

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

DECLARATION OF JOSEPH D. SMITH, PH.D.

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I. Introduction

1. My name is Dr. Joseph D. Smith, Ph.D. I have been retained by L'Air Liquide, Société Anonyme pour l'Etude et l'Exploitation des Procédés Georges Claude (“Air Liquide”) as an independent expert consultant in this inter partes review (“IPR”) proceeding before the United States Patent and Trademark Office (“PTO”).

II. Professional Background

2. All of my opinions stated in this Declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and experience in designing, developing, researching, and teaching the technology referenced in this Declaration.

3. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. I understand that a copy of my current curriculum vitae (“CV”), which details my education and professional and academic experience is submitted concurrently as EX2022. The following provides a brief overview of some of my experiences that are relevant to the matters set forth in this Declaration.

4. I hold a Bachelor of Science in Chemical Engineering, Master of Science in Chemical Engineering, and a Doctor of Philosophy (Ph.D.) in Chemical Engineering. For thirty years, I have worked and taught in various areas related to

combustion technologies applied to the chemical, petrochemical, and power industries.

5. I graduated from Brigham Young University (“BYU”) in 1983 with a Bachelor of Science degree in Chemical Engineering. After graduation, I continued my studies at BYU. In 1984, I obtained a Master of Science degree in Chemical Engineering where my research focused on Prediction of the Effects of Coal Quality on Utility Furnace Performance. In 1990, I earned a Ph.D. in Chemical Engineering, with a focus on evaluating comprehensive simulation software describing pulverized-coal combustion and gasification using advanced sensitivity analysis techniques. During my studies at BYU, I worked in the Advanced Combustion Energy Research Laboratory under Dr. L.D. Smoot and Dr. P.J. Smith and was awarded an American Western Universities Fellowship at the Los Alamos National Laboratory.

6. I have published over seventy papers and have given more than one hundred and twenty conference papers in the areas of combustion engineering, industrial flare technology, computational fluid dynamics (CFD), gasification, hybrid energy systems, environmental monitoring and related chemical and petrochemical process technologies. I also authored several book chapters: two chapters in the John Zink Combustion Handbook, one chapter in the Industrial Burner Handbook, and one chapter in the Encyclopedia of Chemical Technology on

Hybrid Energy Systems. Recently, I authored and published a book titled Computational Fluid Dynamics for the Chemical and Petrochemical Process Industries. In addition, I invented several novel technologies relating to sensor systems, air-quality measurement systems, flare technologies, catalytic devices and nanoparticle production and have 12 patents directed to these technologies.

7. My professional experiences throughout the past thirty years have focused on environmental monitoring and control, industrial flare design and operation, fossil fuel fired power generation, process development and optimization, product evaluation, and fire cause and origin inspection. I developed and applied comprehensive CFD models for reactive flow systems including pulverized-fuel combustion and gasification systems, process heaters, and gas flares.

8. In 1990-1997, I was a Research Leader at The Dow Chemical Company. As Research Leader, I focused on environmental monitoring and control. I led the design and optimization of the LGTI Coal Gasifier and helped optimize the Wabash Coal Gasification Plant in Indiana. Many of the projects that I was involved with at Dow Chemical involved advanced computational fluid dynamics tools and modeling techniques to improve vapor distribution in distillation columns, increase combustion efficiency and reduce CO emissions and slag buildup. Alongside technical leadership, I served as a certified facilitator for “Consulting Skills” and “Managing Interpersonal Relations” training courses.

9. I was also a Corporate Leader of Process Development at Cabot Corporation, where I focused on developing new fumed-metal oxide based products. I led the company's first Reactive Chemistry Analysis team and gained competency in reactive chemical evaluations by leading the company's first Reactive Chemistry Analysis team and directing explosion investigations to identify and mitigate "reactive chemicals."

10. In 2000-2003, I served as the R&D Director at John Zink Company in the CFD and Flare Technology group. I directed an R&D group to establish strategic development plan for advanced gas flare technology and to provide advanced combustion analysis for the petrochemical industry using CFD. As the leader of the Flare Research Group, I conducted many design analyses for enclosed flare, multi-point ground flares, and air and steam assisted elevated flares.

11. I also co-founded and led three startup companies that provided combustion-related engineering services to the chemical, petrochemical, and fossil power industries. My first company, CDA-Access, provided advanced engineering analysis for chemical and petrochemical companies. The second startup, Systems Analyses & Solutions, provided engineering analysis of combustion systems and investigative engineering services. At my most recent startup, Elevated Analytics, I developed and applied nanotube sensor technology to measure air quality from mobile platforms and conducted CFD analysis of combustion-based technologies.

12. More recently, I worked at the Idaho National Laboratory as leader for the Advanced Process and Decision Systems group. Here I developed advanced process technologies for clean and efficient energy production and use and developed transformational hybrid energy systems.

13. I have served on faculties at Tennessee Technological University, University of Michigan, University of Illinois-Urbana/Champaign, and University of Tulsa, where I taught courses in areas such as computational fluid dynamics, unit operations, industrial catalysis, applied numerical methods, modeling, waste handling, and fluid mechanics, heat transfer, and transport processes. I also advised undergraduate and graduate students, and doctoral candidates in research areas like multiphase flow modeling, turbulent reacting flow modeling and oil extraction methods.

14. I am currently a Professor in the Department of Chemical and Biochemical Engineering at Missouri University of Science and Technology. I was the Wayne and Gayle Laufer Endowed Energy Chair at Missouri University of Science and Technology and held the that position from 2011-2021. I served as Director of the Energy Research and Development Center from 2013-2018 and formed and led the Small Nuclear Modular Reactor Research and Development Consortium from 2013-2016. I have received several awards for my contributions to the fields of chemical and combustion engineering. I am currently in my third

year of my term as the elected president of the American Institute of Chemical Engineers (AIChE).

III. Compensation

15. My work on this matter is being billed at on a conventional hourly rate basis. Additionally, I am being reimbursed for reasonable expenses that may be incurred in relation to my services. I have no financial interest in the outcome of this proceeding and will be paid regardless of the outcome of this proceeding.

IV. Legal Considerations

16. I am not an attorney and I offer no legal opinions. My understanding of the law is based on information provided by counsel for Air Liquide.

A. Anticipation

17. I understand that a reference anticipates a claim if it discloses each and every element recited in the claim, arranged as in the claim, so as to enable a POSITA to make and use the claimed invention without the need for undue experimentation in light of the general knowledge available in the art. I understand that a U.S. Patent document is presumed to have sufficient description to include sufficient detail for a POSITA to make and use the subject matter that document describes.

18. I also understand that a claim limitation may be present in an alleged prior art reference either expressly or inherently, but inherency may be established

only if such limitation is necessarily present in the reference. I understand that inherency cannot be established by probabilities or possibilities, and the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish inherency.

B. Obviousness

19. I understand that a claimed invention is obvious, and therefore, not patentable if the subject matter claimed would have been obvious to a person of ordinary skill in the art (“POSITA”) at the time of the invention of U.S. Patent No. 11,673,805 (the “’805 Patent”), which I have been asked to treat as August 11, 2020, the earliest claimed priority date of the ’805 Patent.

20. I understand that a claim can be obvious in view of a single prior art reference (e.g., via modification of that prior art reference) or multiple prior art references (e.g., via a combination of two or more prior art references), if such a modification or combination was within the skill of a POSITA. I understand that there must be some articulated reasoning with some rational underpinning to support a conclusion of obviousness. I also understand that to establish a finding of obviousness one must show that a POSITA would have had a motivation to combine the prior art references to produce the claimed invention and a reasonable expectation that the combination would be successful.

21. I further understand that exemplary rationales that may support a conclusion of obviousness include: (1) simply arranging old elements in a way in which each element performs the same function it was known to perform, and the arrangement yields expected results, (2) merely substituting one element for another known element in the field, if the substitution yields no more than a predictable result, (3) combining elements in a way that was “obvious to try” because of a design need or market pressure, where there was a finite number of identified, predictable solutions, (4) that design incentives or other market forces in a field would have prompted variations in a work that were predictable to a POSITA, and (5) that there was some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify or combine prior art references to arrive at the claimed invention.

