

11 UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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TOPSOE, INC.,

Petitioner

v.

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

Patent Owner

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Case IPR2025-01173  
Patent No 11,673,805

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**PATENT OWNER’S EXHIBIT LIST**

<b>Exhibit</b>	<b>Shorthand</b>	<b>Description</b>
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: <a href="https://patents.google.com/?q=(C01B3%2f40+OR+B01D53%2f047+OR+C01B3%2f48+OR+C01B2203%2f0233+OR+C01B2203%2f0244+OR+C01B2203%2f0405+OR+C01+B2203%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+CO1B2203%2f0283+OR+CO1B2203%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)&amp;country=WO,US,EP,JP&amp;before=filing:20221005">https://patents.google.com/?q=(C01B3%2f40+OR+B01D53%2f047+OR+C01B3%2f48+OR+C01B2203%2f0233+OR+C01B2203%2f0244+OR+C01B2203%2f0405+OR+C01+B2203%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+CO1B2203%2f0283+OR+CO1B2203%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)&amp;country=WO,US,EP,JP&amp;before=filing:20221005</a>
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

<b>Exhibit</b>	<b>Shorthand</b>	<b>Description</b>
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

## I. Introduction

All claims should be upheld.

For Ground 1, Petitioner fails to show that Reinertsen discloses PSA H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation, as required by claim 1. As such, Reinertsen does not anticipate claim 1 or any of its dependents.

For Ground 2 Petitioner fails to show that a POSITA would have modified Reinertsen with Darde to add the missing PSA H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation. Indeed, as Patent Owner's expert explains, a POSITA would have instead been motivated to *not* make such a modification to Reinertsen because doing so would—among other shortcomings—materially hurt the primary function of H<sub>2</sub> production, and would not any of the features Darde sought to achieve.

For Ground 3, Petitioner similarly fails to show that Rytter discloses PSA H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation, as required by claim 1. Petitioner also fails to show that a POSITA would have modified Rytter with Darde to add the missing PSA H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation. Indeed, as Patent Owner's expert explains, a POSITA would have been motivated to *not* make such a modification to Rytter because doing so would—among other shortcomings—materially hurt the primary function of H<sub>2</sub> production, and would not any of the features Darde sought to achieve.

## II. The Petition Maps Only the Series Configuration of Claim 1

The sole independent claim—Claim 1—recites two options for the configuration of the endothermic reforming step and the autothermal reforming step: (1) a series configuration and (2) a parallel configuration. *Compare* EX1001, 14:57-67 (parallel: mixing respective outputs of parallel endothermic reforming and autothermal reforming) *with id.*, 15:1-3 (series: routing first synthesis gas output of endothermic reforming as a feed into an autothermal reforming step). Examples of these two alternative configurations are also shown in the figures of the '805 Patent.

Figure 2 (annotated below) shows an example of the parallel configuration. *See* EX1001, 9:28-31 (“parallel arrangement of the reforming units for the endothermic and autothermal reforming steps”). In the parallel configuration, “[a] feed gas stream FG is divided into two substreams,” a first of which “is introduced into an [blue] endothermic reforming unit 200” and the second of which is “introduced into an [red] autothermal reforming unit 201.” EX1001, 11:16-23.

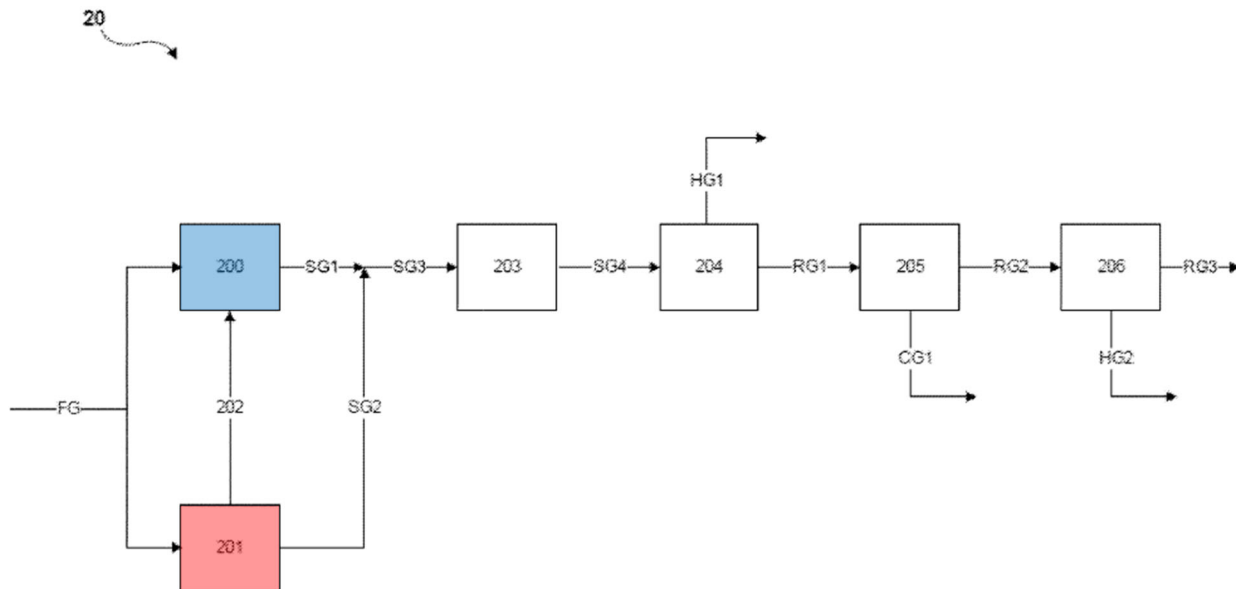


Fig. 2

Figure 3 (annotated below) shows an example of the series configuration. *See* EX1001, 9:32-35 (“series arrangement”). In the series configuration, “[a] feed gas stream FG is introduced into an [blue] endothermic reforming unit 200 and converted into a synthesis gas stream SG1” that “is [next] converted to a synthesis gas stream SG3 in the [red] autothermal reforming unit 201.” EX1001, 13:9-13.

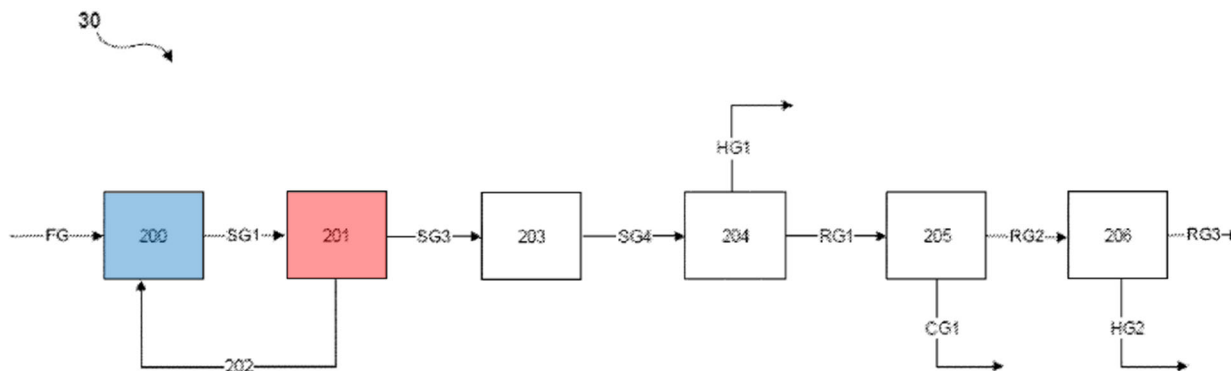


Fig. 3

Of these two configurations, the Petition in this proceeding addresses only the series configuration. *See, e.g.*, Pet., 10 (“Reinertsen describes a dual reformer arranged in a *series* configuration”<sup>1</sup>), 14 (“Figure 1 of Rytter illustrates a process including a GHR and an ATR arranged in a series configuration”); *see also* Paper 3, 4 (contrasting with the different “01174 ‘Parallel’ Petition”—“the ‘Series’ Petition (Petition 1, IPR2025-01173) demonstrates that it was known and/or obvious to employ such a [series] configuration”); EX2023, 31:13-16.

Thus, the Petition maps only the series configuration of claim 1.

### **III. Level of Ordinary Skill**

While Patent Owner does not necessarily agree with all aspects of Petitioner’s statement of the level of ordinary skill in the art, Patent Owner does not believe any potential disagreements would materially impact the analysis of the below issues. EX2021, ¶32.

### **IV. Claim Construction**

The claims are interpreted according to the Phillips claim construction standard. 83 Fed. Reg. 51340, 51340-44 (Oct. 11, 2018); *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (*en banc*).

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<sup>1</sup> All emphasis added throughout unless otherwise noted.

Patent Owner does not believe formal constructions are necessary to understand what is claimed or to resolve the issues raised below.

**V. Ground 1: Reinertsen Does Not Anticipate Claim 1**

Reinertsen fails to disclose *all elements* of independent claim 1 *arranged as in the claim*. To anticipate claim 1, Reinertsen must “disclose all elements of the claim within the four corners of the document,” and it must “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)). Reinertsen does not.

**A. Claim Elements [1.5] & [1.6]: Reinertsen does not disclose PSA hydrogen separation *upstream of cryogenic CO<sub>2</sub> separation***

Claim 1 of the '805 Patent recites [Element 1.5] “(e) separating hydrogen from the fourth synthesis gas stream by pressure swing adsorption ...” and [Element 1.6] “(f) separating carbon dioxide from the first residual gas stream obtained in step (e) by cryogenic carbon dioxide separation...” EX1001, 15:15-35.

