

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AIR LIQUIDE LARGE INDUSTRIES U.S. LP,
Petitioner,

v.

PRAXAIR TECHNOLOGY, INC.,
Patent Owner.

Case IPR2015-01072
Patent 7,078,011 B2

Before WILLIAM V. SAINDON, CHRISTOPHER L. CRUMBLEY, and
JEFFREY W. ABRAHAM, *Administrative Patent Judges*.

CRUMBLEY, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318 and 37 C.F.R. § 42.73

I. INTRODUCTION

In this *inter partes* review trial, instituted pursuant to 35 U.S.C. § 314, Petitioner Air Liquide Large Industries U.S. LP challenges the patentability of claims 1, 3, 7, and 8 of U.S. Patent No. 7,078,011 B2 (“the ’011 patent,” Ex. 1001), owned by Praxair Technology, Inc.

We have jurisdiction under 35 U.S.C. § 6(b). This Final Written Decision, issued pursuant to 35 U.S.C. § 318(a), addresses issues and arguments raised during trial. For the reasons discussed below, we determine that Air Liquide has proven, by a preponderance of the evidence, that claims 1, 3, 7, and 8 of the ’011 patent are unpatentable.

A. Procedural History

On April 18, 2015, Air Liquide requested an *inter partes* review of claims 1–3, 7, and 8 of the ’011 patent. Paper 1, “Pet.” Praxair filed a Patent Owner Preliminary Response. Paper 10. In a Decision on Institution of *Inter Partes* Review, we instituted trial as to claims 1, 3, 7, and 8, but denied institution as to claim 2. Paper 12, “Dec. on Inst.” Trial was instituted on the following grounds of unpatentability:

1. Whether claims 1, 3, and 8 are unpatentable under 35 U.S.C. § 103(a) as having been obvious over Pottier¹, CGA Spec², and CGA Handbook³;
2. Whether claims 1, 3, and 8 are unpatentable under 35 U.S.C. § 103(a) as having been obvious over Pottier, CGA Spec, CGA Handbook, and Scott;⁴
3. Whether claim 7 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over Pottier, CGA Spec, CGA Handbook, and Kelley;⁵ and
4. Whether claim 7 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over Pottier, CGA Spec, CGA Handbook, Scott, and Kelley.

Dec. on Inst. 15–16.

On the same day, we also instituted two related *inter partes* review trials between Air Liquide and Praxair: in IPR2015-01071, we instituted trial as to 1, 3, and 8 of the '011 patent; and in IPR2015-01073, we instituted trial as to claims 1–3, 7, and 8 of the '011 patent.

¹ Pottier, J.D. et al., *Mass Storage of Hydrogen*, PROCEEDINGS OF THE NATO ADVANCED STUDY INSTITUTE ON HYDROGEN ENERGY SYSTEM, UTILIZATION OF HYDROGEN AND FUTURE ASPECTS (Jan. 1, 1995) (Ex. 1002).

² CGA G-5.3 Commodity Specification for Hydrogen, 4th Ed., Compressed Gas Association (1997) (Ex. 1003).

³ HANDBOOK OF COMPRESSED GASES, 3d ed., Compressed Gas Association (1990) (Ex. 1004).

⁴ U.S. Patent 4,365,978 (Dec. 28, 1982) (Ex. 1009).

⁵ Kelley, J.H. et al., *Storage, Transmission and Distribution of Hydrogen*, 5 INT'L J. HYDROGEN ENERGY 35 (1980) (Ex. 1005).

Following institution of trial, Praxair filed a Patent Owner Response (Paper 20, “PO Resp.”), and Air Liquide filed a Reply (Paper 21, “Pet. Reply”).

Air Liquide supported its Petition with the Declaration of Dr. Joe L. Ratigan (Ex. 1006) and the Declaration of Bhadra S. Grover⁶ (Ex. 1010), and with its Reply submitted a Supplemental Declaration of Dr. Ratigan (Ex. 1014). With its Response, Praxair submitted the Declaration of Dr. James A. Ritter (Ex. 2101) and the Declaration of Rommel Marquis Oates (Ex. 2102). Neither party submitted a deposition transcript of the cross-examination of any witness.

Oral hearing was requested by Praxair, and a consolidated hearing for all three related *inter partes* review trials was held June 23, 2016. A transcript of the oral hearing is included in the record. Paper 27, “Tr.”.

B. The '011 Patent

The '011 patent, titled “Method of Storing and Supplying Hydrogen to a Pipeline,” issued July 18, 2006, from U.S. Patent Application No. 10/812,084, filed on March 30, 2004. Ex. 1001, at (54), (45), (21), (22). The '011 patent generally relates to storage of compressed hydrogen in a salt

⁶ Air Liquide also filed with its Petition a second Declaration of Mr. Grover (Ex. 1007), entitled “General Background Declaration,” but did not cite to the General Background Declaration in any paper or exhibit. At oral hearing, counsel for Air Liquide conceded that it had not relied on the General Background Declaration, and it would be proper to expunge it from the record of the case. Paper 27, 28–29.

cavern, followed by recovery and purification of the stored hydrogen prior to supplying the hydrogen to a pipeline. *Id.* at Abstract.

The patent states that while hydrogen and other gases have been stored in underground salt caverns, due to the presence of contaminants in the salt cavern such storage had previously only been undertaken when there were no purity requirements for the recovered hydrogen. *Id.* at 1:53–60. The '011 patent purports to allow salt cavern storage of hydrogen that is “under a purity specification” by purifying the recovered hydrogen to remove contaminants, in particular water vapor and carbon dioxide. *Id.* at 2:3–14. Alternatively, the storage may be dependent on the demand for hydrogen: during periods of low demand, a portion of the hydrogen produced at the production facility is diverted, without purification, into the salt cavern for storage, but during periods of high demand, the stored hydrogen may be recovered and purified to supplement the hydrogen being produced by the facility. *Id.* at 2:31–41.

C. Illustrative Claim

Of the challenged claims, only claim 1 is independent, and is reproduced below:

1. A method of storing and supplying a gaseous hydrogen product to a pipeline under a product purity specification, having a pre-specified [sic] hydrogen purity and an impurity level of impurities comprising carbon dioxide and water vapor, said method comprising:
compressing a hydrogen stream [sic]⁷ made up of gaseous hydrogen to form a compressed hydrogen stream;

⁷ Claim 1 as written in the '011 patent recites “compressing a hydrogen

introducing the compressed hydrogen stream into a salt cavern
for storage of the gaseous hydrogen;
recovering a crude hydrogen stream from the salt cavern;
purifying the crude hydrogen stream by sufficiently removing
at least the carbon dioxide and the water vapor from the
crude hydrogen stream to at least in part produce a hydrogen
product steam [sic] having the impurity level of the carbon
dioxide and water vapor at or below the product purity
specification; and
supplying the gaseous hydrogen product to the pipeline by
introducing said hydrogen product stream into said pipeline.

