

In the Matter Of:

Topsoe, Inc., vs

L'Air Liquide, et al.

HARALD KLEIN

August 07, 2026



1	1 UNITED STATES PATENT AND TRADEMARK OFFICE 2 BEFORE THE PATENT TRIAL AND APPEAL BOARD 3 4 TOPSOE, INC., 5 Petitioner, 6 vs. 7 L'AIR LIQUIDE, SOCIÉTÉ ANONYME POUR L'ETUDE 8 ET L'EXPLOITATION DES PROCÉDÉS GEORGES 9 CLAUDE, 10 Patent Owner. 11 Case IPR2025-01173 12 Patent No. 11,673,805 13 14 15 REMOTE DEPOSITION OF HARALD KLEIN 16 17 18 19 Friday, August 7, 2026 20 8:00 a.m. (CDT) 21 22 23 Reported by: 24 Joan Ferrara, RMR, FCRR 25 Job No. 2026-1033870	3
2	1 REMOTE APPEARANCES: 2 3 ON BEHALF OF PETITIONER: 4 SPENCER FANE LLP 5 3040 Post Oak Boulevard 6 Suite 1400 7 Houston, Texas 77056 8 BY: JEFFREY J. PHILLIPS, ESQ. 9 jphillips@spencerfane.com 10 11 12 ON BEHALF OF PATENT OWNER: 13 NORTON ROSE FULBRIGHT US LLP 14 98 San Jacinto Boulevard 15 Suite 1100 16 Austin, Texas 78701 17 BY: EAGLE ROBINSON, ESQ. 18 SOPHIA POIRIER, ESQ. 19 eagle.robinson@nortonrosefulbright.com 20 sophia.poirier@nortonrosefulbright.com 21 22 23 ALSO PRESENT: 24 KYRIL TALANOV 25	4
2	1 2 3 4 August 7, 2026 5 8:00 a.m. (CDT) 6 7 8 9 10 Deposition of HARALD KLEIN, held 11 remotely via Zoom, before Joan Ferrara, 12 a Registered Merit Reporter, Certified 13 Realtime Reporter, and Notary Public. 14 15 16 17 18 19 20 21 22 23 24 25	4

5 1 HARALD KLEIN, 2 called as a witness, having been 3 duly sworn by a Notary Public, was 4 examined and testified as follows: 5 EXAMINATION BY 6 MR. ROBINSON: 7 Q Good morning, Dr. Klein. 8 A Hi, Mr. Robinson. Good morning. 9 Q Thank you for joining us again 10 today. I'll try to keep this as short, as 11 painless as possible. 12 Brief reminder. Let's please 13 try not to talk over each other. So if I 14 ask a question, just wait for me to finish. 15 Is that fair? 16 A Sure. 17 Q And if anything I ask is 18 unclear, please feel free to ask me to 19 restate it. 20 So we are here today to address 21 your reply declaration relating to the '805 22 Patent. Is that your understanding? 23 A That's my understanding, yes. 24 Q Okay. And that is for 25 IPR2025-01173, correct?	7 1 most curious if you've got Outlook or any 2 other email client open or any instant 3 messaging client open. 4 A No. I closed my Outlook not to 5 get disturbed by any warning signals. 6 Q Great. Thank you. 7 So I'm not sure that we'll need 8 the Bridge Mobile link. I plan to just 9 share the documents through the chat, since 10 we all already have those, but I don't 11 think it's going to hurt anything if you 12 have that open. 13 MR. PHILLIPS: Eagle, this is 14 Jeff. I just wanted to point out, I 15 think Dr. Klein has in front of him 16 his binder with some of the relevant 17 documents, the same one that he had 18 before -- and I think he's added -- he 19 can tell you what's in it, but I think 20 he added his new declaration as well 21 to it. 22 MR. ROBINSON: Gotcha. 23 BY MR. ROBINSON: 24 Q Well, then that may make it 25 easy. I can ask you to refer to certain
6 1 A Correct. 2 Q Okay. What did you do to 3 prepare for today's deposition, sir? 4 A I went again through this 5 supplementary declaration to get prepared 6 again for your discussion. 7 I especially went through the 8 main references, the exhibits again, 9 Reinertsen, Darby and Ritter. 10 And I also went through my 11 original declaration where I describe the 12 contents of these exhibits. 13 Q Before I forget, do you have any 14 windows open on your computer other than 15 the Zoom platform that we're using for this 16 communication now, Dr. Klein? 17 A I just got a link from -- I 18 think it was from the court reporter. And 19 then my Chrome opened up with a window 20 called Bridge Mobile. I do not know 21 whether I need that. I'm not familiar with 22 that tool. I just used the link, what the 23 court reporter prepared in the chat. 24 Shall I close that? 25 Q That doesn't bother me. I'm	8 1 documents since they're already in the 2 record. That'll save us some time waiting 3 for PDFs to upload and download from the 4 chat. 5 Dr. Klein, just a general 6 matter, did you perform any process 7 simulations or numerical modeling between 8 the time of your first deposition and the 9 submission of your reply declaration, 10 Exhibit 1031? 11 A I did perform some single-spaced 12 process calculations, but for other 13 projects, not to relate to this IPR, no. 14 But I did, of course, single calculation, 15 that's my daily business, but not for the 16 IPR. 17 Q I appreciate the precision of 18 your answer. You've done no process 19 modeling or numerical calculations for this 20 proceeding. 21 A No. 22 Q Thank you. 23 I'm going to ask you to refer to 24 the Reinertsen reference, Exhibit 1005. 25 A Yes, it's in front of me.