The Petition points to Reinertsen’s Figure 4 as allegedly anticipating claim 1. *See, e.g.*, Pet. 20-22, 24, 25-37. But Reinertsen’s Figure 4 does not separate hydrogen by pressure swing adsorption or “PSA.” EX2021, ¶35; *see also* Pet., 33 (“[I]n Figure 4, Reinertsen discloses producing a hydrogen stream 121 by hydrogen

separation using a Pd-membrane 12.”); EX1005, ¶[0109] (“Pd-membrane”). Thus, the embodiment of Reinertsen’s Figure 4 does not anticipate claim 1.

The Petition tries to plug that gap by taking general passages out of context to misleadingly suggest that Reinertsen might disclose substituting PSA for Pd-membrane hydrogen separation *in the embodiment of Reinertsen’s Figure 4*. EX2021, ¶36. But Reinertsen does not. *Id.* More specifically, the Petition points to Reinertsen’s mention that “[e]mbodiments may *alternatively* use PSA to separate hydrogen from the gas output from the WGS reactor.” Pet., 34 (citing EX1005, ¶¶[0081], [0085]). The Petition also points to a sentence in Reinertsen stating that “[p]referably, the hydrogen separation process comprises a PSA process.” Pet., 34 (quoting EX1005, ¶[0012]).

Petitioner’s reliance on these statements is both misleading and insufficient. EX2021, ¶37. Neither statement bears any relation to the embodiment of Figure 4. *Id.* The second, “preferably” statement appears in the summary and is preceded with “[p]referably, the hydrogen separation process ... [uses] a Palladium membrane ... [not PSA].” EX1005, ¶[0011]; EX2021, ¶37. The first, “alternatively” statement on its face refers to *alternative* embodiments. *See, e.g.*, EX1005, Figure 2; EX2021, ¶37. And Petitioner fails to mention that, in those *other embodiments*, Reinertsen’s system uses *amine separation for CO<sub>2</sub>* before the PSA separation for hydrogen—which is both opposite to the order and lacks the requisite cryogenic separation of

claim 1 here. *See, e.g.*, EX1005, Figure 2, ¶[0103] (“Amine type separation process 8 separates CO<sub>2</sub> ...”); EX2021, ¶37. Notably, Figure 2—the only disclosed system with PSA—is a “Comparative Example” as a contrast for Reinertsen’s Embodiment Examples 1-12 (*all* of which use Pd-membrane). EX1005, ¶¶[0101]-[0103] (Reinertsen providing a “Comparative Example” in FIG. 2 before describing Embodiment Examples 1-12), Figure 10 (summarizing the process schemes of a comparative example (using PSA) and several embodiment examples (using Pd-membrane)); EX2021, ¶37. Thus, as Dr. Smith explains, “the fact that Reinertsen notes the possibility of PSA H<sub>2</sub> separation is entirely consistent with its disclosure of PSA H<sub>2</sub> separation *downstream of* amine CO<sub>2</sub> separation, and would not inherently disclose to a POSITA the use of PSA H<sub>2</sub> separation *upstream of* cryogenic CO<sub>2</sub> separation.” EX2021, ¶37. This is further emphasized by Reinertsen’s explanation of its own disclosure:

A number of process schemes are analyzed. These include one comparative example and a number of implementations of embodiments, *four of which are summarized in Table 1 in FIG. 10. The schemes* vary in WGS temperature, use of *Pd-membrane or PSA* for hydrogen separation, use of *amine solvents or cryogenic CO<sub>2</sub>* separation, as well as the position of water condensation.

EX1005, ¶[0097]; EX2021, ¶37. As is apparent, Reinertsen simply summarizes its disclosed “process schemes” in a general way; Reinertsen does *not* suggest that PSA

hydrogen separation might be used *upstream of* cryogenic CO<sub>2</sub> separation. EX2021, ¶37. This is especially so because, as explained below in Section V.B, the Pd-membrane H<sub>2</sub> separation provides both of the H<sub>2</sub>-rich and CO<sub>2</sub>-rich streams at high pressures, avoiding the need to compress the CO<sub>2</sub> rich stream for cryogenic CO<sub>2</sub> separation. *Id.*; *see also* EX1005, ¶[0084] (leaving hydrogen at a pressure comparable to the process gas); *see also* EX2023, 68:10-69:8 (“His examples, besides the comparative example, *all include palladium membrane, yes.*”).

Reinertsen also explains in several places—ignored by Petitioner—why PSA hydrogen separation is used only *after* CO<sub>2</sub> separation in Reinertsen’s system. *See, e.g.*, EX1005, ¶[0056] (“PSA processes may also result in CO<sub>2</sub> 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 CO<sub>2</sub> is separated *before* PSA hydrogen separation.]”); EX2021, ¶38. Critically, Reinertsen also explains that while “embodiments include the reforming process shown in FIG. 1 [relied on by Petitioner for Claim Elements 1.2 and 1.3 (*see* Pet., 24-31 (citing EX1005, ¶[0074])), embodiments also include *alternatively* using any other type of reforming process ... [e.g.,] *only* using an autothermal reformer or *only* using a gas-heated reformer.” EX1005, ¶[0075]; EX2021, ¶38. Thus, the “other embodiments” with PSA explicitly need not include the reformers of

Reinertsen's Figure 1 that Petitioner relies on for its mapping of Claim Elements 1.2 and 1.3. EX2021, ¶38.

Further Reinertsen explicitly highlights its “advantageous methods and system for production of hydrogen and/or ammonia.” EX1005, ¶[0149]; EX2021, ¶39. “In particular, the *use of a Pd-membrane to separate hydrogen immediately downstream of a WGS reactor* has a surprisingly synergistic effect” and “[c]ontrary to known techniques, the WGS reactor may be operated at substantially the same temperature as the Pd-membrane.” EX1005, ¶[0149]; EX2021, ¶39; *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.”).

For these reasons, Reinertsen does not disclose PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation and, thus, does not anticipate claim 1 (EX2021, ¶40), which Petitioner tacitly concedes. *See* Pet., 41 (“may nonetheless argue that the specific combination of PSA upstream of cryogenic CO<sub>2</sub> separation is not specifically exemplified in Reinertsen.”). Claim 1 and its dependents are therefore novel over Reinertsen.

**B. Claim 11: Reinertsen does *not* disclose cryogenic CO<sub>2</sub> separation subjecting the first residual gas stream to a compression step**

The Petition asserts that Reinertsen’s mention of “pressure” necessarily discloses “a compression step.” Pet., 38 (citing EX1005, FIGURE 4, ¶¶[0103], [0110]; EX1022, p. 19, ln. 5–21, p. 21, ln. 3-5; EX1023, p. 19, ln. 15-31, p. 21, ln. 13-15; EX1003, ¶¶[158–160]). Specifically, the Petition points to Reinertsen’s explanation that “embodiments preferably use cryogenic separation to separate CO<sub>2</sub>. That is to say, the gas steam is cooled to a temperature, and at a pressure, where CO<sub>2</sub> is liquefied.” Pet., 38 (emphasis in original) (quoting EX1005, ¶[0059]; citing EX1022, p. 9, ln. 14-16; EX1023, p. 9, ln. 16-19). For each of multiple reasons, the Petition fails to establish disclosure of a compression step.

First, as clearly indicated by the sentence in which it appears, the mention of “a pressure” does not explicitly disclose a compression step. *See* EX1005, ¶[0059]; EX2021, ¶42. Specifically, the sentence says that the gas stream is “cooled *to* a temperature, and *at* a pressure,” indicating that there is a change in temperature, but is not a change in pressure. *See* EX1005, ¶[0059]; EX2021, ¶42. Critically, Dr. Klein himself conceded that “Reinertsen does not disclose a compressor between [its] palladium membrane at 12 and the CO<sub>2</sub> capture unit at 13.” EX2023, 99:6-9. Dr. Klein’s concession should be the end of Petitioner’s assertion that Reinertsen expressly discloses a compression step; it does not. EX2021, ¶42.

Second, Reinertsen fails to inherently disclose a compression step. Dr. Klein also conceded that “[i]f the pressure would be high enough” entering the CO<sub>2</sub> capture unit, then there would be: “*No compression required.*” EX2023, 104:2-11. The question then is: what pressure would be “high enough?” Darde discloses “compression to a pressure between 20 and 100 bar.” EX1008, p. 8, ll.16-17; EX2021, ¶43. The next question is then whether CO<sub>2</sub>-rich (hydrogen depleted) stream 122 exits Reinertsen’s Pd-membrane separator 12 at a pressure that is “high enough.” EX2021, ¶43. Reinertsen explicitly says that it does: “[a]nother advantage is that the gas containing CO<sub>2</sub> that does not pass through the [Pd-]membrane, which is referred to as the retentate, is at an elevated pressure, typically above 10 bar, *more typically between 20 and 40 bar, but sometimes even at pressures up to 100 bar.*” EX1005, ¶[0062]; EX2023, 64:25-65:9. Dr. Klein confirmed as much in his testimony that—in Rytter’s FIG. 3 system—he would expect the pressure in stream 121 (exiting the [water-gas-]shift reactor 12 in Rytter to be at least 32 bar. EX2023, 106:22-108:23; EX2021, ¶43. As explained by Dr. Smith, the steps in Rytter’s FIG. 3 embodiment resulting in stream 121 are substantially similar to those in Reinertsen’s FIG. 4 embodiment resulting in stream 61 exiting Reinertsen’s WGS reactor 6. EX2021, ¶43; compare EX1005, FIG. 4 with EX1009, FIG. 3. As such, Dr. Klein’s prediction of the *at least* 32 bar pressure of Rytter’s stream 121 applies equally to Reinertsen’s stream 61. EX2021, ¶43.

