of 93%, significantly higher than the H₂ recovery of just 86% for its embodiment with PSA H₂ separation *downstream of* amine CO₂ separation. *See, e.g.*, EX1005, FIG. 11 (*compare* H₂ recovery factor of Comparative Example *with* that of Embodiment Examples 1-4).

On the other hand, despite lower hydrogen recovery, Reinertsen’s embodiment with PSA H₂ separation *downstream of* amine CO₂ separation at least improves carbon capture (97.5%) relative to the 90% carbon capture of Pd-membrane upstream of cryogenic CO₂ separation. These embodiments represent reasonable tradeoffs within the context of Reinertsen’s stated goals of producing hydrogen while capturing CO₂ that might be “suitable” even if not ideal for hydrogen production. *Intel*, 61 F.4th at 1380-81. In contrast, a POSITA would have recognized from Reinertsen’s disclosed H₂ and CO₂ capture rates that combining PSA H₂ separation upstream of cryogenic CO₂ separation would achieve the worst

of both worlds. *See* POR, 16-18; EX2021, ¶¶57-63. With no identified benefit, that undisclosed combination of features would significantly harm both H₂ production and CO₂ capture and, thus, is not “suitable” for Reinertsen’s stated purpose.

E. Darde does not disclose a “suitable option” for Reinertsen or Rytter

As explained above, Reinertsen’s own disclosure indicates that Darde’s combination of PSA H₂ separation upstream of cryogenic CO₂ separation would be the very worst combination of individual separation steps both in terms of achieving the worst possible H₂ capture and the worst possible carbon capture. That begs the question: why on earth would Darde have used that combination? The answer lies in the additional variables for which Darde sought to solve—i.e., (1) steam production (EX1008, Title) and (2) capturing condensates (*id.*, Abstract). EX2021, ¶51; POR, 13-14 (§VI.B). Of course, Darde’s system requires additional equipment to achieve the additional benefits that apparently offset worse hydrogen production and worse carbon capture. EX2021, ¶51; POR, 13-14 (§VI.B).

Petitioner’s combination does ***not*** purport to be motivated by a desire to add Darde’s steam production or condensate capture to either of Reinertsen’s or Rytter’s respective systems. *See, e.g.*, Pet., 40-44, 58-63; POR, 17, fn.2; EX2021, fn.1. Petitioner’s combination also does ***not*** purport to add any of the equipment Darde relies on for that steam or condensate capture. *See* POR, 17, fn.2; EX2021, fn.1. Thus, Petitioner’s alleged modification—without alleged or even incidental

benefit—would materially harm both the hydrogen production and carbon capture of each of the Reinertsen and Rytter systems.

Moreover, Reinertsen articulates a clear preference for “the use of a *Pd-membrane* to separate hydrogen *immediately downstream* of a WGS reactor,” specifically because that configuration “has a surprising synergistic effect.” EX1005, ¶[0149]. “Contrary to known techniques, the WGS reactor may be operated at substantially the same temperature as the Pd-membrane” (*id.*), which Dr. Klein concedes would **not** be true for PSA H₂ separation immediately downstream of a WGS reactor because cooling would be needed before shifted gas can be fed to a PSA. EX2024, 38:23-39:4. The inability to send shifted gas directly to a PSA is yet another reason a POSITA would have known to avoid placing PSA H₂ separation upstream of cryogenic CO₂ separation in either of Reinertsen or Rytter’s systems. This is especially so because a POSITA would have recognized that amine CO₂ separation *upstream* of PSA H₂ separation—between the WGS reactor and the PSA—mitigates that issue by cooling the shifted gas before the PSA. *See, e.g.*, EX1005, FIG. 2, ¶[0103] (shifted gas cooled in condenser 7). Thus, Petitioner’s alleged modification would also dismantle the very configuration Reinertsen relies on for its “surprising synergistic effect.”