9 1 Q Paragraphs 47 to 51 disclose a 2 method for producing hydrogen that 3 specifically separates co2 before it 4 separates hydrogen, correct? 5 A Which paragraphs do you mean in 6 detail, 47 up to -- 7 Q 47 to 51. 8 A And your question was whether 9 the hydrogen separation is performed 10 upstream of the co2 separation? 11 Q No, sir. These paragraphs 12 expressly describe co2 being separated 13 upstream from hydrogen, correct? 14 A Yes, it does. That's paragraph 15 50. 16 Q I'm going to ask you to refer to 17 Claim 1 in that same Reinertsen document, 18 please. 19 (Reporter seeks clarification.) 20 THE WITNESS: Five zero. 21 A Yes, Claim 1 on page 28 of 29. 22 Q Perfect. Thank you. 23 Do you see where -- I think it's 24 the third clause of Claim 1 -- it says 25 performing a water gas shift process.	11 1 Q And that's the shifted gas 2 coming from the water gas shift reactor? 3 A Yes. 4 Q So Claim 1 doesn't specify an 5 order of hydrogen separation and carbon 6 dioxide separation, does it? 7 A It says "and". It says 8 hydrogen -- that's the first part of the 9 sentence. And the second part after the 10 "and" is the carbon separation, carbon 11 dioxide separation, but it doesn't 12 explicitly say the order. 13 Q And so Claim 1, for example, 14 would be broad enough to cover the process 15 we looked at in paragraphs 47 through 50 16 where carbon dioxide is separated before 17 hydrogen? 18 A Yeah. 19 MR. PHILLIPS: Objection. 20 Objection to form. 21 A Can you -- sorry, Mr. Robinson, 22 what was your question? 23 Q So that Claim 1 would be broad 24 enough to cover the process we looked at in 25 paragraphs 47 through 50, where carbon
10 1 A Yes. 2 Q On the reformed gas. 3 A Yes, I see it. 4 Q All right. Thanks. 5 And then it says performs the 6 water gas shift process on the reformed gas 7 so as to generate a shifted gas comprising 8 hydrogen and carbon dioxide. 9 A I see it, yes. 10 Q Okay. And then that next step, 11 it says performing a hydrogen separation 12 process and a carbon dioxide separation 13 process on the shifted gas. 14 Do you see that? 15 A Yes. 16 Q So Claim 1 expressly recites 17 performing both a hydrogen separation 18 process and a carbon dioxide separation 19 process on the shifted gas from the water 20 shift gas process, correct? 21 A That's the fourth clause, 22 separation process -- performing a hydrogen 23 separation process and a carbon dioxide 24 separation process on the shifted gas. 25 Yes.	12 1 dioxide is separated upstream of hydrogen 2 separation? 3 A According to Claim 1, that's 4 possible. And that's also shown in Figure 5 2 of Mr. Reinertsen's comparative example. 6 Q I'm going to ask you to refer to 7 paragraph 83 of Reinertsen. 8 A Yes, I have it in front of me. 9 Q Paragraph 83 specifically 10 addresses hydrogen separation using a 11 membrane, correct? 12 A Yes. Palladium membrane. 13 Exactly. 14 Q And the gas output from the 15 reactor is the shifted gas, correct? 16 A Yes. 17 Q Is any co2 separation method 18 perfect, meaning will it capture 100% of 19 co2 in a process stream? 20 MR. PHILLIPS: Objection to 21 form. 22 A A separation, that's one rule of 23 thermal separation process, is the 24 separation is never ever 100.0000 perfect. 25 Q And that's true of both amine

13 1 co2 separation and cryogenic co2 2 separation, correct? 3 A Correct. 4 Q So downstream of either amine 5 separation or co2 separation, there will 6 still be some co2 in the process stream? 7 A Sorry, I didn't understand the 8 question. You said downstream an amine 9 separation or a co2 separation? 10 An amine separation can be a co2 11 separation. Do you mean -- what do you 12 mean with amine separation and co2 13 separation? 14 Q So, great question. Let me 15 clarify. 16 Regardless of whether you use 17 amine separation or cryogenic separation 18 for co2, there will still be some co2 in 19 the process stream downstream, correct? 20 A Depending on the design of the 21 system, of the separation system, there can 22 be some co2 in the -- when you say process 23 stream, that's then the co2 depleted 24 stream. There can be traces of co2. And 25 there can be also, let's say, in percentage	15 1 of co2 while hydrogen is kept back. 2 This describes a separation of 3 co2 from a hydrogen containing stream, 4 yeah. 5 Q So I think it would be helpful 6 to align on what we mean by separation 7 here. 8 My understanding of paragraph 9 85, or at least your discussion of 10 paragraph 85 in your declaration, is that 11 the membranes in 85 are being used for 12 hydrogen separation in the sense of 13 separating an isolated hydrogen product. 14 A To which paragraph of my 15 declaration do you refer to? 16 Q Well, we'll go to that in just a 17 second. 18 Let's start with Reinertsen. 19 Help me understand, what's your 20 understanding of paragraph 85? Is that -- 21 and let me ask that more specifically, 22 sorry. 23 Is it your understanding that 24 paragraph 85 is discussing membranes for 25 sort of any isolation of any gas species
14 1 range co2 left in intentionally, because 2 you need some co2 in the process stream. 3 If co2 is to be avoided, it can 4 go down to a very low PPM level. 5 Q But even if you want to remove 6 as much co2 as possible, the co2 depleted 7 stream will always include at least some 8 co2, correct? 9 A Yes. And that can go down to 10 the low PPM level. 11 Q I'm going to ask you to refer to 12 paragraph 85 of Reinertsen, please, 13 Dr. Klein. 14 A 85, okay. Same page, yeah. 15 Q Paragraph 85 doesn't mention 16 shifted gas, does it? 17 A In line 5, it says gas output 18 from a WGS reactor. This is shifted gas. 19 Q Oh, okay. 20 Does paragraph 85 discuss 21 isolation of co2? 22 A What do you mean with isolation, 23 separation? 24 Q Sorry, yes. 25 A Yeah. It says rapid permeation	16 1 generally, or is it discussing membranes 2 specifically for the separation of hydrogen 3 alone as an isolated product? 4 MR. PHILLIPS: Objection to 5 form. 6 A Can I read, in detail, through 7 paragraph 85? 8 Q Of course, sir. 9 A The first part of paragraph 85 10 describes rapid permeation of co2 while 11 hydrogen is kept back. 12 This is separation of co2 with a 13 membrane, which is selective for permeation 14 of co2. That's the -- Reinertsen starts in 15 85, paragraph 85, with embodiments may 16 alternatively use a combination of solid 17 membranes. 18 So my understanding of that 19 paragraph is it's really alternatively to, 20 let's say, the main parts of -- in his 21 patent where it describes co2 separation. 22 There are two other processes he 23 focuses on, which is in Figure 2, the -- we 24 talked about that already, the amine 25 separation; and in his Figure 4, his main