C. Claim Interpretation

22. I understand that a claim term is interpreted according to its ordinary and customary meaning as a POSITA would have understood the term in light of the surrounding claim language, other claims, the specification, and the patent’s prosecution history, which are referred to as intrinsic evidence. I also understand that prior art references cited in the patent’s prosecution history are considered intrinsic evidence. I further understand that evidence outside the patent and its prosecution history (e.g., dictionaries and technical articles), may inform the context in which a POSITA would have understood the claims of a patent. I understand this

ordinary and customary meaning applies absent unique circumstances, such as where a patent clearly expresses an intent to set forth a special meaning for a term, or a claim term does not convey any particular structure to a POSITA (e.g., “means”).

V. Overview of Task & Basis for Opinions

23. I have been asked to review the '805 Patent. I have been asked to provide opinions related to certain issues from the perspective of a POSITA, having knowledge of the relevant art, as of August 11, 2020, and—except where otherwise noted—the opinions stated in this declaration are from that perspective.

24. My opinions are based on my education, training, and experience as well as items that I reviewed to prepare my opinions, including the documents listed in Dr. Klein’s Declaration (EX1003) and the following additional documents:

Exhibit	Shorthand	Description
2023	Klein Depo	Transcript of 4/2/2026 Deposition of Dr. Klein

25. I understand that other issues may arise that require further explanation, and I will provide that explanation if appropriate. As a result, I respectfully reserve the right to update and supplement this Declaration and the information and opinions provided herein.

VI. Level of Skill in the Relevant Art

26. I understand that a patent must be analyzed from the perspective of a POSITA as of the time of invention of the patent, which is typically considered to be the patent's earliest filing date. While I do not necessarily agree with every aspect of Dr. Klein's explanation of the level of ordinary skill in the art, I do not currently believe the aspects of that explanation I would change or clarify would impact the analysis set forth in this declaration. For purposes of this declaration, my opinions are therefore provided from the perspective of the POSITA described in paragraph 55 of Dr. Klein's Declaration (EX1003) as of August 11, 2020, which is produced below:

3-5 years of experience with steam reforming methane, partial oxidation, water gas shift process and synthesis gas separation; and a graduate degree in chemical engineering (M.Sc. level).

As reflected by my education, technical expertise, and personal knowledge discussed in Section II and EX2022, I at least met the qualifications of a POSITA as of August 11, 2020.

VII. Dr. Klein Maps Only the Series Configuration of Claim 1

27. 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 EX1001, 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. *See* EX1001, FIGs 2, 3.

28. 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.

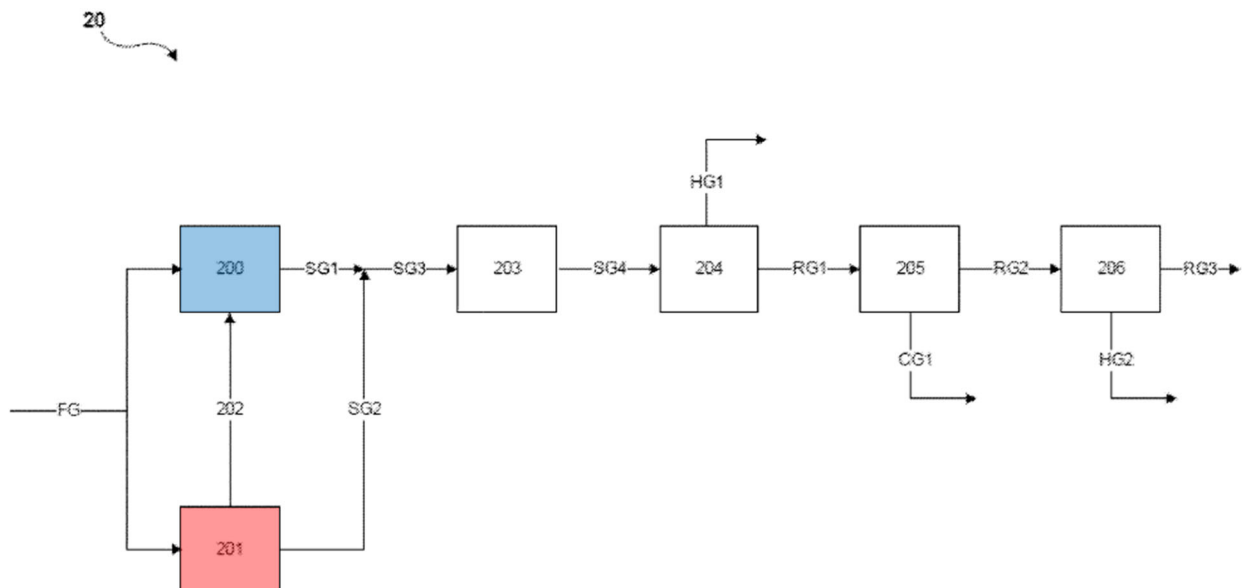


Fig. 2

29. 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.

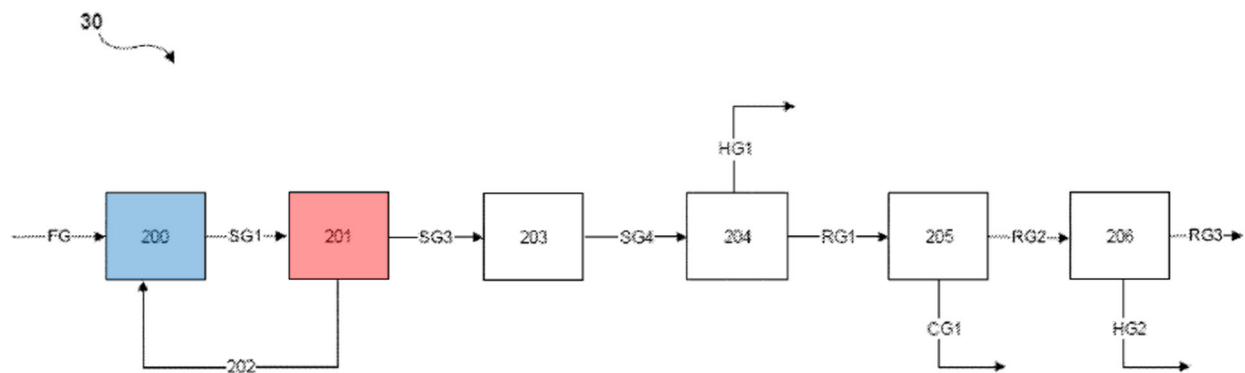


Fig. 3

30. Of these two configurations, Dr. Klein’s analysis addresses only the series configuration. See, e.g., EX1003, ¶¶60 (“The method of Reinertsen includes an endothermic reforming step using a GHR (1) and an autothermal reforming step using an ATR (2), where the GHR and ATR components are in a series configuration. . . .”) (citing EX1005, ¶¶[0009], [0047], [0102], FIGURES 1, 4), ¶61 (“The method of Reinertsen clearly teaches the series configuration of an ATR with a GHR”) (citing EX1005, FIGURE 1), ¶62 (“In the series reformer configuration illustrated in FIGURE 1”) (citing EX1005, FIGURE 1).

VIII. Claim Construction

31. I understand that the claims are interpreted according to the Phillips claim construction standard.

32. I also understand that Patent Owner does not believe formal constructions are necessary to understand what is claimed. For purposes of the below analysis, I agree that formal constructions are unnecessary.

IX. Ground 1: Reinertsen Does Not Anticipate Claim 1

33. Dr. Klein's analysis of Reinertsen does not establish that Reinertsen discloses all elements of independent claim 1 arranged as in the claim. It is my understanding that to anticipate claim 1, Reinertsen must disclose each and every element of the claim and it must disclose those elements arranged as in the claim. For the following reasons, a POSITA would not understand Reinertsen to disclose all features of claim 1.

A. Claim Elements [1.5] & [1.6]: Reinertsen does not disclose PSA hydrogen separation *upstream of cryogenic CO₂ separation*

34. 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.

35. Dr. Klein points to Reinertsen's Figure 4 as allegedly disclosing each element of claim 1. *See, e.g.*, EX1003, ¶¶108-160. But Reinertsen's Figure 4 does not separate hydrogen by pressure swing adsorption or "PSA." *See, e.g.*, EX1003, ¶147 ("In the process illustrated in FIGURE 4 [], the 'shifted gas' enters 'a hydrogen separation vessel that comprises a Pd-membrane 12.'"); *see also* EX1005, ¶[0109] ("Pd-membrane"). Thus, the embodiment of Reinertsen's Figure 4 does not disclose each and every element of claim 1.