Ex. 1001, 6:61–7:12.

II. ANALYSIS

A. Claim Construction

For purposes of our Decision on Institution, we analyzed each claim term in light of its broadest reasonable interpretation, as understood by one of ordinary skill in the art and consistent with the specification of the '011 patent. 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable interpretation standard, and absent any special definitions, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *In re Translogic Tech. Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). Any special definitions for claim terms or phrases must be set forth with reasonable clarity,

steam.” We interpret this to be a typographical error, and that the patentee intended to refer to a “hydrogen stream.” See Ex. 1012, 2 (amendments to claims during prosecution that recite “hydrogen stream”).

deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

In its Petition, Air Liquide proposed a construction for each of the following claim terms or phrases: “pipeline,” “purity specification,” “hydrogen stream,” “crude hydrogen stream,” and “hydrogen product stream.” Pet. 10–12. In the Decision on Institution, we determined that, based on the record at the time, no claim term required express construction. Dec. on Inst. 6. During the instituted trial, however, the parties continued to dispute the meaning of several terms; in its Response, Praxair addressed “crude hydrogen stream” and “pipeline.” PO Resp. 7–14. We address the broadest reasonable interpretation of “crude hydrogen stream,” as well as “purity specification,” below. We can resolve the dispute between the parties without construing “pipeline,” and therefore decline to do so.

1. purity specification

Claim 1 is directed to “[a] method of storing and supplying a gaseous hydrogen product to a pipeline under a product *purity specification*,” and later recites a purification step that produces a hydrogen product stream having impurity levels “at or below the product *purity specification*.” Ex. 1001, 6:61–62, 7:4–9 (emphasis added). Air Liquide contends that “purity specification refers to a level where hydrogen must be at least as pure as described by the specification level and must have less than a specified amount of one or more identified impurities.” Pet. 11. In its Response, Praxair did not dispute Air Liquide’s contention or provide its own construction. During oral argument, however, counsel for Praxair contended that “purity specification” implied that the hydrogen was for commodity use,

rather than fuel use. Tr. 65:6–7 (“The burning uses of things . . . I don’t think you would normally talk about as having a specification.”). Counsel also suggested that a product purity specification typically requires hydrogen purity above 95 percent. *Id.* at 65:14–16. In response, counsel for Air Liquide conceded that he had “assumed . . . the 95 percent uses would be included,” but disagreed that there is a requirement for a particular percentage of hydrogen gas. *Id.* at 93:19–94:2.

Beginning with the language of the claims, we note that claim 1 does provide context as to the meaning of “purity specification,” requiring that the specification “hav[e] a pre-specif[i]ed hydrogen purity and an impurity level of impurities comprising carbon dioxide and water vapor.” We decline to adopt any strict numerical purity requirement for this “pre-specified hydrogen purity,” however, especially in light of the fact that Praxair’s argument to this effect was raised for the first time at oral hearing. The specification of the ’011 patent refers to situations in which hydrogen “is supplied under pipeline product specification[s] that require a hydrogen purity typically above 95% and possibly of 99.99% for ultra high purity hydrogen.” Ex. 1001, 1:43–46. The recognition of purity specifications that require purity above 95%, however, does not rule out the existence of purity specifications which permit a less pure hydrogen. Furthermore, we note that when the patentees wished to set a discrete lower boundary for hydrogen purity under a purity specification, they did so; claim 8 depends from claim 1 and recites “wherein the product purity specification of the hydrogen product stream is about 99.99 percent pure hydrogen.” As claim 1 lacks such a numerical requirement, we decline to read one into the claim.

Nor does the record support Praxair's contention that a "purity specification"—and in particular, a purity specification having a pre-specified hydrogen purity and impurities of carbon dioxide and water vapor—is necessarily hydrogen intended for commodity use, as opposed to fuel. As Air Liquide correctly notes, the CGA Spec shows that at least some grades of fuel hydrogen were known to have requirements for carbon dioxide and water impurity levels. Pet. Reply 13; Ex. 1003 Table 1 (QVL D shows "typical uses" including "fuel"). We do not consider it proper to read into the claims a limitation to commodity hydrogen.

For these reasons, we conclude that the meaning of "purity specification" is clear from the context of claim 1 and requires no further construction.

2. *crude hydrogen stream*

Claim 1 requires steps of "recovering a *crude hydrogen stream* from the salt cavern," and "purifying the *crude hydrogen stream* by sufficiently removing at least the carbon dioxide and the water vapor from the *crude hydrogen stream*." Ex. 1001, 7:3–6 (emphasis added). Air Liquide simply states that "a 'crude hydrogen stream' is recovered from the salt cavern." Pet. 12. Praxair disputes this interpretation to the extent it "implies that *any* hydrogen gas recovered from a salt cavern is a crude hydrogen stream." PO Resp. 8. Praxair instead proffers the construction "hydrogen having impurities, including water vapor and carbon dioxide, in amounts exceeding those specified by the product purity specification." *Id.*

Despite Praxair's allegation of a dispute, we do not believe one exists between the parties on this issue. In its Petition, in the section immediately

following the construction of “crude hydrogen stream,” Air Liquide discusses the claim term “hydrogen product stream,” and states that:

The person of ordinary skill in the art would not consider a “crude [h]ydrogen stream” to become a “hydrogen product stream” without the starting “crude hydrogen stream” being *first out of specification for water vapor and carbon dioxide* and then purified to bring the gas stream into specification for at least these two contaminants.

Pet. 12 (emphasis added). The parties thus agree that a “crude hydrogen stream” must contain an excess of water vapor and carbon dioxide.⁸ As Praxair correctly notes, this is required by the context of claim 1, and is supported by the specification of the ’011 patent. PO Resp. 8. Upon review, we agree with the parties that the broadest reasonable interpretation of “crude hydrogen stream” is “hydrogen having impurities, including water vapor and carbon dioxide, in amounts exceeding those specified by a product purity specification.”