That a compression step is not needed if the pressure is “high enough” is a key concession on Dr. Klein’s part because Darde affirmatively indicates that a pressure of 20 bar is “high enough” for cryogenic CO<sub>2</sub> separation. EX2021, ¶44; *see* EX1008, p. 8, ll. 16-17. Reinertsen therefore does not inherently disclose a compression step for its cryogenic CO<sub>2</sub> separation; as Dr. Smith and Dr. Klein agree, a compression step was not necessary for Reinertsen’s FIG. 4 embodiment because Reinertsen explicitly discloses that the CO<sub>2</sub>-rich stream leaving the Pd-membrane separator did so at a “high enough” pressure to avoid compression. EX2021, ¶44; EX2023, 104:2-11.

For these additional reasons, Reinertsen does not anticipate claim 11.

## **VI. Ground 2: Reinertsen-Darde Does Not Render Obvious Claim 1**

In Ground 2, the Petition contends it would have been obvious to modify Reinertsen’s Figure 4 embodiment with Darde to include PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation. Pet., 39-44. Ground 2 fails each of at least two independent reasons. First, a POSITA would not have been motivated to modify Reinertsen to replace Pd-membrane separation with Darde’s PSA separation as Petitioner contends. EX2021, ¶45. Second, the Petition fails to articulate motivations that would have led to the particular modifications asserted. *Id.*

**A. Reinertsen already performs with a 93% capture rate for H<sub>2</sub> at a purity often greater than 99.9%**

To assess the weight that should be accorded Petitioner’s “motivations” for modifying Reinertsen, it is important to understand Reinertsen’s starting point.

Reinertsen’s FIG. 4 embodiment is already “a method for production of hydrogen from natural gas with separation of CO<sub>2</sub>.” EX1005, ¶[0109]; EX2021, ¶48.

Reinertsen’s FIG. 4 system already exhibits an *H<sub>2</sub> capture rate of 93%* (EX1005, FIG. 11 (Embodiment Example 2) and—with its Pd-membrane approach—does so with “high purity; that may be greater than 99% and is often *greater than 99.9%*” (*id.*, ¶[0062]). EX2021, ¶49.

For carbon dioxide, Reinertsen’s FIG. 4 system exhibits a *CO<sub>2</sub> capture rate of 90%* with a purity of 99.9%. EX1005, FIG. 11; EX2021, ¶50. It is worth noting that Reinertsen’s FIG. 4 embodiment using cryogenic CO<sub>2</sub> capture actually exhibits a lower CO<sub>2</sub> capture rate and purity than its FIG. 3 embodiment that instead uses amine CO<sub>2</sub> separation. EX1005, FIG. 11 (*compare* Embodiment Example 2 with Embodiment Example 1); EX2021, ¶50.

**B. Darde’s focus is on steam production and capturing condensates**

Darde also produces hydrogen with carbon capture, but its focus is on doing so with (1) steam production (EX1008, Title) and (2) capturing condensates (*id.*, Abstract). EX2021, ¶51. For example, Darde’s Abstract explains that “[t]he

condensates from the cooling of the synthesis gas at the outlet of the shift reactor are used in the process for producing impure steam supplying the mixing point; the CPU unit also produces CPU condensates that are recycled to be treated jointly with the process condensates.” EX1008, Abstract. Darde repeatedly focuses on the uniqueness of these aspects its system. *See, e.g.*, EX1008, p. 4, ll. 13-14; p. 4, ln. 17–p. 5, ln. 4; p. 6, ll. 13-27; p. 9, ln. 15 – p. 10, ll. 15-24; p. 11, ln. 10 – p. 13, ln. 17; EX2021, ¶51.

While Darde mentions 99% pure hydrogen (EX1008, p. 16, ll. 6-7) and CO<sub>2</sub> purities greater than 99% (*id.*, p. 8, ll. 20-21), Darde does not discuss capture rates. EX2021, ¶52. A POSITA would have at least suspected that the absence of any mention of capture rates suggested that such capture rates were not high enough to be favorable if focused on maximizing the capture of H<sub>2</sub> and CO<sub>2</sub> as opposed to producing steam and capturing condensates (as Darde is). *Id.*

**C. Claim Elements [1.5] & [1.6]: The Petition’s purported motivations would not have led a POSITA to modify Reinertsen to include PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation**

As explained in Section V.A above, Reinertsen’s system uses either (1) membrane hydrogen separation upstream of cryogenic CO<sub>2</sub> separation or (2) amine CO<sub>2</sub> separation upstream of PSA hydrogen separation. The Petition purports to modify Reinertsen to instead include PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation. Pet., 41 (“The Patent Owner may nonetheless argue

that the specific combination of PSA upstream of cryogenic CO<sub>2</sub> separation is not specifically exemplified in Reinertsen. EX1005, ¶[0012]. However, a POSA would have been motivated to select this option of PSA in view of description in Darde. EX1003, ¶¶168–172.”). In support of this alleged modification, the Petition offers three “motivations.”

First, the Petition contends that Reinertsen and Darde share “a common problem recognized in the art, namely the production of hydrogen with reduced CO<sub>2</sub> emissions.” Pet., 40 (citing EX1005, ¶[0141; EX1008, p.7, ln.3-13). Second, the Petition contends that “Darde shows PSA upstream of cryogenic CO<sub>2</sub> separation achieves a ‘gaseous stream of highly pure (greater than 99%) hydrogen’ (EX1008, p.16, ln.7) and an offgas having a high CO<sub>2</sub> content such that ‘[b]y virtue of this relatively high CO<sub>2</sub> content, the cryogenic CO<sub>2</sub> capture solution may be applied to the PSA offgas’. EX1008, p.8, ln.10–11.” Pet., 42. Third, the Petition contends that “performance benefits achieved by implementing hydrogen separation and carbon capture in gas reforming provided additional motivation to combine.” Pet., 42. Finally, the Petition contends that a POSITA would have “reasonably expected to successfully practice the method of claims 1-6, 11, and 12 of the Challenged Patent” because “overlapping reforming and separation processes of Reinertsen with Darde would be compatible with similar process conditions ..., process inputs, ... intermediates ..., and process outputs....” Pet., 43-44.

The alleged motivations fail both because (1) all of the alleged motivations would be better served by using Reinertsen in its original form rather than modifying Reinertsen with Darde, and (2) all of the alleged motivations are utterly generic to Reinertsen alone or Reinertsen-Darde and therefore would not have motivated a POSITA to make any modification to Reinertsen.

***1. A POSITA would have been motivated to not substitute PSA H2 separation for Reinertsen's Pd-membrane H2 separation***

Petitioner alleges that a POSITA would have been motivated produce hydrogen with reduced CO<sub>2</sub> emissions to achieve a highly pure (greater than 99%) hydrogen to achieve “performance benefits achieved by implementing hydrogen separation and carbon capture in gas reforming provided additional motivation to combine.” Pet., 40-42. Taking all of this at face value, a POSITA would have been motivated to maximize not only purity of H<sub>2</sub>, but also capture rate of H<sub>2</sub>, purity of CO<sub>2</sub>, and capture rate of CO<sub>2</sub>. EX2021, ¶57.

That is the foundation from which a POSITA considering Darde would have asked the fundamental question of whether attempting to modify Reinertsen with Darde would improve Reinertsen's performance for H<sub>2</sub> capture or CO<sub>2</sub> capture. EX2021, ¶58.

First, Reinertsen already outperforms Darde for H<sub>2</sub> purity (often greater than 99.9% pure using Pd-membrane vs. 99% pure using PSA) and CO<sub>2</sub> purity (99.9% downstream of Pd-membrane H<sub>2</sub> separation vs. greater than 99% downstream of

PSA H<sub>2</sub> separation). EX2021, ¶59; *compare* §VI.A with §VI.B above. Thus, a POSITA considering H<sub>2</sub> and CO<sub>2</sub> purities would have been motivated to *not* modify Reinertsen with Darde's PSA separation. EX2021, ¶59.

Second, for capture rates (the amount of H<sub>2</sub> and CO<sub>2</sub> actually harvested), Darde says nothing about either of its H<sub>2</sub> capture rate or its CO<sub>2</sub> capture rate. EX2021, ¶60 However, Reinertsen itself indicates that Darde's PSA would hurt, rather than help, the performance of Reinertsen's system.<sup>2</sup> *Id.* Specifically, as explained above in Section VI.A, Reinertsen's FIG. 4 system already exhibits an **H<sub>2</sub> capture rate of 93%** and—with its Pd-membrane approach—produces H<sub>2</sub> with “high purity; that may be greater than 99% and is often **greater than 99.9%**” (EX1005, ¶[0062]). EX2021, ¶60. Similarly, Reinertsen's FIG. 4 system already exhibits a **CO<sub>2</sub> capture rate of 90%** with a purity of 99.9%. EX1005, FIG. 11; EX2021, ¶60. In contrast, Reinertsen also includes a comparative example using PSA for hydrogen separation, which exhibits an H<sub>2</sub> capture rate of only 86%. EX1005, FIG. 11 (Comparative Example); EX2021, ¶60.

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<sup>2</sup> As explained above in Section VI.B, Darde is focused on adding steam production and condensate capture to a hydrogen production plant with carbon capture. But neither Petitioner nor Dr. Klein asserts that either of those things would have motivated, or been included in, the Reinertsen-Darde combination. EX2021, fn.1.

A POSITA would have understood and expected from this that PSA hydrogen separation would have a materially lower H<sub>2</sub> capture rate than Reinertsen's Pd-membrane separation. EX2021, ¶61. Petitioner may note that this Comparative Example using PSA does so in combination with amine, rather than cryogenic, CO<sub>2</sub> separation. *Id.* However, the same Table shows similar hydrogen capture rates for both types of CO<sub>2</sub> separation when used with Pd-membrane H<sub>2</sub> separation, and a POSITA would have expected a similar result for PSA H<sub>2</sub> separation. *Id.*; EX1005, FIG. 11 (*compare* Embodiment Example 1 *with* Embodiment Example 2). Specifically, a POSITA would have reasonably expected PSA H<sub>2</sub> separation to exhibit a similar, H<sub>2</sub> capture rate of 86% that is—again—***materially lower*** than that the original Pd-membrane H<sub>2</sub> separation of Reinertsen's FIG. 4 embodiment on which Petitioner relies. EX2021, ¶61.