36. Dr. Klein believes that general passages from other parts of Reinertsen might supply the missing aspects, but a POSITA would not read those passages in the way Dr. Klein asserts. Broadly, Dr. Klein asserts that Reinertsen's explanation that PSA and Pd-membrane methods are both known for H₂ separation might disclose substituting PSA for Pd-membrane hydrogen separation *in the embodiment of Reinertsen's Figure 4* with H₂ separation upstream of CO₂ separation. *See* EX1003, ¶148. More specifically, Dr. Klein points to Reinertsen's sentence that "[e]mbodiments may *alternatively* use PSA to separate hydrogen from the gas output from the WGS reactor." EX1003, ¶148 (citing EX1005, ¶[0085]). And Dr. Klein relies on Reinertsen's statement that "[p]referably, the hydrogen separation process comprises a PSA process." EX1003, ¶148 (citing EX1005, ¶[0012]).

37. Dr. Klein's reliance on these statements is misguided. Neither statement bears any relation to the embodiment of Figure 4. *See* EX1005, ¶¶[0011],

[0063]. 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]. The first, “alternatively” statement explicitly refers to other embodiments. *See, e.g.*, EX1005, Figure 2. And Dr. Klein overlooks that, in those other embodiments, Reinertsen’s system uses amine separation for CO₂ **before** the PSA separation for hydrogen—which is both opposite to the order and lacks the requisite cryogenic separation of the ’805 Patent’s claim 1. *See, e.g.*, EX1005, Figure 2, ¶[0103] (“Amine type separation process 8 separates CO₂ ...”). 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)). Therefore, “the fact that Reinertsen notes the possibility of PSA H₂ separation is entirely consistent with its disclosure of PSA H₂ separation **downstream of** amine CO₂ separation, and would not inherently disclose to a POSITA the use of PSA H₂ separation **upstream of** cryogenic CO₂ separation.” This is also illustrated 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 CO₂* separation, as well as the position of water condensation.

EX1005, ¶[0097]. 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 CO₂ separation. This is especially so because, as explained below in Section XI.C, the Pd-membrane H₂ separation provides both of the H₂-rich and CO₂-rich streams at high pressures, avoiding the need to compress the CO₂ rich stream for cryogenic CO₂ separation. *See* 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.*”).

38. Reinertsen also explains in several places why PSA hydrogen separation is used only *after* CO₂ separation in Reinertsen’s system. *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].”). It is important to note

that Reinertsen also explains that while “embodiments include the reforming process shown in FIG. 1, 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]. Thus, the “other embodiments” with PSA explicitly need not include the reformers of Reinertsen’s Figure 1 that Dr. Klein relies on for Claim Elements 1.2 and 1.3.

39. Further Reinertsen explicitly highlights its “advantageous methods and system for production of hydrogen and/or ammonia.” EX1005, ¶[0149] “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]; *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.”).

40. In sum, Reinertsen does not disclose PSA hydrogen separation upstream of cryogenic CO₂ separation and Reinertsen therefore does not disclose every element of claim 1.

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

41. Dr. Klein claims that Reinertsen's mention of "pressure" necessarily discloses "a compression step." EX1003, ¶¶158–160. Specifically, Dr. Klein points to Reinertsen's explanation that "embodiments preferably use cryogenic separation to separate CO₂. That is to say, the gas st[r]eam is cooled to a temperature, and at a pressure, where CO₂ is liquefied." EX1005, ¶[0059] (quoting EX1005, ¶[0059]; citing EX1022, p.9, ln. 14-16; EX1023, p.9, ln. 16-19). For each of multiple reasons, Dr. Klein does not establish disclosure of a compression step.

42. First, the mention of "a pressure" does not explicitly disclose a compression step. *See* EX1005, ¶[0059]. 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* EX1003, ¶[0059]. Dr. Klein himself stated that "Reinertsen does not disclose a compressor between [its] palladium membrane at **12** and the CO₂ capture unit at **13**." EX2023, 99:6-9. That appears to be the full extent of Dr. Klein's assertion that Reinertsen expressly discloses a compression step. And as shown above, Reinertsen does not.

43. Second, Reinertsen does not inherently disclose a compression step. Dr. Klein also conceded that "[i]f the pressure would be high enough" entering the CO₂ 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. The next question is then whether CO₂-rich (hydrogen depleted) stream **122** exits Reinertsen’s Pd-membrane separator **12** at a pressure that is “high enough.” Reinertsen explicitly says that it does: “[a]nother advantage is that the gas containing CO₂ 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. 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**. *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**.

44. 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 CO₂ separation. EX1008, p. 8, ll. 16-17. Reinertsen therefore does not inherently disclose a compression step for its cryogenic CO₂ separation, because, as Dr. Klein agrees, a compression step was not

necessary for Reinertsen's FIG. 4 embodiment; Reinertsen explicitly discloses that the CO₂-rich stream leaving the Pd-membrane separator did so at a "high enough" pressure to avoid compression. EX2023, 104:2-11; *see* EX1005, ¶[0062].

45. For these additional reasons, Reinertsen does not disclose every feature of claim 11.

X. Ground 2: Reinertsen-Darde Does Not Render Obvious Claim 1

46. For Ground 2, Dr. Klein opines that it was obvious to modify Reinertsen's Figure 4 embodiment with Darde to include PSA hydrogen separation *upstream* of cryogenic CO₂ separation. EX1003, ¶¶ 164-172. Dr. Klein's analysis for Ground 2 overlooked critical aspects of Reinertsen and, ultimately, reaches a conclusion that is mistaken. First, a POSITA would not have been motivated to modify Reinertsen to replace Pd-membrane separation with PSA separation as Dr. Klein concludes. Second, Dr. Klein does not articulate motivations that would have led to the particular modifications asserted.

A. Reinertsen already performs with a 93% capture rate for H₂ at a purity often greater than 99.9%.

47. To evaluate Dr. Klein's stated "motivations" for modifying Reinertsen, it is important to understand Reinertsen's starting point.

48. Reinertsen's FIG. 4 embodiment is already "a method for production of hydrogen from natural gas with separation of CO₂." EX1005, ¶[0109].

49. Reinertsen's FIG. 4 system already exhibits an *H₂ 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%*” (EX1005, ¶[0062]).

50. For carbon dioxide, Reinertsen's FIG. 4 system exhibits a *CO₂ capture rate of 90%* with a purity of 99.9%. EX1005, FIG. 11. It is worth noting that Reinertsen's FIG. 4 embodiment using cryogenic CO₂ capture actually exhibits a lower CO₂ capture rate and purity than its FIG. 3 embodiment that instead uses amine CO₂ separation. EX1005, FIG. 11 (*compare Embodiment Example 2 with Embodiment Example 1*).

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

51. Darde also produces hydrogen with carbon capture, but its focus is on doing so with (1) steam production (EX1008, Title) and (2) capturing condensates (EX1008, Abstract). 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.

52. While Darde mentions 99% pure hydrogen (EX1008, p. 16, ll. 6-7) and CO₂ purities greater than 99% (EX1008, p. 8, ll. 20-21), Darde does not discuss capture rates. 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 H₂ and CO₂ as opposed to producing steam and capturing condensates (as Darde is).

C. Claim Elements [1.5] & [1.6]: Dr. Klein’s purported motivations would not have led a POSITA to modify Reinertsen to include PSA hydrogen separation upstream of cryogenic CO₂ separation

53. As explained in Section IX.A above, Reinertsen’s system uses either (1) membrane hydrogen separation upstream of cryogenic CO₂ separation or (2) amine CO₂ separation upstream of PSA hydrogen separation. Dr. Klein suggests modifying Reinertsen to instead include PSA hydrogen separation *upstream of* cryogenic CO₂ separation. EX1003, ¶¶168-172. In support of this alleged modification, Dr. Klein offers three “motivations.” See EX1003, ¶¶164–172.