B. The Level of Ordinary Skill in the Art

Air Liquide’s two experts provided different descriptions of the person of ordinary skill in the art. Dr. Ratigan, whose background is in civil, mechanical, and geologic engineering, testified that the person of ordinary skill would have been a degreed engineer with 5 years of experience “in the fields of planning, design, engineering analysis, and/or field testing of

⁸ As Praxair correctly noted at oral argument, Air Liquide’s expert Dr. Ratigan testified that “crude hydrogen stream likewise may or may not meet the hydrogen product purity specification.” Ex. 1006 ¶ 18. Air Liquide, however, does not appear to have adopted Dr. Ratigan’s testimony on this issue, as the argument was not made in its briefs.

subsurface geologic engineering projects.” Ex. 1006 ¶ 9. Meanwhile, Mr. Grover’s background is in chemical engineering, and he testified that the person of ordinary skill in the art would have “experience in design, or operation of hydrogen or syngas production, or syngas purification, or transportation of hydrogen or syngas via pipeline.” Ex. 1010 ¶ 9. Praxair characterizes the experts’ testimony as setting forth “starkly *different* levels of skill” which are in conflict. PO Resp. 6. In response, Air Liquide argues that each expert’s description of the person of ordinary skill is appropriate with respect to different embodiments in the ’011 patent: Mr. Grover’s to embodiments where impure hydrogen is stored in a salt cavern; Dr. Ratigan’s to embodiments in which high purity hydrogen is stored. Pet. Reply 3–4.

We do not consider it appropriate to bifurcate the definition of the person of ordinary skill in the art among embodiments of the ’011 patent as Air Liquide proposes. Obviousness of an invention is to be assessed from the standpoint of “a person having ordinary skill in the art to which the claimed invention pertains.” 35 U.S.C. § 103. The art of the *invention* of the ’011 patent does not change depending on whether impure or high-purity hydrogen is stored in the salt cavern.

Praxair cites the testimony of Dr. Ritter, and argues that a person of ordinary skill in the art “would have a minimum level of skill of a bachelor’s degree in chemical engineering, or a similar discipline, and at least 3 years of experience with storage of hydrogen gas, purification of hydrogen gas, and pipeline delivery of hydrogen gas.” PO Resp. 7 (citing Ex. 2101 ¶ 10).

The '011 patent defines the field of the invention as “storing and supplying a gaseous hydrogen product to a pipeline” wherein the hydrogen is “stored in a salt cavern” and then purified. Ex. 1001, 1:6–12. The person of ordinary skill in the art would therefore have had experience with hydrogen storage and purification, but also with salt cavern storage—“subsurface geologic engineering projects,” as Dr. Ratigan described it. For this reason, we consider Praxair’s definition to be too narrow, and the person of ordinary skill in the art would have been a hybrid of those described by Air Liquide’s experts. The interdisciplinary nature of the person of ordinary skill in the art is supported by the prior art such as Foh,⁹ which focuses not only on subsurface geology and various types of underground storage (*see generally* Ex. 2103, 6–62), but also on various issues relating to hydrogen transportation and storage (*see generally id.* at 62–76). *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (prior art may reflect appropriate level of skill).

The parties are generally in agreement that the person of ordinary skill in the art would have had an engineering degree, and between 3–5 years of experience in the relevant field. Ex. 1006 ¶ 9; Ex. 2101 ¶ 10. We agree, and find that the person of ordinary skill would have had experience in the fields of transportation and storage of gaseous hydrogen, as well as subsurface geologic engineering. This person would have had familiarity with the problems encountered in transporting hydrogen, such as hydrogen

⁹ Foh, Stephen et al., UNDERGROUND HYDROGEN STORAGE FINAL REPORT, Department of Energy and Environment, Brookhaven National Laboratory, Upton, New York, US (Dec. 1979) (Ex. 1002).

embrittlement (Ex. 2103, 67–68¹⁰), as well as the possibility of contamination due to storage in an underground chamber (*id.* at 59–62).

C. Obviousness Over Pottier, CGA Spec, and CGA Handbook

Air Liquide contends that claims 1, 3, and 8 are unpatentable under 35 U.S.C. § 103(a), as they would have been obvious over the combined disclosures of Pottier, CGA Spec, and CGA Handbook. Pet. 15–30. An obviousness inquiry involves four underlying determinations: the scope and content of the prior art; the differences between the prior art and the claims at issue; the level of ordinary skill; and any objective indicia of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966).

Pottier discusses the transportation and storage of hydrogen for use in chemical or energy applications. Ex. 1002, 167. In particular, Pottier notes that salt cavities have been used for the storage of hydrogen gas, including a facility at Teeside, United Kingdom in which the cavities were operated at a pressure of 44 bar by the injection or withdrawal of salt water. *Id.* at 170. Pottier discloses that frequently, the gas drawn off from salt cavities contains water vapor and hydrogen sulfide, and that purification of gas produced from storage is necessary. *Id.* at 172. Air Liquide contends that a “person of ordinary skill in the art would understand the existence of a product purity specification from Pottier’s discussion of hydrogen pipelines for delivery to chemical industry customers.” Pet. 16.

¹⁰ We cite to the original pagination of the document, and not the page numbers entered by Petitioner.

The CGA Spec and CGA Handbook each set forth levels of impurities that are permitted in various types of hydrogen streams. Ex. 1003, 2; Ex. 1004, 398. Dr. Grover testifies that such purity specifications typically include a minimum hydrogen concentration, as well as impurity concentration limits for “carbon dioxide, carbon monoxide, nitrogen, oxygen, and hydrocarbons; and maximum dew point or limit on water content.” Ex. 1010 ¶ 19.

1. The Parties’ Arguments

At the outset, we note that the parties agree on several facts. The ’011 patent uses existing, conventional purification techniques; Praxair does not contend otherwise. Ex. 1001, 5:12–24; Tr. 11:16–18, 79:18–22 (Praxair’s counsel: “there is no specific purification technique that is new to the patent.”). Nor does Praxair contend that it was nonobvious to purify gas to meet a specific purity standard, once that standard was known. Tr. 80:12–16. Finally, Praxair concedes that storage of gases, including hydrogen, in salt caverns was known, and that there was a recognized problem with contamination of the stored gas. *Id.* at 33:9–16.