17 1 embodiment, the cryogenic co2 separation. 2 And, in 85, he describes 3 alternatives. And there is also the 4 possibility to have co2 selective 5 membranes, besides cryogenic, besides 6 amines, to separate the co2 out of 7 hydrogen -- to separate the co2 from the 8 hydrogen. 9 That's the first part of 10 paragraph 85. 11 And actually the second part 12 starts already at line -- one, two, three, 13 four, five -- end of line 5, the remaining 14 two-thirds of paragraph 85 is describing 15 the pressure swing adsorption to separate 16 acid gas mixture. 17 That's my understanding of 85. 18 Q Thank you. 19 Just to make sure the record's 20 clear, the sentence "embodiments may 21 alternatively use PSA to separate 22 hydrogen," I believe starts on line 4 of 23 paragraph 85. 24 A Correct. 25 Q Okay.	19 1 So a PSA -- but I know what -- 2 it's quite common probably in engineering 3 of thermal separations. A co2 selective 4 membrane separates co2, leaving the other 5 stream rich in hydrogen. That's also 6 separation of hydrogen. And vice versa, 7 when you do a separation of hydrogen from 8 -- oh, the court reporter doesn't see my 9 quotes. 10 Anyway, if you separate hydrogen 11 with a PSA, you have a residual gas, purge 12 gas, rest gas -- you can find all 13 expressions in all the exhibits. 14 In that other gas, there is an 15 enrichment of co2, and therefore you can 16 also, in quotes, say in a PSA you separate 17 co2 from the hydrogen, because the co2 is 18 not there and then anymore in the hydrogen 19 stream, so... 20 Q So, this is a good point. 21 Shifted gas includes what components? 22 A It contains hydrogen. It 23 contains co2. It contains excess steam, 24 water vapor. It also contains some carbon 25 monoxide, CO, which has not been converted
18 1 A Actually, it's only the first 2 one, two, three lines of paragraph 85 3 describing the co2 permeable membrane, 4 yeah. 5 Q Okay. And so then starting at 6 line 4, it pivots to the use of PSA to 7 separate hydrogen, correct? 8 A Exactly. Yes, correct. 9 Q Okay. Other than those first 10 three lines, does paragraph 85 discuss co2 11 separation? 12 A Starting from line 4, it 13 describes pressure swing adsorption, PSA. 14 When you talk about separation 15 in thermal separation processes in our, 16 let's say, scientific field, yeah, it's 17 quite common to talk about separate 18 component A or separate component B. 19 But you can also flip it around. 20 When you separate -- you have a mixture of 21 A/B. And when you separate A, the other 22 stream is then enriched in B, which can be 23 also enriched in B to a very high level. 24 Then you can also classify that process as 25 separating B.	20 1 in the water gas shift reactor. 2 And upstream of the water gas 3 shift reactor, there is any kind of a steam 4 reformer, ATR/GHR combination where some of 5 the methane is also not converted. 6 In syngas technology, we talk 7 about from the reformer. That's a methane 8 slip that's in the shifted gas. 9 And we talk about the CO slip, 10 which is also present in the shifted gas. 11 But the main components is 12 hydrogen and co2. 13 Q So just to summarize, the main 14 components are hydrogen and co2. But 15 shifted gas also includes carbon monoxide, 16 co2, and water in the form of steam, h2o, 17 and some unreacted methane which I believe 18 is ch4? 19 A Exactly. 20 Q Okay. So, generally speaking, 21 when Reinertsen talks about separating co2, 22 he's referring to removing co2 from that 23 process stream to get primarily isolated 24 co2? 25 A If you perform a first

21 1 separation on the shifted gas, which is an 2 amine absorption, then you perform a co2 3 separation on the water gas shift outlet, 4 yes. 5 Q And, similarly, when Reinertsen 6 talks about separating hydrogen or h2, 7 generally that references removing hydrogen 8 from the shifted gas to get primarily a 9 hydrogen product stream? 10 A Yeah. You can also -- after the 11 shift reactor, you can also start with the 12 hydrogen separation. Then it's either a 13 membrane or a PSA. And then do the co2 14 separation on the residual gas, on the rest 15 gas of the PSA, or the membrane. 16 Q So with that understanding, 17 let's go back to paragraph 85 for a moment. 18 Other than the first three 19 sentences, does paragraph 85 discuss co2 20 separation? 21 A It describes in the first three 22 lines an alternative process with co2 23 selective membranes to separate the co2 24 from the shifted gas. 25 Then the remaining part of	23 1 bit -- you can consider this, this is 2 separation of hydrogen, but you also 3 separate the co2 from the hydrogen because 4 he doesn't say that explicitly, but that's 5 then left in the rest gas, yeah. 6 Q Right. But generally, this -- 7 and paragraph 85 refers to this as hydrogen 8 separation because the hydrogen is 9 separated from a mixture, but the rest of 10 the mixture is adsorbed. 11 A Exactly. 12 Q So when the rest of that mixture 13 is released from the adsorbent, it does so 14 as a mixture of carbon monoxide, co2 and 15 ch4, correct? 16 A Correct. May I add, there is 17 also hydrogen then in that mixture. 18 Q So the hydrogen isolation is not 19 perfect either. 20 A You get an ultra pure hydrogen 21 stream, but you don't get all the hydrogen. 22 Q Gotcha. 23 A So it's always -- we, in some 24 separation processes we call -- we talk 25 about purity and recovery rate, or yield.
22 1 paragraph 85 is about PSA. It describes 2 the PSA technology that you get 3 separation -- you get adsorption of all 4 components besides hydrogen. 5 And then there is -- yes, it 6 describes that the hydrogen is separated 7 from the other components in the PSA, yeah. 8 Q I just want to make sure I 9 understand that. 10 So other than the first three 11 sentences of paragraph 85, paragraph 85 12 does not discuss co2 separation? 13 MR. PHILLIPS: Objection to 14 form. 15 A The remaining part, starting 16 with line 4, embodiments may alternatively 17 use PSA to separate hydrogen on the 18 remaining part of that paragraph. It does 19 not mention co2 separation. It mentions 20 again in the five last lines the mixture of 21 gases which are going to the PSA in the 22 present mixture of gases, co, co2 and ch4 23 are adsorbed, letting the hydrogen pass 24 through. 25 So this is, again, a little	24 1 There are two different stories. 2 High purity does not mean automatically 3 high yield, and vice versa. 4 Q Okay. Paragraph 85 doesn't 5 discuss the residual gas from the PSA unit, 6 does it? 7 A I cannot read the word residual, 8 rest, of whatever gas. It just says the 9 components which are adsorbed. 10 Q And just let me ask that a 11 little bit of a different way. 12 Paragraph 85 doesn't address 13 what happens to those adsorbed components 14 downstream of the PSA, does it? 15 A No. Correct. 16 Q And paragraph 85 doesn't mention 17 any figures, does it? 18 A Correct. 19 Q I'm going to ask you to refer 20 back to paragraph 56 of Reinertsen, please. 21 A Uh-huh, I have it. 22 Q Paragraph 56 says that PSA 23 processes may also result in co2 being 24 released at low pressure, e.g. atmospheric 25 pressure, and so there is a subsequent need