In addition to materially worse performance for at least H<sub>2</sub> capture rate, a POSITA would have been motivated ***not*** to modify Reinertsen with Darde's PSA separation because, as Dr. Klein explained and conceded, doing so would require adding compression that “generally has to be done with imported electricity instead of [existing] steam” (EX2023, 85:3-11), which would needlessly add cost. EX2021, ¶62.

Thus, a POSITA considering H<sub>2</sub> capture rates would have been motivated to ***not*** modify Reinertsen with Darde's PSA separation. EX2021, ¶63.

**2. *The Petition’s purported motivations—on their face—fail to adequately support the combination of Reinertsen and Darde***

The Petition’s alleged “motivations” are generic to hydrogen production with CO<sub>2</sub> capture, and therefore would *not* have led a POSITA to the particular combination of PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation recited in Elements [1.5] & [1.6].

**a. *That Reinertsen and Darde both disclose hydrogen production with CO<sub>2</sub> separation would not motivate a POSITA to modify Reinertsen with isolated parts of Darde***

The Petition states that both Reinertsen and Darde recognize “the problem known in the art of reducing CO<sub>2</sub> emissions from gas reforming.” Pet., 40 (citing EX1005, ¶¶[0141]; EX1008, p.7, ln.3–13). The Petition then contends that “[t]o solve this art recognized problem, each of Reinertsen and Darde use a combination of hydrogen separation and CO<sub>2</sub> separation to provide for gas reforming with capture of CO<sub>2</sub>.” Pet., 41. The Petition then asserts that “Reinertsen provides processes for hydrogen separation using a Pd-membrane provided upstream of cryogenic CO<sub>2</sub> separation” and notes recognizes PSA as “an alternative for hydrogen separation.” *Id.* (citing EX1005, ¶¶[0012], [0101]–[0109], FIGURE 4). Yet the Petition tacitly concedes that, as explained in Section V.A above, Reinertsen does not disclose PSA as an alternative *upstream* of cryogenic CO<sub>2</sub> separation in Reinertsen’s system. Pet., 41, (“The Patent Owner may nonetheless argue that the specific combination of PSA

upstream of cryogenic CO<sub>2</sub> separation is not specifically exemplified in Reinertsen.”).

So, the Petition continues, “a POSA would have been motivated to select this option of PSA in view of description in Darde.” *Id.* (citing EX1003, ¶¶168-172). However, if it were as simple as “PSA is preferable to Pd-membrane,” then a POSITA would have chosen amine CO<sub>2</sub> separation followed by PSA hydrogen separation as disclosed in Reinertsen for Reinertsen’s particular system. EX2021, ¶66. Specifically, as explained in Section V.A above, Reinertsen discloses either (1) amine CO<sub>2</sub> separation followed by PSA hydrogen separation or (2) Pd-membrane hydrogen separation followed by cryogenic CO<sub>2</sub> separation. *Id.* If a POSITA were motivated simply to select PSA over Pd-membrane, then that motivation would have led to the selection of Reinertsen’s option (1) with amine-CO<sub>2</sub> separation followed by PSA hydrogen separation. *Id.*

***b. Darde’s 99%+ pure hydrogen is inferior to Reinertsen’s 99.9%+ pure hydrogen and, thus, would not have motivated a POSITA to modify Reinertsen’s hydrogen and CO<sub>2</sub> separation***

The Petition states that “Darde shows PSA upstream of cryogenic CO<sub>2</sub> separation achieves a ‘gaseous stream of **highly pure (greater than 99%) hydrogen**’ (EX1008, p.16, ln.7) and an offgas having a high CO<sub>2</sub> content such that ‘[b]y virtue of this relatively high CO<sub>2</sub> content, the cryogenic CO<sub>2</sub> capture solution may be applied to the PSA offgas’. EX1008, p.8, ln.10–11.” Pet., 41-42. However,

Reinertsen already achieves superior hydrogen purity using Pd-membrane hydrogen separation:

Embodiments include using a Palladium membrane (Pd-membrane) to separate hydrogen from the reformed natural gas; or more generally from a reformed gas containing hydrocarbons. One advantage is that hydrogen is obtained with high purity; that may be greater than 99% and is *often greater than 99.9%*.

EX1005, ¶[0062]; EX2021, ¶67. Similarly, a POSITA would have been aware that options *other than* Darde's PSA H<sub>2</sub>-cryogenic CO<sub>2</sub> would also provide better hydrogen separation than in Darde. *See* EX2021, ¶67; *see also, e.g.,* EX1009, p. 15/35, ll. 26-27 ("Hydrogen specification is > 99.97 mol% for fuel cells ...." using amine CO<sub>2</sub> separation followed by PSA hydrogen separation).

Thus, a POSITA would not have been motivated by any improvement in hydrogen separation to replace the Pd-membrane hydrogen separation of Reinertsen's Figure 4 embodiment with Darde's PSA hydrogen separation. *See* EX2021, ¶68; *see also, e.g., Ex parte Rinkevich*, Appeal No. 2007-1317, slip op. at 8-9 (BPAI May 29, 2007) ("the problem proffered by the Examiner is already solved" by the primary reference, and explaining that "a person of ordinary skill in the art having common sense at the time of the invention would not have reasonably looked at [a secondary reference] to solve a problem already solved by [the primary reference].").

Moreover, Darde’s explanation that high CO<sub>2</sub> content in its PSA offgas means that cryogenic CO<sub>2</sub> capture *may be* used does not add anything to motivate a POSITA to modify Reinertsen. *See* EX2021, ¶69; *see also Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (obviousness concerns not only whether POSITA “*could* have made” the proposed combination, but whether they “*would have been motivated to [do so]*” (emphasis in original)). Specifically, the Petition points to Darde’s explanation that “[b]y virtue of this relatively high CO<sub>2</sub> content, the cryogenic CO<sub>2</sub> capture solution *may be* applied to the PSA offgas.” Pet., 41-42 (quoting EX1008, p.8, ll.10–11). But the fact that cryogenic CO<sub>2</sub> separation “may be” used downstream of PSA hydrogen separation says nothing about any advantage or benefit that would have motivated a POSITA to do so. EX2021, ¶69.

Ultimately, the Petition fails to address Reinertsen’s superior hydrogen purity, and does not explain why a POSITA would have preferred Darde’s 99% hydrogen purity to Reinertsen’s 99.9% hydrogen purity. *See* Pet., 41; EX2021, ¶70. That silence is fatal to the alleged combination given that the Petition points to “highly pure ... hydrogen” as a desired product. EX2021, ¶70.

***c. The Petition’s two-option premise for selecting PSA hydrogen separation is false and therefore does not support the replacement of Reinertsen’s Pd-membrane with Darde’s PSA***

The Petition asserts that Darde’s 99% hydrogen purity and that PSA “may be” used downstream of PSA in Darde’s system would have been viewed by a POSITA

as “directly applicable to the dual reforming process of Reinertsen.” Pet., 42. The Petition therefore continues that “a POSA would have been motivated to select PSA as one of the finite options disclosed in Reinertsen (i.e., PSA and Pd-membrane) to function in its normal and expected way, as demonstrated in Darde, to achieve the benefit of reduced CO<sub>2</sub> emissions by energetically efficient CO<sub>2</sub> capture.” Pet., 42 (citing EX1003, ¶168).

Setting aside that Reinertsen already achieves superior hydrogen purity (99.9%) than Darde (99%), Petitioner’s premise that Reinertsen discloses only two ways of separating hydrogen is demonstrably false and thereby undermines the rest of Petitioner’s theory. EX2021, ¶72. In particular, Reinertsen discloses that gases (e.g., H<sub>2</sub> and CO<sub>2</sub>) can be separated by “absorption, adsorption and cryogenic distillation” (EX1005, ¶[0082]) and membranes, of which a Pd-membrane is only one type (*id.*, ¶[0083]). Reinertsen goes on to discuss multiple types of membranes, including combinations of solid and liquid membranes. *Id.*, ¶[0085]. Reinertsen also discloses swing adsorption in which “temperature can swing instead of the pressure.” *Id.* Thus, Reinertsen expressly undermines the premise of Petitioner’s “finite options” reasoning, which necessarily fails given the Petition’s failure to acknowledge the majority of options (and the resulting permutations) Reinertsen actually discloses for hydrogen separation.

***d. Reinertsen’s own “performance benefits” would not have led a POSITA to change Reinertsen’s hydrogen and CO<sub>2</sub> separation methods***

Next, the Petition points to “performance benefits achieved by implementing hydrogen separation and carbon capture in gas reforming.” Pet., 42-43. But this is utterly generic, and would not have motivated a POSITA to modify Reinertsen because Reinertsen already implements hydrogen separation and carbon capture. *See, e.g.*, Pet., 41 (“Reinertsen and Darde use a combination of hydrogen separation and CO<sub>2</sub> separation”); *see also Ex parte Rinkevich*, Appeal No. 2007-1317, slip op. at 8-9 (a POSITA “would not have reasonably looked at [a secondary reference] to solve a problem already solved by [the primary one].”).