The primary dispute between the parties is whether a person of ordinary skill in the art would have had reason to store hydrogen in a salt cavern when the recovered hydrogen will need to be under a purity requirement after extraction. Specifically, Praxair contends that the art recognized that impurities would result from underground storage of hydrogen, but there was uncertainty over the exact nature of the contaminants—for example, the art did not recognize the possibility of contamination from carbon dioxide. PO Resp. 26 (“concerns about

impurities such as carbon dioxide were not even appreciated”). Given this uncertainty, Praxair argues, a person of ordinary skill in the art would have no reason to attempt to store hydrogen intended for commodity use in a salt cavern:

[P]eople who were considering storing hydrogen in a salt cavern for whatever initial purity didn't know what the consequence to purity of that stored gas would be. So if they wanted to use it for a specification, purity specification purpose at the end, they didn't know whether it would be, you know, a big deal or a small deal, what the parameters would be.

Tr. 42:17–25. This is echoed by the specification of the '011 patent, which states that “hydrogen storage has only taken place where there are no purity requirements placed upon the hydrogen product. As such, contamination of the hydrogen from being stored in a salt formation is an unknown variable.”

Ex. 1001, 1:56–60.

Air Liquide contends that Pottier discloses compressing and storing hydrogen in an underground salt cavern, and subsequently recovering the stored gas and supplying it to a pipeline, as required by the steps of method claim 1. Pet. 15–18. Furthermore, Pottier teaches that the recovered hydrogen will contain water vapor, which must be removed in a purification step. *Id.* at 17–18.

Air Liquide concedes that Pottier does not disclose purifying the recovered hydrogen to remove carbon dioxide, but asserts that such purification would have been obvious if the skilled artisan would have expected carbon dioxide to be present in the recovered gas. *Id.* at 18. For several reasons, Air Liquide contends that such an expectation would have been reasonable. *Id.* at 19–23. First, Air Liquide notes that the claims do

not require that the carbon dioxide impurities come from the salt cavern, but also may be generated during the hydrogen production process. *Id.* at 21. Arguing that “purification of a product, by itself, does not render the product unobvious,” Air Liquide contends that the removal of carbon dioxide would have been an obvious addition to Pottier. *Id.* at 22 (citing MPEP 2144.04).

Second, Air Liquide notes that Pottier discloses that hydrogen removed from storage contains “very small concentrations” of impurities other than water vapor. *Id.* at 22 (citing Ex. 1002, 170). Air Liquide argues that this disclosure of impurities would have motivated the skilled artisan to ensure that contaminants did not render the produced hydrogen “off spec” from the purity requirements. *Id.*

As noted above, Praxair primarily contests whether a person of ordinary skill in the art would have had reason to combine Pottier with CGA Spec or CGA Handbook. PO Resp. 15–25. According to Praxair, Pottier is concerned with the storage of hydrogen at 95% purity or less that is to later be used as fuel, whereas CGA Spec and CGA Handbook are concerned with commodity hydrogen having far higher purity. *Id.* at 19. Additionally, Pottier discloses underground storage of hydrogen, whereas Praxair argues that the CGA references are directed to container storage. *Id.* at 20. According to Praxair, Air Liquide “never explains why one of ordinary skill would look to (or even consider) modifying Pottier’s underground storage of hydrogen with CGA Spec/CGA Handbook’s teachings of storing hydrogen in shipping containers.” *Id.* at 21.

Second, Praxair argues that the cited prior art references do not recognize the problem addressed by the ’011 patent, and as such there would

have been no reason to modify their teachings to address the problem. *Id.* at 15–16. Relying on cases such as *In re Spinnoble*, 405 F.2d 578 (CCPA 1969) for the proposition that “a patentable invention may lie in the discovery of the source of a problem even though the remedy may be obvious once the source of the problem is identified,” Praxair contends that Air Liquide improperly relies on the disclosure of the ’011 patent itself to identify the problem. PO Resp. 16–17.

Praxair also argues that the prior art, even if combined, does not disclose certain elements of claims 1, 3, and 8. We summarize these arguments separately below, after analyzing the reason to combine.

2. Reason to Combine

We conclude that a person of ordinary skill in the art would have had reason to combine the teachings of Pottier and the CGA references in the manner suggested by Air Liquide. From Pottier, a person of skill in the art would learn that underground caverns may be used for large-scale storage of gas, including hydrogen. Ex. 1002, 170. Indeed, Pottier discloses that the Teeside facility in England had been in existence for more than ten years. *Id.* Contrary to Praxair’s argument that Pottier is concerned only with storage of fuel hydrogen, Air Liquide notes (Pet. Reply 10–11) that the person of ordinary skill would know from references such as Kelley¹¹ that

¹¹ During oral hearing, counsel for Praxair objected to Air Liquide’s reliance on Kelley in the Reply, claiming that Kelley was not part of the ground of unpatentability and therefore was a new argument raised for the first time in a reply. We disagree. Air Liquide cited Kelley to directly rebut an argument made by Praxair in its Patent Owner Response, that the Teeside facility was limited to fuel hydrogen. See PO Resp. 19; Pet. Reply 10–11.

the Teeside facility “feeds plants for carbonylation, aniline and nylon production and, when necessary, the aromatics production complex,” which are commodity hydrogen uses. Ex. 1005, 48–49.

From Pottier, a person of ordinary skill would also know that hydrogen produced from salt cavities contains water vapor “and sometimes other impurities,” and that the hydrogen will need to be purified. Ex. 1002, 170, 172. Pottier does not provide any details as to the “other impurities” other than “frequently the drawn-off gas contains . . . an appreciable amount of hydrogen sulfide” (*id.* at 172), and does not provide details of any applicable purity specifications.

The person of ordinary skill in the art would have been aware of such purity requirements, as evidenced by documents such as the CGA Spec or the CGA Handbook. As demonstrated by these references, the person of ordinary skill would have known that the gas of Pottier would need to be purified to meet the impurity levels listed. *See* Ex. 1003 Table 1; Ex. 1004 Table 1. As Mr. Grover testified, “[b]ased on the specific intended uses of the hydrogen by customers on a pipeline, a person of ordinary skill in the art would include Carbon Dioxide as a specified impurity with a concentration limit for the same reasons that such a criteria exists in many standards in the industry.” Ex. 1010 ¶ 48. Based on these disclosures, a person of ordinary skill, upon recovering hydrogen from the salt cavern of Pottier, would have

This is a proper use of reply evidence, and Praxair’s objection is overruled. *See Genzyme Therapeutic Prod. Ltd. P’ship v. Biomarin Pharm. Inc.*, 825 F.3d 1360, 1366–69 (Fed. Cir. 2016).

considered it obvious to ensure that impurities such as water vapor or carbon dioxide were within that specified for the desired end use. If it were determined that such impurities were greater than permitted by the appropriate specification, the person of ordinary skill would have known to purify the gas to remove those impurities. Ex. 1002, 172 (“purify the gas produced from storage”).