25 1 for compression and cooling. 2 Do you see that? 3 A Yes, I see it. 4 Q Okay. Co2 is often compressed 5 for transport and storage, correct? 6 A Correct. 7 Q And that sentence says that PSA 8 processes may result in co2 being released 9 at low pressure, not that it necessarily 10 will result in co2 being released at low 11 pressure, correct? 12 A Reinertsen says may result in, 13 yes. 14 Q Wouldn't that depend, in part, 15 on whether a PSA hydrogen separation 16 process is inserted upstream or downstream 17 of co2 separation? 18 A If PSA is installed downstream, 19 a co2 separation, then this co2 separation 20 in between the water gas shift and the PSA 21 would be an amine absorption system, which 22 releases the co2 also at low pressure. 23 Q So if you remove the co2 24 upstream of the PSA, then the PSA would not 25 result in a meaningful co2 being released	27 1 Q So in a PSA, the adsorbent, is 2 that a physical material? 3 A The adsorbent are solid 4 materials, yes, different materials. 5 Zeolites, most important ones. 6 Q Are they a porous material? 7 A Very porous. You need a high 8 surface per volume. Because zeolites, also 9 mol sieves, it's like they sieve everything 10 out besides the hydrogen. 11 And to catch all other gases 12 like co2, co, ch4, you need a high 13 adsorption area. Otherwise, you cannot 14 design economically an adsorbent -- an 15 adsorber, the piece of equipment. Yes, 16 it's very porous. 17 Q You mentioned surface area. 18 Does the required surface area increase 19 with the volume of gases you need to 20 adsorb? 21 A When you talk about volume of 22 gas, do you think about a microscopic level 23 in terms of really volume, maybe even per 24 time, in a plant, or do you think about in 25 angstrom level how big is a molecule?
26 1 at low pressure downstream of PSA, correct? 2 MR. PHILLIPS: Objection to 3 form. 4 A If you install an amine-based 5 co2 removal system downstream of a water 6 gas shift reactor and your target is to 7 remove all co2, then there is no co2 going 8 to the PSA. Therefore, there is no co2 9 released in the residual gas of the PSA. 10 That's one alternative process 11 configuration. 12 Let's say the co2 has a very 13 high value and you really want to remove it 14 completely, you can also design an 15 amine-based system to leave 50%, 60%, 90%, 16 10% of the co2 in the outlet of the co2 17 removal. 18 And then there is some -- 19 there's then co2 going to the PSA. And 20 then there is also then, of course, co2 in 21 the rest gas of the PSA. 22 It depends on the application. 23 It's like building blocks depending on the 24 boundary conditions of the plant you 25 design.	28 1 Co2 is a bigger molecule than 2 hydrogen molecule. 3 What do you mean with volume of 4 a molecule? 5 Q That's fair. Let me see if I 6 can ask that a little more plainly. 7 If co2 is not removed upstream 8 of a PSA unit, the PSA unit would need to 9 be larger to handle the co2, correct? 10 A Correct. And on top of that, to 11 be more precise, we talked about the solid 12 adsorbents, the zeolites, the molecular 13 sieves, the moles, sieves which adsorb all 14 these components. 15 And when you have a 16 co2-containing feed going to a PSA, a PSA 17 adsorber is -- it's stacked -- how do you 18 say -- staggered. There are different kind 19 of materials. 20 The first part is simple silica 21 gel. If you buy a new laptop and you 22 unpack it, you have this small packets and 23 it usually says "do not eat," please don't 24 do it because it has silica gel in it and 25 it really adsorbs water.

29 1 And this is cheap material. And 2 this is the first layer in a PSA bed. It 3 takes out the water, and actually it leaves 4 the other molecules co, ch4, also co2 and 5 of course hydrogen through. 6 And then after the water is 7 removed, there is a special layer of co2 8 removal adsorbent, which has bigger pores 9 that the co2 get adsorbed. And the co and 10 the hydrogen and the methane slip through. 11 And then there is a next layer. 12 Now we start with the more expensive 13 materials, the zeolites. And the first 14 zeolite is designed to take out the still 15 bigger ch4 as compared to the co. 16 And then the very last layer -- 17 and now it gets -- that's the toughest 18 separation task in a PSA, to separate the 19 co from the hydrogen -- and therefore you 20 need another type of zeolite, which is 21 really very selective in co and lets the 22 hydrogen slip through. 23 And if you would take -- let's 24 flip it around. If you would take the most 25 expensive finest material, the co, the co	31 1 sharp design of an amine -- sharp meaning 2 really taking out co2 down to a PPM level. 3 And the PPM level also can -- there is no 4 extra capacity required to remove 20 PPM 5 out of -- if it's downstream of an amine 6 system. 7 And then the 20 PPM, they will 8 be removed then by the methane and the co 9 layers, but they will not occupy that to a 10 large extent. 11 So, therefore, yes, co2, the 12 remaining part of co2 would be removed, but 13 there is no extra layer required. 14 Q Gotcha. 15 I'm going to ask you to refer to 16 paragraph 82 of Reinertsen. 17 A Yes, I have it. 18 Q So that first sentence says: 19 Gas is in the mixture after the shift 20 reactor or the shift reactors can be 21 separated more or less completely based on 22 the different properties of the gas 23 molecules. 24 Do you see that? 25 A Yes.
30 1 removing zeolite for the full bed, you 2 would cover it all with water, which is not 3 necessary, and then there is less capacity 4 left for the important co. 5 So, therefore, a good PSA 6 designer, he knows the materials available. 7 And the art of PSA design is to have this 8 staggered design of different adsorbent 9 materials. 10 So they have different pores 11 depending on the molecules they have to 12 adsorb. 13 Q Okay. And so if co2 is removed 14 upstream of the PSA, then if I understand 15 you, the layer of co2 adsorbent could be 16 omitted from the PSA, is that correct? 17 A Yeah, you would -- yeah, you 18 could -- there is no co2 anymore to be 19 removed. 20 Maybe there are some PPM parts, 21 which the amine is not designed for to take 22 it out. Then you can work on the PPM 23 removal still on the -- on an extra layer 24 in the PSA. 25 But let's say if there is a	32 1 Q That sentence isn't specific to 2 any particular molecule, for example, 3 hydrogen or co2, is it? 4 A The sentence doesn't say -- it's 5 nice. What Reinertsen calls more or less, 6 half an hour ago I said no separation is 7 ever 100% complete. This is what means -- 8 what's meant here, more or less, yeah. 9 Q Okay. And the second sentence: 10 The most common techniques are absorption, 11 adsorption, and cryogenic distillation. 12 Do you see that sentence, sir? 13 A I see that, yes. 14 Q And is that specific to any 15 particular molecule? 16 A No, not in that sentence. 17 Q Okay. Is adsorption a way of 18 separating co2? 19 A It is a method, it's a technical 20 relevant process, but not in the context of 21 the '805 Patent. 22 Q Can adsorption be used to 23 separate co2? 24 A Sorry again, ad or ab? 25 Q Ad. A-D, as in dog.