***e. The Petition’s only benefits even alleged to be specific to PSA hydrogen separation would not have motivated a POSITA to modify Reinertsen’s hydrogen and CO<sub>2</sub> separation***

The Petition finally pays lip service to PSA hydrogen separation specifically, but relies entirely on unsupported conclusions from its expert. Pet., 42-43 (citing EX1003, ¶¶169-170 (expert not citing any documentary support for motivations)); EX2023, 101:1-11 (conceding absence of simulations or comparative analyses of differences in hydrogen production and CO<sub>2</sub> capture if PSA were substituted for Pd-membrane for hydrogen separation in Reinertsen’s block 12), 102:8-19 (same for relative reliability), 102:21-103:5 (same for relative costs); EX2021, ¶74. The Petition ultimately alleges just two benefits allegedly specific to PSA: “(i) the

capability for generating high purity H<sub>2</sub> at a useful pressure, and (ii) the practical robustness and ease of implementation of PSA with gas reforming and cryogenic CO<sub>2</sub> separation.” Pet., 43 (citing EX1003, , ¶¶169-170). But Petitioner fails to define “useful pressure” or compare the performance of PSA to that of membrane separation. *See id.*; EX2021, ¶74. The absence of any such definition was likely intentional because Reinertsen’s FIG. 4 system explicitly includes “*compression* of hydrogen 11,” even though the Pd-membrane H<sub>2</sub> separation can separate hydrogen at “at a pressure comparable to the process gas.” EX2021, ¶74; EX1005, FIG. 4, ¶¶ [0109], [0084]. Indeed, as Dr. Klein conceded in his deposition, hydrogen *still* must be compressed or liquified for transport to pressures far in excess of even process pressures (30-40 bar). EX2023, 125:25-127:10; EX2021, ¶74.

In any event, Reinertsen’s Pd-membrane separation can already obtain hydrogen at elevated pressure (membrane that “leav[es] hydrogen at a [elevated] pressure ... comparable to the process gas”). EX1005, ¶¶[0083], [0084]. Reinertsen also shows “the practical robustness and ease of implementation of [Pd-membrane hydrogen separation] with gas reforming and cryogenic CO<sub>2</sub> separation.” *See* EX2021, ¶75. And, with Reinertsen’s Pd-membrane, “hydrogen is [already] obtained with high purity.” EX1005, ¶[0062] (“often greater than 99.9%”). Petitioner’s “motivations” therefore add nothing to Reinertsen, and would not lead a POSITA to modify Reinertsen. EX2021, ¶75. Indeed, Reinertsen also expressly

explains in the context of an ammonia synthesis loop that a plant using PSA for hydrogen separation was “*not* favorably designed for separating a pure CO<sub>2</sub>-stream for storage.” EX1005, ¶[0094]; EX2021, ¶75.

Reinertsen also shows that Pd-separation recovered significantly more hydrogen than PSA hydrogen separation. *See* EX2021, ¶76; EX1005, FIG. 11. For example, Reinertsen expressly compares a “Comparative Example” with PSA hydrogen separation to multiple “Embodiment Examples” with Pd-membrane hydrogen separation. *See, e.g.*, EX1005, FIG. 11; EX2021, ¶76. Critically—given that Reinertsen’s fundamental purpose is hydrogen production (*see, e.g., id.*, Title, Abstract)—Reinertsen shows that its embodiments using Pd-membrane hydrogen separation recover 93% of hydrogen versus only 86% for PSA hydrogen separation. *Id.*, FIG. 11; EX2021, ¶76. Thus, Reinertsen itself would have directly dissuaded a POSITA viewing Reinertsen and Darde from modifying Reinertsen’s Figure 4 embodiment to use PSA hydrogen separation instead of Pd-membrane hydrogen separation. EX2021, ¶76.

***f. Petitioner’s “reasonable expectation of success” allegations rely on hindsight and wholly neglect the differences between the processes of Reinertsen and Darde***

First, the Petition contends that “a POSA combining the teachings of Reinertsen and Darde would have reasonably expected to successfully practice the method of claims 1–6, 11, and 12.” Pet., 43. This reference to the challenged claims,

on its face, reveals the hindsight basis of Petitioner's theory. And the explanation that follows fares no better in that it utterly fails to address the particular modifications the Petition asserts:

Reinertsen discloses the process steps, in the same sequence, as the process of claim 1 of the '805 patent. To the extent that a POSA would require some additional degree of teaching, Darde addresses the goal identified in Reinertsen of generating hydrogen by gas reforming with reduced CO<sub>2</sub> emissions using the same downstream processes of WGS conversion with hydrogen separation and cryogenic CO<sub>2</sub> separation. Given that each of Reinertsen and Darde use well-known processes to achieve the same solution of CO<sub>2</sub> capture to reduce CO<sub>2</sub> emissions in gas reforming, a POSA would have been readily able to adapt the teachings of these references to arrive at the claimed invention with a reasonable likelihood of success. EX1003, ¶¶224–228; see *Wyers v. Master Lock Co.*, 616 F.3d 1231, 1240 (Fed. Cir. 2010) (“where all of the limitations of the patent were present in the prior art references, and the invention was addressed to a known problem, KSR...compels the grant of summary judgment of obviousness.”).

Pet., 43-44; EX2021, ¶77. Nothing in these paragraphs addresses PSA hydrogen separation. EX2021, ¶77. The Petition's explanation of the purported “reasonable expectation of success” therefore fails even to address the differences between the prior art and the claims, much less explain why the allegedly modified system would have had a reasonable expectation of success. EX2021, ¶77.

Second, the Petition asserts that “overlapping reforming and separation processes of Reinertsen with Darde would be compatible with similar process conditions ..., process inputs, ... intermediates ..., and process outputs...” Pet., 44.

In full, the Petition contends:

A POSA would have reasonably concluded that the overlapping reforming and separation processes of Reinertsen with Darde would be compatible with similar process conditions (e.g., pressures, flow rates, temperatures), similar process inputs (e.g., feed stream), intermediates (synthesis gas streams, shifted syngas stream and residual gas stream) and similar process outputs (e.g., hydrogen-rich stream and CO<sub>2</sub> rich stream). EX1003, ¶¶172, 227.

Pet., 44; EX2021, ¶78. However, neither the Petition nor Dr. Klein address or compare any particular process conditions.

Petitioner instead blatantly neglects the complexity of the respective Reinertsen and Darde systems. EX2021, ¶79. For example, the properties of Reinertsen’s WGS reactor and Pd-membrane are carefully selected to work together, such that switching to PSA separation would also require changes to the WGS reactor scheme. EX1005, ¶[0080]; *see also id.*, ¶[0081] (suggesting use of PSA [as in Figure 2 with amine CO<sub>2</sub> separation before PSA for hydrogen] would likely require *different and more* WGS reactors); EX2021, ¶79. Yet the Petition relies on the original WGS reactor of Reinertsen’s Figure 4. Pet., 48 (for Element [1.4],

referencing Reinertsen mapping of Ground 1, citing Darde for generic disclosure without modification to Reinertsen); Pet., 31 (for Element [1.4], pointing to Reinertsen’s shift reactor 6); EX2021, ¶79.

Similarly, Reinertsen makes clear that its Pd-membrane hydrogen separation is important for cryogenic CO<sub>2</sub> separation, namely that “the CO<sub>2</sub> gas can be separated from the H<sub>2</sub>/CO<sub>2</sub> mixture *at an elevated pressure*, [such that] *significant compression work can be avoided.*” EX1005, ¶[0087]; EX2021, ¶80. On the other hand, Darde takes an *opposite* approach to that of Reinertsen—specifically noting that “[t]he PSA offgas [from which CO<sub>2</sub> is separated in Darde] ... is available at a [very low] pressure below 2 bar(a).” EX1008, p. 5, ll.8-10; EX2021, ¶80. Petitioner neglects these differences, relying instead on a sweeping conclusion of its expert that “Reinertsen with Darde would be compatible with similar process conditions (e.g., pressures, flow rates, temperatures).” Pet., 44 (citing EX1003, ¶¶172, 227 (not addressing any Reinertsen or Darde pressure, flow rate, or temperature needs)); EX2021, ¶80. Thus, the Petition’s assertions of a reasonable expectation of success—even to the extent parroted by its expert—are therefore mere conclusory assertions that are entitled to no weight. *See, e.g.*, 37 C.F.R. § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”); *see also* Consolidated Trial Practice Guide (CTPG) at 35, 40-41 (PTAB Nov. 2019).

**D. Claim 11: Reinertsen-Darde does not render obvious cryogenic CO<sub>2</sub> separation subjecting the first residual gas stream to a compression step**

The Petition first refers back to its contention that Reinertsen discloses a compression step. Pet., 57 (citing Pet., § VIII.A.17). But that contention is incorrect, as explained above in Section V.A.

The Petition next asserts that “the combination with Darde makes this property explicit, as Darde discloses compression and cooling in cryogenic CO<sub>2</sub> separation.” Pet., 58 (citing EX1008, p. 8, ll. 12-18); EX1003, ¶¶219-220. But this contention is also insufficient because it merely refers to what cryogenic CO<sub>2</sub> separation includes in the context of Darde’s system, not why a POSITA would have found it desirable to implement compression that was unnecessary in Reinertsen’s original configuration. See § V.A above; EX2021, ¶82. Indeed, for the reasons explained above, a POSITA would have sought to avoid unnecessary compression. EX2021, ¶82.

**VII. Ground 3: Rytter-Darde Does Not Render Obvious Claim 1**

**A. Rytter does not disclose PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation**

The portions of Rytter relied upon by Petitioner are largely cumulative of Reinertsen. *E.g., compare* EX1005, Figure 1 *with* EX1009, Figure 1; EX2023, 72:2-7 (Dr. Klein confirming that Rytter FIG. 3 is “similar to Reinertsen’s comparative example in that amine CO<sub>2</sub> separation is upstream of PSA hydrogen separation”);

EX2021, ¶83. For example, Petitioner relies upon Rytter’s Figure 3, which is nearly identical to Reinertsen’s Figure 2 addressed above (with CO<sub>2</sub> separation *preceding* PSA hydrogen separation). *See, e.g.*, Pet., 3; EX2021, ¶83. The Petition concedes that “Rytter discloses CO<sub>2</sub> separation (13) occurs upstream of H<sub>2</sub> separation (15) in ... FIGURE 3,” but points to Rytter’s statement that “[e]mbodiments also include the hydrogen being separated from the gas mixture before the carbon dioxide is separated ..., or ... at the same time in a single process.” Pet., 59 (citing EX1009, p. 20/35, ll. 8-10). But this does not suggest that the order might be reversed *with* cryogenic CO<sub>2</sub> separation *after* PSA hydrogen separation. EX2021, ¶83. Rytter—like Reinertsen—also discloses Pd-membrane hydrogen separation (EX1009, p. 12/35, ll. 10-20), and other methods of separating hydrogen and CO<sub>2</sub>, like absorption, adsorption, and membranes. *Id.*, p. 11/35, ll. 30 – p. 12/35, ll. 29; EX2021, ¶83.