We are not persuaded by Praxair’s argument that Pottier discloses underground storage of fuel hydrogen, whereas the CGA references disclose containerized storage of commodity hydrogen. At oral hearing, Praxair’s counsel clarified that it was not arguing that the references were non-analogous art. Tr. 54:14–16. Rather, Praxair argues that a person of ordinary skill would have no reason to combine such allegedly disparate references. We disagree, especially in light of the fact that Pottier explicitly discloses the Teeside facility, which is a commodity gas facility. Ex. 1002, 170; Ex. 1005, 48–49. Thus, storage of commodity hydrogen is explicitly disclosed by Pottier, yet Pottier is silent as to the purity requirements for commodity hydrogen other than the need to purify the withdrawn gas. Reading this passage, a person of ordinary skill in the art would have consulted purity requirements found in documents such as the CGA references.

Nor do we agree with Praxair that the present case is analogous to cases such as *In re Sponnoble*, where discovery of the cause of a problem led to a patentable invention. The discovery in *Sponnoble*, that the cause of moisture leakage was due to transmission through a plug, was in direct contradiction to the prevailing theory that moisture was passing around the

plug. *In re Sponnoble*, 405 F.2d at 586. Therefore, although the “remedy may be obvious once the source of the problem is identified,” the court held that the discovery of the source of the problem itself gave rise to a patentable invention. *Id.* at 585. By contrast, in the case at hand the alleged discovery was, according to Dr. Ritter, that “the inventors of the ’011 Patent discovered that storage of hydrogen in salt caverns produces unacceptably high levels of carbon dioxide and other impurities.” Ex. 2101 ¶ 15 (citing Ex. 1001, 2:17–20). Praxair has presented no evidence that those of skill in the art at the time of the invention had misidentified the problem with storing hydrogen in salt caverns, or that there was any confusion or doubt at the time regarding the problem.

Even under the doctrine of *Sponnoble*, the discovery of the cause of a problem does not impart patentability when the problem was within the general knowledge of one of ordinary skill in the art, regardless of whether the prior art disclosed the problem. *See Cross Med. Prod., Inc. v. Medtronic Sofamor Danek, Inc.*, 424 F.3d 1293, 1323 (Fed. Cir. 2005). As discussed above, the record here shows that the discovery of the presence of CO₂ impurities in commodity hydrogen would have been clear to those of skill in the art at the time the hydrogen was recovered from a salt cavern; there is no evidence that such recognition would have been beyond the general knowledge of the person of ordinary skill.

Nor does *Sponnoble* apply where “the solution is obvious from the prior art which contains the same solution for a similar problem.” *In re Wiseman*, 596 F.2d 1019, 1023 (CCPA 1979). Here, the prior art contains the same solution—purifying the contaminated hydrogen—to a similar

problem: Pottier discusses removing impurities such as water vapor from hydrogen that has been stored in a salt cavern. Ex. 1002, 172.

In essence, Praxair's assertions reduce to the argument that even if the presence of CO₂ would have been recognized once the hydrogen was removed from the salt cavern, that recognition never happened; the uncertainty over the potential impurities that might result would have dissuaded skilled artisans from putting hydrogen into the ground in the first place. This argument is contrary to the record. First, as discussed above, Pottier discloses the Teeside facility, which is a commodity hydrogen storage facility and under Praxair's reasoning must have been operating under a purity specification. Ex. 1002, 170; Ex. 1005, 48–49.

Second, we do not find persuasive the testimony of Praxair's declarant, Mr. Oates, that "[p]rior to the filing of the '011 Patent, no one in the world had stored 99.99% purity hydrogen in a salt cavern." Ex. 2102 ¶ 2. It is irrelevant whether a person of ordinary skill in the art would have put ultrapure hydrogen *into* a salt cavern, because all that the claims require is that the hydrogen is purified after its *removal* from the salt cavern. In other words, the claims permit the hydrogen to be at any purity level when it is pumped into the ground. As disclosed by Pottier, this was already occurring at the Teeside facility. A person of ordinary skill would have recognized that—given the lack of a purity requirement for the hydrogen when inserted—the removed gas would have to be analyzed for any prohibited impurities when removed, and would have discovered the presence of water vapor and carbon dioxide.

For these reasons, we conclude that a person of ordinary skill in the art would have combined the disclosure of Pottier with that of the CGA references in the manner proposed, and would have had a reasonable expectation of success in doing so.

3. Arguments Regarding Specific Claim Elements

Praxair also argues that, even if combined, Pottier and the CGA references do not teach all elements of the claims. First, Praxair contends that Pottier fails to disclose a “recovering a crude hydrogen stream” or “purifying a crude hydrogen stream” as required by claim 1. PO Resp. 25–31. As discussed above, the broadest reasonable interpretation of “crude hydrogen stream” is “hydrogen having impurities, including water vapor and carbon dioxide, in amounts exceeding those specified by a product purity specification.” According to Air Liquide, this limitation is met because Pottier discloses that hydrogen recovered from a salt cavern will have water vapor, and also that the recovered gas may have other impurities in small amounts that will need to be removed. Pet. 17–18, 22–23. Alternatively, Air Liquide contends that the stored hydrogen will have carbon dioxide impurities resulting from its synthesis process that are not removed prior to storage. Pet. 21–22.

Praxair argues that because Pottier does not explicitly recognize the presence of carbon dioxide in its extracted hydrogen, it cannot teach a “crude hydrogen stream.” PO Resp. 25–26. According to Praxair, Pottier’s disclosure of “other impurities in very small quantities” does not suggest recovering a stream having carbon dioxide, because “knowledge of a need to

remove one impurity does not render obvious the recognition and removal of other impurities.” *Id.* at 26–27.

We do not find Praxair’s arguments convincing. The ground of unpatentability as set forth by Air Liquide, and as instituted by the Board, does not rely on an explicit disclosure of carbon dioxide impurities in Pottier. Rather, as set forth above, Air Liquide’s argument is that a person of ordinary skill in the art would have had reason to store hydrogen in a salt cavern based on Pottier’s disclosure, and then would have extracted the hydrogen and purified it to meet the requirements of the CGA references. Air Liquide has set forth evidence sufficient to establish that the recovered hydrogen stream would contain carbon dioxide, either resulting from the production process or the storage of the hydrogen in a salt cavern. Praxair does not dispute that hydrogen recovered from a salt cavern will contain carbon dioxide impurities; indeed, that is the asserted nature of the ’011 patent’s alleged discovery. There need not be any recognition in Pottier of this carbon dioxide when it is undisputed that the impurity will be present in the recovered gas. *See MEHL/Biophile Int’l Corp. v. Milgraum*, 192 F.3d 1362, 1366 (Fed. Cir. 1999) (“Where ... the result is a necessary consequence of what was deliberately intended, it is of no import that the article’s authors did not appreciate the results.”).