33 1 A Yeah, adsorption is a method to 2 remove traces of co2. That's done, for 3 instance, when you do a cryogenic air 4 separation. 5 All we know that the co2 content 6 is increasing on our earth. It's too high 7 for the climate, but it's still very low, 8 400 PPM. 9 But this 400 PPM would disturb 10 the air separation process. It goes down 11 to very low cryogenic temperatures, minus 12 180 degrees C. At that temperature, any 13 co2 would freeze and block the compact heat 14 exchangers. 15 So, therefore, besides water 16 vapor from our atmosphere, also co2 is 17 removed via adsorption -- dog, D -- yes, 18 co2 removal via adsorption is possible, but 19 not in the context of a water gas shift 20 outlet. 21 Q Okay. And adsorption is one way 22 of separating hydrogen, correct? 23 A Adsorption is done in a PSA. 24 Actually, it's done to separate hydrogen, 25 but you adsorb the other components.	35 1 In engineering, it's not labeled 2 as a hydrogen separation. It's a co2 3 separation, like PSA is labeled as a 4 hydrogen separation. 5 Q Okay. Reinertsen is -- sorry. 6 The Reinertsen reference is 7 directed to a hydrogen production process, 8 correct? 9 A Hydrogen production process with 10 the byproduct carbon dioxide co2. 11 Q And Reinertsen also mentions 12 ammonia production, correct? 13 A Can you guide me to a paragraph? 14 Q Sure. So just the title, for 15 example, is hydrogen and/or ammonia 16 production process. 17 A Yes, the title says that. 18 Q And I refer you to paragraph 1 19 as well. It's on page 18 of 29. 20 Even for ammonia production, the 21 hydrogen -- that just means that the 22 hydrogen is then used in a subsequent step 23 for ammonia, correct? 24 A Exactly. It says generating 25 hydrogen, which can be used for ammonia
34 1 Q Right. For example, in the PSA 2 that we discussed earlier. 3 A Yeah. 4 Q Gotcha. 5 Can cryogenic distillation be 6 used to separate hydrogen? 7 A Not to get a hydrogen product 8 stream, but you separate in the cryogenic 9 co2 separation. You separate hydrogen and 10 co from each other. 11 The cryogenic co2 separation 12 generates a high pure co2 stream. Because 13 in the feed from a PSA, or from a palladium 14 membrane, there's also hydrogen contained. 15 And here, in the cryogenic 16 separation, you separate in a way that you 17 get a pure co2 stream. 18 And, of course, the mass balance 19 requires that there is also another stream 20 going out of that unit. And this is a 21 hydrogen-containing stream. 22 I wouldn't consider this as 23 hydrogen separation. This is -- I mean, it 24 separates hydrogen from co -- or co -- 25 sorry, co2 from hydrogen.	36 1 synthesis. 2 Q So even when Reinertsen is 3 producing ammonia, its focus is still the 4 production of hydrogen, correct? 5 A Yes, correct. 6 Q I'm going to ask you to refer to 7 paragraph 149 of Reinertsen, please. 8 A 149, okay. 9 Q Yes. 10 So the first sentence says: The 11 embodiments presented throughout the 12 present document provide advantageous 13 methods and systems for the production of 14 hydrogen and/or ammonia. 15 Did I read that correctly? 16 A Correct. 17 Q Okay. And then the second 18 sentence says: In particular, the use of a 19 palladium membrane to separate hydrogen 20 immediately downstream of a WGS reactor has 21 a surprising synergistic effect. 22 Did I read that correctly? 23 A Correct. 24 Q Okay. And then the third 25 sentence says: Contrary to known