**B. Claim Elements [1.5] & [1.6]: The Petition’s purported motivations would not have led a POSITA to modify Rytter to include PSA hydrogen separation upstream of cryogenic CO<sub>2</sub> separation**

The Petition contends that it would have been obvious “to substitute the sequence of hydrogen separation provided upstream of cryogenic CO<sub>2</sub> separation, as disclosed in Darde.” Pet., 59. In support of this alleged modification, the Petition offers four “motivations.” First, the Petition contends that “Rytter and Darde implement a similar combination of known gas reforming and separation processes

to achieve a common purpose, namely production of a hydrogen product by reforming with reduced CO<sub>2</sub> emissions.” Pet., 59 (citing EX1003, ¶¶231-241; EX1009, p.3, ln.17-18; EX1008, p.7, ln.2-12). Second, the Petition contends that “[a] POSA would have been motivated to substitute the sequence of hydrogen separation provided upstream of cryogenic CO<sub>2</sub> separation, as disclosed in Darde, into the process of Rytter to achieve energetically efficient CO<sub>2</sub> capture for reducing emissions of CO<sub>2</sub>.” Pet., 60 (referencing Pet., §§VIII.B.1.(m)–(p) (mapping *Reinertsen-Darde* to Elements [1.5]-[1.6.1]); EX1003, ¶¶234–237). Third, the Petition contends that PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation would have been an obvious choice from among only six possible combinations based on routine optimization. Pet., 61. Fourth, the Petition points generically to “recognized performance benefits achieved by implementing hydrogen separation and carbon separation/capture in gas reforming.” Pet., 62.

The alleged motivations fail both because (1) all of the alleged “motivations” would be better served by using Rytter in its original form rather than modifying Rytter with Darde, and (2) all of the alleged motivations are utterly generic to Reinertsen alone or Rytter-Darde and therefore would not have motivated a POSITA to make any modification to Rytter.

**1. A POSITA would have been motivated to not substitute PSA H<sub>2</sub> separation for Rytter's Pd-membrane H<sub>2</sub> separation**

Petitioner alleges that a POSITA would have been motivated to modify Rytter to separate hydrogen upstream of CO<sub>2</sub> separation due to Rytter and Darde sharing the common purpose of producing hydrogen with carbon capture to achieve “recognized performance benefits achieved by implementing hydrogen separation and carbon separation/capture in gas reforming.” Pet., 59-62. The only statement specific to PSA followed by cryogenic separation is that it is one of a limited number of options. Pet., 61; EX2021, ¶86ry.

Again taking all of this at face value, a POSITA would have been motivated to maximize not only purity of H<sub>2</sub>, but also capture rate of H<sub>2</sub>, purity of CO<sub>2</sub>, and capture rate of CO<sub>2</sub>. EX2021, ¶87.

That is the foundation from which a POSITA considering Darde would have asked the fundamental question of whether attempting to modify Rytter with Darde would improve Rytter's performance for H<sub>2</sub> capture or CO<sub>2</sub> capture. EX2021, ¶88.

First, as the Petition concedes, “Rytter discloses CO<sub>2</sub> separation (13) occurs upstream of H<sub>2</sub> separation (15) in ... FIGURE 3.” Pet., 59 (citing EX1009, p. 20/35, ll. 8-10); EX2021, ¶89. In the system of Rytter's FIG. 3, a POSITA would have understood the CO<sub>2</sub> separation at 13 to involve a solvent-based separation process, and the H<sub>2</sub> separation at 15 to involve any of various methods, including but not

limited to, PSA separation or Pd-membrane separation. *Id.*; EX2023, 104:13-18 (confirming CO<sub>2</sub> is separated at block 13 with an amine process).

Notably, Rytter—like Reinertsen—discloses Pd-membrane H<sub>2</sub> separation and cryogenic CO<sub>2</sub> separation. EX2021, ¶90. A POSITA at the critical date weighing hydrogen separation options including PSA and Pd-membrane, CO<sub>2</sub> separation options including cryogenic and amine, and potential orders of H<sub>2</sub> separation upstream or downstream of CO<sub>2</sub> separation would have held certain conventional expectations about relative performance, as reflected in Reinertsen and discussed above in Section VI.C.1. *Id.*, ¶90.

For the same reasons explained above in Section VI.C.1, a POSITA would have expected Rytter's—like Reinertsen's—Pd-membrane H<sub>2</sub> separation upstream of CO<sub>2</sub> separation to meaningfully outperform Darde's PSA H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation. *Id.*, ¶91.

Additionally, a POSITA would have expected Rytter's amine CO<sub>2</sub> separation upstream of PSA H<sub>2</sub> separation to outperform Darde's arrangement for at least CO<sub>2</sub> capture rate. *Id.*, ¶92. For example, a POSITA's performance expectations would have been generally consistent with the data shown in in Reinertsen's FIG. 11 for the Comparative Example, which includes a similar arrangement of amine CO<sub>2</sub> separation upstream of PSA hydrogen separation and exhibits a *CO<sub>2</sub> capture rate of 97.5%*, whereas a comparison of Embodiment Examples 1 and 3 in the same FIG.

11 show amine CO<sub>2</sub> separation significantly outperforming (96% vs. 90%) cryogenic CO<sub>2</sub> separation in Embodiment Examples 2 and 4. EX2021, ¶92; EX1005, FIG. 11. Thus, a POSITA considering whether to implement Darde's cryogenic CO<sub>2</sub> separation downstream of PSA H<sub>2</sub> separation would have expected it to meaningfully hurt CO<sub>2</sub> capture rate. EX2021, ¶92.

Next, for selection of a hydrogen capture method, for the same reasons explained above in Section VI.C.1, a POSITA would have expected Rytter's Pd-membrane upstream of cryogenic CO<sub>2</sub> separation to significantly outperform Darde's arrangement for H<sub>2</sub> purity (often greater than 99.9% pure using Pd-membrane vs. 99% pure using PSA) and CO<sub>2</sub> purity (99.9% downstream of Pd-membrane H<sub>2</sub> separation vs. greater than 99% downstream of PSA H<sub>2</sub> separation). EX2021, ¶93; *compare* §VI.A with §VI.B above. Further, even if considering cryogenic CO<sub>2</sub> separation downstream of hydrogen separation, a POSITA would have been motivated to use Pd-membrane H<sub>2</sub> separation to avoid any need for compression because, as Dr. Klein explained "[w]hen the cryogenic separation is downstream the palladium membrane, as in Reinertsen, the CO<sub>2</sub>-rich stream is at the same pressure level as at the inlet of the membrane." EX2023, 81:20-24; EX2021, ¶93.

Indeed, a POSITA starting with Reinertsen's FIG. 3 would have expected Rytter's Pd-membrane upstream of amine CO<sub>2</sub> separation to perform even better

than with cryogenic CO<sub>2</sub> separation. EX2021, ¶94. As reflected in Reinertsen’s FIG. 11, the use of amine CO<sub>2</sub> separation instead of cryogenic CO<sub>2</sub> separation would have been expected to materially increase CO<sub>2</sub> capture rate—*i.e.*, 96% vs. 90%. EX2021, ¶94; EX1005, FIG. 11 (*compare* Embodiment Example 1 with Embodiment Example 2). Moreover, even to the extent Petitioner might—despite Dr. Klein’s concessions—argue that some compression would have been needed downstream of Pd-membrane separation, a POSITA would be motivated to use amine CO<sub>2</sub> separation instead of cryogenic CO<sub>2</sub> separation to avoid any alleged compression because “compression energy ... is high [value] electrical energy, and for the thermal regeneration of the amine you have only low-pressure steam to take into account.” EX2023, 82:18-24; EX2021, ¶94.

Thus, a POSITA considering H<sub>2</sub> *and* CO<sub>2</sub> purities would have been motivated to *not* modify Rytter with Darde’s PSA separation upstream of cryogenic CO<sub>2</sub> separation. EX2021, ¶95.

**2. *The Petition’s purported motivations—on their face—fail to adequately support the combination of Rytter and Darde***

The Petition’s alleged “motivations” are generic to all forms hydrogen production with CO<sub>2</sub> capture, and therefore would *not* have led to a POSITA to the particular combination of PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation recited in Elements [1.5] & [1.6].

*a. That Rytter and Darde both disclose hydrogen production with CO<sub>2</sub> separation would not motivate a POSITA to modify Rytter with isolated parts of Darde*

The Petition states that both Rytter and Darde share “a common purpose, namely production of a hydrogen product by reforming with reduced CO<sub>2</sub> emissions.” Pet., 59 (citing EX1003, ¶¶234-241). The Petition therefore contends that “a POSA would have been motivated to incorporate [some, but only some] aspects from Darde into the reforming process in Rytter to reduce CO<sub>2</sub> emissions by cryogenic capture of CO<sub>2</sub>.” Pet., 59 (citing EX1003, ¶¶231–233). But neither the premise nor the motivation are specific to cryogenic CO<sub>2</sub> separation and, thus, would not have led a POSITA to modify Rytter to both (1) separate CO<sub>2</sub> *after* separating hydrogen and (2) use cryogenic CO<sub>2</sub> separation instead of amine CO<sub>2</sub> separation. EX2021, ¶97. To the contrary, as in Reinertsen, Rytter’s one specific disclosure of CO<sub>2</sub> separation downstream of hydrogen separation uses membrane hydrogen separation *instead of* PSA. EX1009, p. 12/35, ll. 19-20 (“By combining solid *membranes* and liquid *membranes* it is also possible to achieve a rapid permeation of CO<sub>2</sub>, while H<sub>2</sub> is kept back.”); *contra id.*, p. 12/35, ll. 21-29 (separately describing PSA); EX2021, ¶97.