Claim 3 depends from claim 1 and further requires that hydrogen is removed from the pipeline and stored in the salt cavern during periods of low demand, and reintroduced into the pipeline during periods of high demand. Ex. 1001, 7:36–42. Air Liquide contends that Pottier discloses the transportation of hydrogen through a transmission network, and that the

stored hydrogen may be used for “an annual storage, a daily storage or a peak-shaving storage.” Pet. 28. Air Liquide notes that the peak-shaving examples of Pottier require “gas stored in a salt cavern to be stored/withdrawn on a pipeline in order to meet peak demands.” Pet. Reply 20–21 (citing Ex. 1002, 174).

Praxair does not contest that Pottier teaches introduction and withdrawal of hydrogen from a salt cavity according to demand, but argues that Pottier does not disclose “the source for the material sent to storage or the destination for material to be withdrawn.” PO Resp. 32. As such, Praxair contends that Pottier cannot disclose that a “pipeline” is both the source of the stored hydrogen and the destination of the withdrawn hydrogen. *Id.* According to Praxair, “in Pottier, that the source of this hydrogen fuel upon entering the salt cavern and the destination of this hydrogen fuel upon leaving the salt cavern are different.” *Id.* at 32.

Upon review of the record, we find that the additional limitations of claim 3 are taught or suggested by Pottier. Praxair’s assertion that the source and destination of the hydrogen in Pottier are different is only supported by a citation to Dr. Ritter’s testimony (*id.* at 32), and Dr. Ritter merely asserts this characterization of Pottier without explanation, and without any citation to the record. Ex. 2101 ¶ 62. We do not find this testimony persuasive. Rather, based on examination of the reference itself, we find that Pottier discloses an injection-withdrawal cycle as required by claim 3. Ex. 1002, 174. Furthermore, Pottier discloses a figure depicting three salt caverns connected to a pipeline network, and also discusses the Teeside facility which, as Air Liquide notes, is connected to a pipeline

system. Pet. Reply 20; Ex. 1002, 170; Ex. 1005, 48–49. Pottier would have suggested withdrawal from, and supply to, a pipeline based on the demand of hydrogen.

Finally, claim 8 recites that the product purity specification is about 99.99 percent pure hydrogen, and also has limits on impurities such as nitrogen, argon, carbon dioxide, methane, water, and hydrogen sulfide. Ex. 1001, 8:37–43. Air Liquide contends that these limits would have been obvious, because known methods permitted purification to these levels and a person of ordinary skill in the art would have achieved these levels once the appropriate end use was recognized. Pet. 29–30. As put by Air Liquide, “[i]t is obvious to establish a pipeline product specification matching the product specifications mandated by one’s pipeline customer(s) in supply contract(s).” *Id.* at 30. Praxair contends that the prior art does not reflect this specific product purity specification, and therefore a person of skill in the art would have no reason to select the particular specification claimed. PO Resp. 34–36.

In essence, the purity specification of claim 8 is to a purified form of a mixture—that mixture being the recovered hydrogen having various impurities. In some instances, a claimed composition that is a purified form of a prior art mixture may not be *prima facie* obvious if, for example, it is unknown “that the purified compound is present in or an active ingredient of the mixture, or the state of the art may be such that discovering how to perform the purification is an invention of patentable weight in itself.” *Aventis Pharma Deutschland GmbH v. Lupin, Ltd.*, 499 F.3d 1293, 1301 (Fed. Cir. 2007). Neither of these caveats are applicable here: it is known

that hydrogen is present in the recovered gas and, as noted above, Praxair does not claim any advance in purification. The *Aventis* court continued:

However, if it is known that some desirable property of a mixture derives in whole or in part from a particular one of its components, or if the prior art would provide a person of ordinary skill in the art with reason to believe that this is so, the purified compound is prima facie obvious over the mixture even without an explicit teaching that the ingredient should be concentrated or purified.

Id. In the present case, the recovered gas is desired precisely because of the presence of hydrogen, so it is prima facie obvious to purify the recovered mixture to obtain purified hydrogen.

Claim 8's recitation of various impurities, and the maximum concentration of each, does not alter our obviousness inquiry. *See Spectrum Pharm., Inc. v. Sandoz Inc.*, 802 F.3d 1326, 1335 (Fed. Cir. 2015) (“[B]ecause the desirable properties of the prior art 50/50 mixture are attributable to only one component, and the slightly impure mixture . . . has not been shown to possess unexpected advantages over the prior art pure material, the less-than-pure material . . . cannot be found to have been nonobvious.”). Given the prima facie obviousness of purified hydrogen, it follows that the presence of certain amounts of various impurities does not confer nonobviousness absent unexpected advantages. Praxair has not provided any evidence that the presence of the levels of impurities specified in claim 8 imparts any advantages, nor is there evidence that these levels of impurities are achievable only with nonobvious techniques. For these reasons, the purity specification of claim 8 does not impart a patentable distinction over claim 1.

For the foregoing reasons, Air Liquide has established by a preponderance of the evidence that all elements of claims 1, 3, and 8 are taught by Pottier, CGA Spec, and CGA Handbook, or that any differences between the art and the claimed invention would have been within the level of ordinary skill in the art.

4. *Objective Indicia of Nonobviousness*

When presented, evidence of the so-called “secondary considerations” of nonobviousness must be considered en route to a determination of obviousness. *Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling USA, Inc.*, 699 F.3d 1340, 1349 (Fed. Cir. 2012). Such evidence will be weighed against the evidence of obviousness determined under other *Graham* factors. *Id.* Praxair alleges that two objective indicia of nonobviousness are present in this case: long-felt need and commercial success.

First, Praxair argues that “prior to the ’011 Patent it was generally believed that storing high purity hydrogen in a salt cavern could not be done.” PO Resp. 37. As such, according to Praxair, “[c]ustomers were . . . in need of a reliable, instantaneous delivery of 99.99% purity hydrogen.” *Id.* at 38. For support, Praxair submits the testimony of Mr. Oates, who states that prior to the ’011 patent, “no one in the world had stored 99.99% purity hydrogen in a salt cavern at either constant or variable pressure.” Ex. 2102

¶ 2. According to Mr. Oates, this is because:

[I]t was believed and written in literature that storage of 99.99% purity hydrogen in salt caverns would require advancements in metallurgy and would be dependent on the particular geological formation for the successful storage of the higher purity gas, if it

was to be possible at all. This belief was driven by the challenges imposed by storing hydrogen at purity levels on the order of 99.99%.