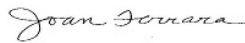
37 1 techniques, the WGS reactor may be operated 2 at substantially the same temperature as 3 the palladium membrane. The WGS reactor 4 may be operated under conditions that are 5 more preferable for the effective operation 6 of palladium membrane, and this can 7 substantially improve the overall 8 efficiencies and effectiveness of the 9 system. 10 Did I read that correctly? 11 A You did, yes. 12 Q Okay. That only addresses 13 palladium membrane hydrogen separation, 14 correct? 15 A Correct. 16 Q And those benefits would not 17 apply to a PSA hydrogen separation 18 immediately downstream of WGS reactor, 19 would they? 20 A I do not agree on that. 21 Q Why not? 22 A The idea of Reinertsen is 23 bringing the membrane separation in 24 connection with the water gas shift reactor 25 that the palladium membrane process can	39 1 A Definitely, in order to knock 2 out the condensate. Otherwise, the silica 3 gel layer in the adsorbers would be -- they 4 cannot be designed for that water amount. 5 You have to knock out the water. 6 And then the first layer of the 7 PSA just takes care of what's left in the 8 vapor stream after knocking out the water, 9 which is then in the low percent level as 10 compared to the excess downstream of the 11 shift -- yeah, you have to cool it down 12 after the shift to route it to a PSA. 13 Q Okay. 14 A That's one argument, knocking 15 out the condensate. 16 And the other argument is 17 adsorption is an exothermic process. And 18 thermodynamics teach us exothermic 19 processes are preferred preferably at not 20 too high temperatures. 21 So, therefore, besides knocking 22 out the water vapor, having the PSA at 23 their temperature sweet spot of, let's say, 24 30, 40 degrees C, that's the second reason 25 to cool it down.
38 1 operate at a higher temperature as compared 2 to the PSA. 3 Therefore, one operation mode, 4 one process option for the membrane process 5 could be to use a high temperature water 6 gas shift reactor. Outlet temperature of, 7 let's say, 400 degrees C, still containing 8 the excess steam, water steam, and as 9 compared to -- you can route that gas 10 directly without knocking out the surplus 11 steam. This can be routed directly to 12 Reinertsen membrane process. 13 So, therefore, a knockout of 14 condensate is one option. 15 Another option with a membrane 16 is not knocking out the condensate. 17 And when you want to knock out 18 the condensate, you have to go down to air 19 cooler, or cooling water temperatures, 20 30 degrees C. And you have to do that not 21 to overload the PSA, when you go for a PSA 22 system. 23 Q So if you use a PSA downstream 24 of a water gas shift reactor, the shifted 25 gas has to be cooled first, correct?	40 1 Q And so the shifted gas needs to 2 be cooled and water removed before it 3 enters a PSA? 4 A Yes. 5 Q Okay. Pages -- I think the 6 paragraph spanning -- sorry, the page 7 numbering gets confusing. 8 I'm going to ask you to refer to 9 your declaration. 10 A The supplemental or the original 11 one? 12 Q Sorry. Good clarification. 13 The supplemental declaration, 14 please. Exhibit 1031, I believe. 15 There is a paragraph spanning 16 pages 17 of 41 and 18 of 41. 17 A Paragraph 31? 18 Q I believe it's paragraph 28. So 19 there's two different sets. I'm referring 20 to the page numbering at the lower 21 right-hand corner. If you're looking at 22 the page numbering in the middle, it's 23 pages 14 to 15. 24 A Okay. 25 Q So this contemplates hydrogen

41 1 being compressed to somewhere between 350 2 and 900 bar for export or transport, 3 correct? 4 A Correct. 5 Q Referring back to Reinertsen, 6 specifically at Figure 4, I believe you 7 previously opined that the pressure coming 8 out of the shift reactor may be something 9 on the order of 32 bar? 10 A Yes. 11 Q So if that is fed to a PSA for 12 hydrogen separation, what would be the 13 pressure of the hydrogen? 14 A In that pressure, minus .5 bar. 15 Q So to keep whole numbers, 31 16 bar. 17 A Yeah. 18 Q Approximately. 19 A Yeah. 20 Q So even in that scenario, the 21 hydrogen would need to be compressed by a 22 factor of 10, at least. 23 A If -- let's -- if we take, let's 24 say, the most -- we're still waiting for 25 the hydrogen business and distribution	43 1 during the break? 2 A We just had a -- no substantial 3 matters, just getting feedback. 4 Q What kind of feedback? 5 A That it's okay that I take my 6 time for the answers and -- yeah. 7 Q Is that all? 8 A Yeah. 9 Q Okay. Reinertsen uses an 10 auto-thermal reformer, correct? 11 A Correct. 12 Q And an auto-thermal reformer is 13 a partial oxidation process, correct? 14 A The first part of the 15 auto-thermal reformer is a partial 16 oxidation. The second part is not. 17 Q And Reinertsen uses natural gas 18 as a feedstock for the partial oxidation, 19 correct? 20 A No, not correct. It uses the 21 effluent of the gas heated reformer as feed 22 to the ATR. You can refer to Figure 1. 23 Q Sorry. The natural gas is the 24 feedstock for the overall reforming process 25 of Reinertsen, correct?
42 1 business, but let's say 300 is a nice 2 number -- yeah, 300 bar, trailer pressure, 3 truck, tank pressure. Factor 10. 4 Q So even downstream of PSA, the 5 hydrogen would need to be compressed by a 6 factor of 10? 7 A Yes. 8 Q Okay. 9 MR. ROBINSON: We've been going 10 for about an hour. Why don't we take 11 a quick bio break, if that's okay. 12 THE WITNESS: That's a good 13 idea. I was going to ask anyway. 14 MR. ROBINSON: Okay. Maybe 10 15 minutes? 16 THE WITNESS: Yes. 17 MR. PHILLIPS: Sounds good. 18 MR. ROBINSON: Great. We'll 19 come back at 20 after the hour then. 20 Thank you. 21 (Recess taken 9:11 a.m.) 22 (Resumed 9:21 a.m.) 23 BY MR. ROBINSON: 24 Q Dr. Klein, did you have any 25 communication with counsel for Topsoe	44 1 A Stream 11 goes to unit 1, yes, 2 correct. 3 Q Okay. How does the output of 4 unit 1 differ from the natural gas input? 5 A Stream 11, it is natural gas. 6 But it's not only natural gas, it's natural 7 gas mixed with process steam. 8 So stream 11 is methane and h2o, 9 maybe some hydrogen from a desulfurization 10 unit -- which is not part of '805 or 11 Reinertsen. 12 Stream number 21 outlet of unit 13 1 is the outlet of the gas heated reformer. 14 It contains hydrogen, co, co2, still 15 unreacted methane, ch4, and also unreacted 16 water. 17 Q Is it fair to say that stream 21 18 includes the same components as stream 11, 19 but with higher proportions of hydrogen and 20 carbon monoxide? 21 MR. PHILLIPS: Objection to 22 form. 23 A Stream number 11 does not 24 contain any co -- and ch -- co2. 25 If there is some hydrogen, this