54. First, Dr. Klein states that Reinertsen and Darde share “a common problem recognized in the art, namely the production of hydrogen with reduced CO₂ emissions.” EX1003, ¶¶164-166. Second, Dr. Klein observes that “Darde demonstrates a PSA process configuration achieving a ‘gaseous stream of highly pure (greater than 99%) hydrogen’ (EX1008, p. 16, ll. 7) and an offgas having a high CO₂ content such that ‘[b]y virtue of this relatively high CO₂ content, the cryogenic

CO₂ capture solution may be applied to the PSA offgas.” EX1003, ¶168 (citing EX1008, p.8, ln.10-11). Third, Dr. Klein alleges “additional advantages of using PSA” like “generating a hydrogen output stream having sufficient high pressure” and “compatibility of the process parameters, such as temperature, pressure and flow rates . . . with downstream cryogenic CO₂ capture” would have supplied the motivation to combine. EX1003, ¶¶169-170. Finally, Dr. Klein concludes that a POSITA would have been “readily able to adapt the teachings of Reinertsen with those of Darde to arrive at the process of claims 1-6, 11, and 12 of the ’805 Patent with a reasonable likelihood of success” because “[t]he processes in Reinertsen and Darde are overlapping and used in a similar manner to achieve the same goal of hydrogen production with reduced CO₂ emissions.” EX1003, ¶¶224-225. More specifically, Dr. Klein opines that “the reforming and separation processes of Reinertsen and Darde would be compatible with each other” because they both include “known reforming and separating processes having similar and overlapping process conditions . . . process inputs . . . [, and] process outputs.” EX1003, ¶227.

55. 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 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

56. Dr. Klein opines that a POSITA “would have recognized a benefit . . . of PSA producing a purified hydrogen stream having a pressure sufficiently high for use in certain industrial applications” which therefore would have motivated the POSITA “to select PSA for hydrogen separation, as shown in Darde, for hydrogen separation in the processes of Reinertsen to achieve a high purity hydrogen product stream having a useful presence.” EX1003, ¶169; *see also* EX1003, ¶228, ¶321.

57. In view of this, a POSITA would have been motivated to maximize not only purity of H₂, but also capture rate of H₂, purity of CO₂, and capture rate of CO₂.

58. 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 H₂ capture or CO₂ capture.

59. First, Reinertsen already outperforms Darde for H₂ purity (often greater than 99.9% pure using Pd-membrane vs. 99% pure using PSA) and CO₂ purity (99.9% downstream of Pd-membrane H₂ separation vs. greater than 99% downstream of PSA H₂ separation). *Compare* §X.A with § X.B above. Thus, a POSITA considering H₂ and CO₂ purities would have been motivated to **not** modify Reinertsen with Darde's PSA separation.

60. Second, for capture rates (the amount of H₂ and CO₂ actually harvested), Darde says nothing about either of its H₂ capture rate or its CO₂ capture

rate. However, Reinertsen itself indicates that Darde's PSA would hurt, rather than help, the performance of Reinertsen's system.¹ Specifically, as explained above in Section X.A, Reinertsen's FIG. 4 system already exhibits an H₂ capture rate of 93% and—with its Pd-membrane approach—produces H₂ with “high purity; that may be greater than 99% and is often greater than 99.9%” (EX1005, ¶ [0062]). Similarly, Reinertsen's FIG. 4 system already exhibits a CO₂ capture rate of 90% with a purity of 99.9%. EX1005, FIG. 11. In contrast, Reinertsen also includes a comparative example using PSA for hydrogen separation, which exhibits an H₂ capture rate of only 86%. EX1005, FIG. 11 (Comparative Example).

61. 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. Dr. Klein may note that this Comparative Example using PSA does so in combination with amine, rather than cryogenic, CO₂ separation. However, the same Table shows similar hydrogen capture rates for both types of CO₂ separation when used with Pd-membrane H₂ separation, and a POSITA would

¹ As explained above in Section X.B, Darde is focused on adding steam production and condensate capture to a hydrogen production plant with carbon capture. But Dr. Klein does not claim that either of those things would have motivated, or been included in, the Reinertsen-Darde combination.

have expected a similar result for PSA H₂ separation. EX1005, FIG. 11 (compare Embodiment Example 1 with Embodiment Example 2). Specifically, a POSITA would have reasonably expected PSA H₂ separation to exhibit a similar, H₂ capture rate of 86% that is—again—materially lower than that the original Pd-membrane H₂ separation of Reinertsen’s FIG. 4 embodiment on which Petitioner relies.

62. In addition to materially worse performance for at least H₂ capture rate, a POSITA would have been motivated *not* to modify Reinertsen with Darde’s PSA separation because, as Dr. Klein explained and admitted, 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.

63. Thus, a POSITA considering H₂ capture rates would have been motivated to *not* modify Reinertsen with Darde’s PSA separation.

2. ***Dr. Klein’s purported motivations do not adequately support the combination of Reinertsen and Darde***

64. Dr. Klein’s alleged “motivations” are generic to hydrogen production with CO₂ capture, and therefore would not have led a POSITA to the particular combination of the PSA hydrogen separation followed by cryogenic CO₂ separated recited in Elements [1.5] & [1.6].

a. That Reinertsen and Darde both disclose hydrogen production with CO₂ separation would not motivate a POSITA to modify Reinertsen with isolated parts of Darde

65. Dr. Klein states that both Reinertsen and Darde recognize a “common goal [of] reducing or preventing CO₂ emissions” from gas reforming.” EX1003, ¶164. Dr. Klein then explains that this “common goal . . . is achieved in Reinertsen and Darde via a cryogenic capture solution, which allows for sequestration of CO₂ and/or the generation of a CO₂ coproduct, in both cases reducing or preventing CO₂ emissions; e.g., to the environment.” EX1003, ¶164. Dr. Klein then asserts that “Reinertsen describes processes for hydrogen separation using a Pd-membrane provided upstream of cryogenic CO₂ separation” and notes that use of a PSA is “optional[.]” EX1003, ¶¶165, 168 (“PSA is disclosed in Reinertsen as an alternative, preferred process for hydrogen separation preferred for some embodiments.”) (citing EX1005, ¶[0012]) (emphasis omitted).

66. Dr. Klein continues, stating that “a POSA would have been motivated to make a selection of PSA as one of the finite number of options disclosed in Reinertsen . . . to achieve benefits . . . as described in Darde.” EX1003, ¶168. However, if it were as simple as “PSA is preferable to Pd-membrane,” then a POSITA would have chosen amine CO₂ separation followed by PSA hydrogen separation as disclosed in Reinertsen for Reinertsen’s particular system. Specifically, as explained in Section IX.A above, Reinertsen discloses either

(1) amine CO₂ separation followed by PSA hydrogen separation or
(2) Pd-membrane hydrogen separation followed by cryogenic CO₂ separation. 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-CO₂ separation followed by PSA hydrogen separation.

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 CO₂ separation

67. Dr. Klein states that "Darde demonstrates a PSA process configuration achieving a 'gaseous stream of ***highly pure (greater than 99%) hydrogen***' (EX1008, p. 16, ln. 7) and an offgas having a high CO₂ content such that '[b]y virtue of this relatively high CO₂ content, the cryogenic CO₂ capture solution may be applied to the PSA offgas'" EX1003, ¶168 (citing EX1008, p. 8, ll. 10-11). 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]. Similarly, a POSITA would have been aware that options ***other than*** Darde's PSA H₂-cryogenic CO₂ would also provide better hydrogen separation

than in Darde. *See, e.g.*, EX1009, p. 15/35, ll. 26-27 (“Hydrogen specification is > 99.97 mol% for fuel cells” using amine CO₂ separation followed by PSA hydrogen separation).

68. 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.

69. Moreover, Darde’s explanation that high CO₂ content in its PSA offgas means that cryogenic CO₂ capture *may be* used does not add anything to motivate a POSITA to modify Reinertsen. Specifically, Dr. Klein points to Darde’s explanation that “[b]y virtue of this relatively high CO₂ content, the cryogenic CO₂ capture solution *may be* applied to the PSA offgas.” EX1003, ¶168 (quoting EX1008, pg. 8, ll. 10–11). But the fact that cryogenic CO₂ 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.

70. Ultimately, Dr. Klein does not 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* EX1003, ¶¶168-172. That silence is consequential to the proposed combination, particularly because Dr. Klein identifies “highly pure ... hydrogen” as a desired product. EX1003, ¶168.

c. Dr. Klein'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

71. To support the proposed modification, Dr. Klein points to Darde's 99% hydrogen purity and Darde's statement that PSA "may be" used downstream of PSA in Darde's system. EX1003, ¶168 (citing EX 1008, p.8, ln.10-11, p.16, ln.7). Thus, in Dr. Klein's opinion, "a POSA would have been motivated to make a selection of PSA as one of the finite options disclosed in Reinertsen (i.e., PSA and Pd-membrane) to achieve benefits of generating a highly pure hydrogen stream with reduced emissions by energetically efficient CO₂ capture, as described in Darde." EX1003, ¶168.