With that foundation—an asserted modification that directly undermines the core purposes of Reinertsen and Rytter—Petitioner’s “routine optimization” theory

just adds lipstick to the pig. *See* Reply, 16-23. As such, in the context of Reinertsen or Rytter, there is nothing “suitable” about Darde’s configuration.²

F. Reinertsen confirms that compressing CO₂ downstream of PSA H₂ separation was significant, undesirable, and avoidable

As explained above in Section II.A, Reinertsen explicitly *discourages* the use of PSA H₂ separation upstream of CO₂ separation. Reinertsen does so because PSA “*may* [if used upstream of CO₂ separation] ... result in CO₂ being released at low pressure, and so there is a subsequent need for compression and cooling.” EX1005, ¶[0056]. Despite this, Reinertsen discloses configurations in which “it may be feasible to use PSA for some hydrogen production plants” (EX1005, ¶[0056])—i.e., those in which CO₂ separation is performed upstream of PSA H₂ separation. EX1005, FIG. 2, ¶¶[0103], [0085]; EX2024, 16:9-17. Thus, Reinertsen explicitly identifies CO₂ compression downstream of PSA H₂ as undesirable, plainly indicates that it may render PSA H₂ separation infeasible for hydrogen production plants, and then discloses alternative configurations—e.g., amine CO₂ separation *upstream of*

² That a POSITA would have viewed Darde’s configuration as *not* suitable for Reinertsen is also confirmed by independent documentary evidence submitted by Petitioner itself. In the context of “Natural Gas Partial Oxidation” (which Reinertsen uses), cryogenic CO₂ separation is conspicuously *absent* from the list of “Suitable purification technologies.” EX1018, 32/108; EX2024, 55:8-56:8.

PSA H₂ separation—that *avoid* the need for CO₂ compression and cooling for cryogenic CO₂ separation.

Undaunted by Reinertsen’s express disclosures on this very point, Petitioner attempts to cast CO₂ compression downstream of PSA H₂ separation as preferable to other options because hydrogen is more difficult to compress. Reply, 16-18. But Petitioner’s framing of this issue as a choice between CO₂ compression and H₂ compression is a red herring.

Reinertsen itself makes clear that hydrogen compression is always necessary, even when using PSA H₂ separation: “Finally, the produced hydrogen 101 is compressed 11 to give hydrogen 111 at 340 bar.” EX1005, ¶[0103] (describing FIG. 2 embodiment). Dr. Klein agrees that “even downstream of PSA, the hydrogen would need to be compressed by a factor of 10.” EX2024, 42:4-7. Indeed, despite its focus on hydrogen production, Reinertsen itself chose to explicitly discourage the use of PSA H₂ separation upstream of CO₂ separation, precisely to avoid a need for compression and cooling of CO₂. EX1005, ¶[0056].

IV. Petitioner’s Criticism of Dr. Smith’s Testimony Is Misplaced

Petitioner attempts to dismiss Dr. Smith’s declaration by distilling his 61-page declaration down to a single point, purportedly that his “declaration’s deciding consideration” was merely “PSA’s supposedly inferior purity.” Reply, 24-25 (citing only EX2021, ¶59). Ironically, it was Petitioner who first pointed to hydrogen purity

as an alleged motivation for modifying Reinertsen and Rytter. *See* Pet., 43 (“the capability for generating ***high purity*** H₂ at a useful pressure”). Petitioner is apparently now happy to abandon purity as a useful metric, to avoid contaminating its own theories. Reply, 13-15, 24-25.

Moreover, Petitioner’s characterization of Dr. Smith’s testimony, as somehow relying on purity alone, is demonstrably false. For example, Dr. Smith explained at length why a POSITA would have expected from Reinertsen’s explicit disclosure that, while maintaining similar hydrogen purities, Petitioner’s modifications would significantly *reduce* hydrogen capture. EX2021, ¶¶60-61. Petitioner’s attempt to dismiss Dr. Smith’s testimony as lacking simulation or design study also rings hollow given Dr. Klein’s choice to forego any such simulation or design study. *See, e.g.*, EX2024, 8:17-21; EX2023, 101:1-103:14. Critical to the weight that should be accorded their respective testimony, Dr. Smith’s analysis addressed the references in their entireties, including parts inconsistent with Petitioner’s desired result.

V. Conclusion

For the reasons explained above and in the POR, Petitioner has failed to establish unpatentability of the challenged claims.

Dated: August 19, 2026

Respectfully submitted,

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(a)(i), the undersigned certifies that this Paper—exclusive of the table of contents, exhibit list, certificate of service, and this certificate of word count—includes 4,887 words. The undersigned relies upon the word count feature of Microsoft Word.

/Eagle H. Robinson/

Eagle H. Robinson (Reg. No. 61,361)

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6(e), the undersigned certifies that on August 19, 2026, complete copies of the foregoing Patent Owner Sur-Reply and EX2024 were served on Petitioner via email (by consent), at the following email address(s):

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