45 1 is just in a very small percentage range. 2 It's added to the natural gas before 3 process steam is added to hydrogenate 4 organic sulfur components. 5 And then there is a low number, 6 percentage number of hydrogen could be in 7 stream 11. 8 And the portion of hydrogen in 9 stream 21 is much higher. 10 Q So stream 11 would not include 11 any carbon monoxide or carbon dioxide? 12 A Correct. 13 Q Zero? 14 A Zero. 15 Q Okay. 16 A Depending -- sorry. Co, zero, 17 if the natural gas source, which is not 18 shown in Figure 1, the natural gas source 19 from a grid, this natural gas contains once 20 in a while some co2 -- not a lot, but 21 usually you try to take it out due to the 22 corrosion of sour gases when they get in 23 contact with water. 24 So if you take it out of a grid, 25 co2 is zero.	47 1 shift. 2 Stream 12 is also too hot still 3 for the water gas shift. It needs also 4 some further cooling before it goes to the 5 water gas shift. 6 Q Unit 5 is an air separation 7 unit, correct? 8 A Which figure are you referring 9 to? 10 Q Figure 4 Reinertsen. 11 A Yes, 5 is an air separation 12 unit. 13 Q And so stream 51 is oxygen, 14 correct? 15 A Correct. 16 Q And that oxygen or the flow rate 17 of oxygen is used to control the rate of 18 the partial oxidation reaction in the 19 auto-thermal reformer, correct? 20 A I would phrase it a little 21 differently. Let me go back to Figure 1 22 which shows the kind of the layout of the 23 auto-thermal reformer. 24 And let's say where they placed 25 the unit 2, this is the oxidation zone of
46 1 If you don't take it out of a 2 grid and your Figure 1 plant is very -- 3 it's a theoretical thought, but it's -- 4 let's say you have a natural gas well, 5 which contains a small amount of co2, and 6 you use this natural gas only for your 7 process in Figure 1, then a POSA would 8 think about I'm creating co2 anyway in unit 9 1, I can leave also the traces of co2 10 coming with the natural gas, I can leave it 11 in. And, therefore, there are cases when 12 stream 11 could contain some co2. 13 Q So then stream 21 goes to unit 14 2, which is the auto-thermal reformer? 15 A Correct. 16 Q And then stream 12 is the stream 17 that goes from the auto-thermal reformer to 18 the water gas shift reactor, correct? 19 A Stream 12 and stream 22, they 20 have the same composition. 21 The difference between 21 -- 22 22 and 12 is that it's cooled down from 21 to 23 12. But composition-wise, the outlet of 24 the auto-thermal reformer 22 is the same 25 composition which goes to the water gas	48 1 the ATR. What we see as shaded area, this 2 is the catalytic zone of the ATR. 3 And in this oxidation zone, yes, 4 it's a partial oxidation, and the oxygen is 5 controlled to avoid too much of total 6 condensation. But total condensation 7 cannot be avoided in a flame in the 8 combustion zone of an ATR. 9 There's also some full oxidation 10 of methane contained in 21, not only 11 partial oxidation to co, but also full 12 oxidation to co2. And this reaction has 13 the highest heat output. And we need this 14 heat output to have a high temperature 15 going into the shaded catalytic bed. 16 And, therefore, there is more 17 oxygen required just which would be 18 required for partial oxidation. 19 You add a little bit more in 20 order to have also the full oxidation. 21 And then if you're very, very 22 precise at the end, you control the 23 temperature of the ATR. And the control 24 element is in stream 21 -- sorry, 22. You 25 don't control the inlet of the bed. Your

49 1 temperature sensor would have a lifetime of 2 two minutes. 3 So you control 22 by the degree 4 of oxidation. That's how I would phrase it 5 in a classroom to teach the students the 6 correct thing. 7 So it's not only controlling the 8 partial oxidation, it's controlling the 9 oxidation zone. 10 Q Okay. But all of that is 11 controlled by the rate at which you deliver 12 oxygen at stream 51, correct? 13 A Exactly. There is a big 14 control -- that's the most important 15 control valve of an ATR. It's the control 16 valve of the oxygen in stream 51, yes. 17 Q Gotcha, okay. 18 Do you have Exhibit 1018 with 19 you? 20 A I have it with me, yes, printed 21 out. 22 Q I'm going to ask you to refer to 23 page 38 of 108. 24 A It shows PSA, yes. 25 Q The lower left-hand corner under	51 1 Air Liquide can provide to customers, 2 correct? 3 A Yes. And I knew that before. I 4 know that from my former life as a process 5 engineer at one of the competitors. I was 6 well aware that that's available from Air 7 Liquide, yeah. 8 Q Okay. I'm going to ask you to 9 refer to page 42 of Exhibit 1018. 10 A Yes. 11 Q Lower left-hand corner under the 12 economics heading, do you see where it says 13 hydrogen recovery is greater than 98%? 14 A Yes. 15 Q So that's higher than the 16 hydrogen recovery of PSA of 60 to 90%, 17 isn't it? 18 A 98% is higher than 60 to 90%, 19 yes. 20 Q Under the heading capacity, just 21 above that -- 22 A Yes. 23 Q -- do you see where it says 24 largest system referenced by Air Liquide is 25 124 membrane cartridges?
50 1 the heading economics. 2 A Yes, I see that. 3 Q It says the h2 recovery rate is 4 60 to 90%, is that correct? 5 A Correct. 6 Q Let me ask a more basic 7 question. What's your understanding of 8 what Exhibit 1018 is? 9 A Exhibit 1018, that's one of the 10 exhibits I brought on the table when 11 preparing the original declaration. It's 12 also in the exhibit list there. It's from 13 the Air Liquide homepage. And to my 14 knowledge, it's -- the title is something 15 like technology handbook. 16 I didn't print out the front 17 page, sorry. 18 Q So your recollection is correct. 19 It says Technology Handbook on the first 20 page. 21 A Exactly. It's a document 22 showing the technology portfolio of an 23 engineering company. In this case, Air 24 Liquide. 25 Q So these are technologies that	52 1 A Uh-huh, I see that. 2 Q So the referenced system 3 terminology or system reference terminology 4 suggests that that's an actual system 5 they're referencing, correct? 6 A Correct. 7 Q Okay. And the fact that they 8 mention a largest system suggests that 9 there are more than one system, correct? 10 A More than one, but lower number 11 of cartridges. 12 Q And then the first phrase under 13 the capacity heading says membrane systems 14 are truly scalable, with virtually no upper 15 capacity limit. Correct? 16 A That's what's stated there, yes. 17 Q And if we refer back to page 38, 18 the same capacity limit, the same capacity 19 heading shows an upper limit for PSA, 20 correct? 21 A 200,000 normal cubic meters per 22 hour. 23 Q So it's limited, and it suggests 24 an upper limit to its capacity, correct? 25 A That's around the largest PSA