72. Setting aside that Reinertsen already achieves superior hydrogen purity (99.9%) than Darde (99%) (see EX1005, ¶[0062]), Dr. Klein's premise that Reinertsen discloses only two ways of separating hydrogen is inconsistent with the reference and thereby weakens the rest of Dr. Klein's analysis. In particular, Reinertsen discloses that gases (e.g., H₂ and CO₂) can be separated by "absorption, adsorption, and cryogenic distillation" (EX1005, ¶[0082]) and membranes, of which a Pd-membrane is only one type (EX1005, ¶[0083]). Reinertsen goes on to discuss multiple types of membranes, including combinations of solid and liquid membranes. EX1005, ¶[0085]. Reinertsen also discloses swing adsorption in which "temperature can swing instead of the pressure." EX1005, ¶[0085]. Thus,

Reinertsen expressly undermines the premise of Dr. Klein’s “finite number of options” reasoning, because Dr. Klein’s analysis does not account for the majority of options (and the resulting permutations) Reinertsen actually discloses for hydrogen separation.

d. Reinertsen’s own “benefits” would not have led a POSITA to change Reinertsen’s hydrogen and CO₂ separation methods

73. Next, in Dr. Klein’s opinion “a POSA . . . would have recognized additional advantages of using PSA, in the manner shown in Darde, in the process of Reinertsen.” EX1003, ¶169; *see also* EX1003, ¶¶169-171 But this is generic, and any of Dr. Klein’s alleged “additional advantages” would not have motivated a POSITA to modify Reinertsen because Reinertsen already implements hydrogen separation and carbon capture, which Dr. Klein recognizes. *See* EX1003, ¶168 (“Reinertsen describes processes for hydrogen separation using a Pd-membrane provided upstream of cryogenic CO₂ separation.”) (citing EX 1005, ¶¶[0105]-[0110], FIGURE 4).

e. Dr. Klein’s only benefits even alleged to be specific to PSA hydrogen separation would not have motivated a POSITA to modify Reinertsen’s hydrogen and CO₂ separation

74. Dr. Klein addresses PSA hydrogen separation but he offers only unsupported conclusions void of any documentary evidence. *See* EX1003, ¶¶169-170 (expert not citing any documentary support for motivations); EX2023, 101:1-11

(admitting absence of simulations or comparative analyses of differences in hydrogen production and CO₂ capture if PSA unite 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). Dr. Klein identifies only two benefits that he characterizes as specific to PSA: “[g]enerating a high purity hydrogen gas at such [sufficiently high] pressure” and “practical robustness and ease of implementation of PSA in combination with gas reforming and cryogenic CO₂ separation.” EX1003, ¶¶169-170. But Dr. Klein does not define “sufficiently high pressure” or compare the performance of PSA to that of membrane separation. EX1003, ¶¶169-170. 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 H₂ separation can separate hydrogen at “at a pressure comparable to the process gas.” EX1005, FIG. 4, ¶¶ [0109], [0084]. Indeed, as Dr. Klein admitted in his deposition, hydrogen in any event must be compressed or liquified for transport to pressures far in excess of even process pressures (30-40 bar). EX2023, 125:25-127:10.

75. 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 CO₂ separation.” Additionally, with Reinertsen’s Pd-membrane, “hydrogen is [already] obtained with high purity.” EX1005, ¶[0062] (“often greater than 99.9%”). Therefore, Dr. Klein’s “motivations” do not add anything to Reinertsen, and would not have led a POSITA to modify Reinertsen. 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 CO₂-stream for storage.” EX1005, ¶[0094].

76. Reinertsen also shows that Pd-separation recovered significantly more hydrogen than PSA hydrogen separation. *See* 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. It is important to note that Reinertsen’s purpose is hydrogen production. *See, e.g.*, EX1005, Title, Abstract. With this foundation, Reinertsen shows that its embodiments using Pd-membrane hydrogen separation recover 93% of hydrogen versus only 86% for PSA hydrogen separation. EX1005, FIG. 11. A POSITA considering whether to modify Reinertsen’s FIG. 4 embodiment—already recovering 93% of H₂ at a purity of “often >99.9%” (EX1005, ¶[0062]) would not have been tempted by Darde’s 99%+ purity via PSA (in its own particular system) when Reinertsen itself demonstrates that PSA would reduce H₂ recovery to 87% instead of 93%. To illustrate, for each 1,000 tons of H₂ in syngas

passing through the hydrogen separation system, Reinertsen shows that Pd-membrane separation would capture 930 tons of H₂ whereas PSA would capture only 870 tons of H₂. As a result, 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. Dr. Klein's conclusion otherwise is faulty because his analysis (1) does not address these disclosures of Reinertsen showing that the use of PSA would reduce H₂ recovery, and (2) does not point to anything in Darde addressing recovery rate, much less suggesting a result different than the negative one indicated by Reinertsen.

f. Dr. Klein's "reasonable likelihood of success" theories rely on hindsight and neglect the differences between the processes of Reinertsen and Darde.

77. Dr. Klein continues his analysis by stating that "a POSA could have been readily able to adapt the teachings of Reinertsen with those of Darde to arrive at the process of claims 1-6, 11, and 12 of the '805 Patent with a reasonable likelihood of success." EX1003, ¶224. Dr. Klein's provided explanation does not address the particular modifications Dr. Klein asserts:

225. The process in Reinertsen and Darde are overlapping and used in a similar manner to achieve the same goal of hydrogen production with reduced CO₂ emissions. Reinertsen describes a process for producing hydrogen from a hydrocarbon-rich feed gas with reduced CO₂

involving i) a reforming process including an endothermic reforming step using a GHR and an autothermal reforming step using an ATR, wherein GHR and ATR components are provided in a series configuration and wherein heated gas from the ATR is utilized for heating the GHR; (ii) downstream conversion of CO to CO₂ via water gas shift conversion; and (iii) separation processes including a hydrogen separation (with the options of a Pd membrane or a PSA) provided upstream of cryogenic CO₂ separation. Darde discloses a similar process using methane reforming (e.g., SMR or ATR) with downstream water shift conversion, and subsequent PSA for hydrogen separation provided upstream of cryogenic CO₂ capture.

226. When combined with Reinertsen, which also provides for PSA as an alternative, the processes disclosed in Darde, provides sufficient teaching to allow a POSA to select and implement PSA for hydrogen separation from the two options disclosed in Reinertsen (i.e., Pd-membrane and PSA)

EX1003, ¶¶225-226. These paragraphs do not address either of Reinertsen's or Darde's particular implementations of PSA hydrogen separation. Dr. Klein asserts that "[t]he guidance provided in Darde, therefore, would have been sufficient to allow for selection of PSA and successful integration into the process of Reinertsen" but points to no "guidance provided in Darde" that would allow for such a selection. *See* EX1003, ¶226. Further, Dr. Klein does not provide any guidance from Reinertsen for a "successful integration [of PSA] into the process of Reinertsen."

See EX1003, ¶¶225-226. Dr. Klein’s explanation of the purported “reasonable likelihood 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.

78. Next, Dr. Klein asserts that “the reforming and separation processes of Reinertsen and Darde would be compatible with each other” because they have “similar and overlapping process conditions, . . . process inputs, . . . [and] process outputs.” EX1003, ¶227. In full, Dr. Klein states:

A POSA would also expect that the reforming and separation processes of Reinertsen and Darde would be compatible with each other. Reinertsen and Darde include known reforming and separation processes having similar and overlapping process conditions, such as pressures, flow rates, and temperatures; similar process inputs such as feed stream; and similar process outputs such [as] the synthesis gas streams, hydrogen-rich stream, residual streams and CO₂ rich stream.

EX1003, ¶227. However, Dr. Klein’s analysis does not address or compare any particular process conditions. See EX1003, ¶¶224-227.

79. Dr. Klein instead neglects the complexity of the respective Reinertsen and Darde systems. 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* EX1005, ¶[0081] (suggesting use of PSA [as in Figure 2 with amine CO₂ separation before PSA for hydrogen] would likely require *different and more* WGS reactors). Yet Dr. Klein relies on the original WGS reactor of Reinertsen's Figure 4. EX1003, ¶188 (for Element [1.4], referencing Reinertsen mapping of Ground 1, citing Reinertsen alone or in view of Darde for generic disclosure without modification to Reinertsen); EX1003, ¶¶137-139 (for Element [1.4], pointing to Reinertsen's shift reactor 6).