***b. The Petition's six-option premise for selecting PSA hydrogen separation is false and therefore does not support the wholesale modification of Rytter's system***

Second, Petitioner contends that “[a] POSA would have readily been aware that the processes and order of H<sub>2</sub>/CO<sub>2</sub> separation steps are selectable, as recognized in Rytter, depending on the goals and requirements of the overall process.” Pet., 60 (citing EX1003, ¶¶235-237). To support this contention, Petitioner begins from a premise that Rytter discloses only six practical permutations for H<sub>2</sub>/CO<sub>2</sub> separation. Pet., 60. But this is demonstrably false because Petitioner ignores that Rytter discloses that gases (e.g., H<sub>2</sub> and CO<sub>2</sub>) can be separated by “absorption, adsorption, . . . and cryogenic distillation” (EX1009, p. 11/35, ll. 30 – p. 12/35, ll. 9) and membranes, of which a Pd-membrane is only one type (*id.*, p. 12/35, ll. 10-20)]. EX2021, ¶98. Rytter goes on to discuss multiple types of membranes, including combinations of solid and liquid membranes. *Id.*, p. 12/35, ll. 10-20; EX2021, ¶98. And a POSITA would have been aware of alternative swing adsorption processes in which “temperature can swing instead of the pressure,” (EX1005, ¶[0085]), as well as various other known methods that Dr. Klein described in his deposition (EX2023, 119:14-120:18); EX2021, ¶98. Thus, Rytter expressly undermines the premise of Petitioner’s “finite options” reasoning, which necessarily fails given the Petition’s failure to acknowledge the majority of options (and the resulting permutations) Rytter actually discloses for hydrogen and CO<sub>2</sub> separation. Regardless, Petitioner

fails to proffer a motivation specific to PSA (H<sub>2</sub>)→cryogenic (CO<sub>2</sub>) as one of six possibilities, much less 14.

*c. Petitioner's routine optimization theory is wholly unsupported and, even if credited, would have led to the membrane hydrogen separation upstream of either amine or cryogenic CO<sub>2</sub> separation option of Rytter itself*

The Petition continues that the asserted modification of Rytter would be mere routine optimization based on a finite number of possibilities. Pet., 61. But Petitioner fails to explain what would be optimized, or how reversing both of Rytter's separation steps and methods to achieve Darde's PSA (H<sub>2</sub>)→cryogenic (CO<sub>2</sub>) configuration would have improved Rytter. EX2021, ¶99. For purported "additional motivation for selecting" CO<sub>2</sub> separation downstream of H<sub>2</sub> separation "for the hydrogen separation process of Rytter," the Petition points to Darde's disclosure that "[t]he PSA offgas is the gaseous stream richest in CO<sub>2</sub> of the process ..." such that "[b]y virtue of this relatively high CO<sub>2</sub> content, the cryogenic CO<sub>2</sub> capture *may be* applied to the PSA offgas." Pet., 61 (quoting EX1008, p. 8/13, ll. 8–11).

This purported "motivation" fails for each of two reasons. EX2021, ¶100. First, Darde's explanation that high CO<sub>2</sub> content in its PSA offgas means that cryogenic CO<sub>2</sub> capture *may be* used does not add anything to motivate a POSITA to modify Rytter. *Id.*; see *Belden*, 805 F.3d at 1073 (obviousness concerns not only whether POSITA "*could* have made" the proposed combination, but whether they

*“would have been motivated to [do so]”* (emphasis in original)). Specifically, the fact that cryogenic CO<sub>2</sub> separation “may be” used downstream of PSA hydrogen separation says nothing about any advantage or benefit that would have motivated a POSITA to do so. EX2021, ¶100. Second, even if this provided a motivation “to place a CO<sub>2</sub> separation step downstream of H<sub>2</sub> separation” (Pet., 61), Rytter already discloses such an option that a POSITA would have simply selected. Specifically, Rytter explains that “[b]y combining solid *membranes* and liquid *membranes* it is also possible to achieve a rapid permeation of CO<sub>2</sub>, while H<sub>2</sub> is kept back.” EX1009, p. 12/35, ll. 19-20; *contra id.*, p. 12/35, ll. 21-29 (separately describing PSA); EX2021, ¶100. And, for the reasons explained above VII.B.1, a POSITA would have expected better hydrogen production and carbon capture using amine or cryogenic CO<sub>2</sub> separation downstream of Pd-membrane H<sub>2</sub> separation. EX2021, ¶100.

***d. Rytter’s own “performance benefits” would not have led a POSITA to change Rytter’s hydrogen and CO<sub>2</sub> separation methods***

Petitioner next points to nonspecific “performance benefits achieved by implementing hydrogen separation and carbon capture in gas reforming.” Pet., 62. But this is utterly generic to any particular combination of hydrogen separation and CO<sub>2</sub> separation techniques, much less that of PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation recited in Claim Elements [1.5] and [1.6]. EX2021, ¶101.

As purported support, the Petition first references the Petition's earlier asserted motivations to combine Reinertsen and Darde. Pet., 62 (referencing Pet., §VIII.B.1). Those Reinertsen-Darde "motivations" fail for the reasons explained in Section VI.A above. EX2021, ¶101. The Petition next contends that "Rytter itself provides results demonstrating the increased energy efficiency achieved by combining dual reforming with CO<sub>2</sub> separation, thereby reinforcing this motivation to combine." Pet., 62 (quoting EX1009, p. 16/35, ll. 10-16). Yet, this too is utterly generic to any particular combination of hydrogen separation and CO<sub>2</sub> separation techniques, much less that PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation recited in Claim Elements [1.5] and [1.6]; EX2021, ¶101.

The Petition thus seeks to support the reversal of Rytter's own separation order and methods by pointing to Rytter's own disclosure of the benefits of its use of a GHR and an ATR. Pet., 62 (quoting EX1009, p. 16/35, ll. 10-16). This has nothing to do with benefits a POSITA would purportedly expect from modifying Rytter's separation steps with Darde's. EX2021, ¶101. If anything, that Rytter achieves these benefits would discourage a POSITA from any modification. EX2021, ¶101. As such, this "motivation" would not have motivated a POSITA to modify Rytter because Rytter already implements hydrogen separation and carbon capture. *See, e.g.*, Pet., 59 ("Rytter and Darde implement a similar combination of combination of known gas reforming and separation processes to achieve a common

purpose, namely production of hydrogen product by reforming with reduced CO<sub>2</sub> emissions”); *see also Rinkevich*, Appeal No. 2007-1317, slip op. at 8-9.

*e. Darde’s 99%+ pure hydrogen is inferior to Rytter’s 99.97% pure hydrogen and, thus, would not have motivated a POSITA to modify Rytter’s hydrogen and CO<sub>2</sub> separation*

The Petition states that “Darde shows PSA upstream of cryogenic CO<sub>2</sub> separation achieves a ‘gaseous stream of *highly pure (greater than 99%) hydrogen*’ (EX1008, p.16, ln.7) and an offgas having a high CO<sub>2</sub> content such that ‘[b]y virtue of this relatively high CO<sub>2</sub> content, the cryogenic CO<sub>2</sub> capture solution may be applied to the PSA offgas’. EX1008, p.8, ln.10–11.” Pet., 41-42 (referenced by Pet., 62 (citing Pet., §VIII.B.1). However, like Reinertsen, Rytter already achieves superior hydrogen purity using its amine CO<sub>2</sub> separation followed by PSA hydrogen separation: “Hydrogen specification is > 99.97 mol% for fuel cells ....” EX1009, p. 15/35, ll. 26-27; EX2021, ¶102. Similarly, a POSITA would have been aware that options *other than* Darde’s PSA H<sub>2</sub>-cryogenic CO<sub>2</sub> would also provide better hydrogen separation than in Darde. EX2021, ¶102; *see also, e.g.*, EX1005, ¶[0062] (“using a Palladium membrane (Pd-membrane) to separate hydrogen ... advantage is that hydrogen is obtained with high purity; that may be greater than 99% and is *often greater than 99.9%*”); EX2023, 101:13-21 (conceding absence of simulations or comparative analyses of differences in hydrogen production and CO<sub>2</sub> capture if

PSA upstream of cryogenic CO<sub>2</sub> capture in Rytter's FIG. 3), 101:22-102:6 (same for relative reliability), 103:7-14 (same for relative costs).

Thus, Petitioner fails to show that a POSITA even *might* have been motivated by any improvement in hydrogen separation or CO<sub>2</sub> capture to replace the amine CO<sub>2</sub>-PSA H<sub>2</sub> separation of Rytter's Figure 3 embodiment with Darde's PSA H<sub>2</sub>-cryogenic CO<sub>2</sub> separation. EX2021, ¶103. Ultimately, the Petition fails to address Rytter's superior hydrogen purity, and does not explain why a POSITA would have preferred Darde's 99% hydrogen purity to Rytter's 99.97% hydrogen purity. EX2021, ¶103. That silence is fatal to the alleged combination given that the Petition points to "highly pure ... hydrogen" as a desired product.