53 1 systems I have also in mind from my 2 experience, 200,000 cubic meters. 3 Above that, above the PSA plant 4 would be a two-train/three-train parallel 5 plant. Up to 200,000, that sounds like a 6 sensible upper limit for one-train PSA 7 plant. 8 When we compare that with the 9 cartridges on page 42, right, the 124 10 cartridges, that means that all these 11 cartridges are parallel. So that's the 12 largest Air Liquide installed. 13 But as compared to a PSA plant, 14 you have to go to a parallel arrangement of 15 10 -- 100, 124 cartridges at a lower feed 16 inlet already. So that means the 124 17 cartridges are 124 parallel membrane units. 18 And that's the largest one they installed. 19 And apparently, you can -- if 20 there is plot space, you can install 125. 21 And you can also install 200 cartridges. 22 Theoretically, there is no limit 23 if you go parallel as you do with this Air 24 Liquide membrane technology. 25 This 200,000 upper limit of a	55 1 Just let me know when you've got 2 that downloaded, Dr. Klein. 3 A Okay. I'll store it on my 4 desktop for a second. It's the fastest 5 one. 6 Okay. I have it open in my 7 Adobe Reader. 8 Q Please refer to page 32 of 108. 9 A Yes. I find it. Gas POX, 10 natural gas partial oxidation, yes. 11 Q So in between -- on the left 12 side of the white portion of this page, in 13 between the description and references 14 heading, there's some bold text that says 15 main features. 16 Do you see that? 17 A Yes. 18 Q Four lines up from that, do you 19 see where it says "suitable product 20 purification technologies include"? 21 A PSA and membrane h2, yes. 22 Q So that's specifically saying 23 that PSA and membrane can both be used for 24 hydrogen separation downstream of natural 25 gas partial oxidation, correct?
54 1 PSA is the limit of a one-train PSA plant. 2 If you go parallel with two of 3 them, you're already at 400,000. 4 And if this is not the limit, 5 then you can go three trains, four trains. 6 So when you go parallel, you're 7 also unlimited with PSA. That's one thing. 8 And to mention that if you look 9 at the feedstock on page 42, it says any 10 purge stream -- sorry -- any purge gas 11 streams with hydrogen concentrations. 12 So it's not used for the Air 13 Liquide membrane technology described on 14 page 42. They don't use that for shifted 15 gas out of a water gas shift reactor. 16 That's my understanding of this 17 technology handbook. 18 Q So let's go back to page 32 of 19 Exhibit 1018. 20 A 32, I did not print out. 21 Q No problem. I can share it in 22 the chat. You can download the PDF. 23 Give me one second. 24 It's uploading. Give it just a 25 second. Hopefully, it's available now.	56 1 A That's correct, yes. 2 Q And then the next line says that 3 amine wash is suitable for co2 removal, 4 correct? 5 A Correct. 6 Q It does not list cryogenic co2 7 separation here, does it? 8 A No. It lists only amine. 9 Q Sorry. I've got too many 10 windows open. Give me just one second 11 here. 12 MR. ROBINSON: All right, Jeff. 13 I think I'll pass the witness, if 14 you've got any redirect. 15 You're on mute. 16 MR. PHILLIPS: Sorry. So you're 17 done with questions? 18 MR. ROBINSON: Yeah. 19 MR. PHILLIPS: Oh, I have no 20 questions either. 21 MR. ROBINSON: Dr. Klein, I'm 22 sorry we couldn't spend more time 23 together on your Friday afternoon. 24 MR. PHILLIPS: Thanks all. 25 MR. ROBINSON: Have a great

57 1 weekend. Joan, do you need anything? 2 THE COURT REPORTER: Jeff, I 3 emailed you regarding your order, but 4 you can just give it to me here. 5 Would you like the same order as 6 Norton? 7 MR. ROBINSON: I believe we are 8 getting a rough draft and 5-day 9 delivery. 10 MR. PHILLIPS: Yes, I'll do the 11 same. 12 THE COURT REPORTER: Thank you 13 everyone. Have a great weekend. 14 (Time noted 9:49 a.m.) 15 * * * 16 17 18 19 <u>HARALD KLEIN</u> 20 21 Subscribed and sworn to 22 before me this day 23 of , 20__ 24 25 NOTARY PUBLIC	59 1 DEPOSITION ERRATA SHEET 2 3 Case Caption: 4 TOPSOE, INC. 5 VS. 6 L'AIR LIQUIDE, et al. 7 8 DECLARATION UNDER PENALTY OF PERJURY 9 I declare under penalty of perjury 10 that I have read the entire transcript 11 of my deposition taken in the captioned 12 matter or the same has been read to me, 13 and the same is true and accurate, save 14 and except for changes and/or corrections, 15 if any, as indicated by me on the 16 DEPOSITION ERRATA SHEET hereof, with the 17 understanding that I offer these changes 18 as if still under oath. 19 SIGNATURE _____ DATE: _____ 20 HARALD KLEIN 21 22 Subscribed and sworn to on the ____ day of 23 _____, 20__ before me, 24 Notary Public, 25 in and for the State of _____
58 1 REPORTER CERTIFICATE 2 3 I, JOAN FERRARA, do hereby certify: 4 That said deposition was taken at the 5 time and place herein named; and that the 6 transcript is a true record of the testimony 7 as reported by me, a disinterested person, 8 and was thereafter transcribed. 9 I further certify that I am not 10 interested in the outcome of the said 11 action, nor connected with, nor related to 12 any of the parties in said action, nor to 13 their respective counsel. 14 IN WITNESS WHEREOF, I have hereunto 15 set my hand this 7th day of August, 2026. 16 17 18 19  20 JOAN FERRARA, RMR, FCRR 21 22 23 24 25	60 1 DEPOSITION ERRATA SHEET 2 Page No. ____ Line No. ____ Change 3 to: _____ 4 Reason for 5 change: _____ 6 7 Page No. ____ Line No. ____ Change 8 to: _____ 9 Reason for 10 change: _____ 11 12 Page No. ____ Line No. ____ Change 13 to: _____ 14 Reason for 15 change: _____ 16 17 Page No. ____ Line No. ____ Change 18 to: _____ 19 Reason for 20 change: _____ 21 22 Page No. ____ Line No. ____ Change 23 to: _____ 24 Reason for 25 change: _____ 26 SIGNATURE: _____ DATE: _____ 27 HARALD KLEIN 28 29 30

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