80. Similarly, Reinertsen makes clear that its Pd-membrane hydrogen separation is important for cryogenic CO₂ separation, namely that “the CO₂ gas can be separated from the H₂/CO₂ mixture *at an elevated pressure*, [such that] *significant compression work can be avoided*. EX1005, ¶[0087]. On the other hand, Darde takes an *opposite* approach to that of Reinertsen—specifically noting that “[t]he PSA offgas [from which CO₂ is separated in Darde] ... is available at a [very low] pressure below 2 bar(a).” EX1008, p. 5, ll. 9-10. Dr. Klein neglects these differences, and instead concludes, without support, that “Reinertsen and Darde would be compatible” because of “similar and overlapping process conditions, such as pressures, flow rates, and temperatures” EX1003, ¶227; *see also* EX1003, ¶172. But Dr. Klein does not address any of Reinertsen or Darde's pressure, flow rate, or temperature needs. Thus, Dr. Klein's assertions of a reasonable likelihood

of success are therefore mere conclusory assertions that are not supported by any documentary evidence.

D. Claim 11: Reinertsen-Darde does not render obvious cryogenic CO₂ separation subjecting the first residual gas stream to a compression step

81. Dr. Klein first refers back to his analysis that Reinertsen discloses a compression step. EX1003, ¶219 (citing EX1003, § XI.A.1-16). But that contention is incorrect, as explained above in Section IX.B.

82. Dr. Klein next states that “Darde discloses that compression steps and cooling steps . . . are steps in cryogenic CO₂ separation.” EX1003, ¶220 (citing EX1008, p. 8, ll. 12-18). Therefore, according to Dr. Klein, “a POSA would have understood to implement cryogenic CO₂ separation following PSA for hydrogen separation using at least one compression step and at least one cooling step.” EX1003, ¶220. But Dr. Klein merely addresses what cryogenic CO₂ 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* § IX.B above. As I explained above, a POSITA would have sought to avoid unnecessary compression.

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

A. Rytter does not disclose PSA hydrogen separation upstream of cryogenic CO₂ separation

83. The portions of Rytter relied upon by Dr. Klein are largely cumulative of Reinertsen. *E.g., compare* EX1005, Figure 1 *with* EX1009, Figure 1; *see* EX1003, ¶¶231-286; EX2023, 72:2-7 (Dr. Klein confirming that Rytter FIG. 3 is “similar to Reinertsen’s comparative example in that amine CO₂ separation is upstream of PSA hydrogen separation”). For example, Dr. Klein relies upon Rytter’s Figure 3, which is nearly identical to Reinertsen’s Figure 2 addressed above (with CO₂ separation *preceding* PSA hydrogen separation). *See, e.g.,* EX1003, ¶244 (citing EX1009, FIG. 3). Dr. Klein admits that “Rytter discloses CO₂ separation (13) occurs upstream of H₂ separation (15) in ... FIGURE 3,” but points to Rytter further describing “processes where the hydrogen is ‘separated from the gas mixture before the carbon dioxide is separated from the gas mixture.’” EX1003, ¶¶234, 266 (citing EX1009, p. 20/35, ll. 8-10). But this does not suggest that the order might be reversed *with* cryogenic CO₂ separation *after* PSA hydrogen separation. Rytter—like Reinertsen—also discloses Pd-membrane hydrogen separation (EX1009, p. 12/35, ll. 10-20), and other methods of separating hydrogen and CO₂, like absorption, adsorption, and membranes. EX1009, p. 11/35, ll. 30 – p. 12/35, ll. 29.

B. Claim Elements [1.5] & [1.6]: Dr. Klein’s purported motivations would not have led a POSITA to modify Rytter to include PSA hydrogen separation upstream of cryogenic CO₂ separation.

84. Dr. Klein concludes that “a POSA would have been motivated to select the [PSA hydrogen separation positioned upstream of cryogenic CO₂ separation process] sequence in view of the description of Darde.” EX1003, ¶234. In support of this proposed modification, Dr. Klein offers four “motivations.” First, Dr. Klein opines that “Rytter and Darde share a common, recognized purpose of producing hydrogen via methane reforming with cryogenic separation of carbon dioxide to generate a carbon dioxide coproduct and/or achieve to reduce carbon dioxide emissions.” EX1003, ¶231. Second, Dr. Klein states that “a POSA would have been motivated to select the [PSA hydrogen separation positioned upstream of cryogenic CO₂ separation process] sequence in view of the description of Darde” to achieve “reduce[d] carbon dioxide emissions.” EX1003, ¶¶231-234. Third, Dr. Klein suggests that PSA hydrogen separation followed by cryogenic CO₂ separation would have been an obvious choice from among only six possible combinations based on routine optimization. EX1003, ¶¶235-236. Fourth, Dr. Klein points generically to “additional advantages of implementing hydrogen separation, such as PSA, upstream of cryogenic CO₂ separation.” EX1003, ¶237.

85. 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 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 H₂ separation for Rytter's Pd-membrane H₂ separation.

86. Dr. Klein states that a POSITA would have been motivated to modify Rytter to separate hydrogen upstream of CO₂ separation due to Rytter and Darde sharing “a common, recognized purpose of producing hydrogen via methane reforming with cryogenic separation of carbon dioxide to generate a carbon dioxide coproduct and/or achieve to reduce carbon dioxide emissions; e.g., to the environment.” EX1003, ¶¶231-233. The only statement specific to PSA followed by cryogenic separation is that it is one of a limited number of options. EX1003, ¶¶235-236.

87. A POSITA would have been motivated to maximize not only purity of H₂, but also capture rate of H₂, purity of CO₂, and capture rate of CO₂.

88. 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 H₂ capture or CO₂ capture.

89. First, as the Dr. Klein admits, “Rytter discloses CO₂ separation (13) occurs upstream of H₂ separation (15) in ... FIGURE 3.” EX1003, ¶234 (citing EX1009, p. 12, ll. 19-20). In the system of Rytter's FIG. 3, a POSITA would have

understood the CO₂ separation at 13 to involve a solvent-based separation process, and the H₂ separation at 15 to involve any of various methods, including but not limited to, PSA separation or Pd-membrane separation. EX2023, 104:13-18 (confirming CO₂ is separated at block 13 with an amine process).

90. Notably, Rytter—like Reinertsen—discloses Pd-membrane H₂ separation and cryogenic CO₂ separation. A POSITA at the critical date weighing hydrogen separation options including PSA and Pd-membrane, CO₂ separation options including cryogenic and amine, and potential orders of H₂ separation upstream or downstream of CO₂ separation would have held certain conventional expectations about relative performance, as reflected in Reinertsen and discussed above in Section X.C.1.

91. For the same reasons explained above in Section X.C.1, a POSITA would have expected Rytter's—like Reinertsen's—Pd-membrane H₂ separation upstream of CO₂ separation to meaningfully outperform Darde's PSA H₂ separation upstream of cryogenic CO₂ separation.

92. Additionally, a POSITA would have expected Rytter's amine CO₂ separation upstream of PSA H₂ separation to outperform Darde's arrangement for at least CO₂ capture rate. 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 CO₂

separation upstream of PSA hydrogen separation and exhibits a *CO₂ capture rate of 97.5%*, whereas a comparison of Embodiment Examples 1 and 3 in the same FIG. 11 show amine CO₂ separation significantly outperforming (96% vs. 90%) cryogenic CO₂ separation in Embodiment Examples 2 and 4. EX1005, FIG. 11. Thus, a POSITA considering whether to implement Darde's cryogenic CO₂ separation downstream of PSA H₂ separation would have expected it to meaningfully hurt CO₂ capture rate.

93. Next, for selection of a hydrogen capture method, for the same reasons explained above in Section X.C.1, a POSITA would have expected Rytter's Pd-membrane upstream of cryogenic CO₂ separation to significantly outperform Darde's arrangement for H₂ purity (often greater than 99.9% pure using Pd-membrane vs. 99% pure using PSA) and CO₂ purity (99.9% downstream of Pd-membrane H₂ separation vs. greater than 99% downstream of PSA H₂ separation). *Compare §X.A with §X.B above.* Further, even if considering cryogenic CO₂ separation downstream of hydrogen separation, a POSITA would have been motivated to use Pd-membrane H₂ 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 CO₂-rich stream is at the same pressure level as at the inlet of the membrane.” EX2023, 81:20-24.