Id. at ¶ 4. Mr. Oates does not disclose what “literature” supports this claim, nor did Praxair submit any.

In any event, we would not find Mr. Oates’ testimony probative even if supported. The need identified by Mr. Oates and Praxair has no nexus to the claimed invention. First, claims 1 and 3 do not require 99.99% pure hydrogen; therefore, any unsatisfied demand for such ultrapure hydrogen is not necessarily met by the process of the claims, which can be performed at a lower purity level. Second, as we have discussed above, the claims do not require *storage* of purified hydrogen in the salt cavern, which is the focus of Mr. Oates’ testimony. Rather, all the claims require is that the hydrogen is purified to meet a purity specification *after* it is recovered from the cavern. The concerns discussed by Mr. Oates, pertaining to the potential issues with storage of ultrapure hydrogen (*see id.* at ¶ 4 (“leaks can be a problem—and this is exacerbated when purity levels are increased”)), simply lack nexus to the claimed invention. Nor are these concerns, such as leaks, addressed by the alleged “discovery” of the patentees that carbon dioxide impurities were present in recovered hydrogen. In other words, because the invention of the ’011 patent does not solve these concerns, the invention cannot have been the reason any long-felt need was finally met. We find that Praxair has not established any nexus between a long-felt need and the claims of the ’011 patent.

Second, Praxair alleges that it has enjoyed commercial success through the use of the invention of the ’011 patent. Praxair contends that it

operates the only commodity hydrogen storage cavern that practices the methods claimed in the '011 Patent, and argues that “[w]here, as here, a product embodies the claimed features and is coextensive with the claims at issue, a nexus is presumed.” PO Resp. 40–41. Praxair goes on to assert that because it operates the only such storage cavern, it is able to continue to supply hydrogen during low availability situations when prices often rise to multiples of the prevailing market price. *Id.* at 42. This commercial success, Praxair contends, supports the nonobviousness of the invention. Praxair again supports its arguments with the testimony of Mr. Oates, who testifies that Praxair’s salt cavern practices the invention of claims 1–3, 7, and 8 of the '011 patent, and that this has permitted Praxair to become “the only hydrogen supplier in the United States to operate a salt cavern for storage and delivery of 99.99% purity hydrogen. Ex. 2102 ¶¶ 7–10.

We need not address whether a presumption of nexus applies in the present case, because even if there were a nexus with the claimed invention, the evidence of commercial success is weak, at best. Praxair has provided no objective evidence that the use of the claimed method has led to greater market share, nor is there any evidence that Praxair can command a price premium other than Mr. Oates’ generalized testimony that “prices often rise to multiples of the otherwise prevailing market price” during periods of low availability. Ex. 2102 ¶ 10. Mr. Oates does not provide any detail as to how large this price premium is, or how often Praxair has been able to charge it. Praxair’s showing of commercial success relies only on mere allegations unsupported by underlying facts or data, which we do not find persuasive. 37 C.F.R. § 42.65(a).

5. Conclusion

We have evaluated the scope and content of the prior art, the differences between the art and the claimed invention, and the level of ordinary skill in the art, and concluded that person of ordinary skill would have combined the disclosures of Pottier, CGA Spec, and CGA Handbook to arrive at the invention of claims 1, 3, and 8 with a reasonable likelihood of success. The evidence of objective indicia of nonobviousness either lacks nexus with the claimed invention, or at best shows weak commercial success. Weighing the evidence, we determine the evidence supporting obviousness outweighs that supporting nonobviousness, and therefore conclude that claims 1, 3, and 8 would have been obvious at the time of the invention.

D. Obviousness Over Pottier, CGA Spec, CGA Handbook, and Kelley

Claim 7 depends from claim 1 and further requires that “the hydrogen stream is compressed to about 2200 psig and the hydrogen product stream is reduced in pressure to between about 600 psig and about 800 psig.” Air Liquide contends that the compression limitation is disclosed by Pottier, which states that the working pressures of the salt cavern may be between 60 and 180 bar, which correspond to approximately 870–2610 psi. Pet. 28 (citing Ex. 1002, 169). This range encompasses the claimed pressure of about 2200 psi.

Air Liquide relies on Kelley to teach the reduction in pressure limitation of claim 7. Pet. 29. Kelley discloses that hydrogen pipeline transmission pressures range from 50–800 psi. Ex. 1005, 47. Mr. Grover testifies that a person of ordinary skill would have considered it obvious to

reduce the pressure of stored gas before injecting it into a pipeline designed to operate at a lower pressure. Ex. 1010 ¶ 52.

Praxair disputes that Pottier discloses compression of hydrogen to such high pressures, noting that the cited passage of Pottier is discussing “the most extreme working pressures” of a cavity 1000 meters deep. PO Resp. 33. According to Praxair, a person of ordinary skill in the art would realize that this disclosure does not mean that hydrogen could *actually* be compressed to such pressures, as a practical matter. *Id.* Dr. Ritter testifies that Pottier discloses an actual cavity located 500 meters deep, which operates at a pressure of 255–837 psi, and that this can be extrapolated to a 1000 meter deep cavity at pressures of 510–1674 psi. Ex. 2101 ¶¶ 63–64. Praxair also submits Foh, which discloses that because of hydrogen embrittlement, the upper pressure limit on the storage of hydrogen was 1000–1200 psi. PO Resp. 33 (citing Ex. 2103, 76).

We find that the record adequately supports Air Liquide’s position, and that Pottier would have disclosed compressing hydrogen to 2200 psig as required by claim 7. Merely because Pottier characterizes such pressures as the “most extreme” does not imply that a person of ordinary skill in the art would ignore it. Nor is Dr. Ritter’s “extrapolation” persuasive. First, it appears Dr. Ritter simply doubled the range of pressures disclosed for a 500 meter cavern, without explaining why this is the proper extrapolation. See 37 C.F.R. § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”). Second, even if this extrapolation is accurate, it does not rule out higher pressures.