***f. Petitioner's "reasonable expectation of success" allegations rely on hindsight and wholly neglect the differences between the processes of Rytter and Darde***

First, the Petition contends that "a POSA combining the teachings of Rytter and Darde would have reasonably expected to successfully practice the method of claims 1-6, 11, and 12." Pet., 62. This reference to the challenged claims, on its face, reveals the hindsight inherent in Petitioner's theory. And the explanation that follows fares no better in that it utterly fails to address the particular modifications the Petition asserts:

Darde addresses the technical goal identified in Rytter of generating hydrogen by gas reforming with reduced CO<sub>2</sub> emissions using the same downstream processes of WGS conversion, hydrogen separation and

cryogenic CO<sub>2</sub> separation. Given that well-known, overlapping processes are used, in the same manner, to achieve the same technical solution in Rytter and Darde, a POSA would have been readily able to adapt the teachings of these references to arrive at the claimed invention with a reasonable likelihood of success. EX1003, ¶¶282–285; *see, Wyers*, 616 F.3d at 1231.

Pet., 62-63; EX2021, ¶104. Nothing in these paragraphs addresses PSA hydrogen separation. EX2021, ¶104. The Petition’s explanation of the purported “reasonable expectation of success” thus fails even to address the differences between the prior art and the claims, much less explain why a POSITA would have had a reasonable expectation of success in the modified system as alleged. EX2021, ¶104.

Second, the Petition asserts that “overlapping reforming and separation processes of Rytter with Darde would be compatible with similar process conditions ..., process inputs, ... intermediates ..., and process outputs...” Pet., 63. In full, the Petition contends:

A POSA would have also reasonably concluded that the overlapping processes of Rytter with Darde would be compatible with similar process conditions (e.g., pressures, flow rates, temperatures), similar process inputs (e.g., feed stream), intermediates (synthesis gas streams, shifted syngas stream and residual gas streams), and similar process outputs (e.g., hydrogen-rich stream and CO<sub>2</sub> rich stream). EX1003, ¶¶282–285.

Pet., 63. However, neither the Petition nor Dr. Klein address or compare any particular process conditions. EX2021, ¶105.

Petitioner instead blatantly neglects the complexity of the respective Rytter and Darde systems. EX2021, ¶106. For example, Rytter—like Reinertsen—explains that the properties of its WGS reactor and Pd-membrane are carefully selected to work with one another, such that using PSA hydrogen separation would also require changes to the WGS reactor scheme. EX2021, ¶106; EX1009, p. 11/35, ll. 25-29. Yet the Petition relies on the original WGS reactor of Rytter’s Figure 3. Pet., 75 (mapping Element [1.4] to Rytter’s “shift reactor 12” and citing Darde for generic disclosure without modification to Rytter). EX2021, ¶106.

Similarly, Rytter—like Reinertsen—makes clear that its Pd-membrane hydrogen separation is important to its cryogenic CO<sub>2</sub> separation, namely that “the CO<sub>2</sub> gas can be separated from the H<sub>2</sub>/CO<sub>2</sub> mixture *at an elevated pressure*, [such that] *significant compression work can be avoided*.” EX2021, ¶107; EX1009, p. 13/35, ll. 2-4. On the other hand, Darde takes an *opposite* approach to that of Rytter—specifically noting that “[t]he PSA offgas [from which CO<sub>2</sub> is separated in Darde] ... is available at a [very low] pressure below 2 bar(a).” EX1008, p. 8, ll. 8-10; EX2021, ¶107. Petitioner neglects these differences, relying instead on a sweeping conclusion of its expert that the two “would be compatible with similar process conditions (e.g., pressures, flow rates, temperatures).” Pet., 63 (citing

EX1003, ¶¶282-285 (not addressing any Rytter or Darde pressure, flow rate, or temperature needs)). Thus, the Petition’s assertions of a reasonable expectation of success—even to the extent parroted by its expert—are therefore mere conclusory assertions that are entitled to no weight. EX2021, ¶107; *see, e.g.*, 37 C.F.R. § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”); *see also* Consolidated Trial Practice Guide (CTPG) at 35, 40-41 (PTAB Nov. 2019).

Critically, nowhere does the Petition allege any motivation specific to modifying Rytter to use PSA hydrogen separation followed by cryogenic CO<sub>2</sub> separation. EX2021, ¶108. That alone is fatal to Petitioner’s Rytter-Darde combination, and the Petition thus cannot show a reasonable likelihood of success for Ground 3.

**C. Claim 11: Rytter-Darde does not render obvious cryogenic CO<sub>2</sub> separation subjecting the first residual gas stream to a compression step**

The Petition asserts that “[t]he cryogenic CO<sub>2</sub> process of Rytter necessarily includes at least one compression step and at least one cooling step.” Pet., 84 (citing EX1003, ¶¶278–279). The Petition offers no explanation for this assertion, and instead attempts to improperly incorporate by reference arguments from Dr. Klein’s declaration. *See* Pet., 84-85. In any event, the contention is incorrect for similar reasons to those explained above in Section V.B for Reinertson.

Dr. Klein first asserts without explanation that “a POSA ... would have understood that the cryogenic CO<sub>2</sub> separation process of Rytter, as in that of Reinertsen, necessarily includes the at least one compression step and at least one cooling step.” EX1003, ¶278. Dr. Klein then asserts that the “the terms ‘cryogenic distillation’ and ‘cryogenic process’, as used by Rytter, would have been readily understood by a POSA as examples of a process including cooling and condensation steps of a gas stream containing CO<sub>2</sub> in a manner necessarily producing a CO<sub>2</sub> rich stream and residual gas stream.” EX1003, ¶278. This too is unsupported and should be given no weight. Moreover, even if correct that these terms *could* refer to a process that includes compression, Dr. Klein does not explain why the terms would do so *in Rytter’s* FIG. 3 system. EX2021, ¶110. The lack of explanation is not purely academic.

First, Rytter does not expressly disclose a compression step. EX2021, ¶111. As is plain on their face, neither of “distillation” or “process” necessarily includes compression. *Id.* Nor does the Petition assert that Rytter expressly discloses a compression step for cryogenic CO<sub>2</sub> separation. *Id.*

Nor does Rytter inherently disclose a compression step. *Id.*, ¶112. As the Petition concedes, “Rytter discloses CO<sub>2</sub> separation (13) occurs upstream of H<sub>2</sub> separation (15) in ... FIGURE 3.” Pet., 59 (citing EX1009, p. 20/35, ll. 8-10); EX2021, ¶112. Specifically, Rytter’s FIG. 3 discloses CO<sub>2</sub> separation upstream of

hydrogen separation. EX1009, FIG. 3; *see also id.*, p. 20, ll. 7-11. In the system of Rytter's FIG. 3, a POSITA would have understood the CO<sub>2</sub> separation at 13 to involve a solvent-based separation process, and the H<sub>2</sub> separation at 15 to involve any of various methods, including but not limited to, PSA separation or Pd-membrane separation. EX2021, ¶112; EX2023, 104:13-18 (confirming CO<sub>2</sub> is separated at block 13 with an amine process). As to CO<sub>2</sub> separation, Rytter explains that "CO<sub>2</sub> is an acid gas, and the most widely used method to separate the mentioned gas from other non-acid gas molecules is *absorption*," for example via solvents such as alcoholamines and methanol. EX1009, p. 11, ln. 33 – p. 12, ln. 8; EX2021, ¶112; EX2023, 104:13-18.

A POSITA would have also understood that such a CO<sub>2</sub> process would *not* require compression. EX2021, ¶113. Indeed, even if a cryogenic process were used at block 15 to separate CO<sub>2</sub>, compression would not be required because it would be provided at elevated pressure immediately downstream of the water-gas-shift reactor at block 12. *Id.*; EX2023, 104:2-11 (that "[i]f the pressure would be high enough" entering the CO<sub>2</sub> capture unit, then there would be: "*No compression required.*").

If instead hydrogen separation were positioned upstream of cryogenic CO<sub>2</sub> separation, a POSITA would have understood from Rytter that Pd-membrane separation would be used for hydrogen separation because Pd-membrane separation could be implemented to maintain the retentate CO<sub>2</sub>-rich stream at the elevated

pressure *and* leave the separated H<sub>2</sub>-rich stream “at a pressure comparable to the process gas.” EX1009, p. 10, ll. 12-19; EX2021, ¶114. This would, like, Rytter’s FIG. 3 embodiment, avoid any need for a compression step in the cryogenic CO<sub>2</sub> process. EX2021, ¶114. Specifically, Dr. Klein concedes that a POSITA would expect the pressure in stream 121 (exiting the [water-gas-]shift reactor 12) to be at least 32 bar. EX2023, 106:22-108:23; EX2021, ¶114. As noted above, Darde discloses, for cryogenic CO<sub>2</sub> separation, “compression to a pressure between 20 and 100 bar.” EX1008, p. 8, ll. 16-17; EX2021, ¶114. Thus, a compression step would not be needed (EX2021, ¶114), and Rytter itself explains that “[i]f the CO<sub>2</sub> gas can be separated ... at an elevated pressure, significant *compression work can be avoided.*” EX1009, p. 11, ll. 2-4; EX2021, ¶114. A POSITA would therefore understand Rytter’s discussion of the possibility of reversing the order to contemplate the use of Pd-membrane H<sub>2</sub> separation upstream of cryogenic CO<sub>2</sub> separation, not PSA H<sub>2</sub> separation. EX2021, ¶114. Rytter thus does not inherently disclose a compression step for its cryogenic CO<sub>2</sub> separation because—as Dr. Smith and Dr. Klein agree—a compression step was not necessary for Rytter’s FIG. 3 embodiment, even if the order of hydrogen and CO<sub>2</sub> separation were reversed. EX2021, ¶114; EX2023, 104:2-11.

For these additional reasons, Rytter-Darde does not render obvious claim 11.

## VIII. CONCLUSION

For the foregoing reasons, Petitioner has failed to establish unpatentability of the challenged claims.

Dated: April 27, 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 10,822 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 April 27, 2026, complete copies of the foregoing Patent Owner Response and EX2021-EX2023 were served on Petitioner via email (by consent), at the following email address(s):

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