94. Indeed, a POSITA starting with Reinertsen's FIG. 3 would have expected Rytter's Pd-membrane upstream of amine CO₂ separation to perform even better than with cryogenic CO₂ separation. As reflected in Reinertsen's FIG. 11, the use of amine CO₂ separation instead of cryogenic CO₂ separation would have been expected to materially increase CO₂ capture rate—*i.e.*, 96% vs. 90%. EX1005, FIG. 11 (*compare* Embodiment Example 1 *with* Embodiment Example 2). Moreover, a POSITA would have been motivated to use amine CO₂ separation instead of cryogenic CO₂ 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.

95. Thus, a POSITA considering H₂ *and* CO₂ purities would have been motivated to *not* modify Rytter with Darde's PSA separation upstream of cryogenic CO₂ separation.

2. *Dr. Klein's purported motivations do not adequately support the combination of Rytter and Darde.*

96. Dr. Klein's alleged “motivations” are generic to all forms hydrogen production with CO₂ capture, and therefore would *not* have led to a POSITA to the particular combination of PSA hydrogen separation followed by cryogenic CO₂ separation recited in Elements [1.5] & [1.6].

a. That Rytter and Darde both disclose hydrogen production with CO₂ separation would not motivate a POSITA to modify Rytter with isolated parts of Darde.

97. Dr. Klein states that both Rytter and Darde share “a common, recognized purpose of producing high purity hydrogen via methane reforming with cryogenic separation of carbon dioxide to generate a carbon dioxide coproduct and/or achieve to reduce carbon dioxide emissions.” EX1003, ¶¶234-241. Dr. Klein therefore opines that “a POSA would have been motivated to incorporate disclosure from Darde into Rytter because these references each achieve a common goal of a reduction of CO₂ emissions by implementing gas reforming . . . for energy efficient capture of CO₂.” EX1003, ¶¶231–233. But neither the premise nor the motivation are specific to cryogenic CO₂ separation and, thus, would not have led a POSITA to modify Rytter to both (1) separate CO₂ *after* separating hydrogen and (2) use cryogenic CO₂ separation instead of amine CO₂ separation. Just like in Reinertsen, Rytter’s one specific disclosure of CO₂ 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 CO₂, while H₂ is kept back.”); *contra* EX1009, p. 12/35, ll. 21-29 (separately describing PSA).

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

98. Second, in Dr. Klein's opinion, "[a] POSA would readily comprehend that the order of H₂ and CO₂ separation steps are interchangeable depending on a number of factors." EX1003, ¶235; *see also* EX1003, ¶¶235-237. To support his opinion, Dr. Klein begins from a premise that Rytter discloses only six practical permutations for H₂/CO₂ separation. EX1003, ¶¶235-237. But this is inconsistent with the reference itself because Dr. Klein ignores that Rytter discloses that gases (e.g., H₂ and CO₂) can be separated by "absorption, adsorption, . . . and cryogenic distillation" (EX1009, p. 11/35, ll. 30 – p. 12/35, ll. 9) and membranes (EX1009, p. 11/35, ll. 30 – p. 12/35, ll. 9), of which a Pd-membrane is only one type (EX1009, p. 12/35, ll. 10-20]). Rytter goes on to discuss multiple types of membranes, including combinations of solid and liquid membranes. EX1009, 12/35, ll. 10-20. 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, 119:14-129:18). Given that Dr. Klein does not consider the majority of options (and the resulting permutations) Rytter actually discloses for hydrogen and CO₂ separation, Rytter cannot and does not support Dr. Klein's "finite set of known

design choice” reasoning. Further, Dr. Klein does not identify a motivation specific to PSA (H₂)→cryogenic (CO₂) as one of six possibilities, much less 14.

c. Dr. Klein’s routine optimization theory is unsupported and, even if credited, would have led to the membrane hydrogen separation upstream of either amine-or cryogenic CO₂ separation option of Rytter itself.

99. Dr. Klein continues his analysis by explaining that the proposed modification of Rytter would be mere routine optimization based on a finite number of design choices. EX1003, ¶237. But Dr. Klein does not explain what would be optimized, or how reversing both of Rytter’s separation steps and methods to achieve Darde’s PSA (H₂)→cryogenic (CO₂) configuration would have improved Rytter. For the purported motivation to make this substitution, Dr. Klein points to Darde’s disclosure that “[t]he PSA offgas is the gaseous stream richest in CO₂ of the process ...” such that “[b]y virtue of this relatively high CO₂ content, the cryogenic CO₂ capture *may be* applied to the PSA offgas.” EX1003, ¶¶236-237 (quoting EX1008, p. 8/13, ll. 8–11).

100. This purported “motivation” fails for each of two reasons. First, Darde’s explanation that high CO₂ content in its PSA offgas means that cryogenic CO₂ capture *may be* used does not add anything to motivate a POSITA to modify Rytter. Specifically, the fact that cryogenic CO₂ 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. Second, even if this provided

a motivation “to place a CO₂ separation step downstream of H₂ separation” (EX1003, ¶236), 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 CO₂, while H₂ is kept back.” EX1009, p. 12/35, ll. 19-20; *contra* EX1009, p. 12/35, ll. 21-29 (separately describing PSA). And, for the reasons explained above in Section XI.B.1, a POSITA would have expected better hydrogen production and carbon capture using amine or cryogenic CO₂ separation downstream of Pd-membrane H₂ separation.

d. Rytter’s own “additional advantages” would not have led a POSITA to change Rytter’s hydrogen and CO₂ separation methods.

101. Dr. Klein next points to nonspecific “additional advantages of implementing hydrogen separation . . . upstream of cryogenic CO₂ separation.” EX1003, ¶237. This statement is generic to any particular combination or order of hydrogen separation and CO₂ separation techniques, much less PSA hydrogen separation followed by cryogenic CO₂ separation recited in Claim Elements [1.5] and [1.6]. As purported support, Dr. Klein states:

A POSA at the critical date would have recognized that separating hydrogen gas upstream reduces the total number of gas provided for cryogenic CO₂ separation, thereby allowing for a physically smaller sized cryogenic unit(s) and beneficial reductions in capital expenditure

(CAPEX) costs and operating expense (OPEX) costs associated with the overall process.

EX1003, ¶238. This statement is also generic to any particular combination or order of hydrogen separation and CO₂ separation techniques, and therefore does not offer anything that would direct a POSITA to replace Reinertsen's Pd-membrane H₂ separation with PSA hydrogen separation.

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 CO₂ separation

102. Dr. Klein states that Darde explains “that it is preferable to place a CO₂ separation step downstream of H₂” because this sequence achieves a “gaseous stream of *highly pure (greater than 99%) hydrogen*” (EX1008, p. 16, ln. 7), and an offgas having a high CO₂ content such that “[b]y virtue of this relatively high CO₂ content, the cryogenic CO₂ capture solution may be applied to the PSA offgas”. EX1008, p. 8, ll. 10–11.” EX1003, ¶¶168, 236. However, like Reinertsen, Rytter already achieves superior hydrogen purity using its amine CO₂ separation followed by PSA hydrogen separation: “Hydrogen specification is > 99.97 mol% for fuel cells” EX1009, p. 15/35, ll. 26-27. Similarly, a POSITA would have been aware that options *other than* Darde's PSA H₂-cryogenic CO₂ would also provide better hydrogen separation than in Darde. *See, 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 (admitting absence of simulations or comparative analyses of differences in hydrogen production and CO₂ capture if PSA upstream of cryogenic CO₂ capture in Rytter's FIG. 3), 101:22-102:6 (same for relative reliability), 103:7-14 (same for relative costs).