Finally, we address Praxair's hydrogen embrittlement argument. We note that Foh, on which Praxair relies for this upper limit on pressure, was published in 1979. Even if hydrogen embrittlement was a problem at the time Foh was published, there is no evidence of the same problem remained unsolved in 1994, when Pottier was published, or in 2004, when the '011 inventors filed a patent application. Indeed, as Air Liquide notes, the '011 patent does not disclose any novel method of overcoming hydrogen embrittlement, yet claims hydrogen pressures well over 1200 psi. Pet. Reply 22. This is evidence that a person of ordinary skill in the art would have known that embrittlement was not a technical hurdle as of the filing of the patent. *See Hybritech, Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1384 (Fed. Cir. 1986) ("a patent need not teach, and preferably omits, what is well known in the art.") (citing *Lindemann Maschinenfabrik GMBH v. Am. Hoist & Derrick*, 730 F.2d 1452, 1463 (Fed. Cir. 1984)); *see also In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994) ("that appellant did not provide the type of detail in his specification that he now argues is necessary in prior art references supports the . . . finding that one skilled in the art would have known how to implement the features of the references and would have concluded that the reference disclosures would have been enabling."). We discern no reason why a person of ordinary skill in the art, learning of the hydrogen pressures used in Pottier, would disregard them as Praxair suggests.¹²

¹² We recognize that in the companion IPR2015-01071 case, we denied institution on claim 7 because of Foh's disclosure of hydrogen embrittlement. In that case, we had not been presented with evidence of

We, therefore, find that it would have been within the level of ordinary skill in the art to combine the teachings of Pottier, Kelley, CGA Spec, and CGA Handbook in the matter suggested by Air Liquide, to arrive at the invention of claim 7 with a reasonable likelihood of success. Praxair's arguments regarding objective indicia of nonobviousness are the same as those discussed above. Our analysis of these arguments is the same as for the prior ground, and we incorporate them herein. For these reasons, we conclude that Air Liquide has met its burden of proving by a preponderance of the evidence that claim 7 would have been obvious over Pottier, CGA Spec, CGA Handbook, and Kelley.

E. Obviousness over Pottier, CGA Spec, CGA Handbook, Kelley, and Scott

Air Liquide presents alternative grounds regarding the obviousness of claims 1, 3, 7, and 8, also based on the combination of Pottier, CGA Spec, CGA Handbook, and Kelley,¹³ but with the addition of Scott. Pet. 23–25.¹⁴ Scott discloses that in solution-mined salt caverns, the residual brine in the cavern often contains dissolved gases such as carbon dioxide. Ex. 1009, 1:24–28. When those caverns are subsequently used to store hydrocarbons, Scott states, the dissolved gases outgas, often in amounts sufficient to exceed specified impurity levels. *Id.* at 1:38–40. Scott therefore discloses that

higher pressures, such as those disclosed in Pottier.

¹³ As outlined above, Kelley is only asserted in grounds directed to claim 7, but we address simultaneously both grounds which add Scott to the combinations discussed above.

¹⁴ While set forth as separate grounds (Pet. 3), Scott is discussed in an amalgamated section treating multiple grounds.

sometimes it is necessary to reprocess the stored hydrocarbon. *Id.* at 1:40–42. Air Liquide contends that, even if the need to remove carbon dioxide from hydrogen recovered from salt caverns is not suggested by Pottier alone, a person of skill in the art would have recognized that need in view of the disclosure of Scott. Pet. 26–27. As Dr. Ratigan testified:

This is the same contaminant, contamination source and the same salt cavern storage context as described in the '011 patent The skilled artisan would be motivated by the existence of a carbon dioxide quality criterion, and the knowledge that some carbon dioxide contamination is to be expected, to at least measure carbon dioxide in hydrogen withdrawn from a salt cavern.

Ex. 1006 ¶ 29.

Praxair challenges this conclusion, noting that Scott is directed to the storage of liquid hydrocarbons, not gaseous hydrogen. PO Resp. 23. This difference is critical, Praxair contends, because the amount of gas that transfers from brine in a cavern to a liquid hydrocarbon is generally much greater than what would transfer into another gas stored above it. *Id.* Dr. Ritter testifies in support of Praxair's argument that the physics of solubility of a gas in a liquid hydrocarbon is very different than the physics of solubility in another gas such as hydrogen. Ex. 2101 ¶¶ 54–55. Praxair argues that Air Liquide has not established any reason why a person of ordinary skill in the art of hydrogen gas storage would have looked to Scott's teachings. PO Resp. 23.

We agree with Praxair and Dr. Ritter that the physics of carbon dioxide transfer from brine to liquid hydrocarbon is different than that from brine to gaseous hydrogen. This difference, however, is one of magnitude,

not type; as Dr. Ritter put it, “the *amount* of each gas that transfer[s] . . . is generally much different.” Ex. 2101 ¶ 54 (emphasis added). Scott would put the person of ordinary skill in the art on notice that residual brine in salt caverns has the potential to offgas carbon dioxide. Even if the degree to which the offgassing occurs is not disclosed, this would be sufficient to provide a reason to monitor for carbon dioxide impurities, as Dr. Ratigan attests. As discussed above in the prior ground, once such carbon dioxide impurities were located in the recovered hydrogen, the person of ordinary skill in the art would have considered it obvious to achieve a purity specification such as those in the CGA references. Scott, therefore, provides another basis for concluding that a person of ordinary skill in the art would have had reason to purify the gas exiting the cavern, and would have had a reasonable expectation of success in doing so.

Praxair’s other arguments regarding these grounds of unpatentability are the same as those discussed above: that some elements of claims 1, 3, 7, and 8 are not taught or suggested by the prior art, and that there are objective indicia of nonobviousness. Our analysis of these arguments is the same as for the prior grounds, and we incorporate them herein. For these reasons, we conclude that Air Liquide has met its burden of proving by a preponderance of the evidence that claims 1, 3, 7, and 8 would have been obvious over Pottier, CGA Spec, CGA Handbook, and Scott.

III. CONCLUSION

For the foregoing reasons, based on a review of the complete record developed during trial, we conclude that Air Liquide has proven, by a

preponderance of the evidence, that claims 1, 3, 7, and 8 of the '011 patent are unpatentable.

IV. ORDER

Accordingly, it is:

ORDERED that claims 1, 3, 7, and 8 of U.S. Patent No. 7,078,011 B2 are *unpatentable*;

FURTHER ORDERED that, pursuant to 35 U.S.C. § 318(b), upon expiration of the time for appeal of this decision, or the termination of any such appeal, a certificate shall issue canceling claims 1, 3, 7, and 8 of U.S. Patent No. 7,078,011 B2; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

IPR2015-01072
Patent 7,078,011 B2

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