103. Thus, Dr. Klein does not show that a POSITA even might have been motivated by any improvement in hydrogen separation or CO₂ capture to replace the amine CO₂-PSA H₂ separation of Rytter's Figure 3 embodiment with Darde's PSA H₂-cryogenic CO₂ separation. Dr. Klein does not 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. That silence is consequential to the proposed combination particularly because Dr. Klein points to "highly pure ... hydrogen" as a desired product.

f. Dr. Klein's "reasonable likelihood of success" theories rely on hindsight and neglect the differences between the processes of Rytter and Darde

104. First, Dr. Klein opines that "a POSA would have been readily able to adapt the teachings of Rytter with Darde to arrive at the process of claims 1-6, 11, and 12." EX1003, ¶282. But Dr. Klein's provided explanation does not address the particular modifications he asserts:

283. The processes in Rytter with Darde are overlapping and used in a similar manner to achieve the same goal of hydrogen production with reduced CO₂ emissions. Rytter describes a process for producing hydrogen from a hydrocarbon-rich feed gas with reduced CO₂ involving i) a reforming process including an endothermic reforming step using a GHR and an autothermal reforming step using an ATR, where GHR and ATR components are provided in a series configuration and where heated gas from the ATR is utilized for heating the GHR; (ii) downstream conversion of CO to CO₂ via water gas shift conversion; and (iii) separation processes including PSA for hydrogen separation and cryogenic CO₂ separation. Darde discloses a similar process using methane reforming (e.g., SMR or ATR) with downstream water shift conversion, and subsequent PSA for hydrogen separation provided upstream of cryogenic CO₂ capture.

284. When combined with Rytter, which also provides for PSA as an alternative, the processes disclosed in Darde, provides sufficient teaching to allow a POSA to select and implement from the finite number of process options disclosed in Rytter (i.e., Pd-membrane and PSA) a configuration having PSA for hydrogen separation provided upstream of cryogenic CO₂ separation.

EX1003, ¶¶283-284. These paragraphs do not address Rytter's or Darde's implementation of PSA hydrogen separation. Dr. Klein states that "[t]he guidance provided in Darde, therefore, would have been sufficient to allow a POSA to select for selection of the sequence of PSA provided upstream of cryogenic CO₂ separation

and successful integration into the process of Rytter” but points to no “guidance provided in Darde” that would allow for such a selection. EX1003, ¶284. Further, Dr. Klein does not provide any guidance from Rytter for a “successful integration [of PSA] into the process of Rytter.” See EX1003, ¶284. Dr. Klein’s explanation of the purported “reasonable likelihood of success” does not even 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.

105. Second, Dr. Klein asserts that “the reforming and separation processes of Rytter and Darde would be compatible with each other” because they have “similar and overlapping process conditions, . . . process inputs, . . . [and] process outputs.” EX1003, ¶285. In full, Dr. Klein states:

A POSA would also expect that the reforming and separation processes of Rytter and Darde would be compatible with each other. Rytter and Darde include known reforming, water-gas shift and separation processes having similar and overlapping process conditions, such as, pressures, flow rates and temperatures; similar process inputs such as feed stream; and similar process outputs such [as] the synthesis gas streams, hydrogen-rich stream, residual streams and CO₂ rich stream.

EX1003, ¶285. However, Dr. Klein does not address or compare any particular process conditions. See EX1003, ¶¶282-285.

106. Dr. Klein instead neglects the complexity of the respective Rytter and Darde systems. 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. EX1009, p. 11/35, ll. 25-29. Dr. Klein’s analysis is faulty because it relies on the original WGS reactor of Rytter’s Figure 3. EX1003, ¶263 (mapping Element [1.4] to Rytter’s “shift reactor 12” and citing Darde for generic disclosure without modification to Rytter).

107. Similarly, Rytter—like Reinertsen—makes clear that its Pd-membrane hydrogen separation is important to its cryogenic CO₂ separation, namely that “the CO₂ gas can be separated from the H₂/CO₂ mixture *at an elevated pressure*, [such that] *significant compression work can be avoided*. 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 CO₂ is separated in Darde] . . . is available at a [very low] pressure below 2 bar(a).” EX1008, p. 5, ll. 9-10. Dr. Klein neglects these differences, and instead concludes, without support, that “Rytter and Darde would be compatible because of “similar and overlapping process conditions, such as pressures, flow rates, and temperatures” EX1003, ¶285; *see also* EX1003, ¶172. But Dr. Klein does not address any of Rytter or Darde’s pressure, flow rate, or temperature needs. Thus, Dr. Klein’s assertions of a reasonable likelihood of

success are therefore mere conclusory assertions, unsupported by any documentary evidence.

108. Dr. Klein does not put forth any motivation specific to modifying Rytter to use PSA hydrogen separation followed by cryogenic CO₂ separation. Dr. Klein's analysis therefore does not point to any "motivation" specific to the particular systems of Rytter and Darde, and his conclusion that the alleged Rytter-Darde combination would have been obvious is therefore unsupported.

C. Claim 11: Rytter-Darde Does Not Render Obvious Cryogenic CO₂ Separation Subjecting The First Residual Gas Stream To A Compression Step

109. Dr. Klein opines that "[t]he cryogenic CO₂ process of Rytter necessarily includes at least one compression step and at least one cooling step." EX1003, ¶¶278–279. Dr. Klein is mistaken for similar reasons to those explained above in Section XI.B for Reinertson.

110. Dr. Klein first asserts without explanation that "a POSA ... would have understood that the cryogenic CO₂ 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 states that "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 CO₂ in a manner necessarily producing a CO₂ rich

stream and residual gas stream.” EX1003, ¶278. But this statement 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. The lack of explanation is not purely academic.

111. First, Rytter does not expressly disclose a compression step. Neither of “distillation” or “process” necessarily includes compression. Nor does Dr. Klein assert that Rytter expressly discloses a compression step for cryogenic CO₂ separation.

112. Nor does Rytter inherently disclose a compression step. Dr. Klein states that “Rytter discloses CO₂ separation (13) occurs upstream of H₂ separation (15) in ... FIGURE 3.” EX1003, ¶234 (citing EX1009, p. 12, ll. 19-20). Specifically, Rytter’s FIG. 3 discloses CO₂ separation upstream of hydrogen separation. EX1009, FIG. 3; *see also* EX1009., p. 20, ll. 7-11. In the system of Rytter’s FIG. 3, a POSITA would have understood the CO₂ separation at 13 to involve a solvent-based separation process, and the H₂ separation at 15 to involve any of various methods, including but not limited to, PSA separation or Pd-membrane separation. EX2023, 104:13-18 (confirming CO₂ is separated at block 13 with an amine process). As to CO₂ separation, Rytter explains that “CO₂ 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; EX2023, 104:13-18.

113. A POSITA would have also understood that such a CO₂ process would *not* require compression. Indeed, even if a cryogenic process were used at block 15 to separate CO₂, compression would not be required because it would be provided at elevated pressure immediately downstream of the water-gas-shift reactor at block 12. EX2023, 104:2-11 (that “[i]f the pressure would be high enough” entering the CO₂ capture unit, then there would be: “*No compression required.*”).

114. If instead hydrogen separation were positioned upstream of cryogenic CO₂ 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 CO₂-rich stream at the elevated pressure *and* leave the separated H₂-rich stream “at a pressure comparable to the process gas.” EX1009, p. 10, ll. 12-19. This would, like, Rytter’s FIG. 3 embodiment, avoid any need for a compression step in the cryogenic CO₂ process. Specifically, Dr. Klein admits 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. As noted above, Darde discloses, for cryogenic CO₂ separation, “compression to a pressure between 20 and 100 bar.” EX1008, p. 8, ll. 16-17. Thus,

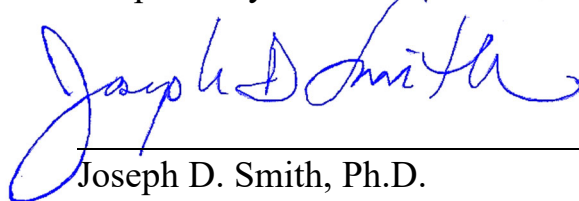
a compression step would not be needed, and Rytter itself explains that “[i]f the CO₂ gas can be separated ... at an elevated pressure, significant *compression work can be avoided*.” EX1009, p. 11, ll. 2-4. A POSITA would therefore understand Rytter’s discussion of the possibility of reversing the order to contemplate the use of Pd-membrane H₂ separation upstream of cryogenic CO₂ separation, not PSA H₂ separation. Rytter thus does not inherently disclose a compression step for its cryogenic CO₂ separation because, as Dr. Klein agrees, a compression step was not necessary for Rytter’s FIG. 3 embodiment, even if the order of hydrogen and CO₂ separation were reversed. EX2023, 104:2-11.

XII. CONCLUSION

115. All statements made herein of my own knowledge are true, all statements made herein on information and belief are believed to be true, and these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

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Respectfully submitted,



Joseph D. Smith, Ph.D.