

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ENERCOP SAND SOLUTIONS INC.
Petitioner,

v.

SPECIALIZED DESANDERS INC.,
Patent Owner

Patent No. 8,945,256

REBUTTAL DECLARATION OF DAVID SIMPSON, P.E.

TABLE OF CONTENTS

	Page
I. THE “INTERFACE LIMITATIONS”	2
A. The claims indicate that “at the fluid outlet” means only close or near the fluid outlet, not at the exact same location.	3
B. The written description portion of the specification indicates that the gas/liquid interface is only located close to or near the fluid outlet.	5
C. A person of ordinary skill in the art would understand that during operation the liquid level is at best described as close or near the fluid outlet.	6
D. Neither Hemstock’s disclosure nor the expected operation of the Hemstock prior art desander supports Patent Owner’s construction.	9
E. The figures of the ’256 Patent conclusively show that Patent Owner’s construction is wrong.	20
II. THE COMBINATION OF HEMSTOCK AND DAVIS	25
A. A person of ordinary skill in the art would have been motivated to combine Hemstock with Davis.	25
1. A person of ordinary skill in the art would not have understood that the fluid stream leaving Hemstock’s vessel was free of all particulates.	25
2. A person of ordinary skill in the art would have considered Hemstock’s vessel to contain a suspension of sand in liquid.	29
3. A person of ordinary skill in the art would have expected laminar flow in Hemstock, and Davis is not limited to laminar flow.	34
4. A person of ordinary skill in the art would have considered Davis’ teachings applicable to Hemstock’s vessel because it is a narrow channel.	36
5. A person of ordinary skill in the art would have considered Davis applicable even though Hemstock is a horizontal vessel.	38

TABLE OF CONTENTS

	Page
B.	A person of ordinary skill in the art would have been motivated by Davis to incline Hemstock such that the fluid inlet is higher than the fluid outlet. 40
III.	THE COMBINATION OF HEMSTOCK AND THE DATA BOOK... 45
A.	The Data Book discloses inclined slug catchers which a person of ordinary skill in the art would understand as including single-phase separators having a gas/liquid interface at the fluid outlet..... 45
B.	A single-phase slug catcher does not operate in the same way as the two-phase slug catchers described in the 2004 Data Book and Rhinesmith. 48
C.	A person of ordinary skill in the art would have been motivated to combine Hemstock and the Data Book. 52
1.	A person of ordinary skill in the art would understand Hemstock to teach that liquid slugs are common in desanding service and that a desanding vessel should be capable of handling them. 52
2.	A person of ordinary skill in the art would have looked to the Data Book's teaching on inclined-pipe desanders because Hemstock's desander may be a modified pipe. 54
IV.	COMBINATIONS WITH MILLER 56
V.	CONCLUSION 57

TABLE OF CONTENTS

Page

LIST OF EXHIBITS CONSIDERED

Exhibit No.	Description
1001	U.S. Patent No. 8,945,256 B2 to Hemstock (the “256 Patent”)
1003	Prosecution File History, U.S. Patent Application (U.S.13/372,291) (’256 Patent)
1004	U.S. Patent No. 6,983,852 to Hemstock et al. (“Hemstock”)
1005	Sedimentation of Noncolloidal Particles at Low Reynolds Numbers, Robert H. Davis and Andreas Acrivos, Annual Review of Fluid Mechanics, Vol. 17, 1985, published by Annual Reviews Inc., pages 91-118 (“Davis”)
1007	U.S. Patent No. 1,458,234 to Miller (“Miller”)
1008	Engineering Data Book, Gas Processors Suppliers Association, Revised Tenth Edition 1994 (the “Data Book”) (Sections 7 and 17)
1011	Deposition Transcript, Cross-Examination of Harold McGowen, August 8, 2019
1013	Canadian Patent 2,433,741
1014	Ex. 1002 page 74 (Annotated)

I, David Simpson, declare as follows:

206. My name is David A. Simpson. I am over the age of 18 years and am fully competent to make this declaration. I make the following statements based on personal knowledge and, if called to testify to them, could and would do so.

207. I have previously provided a declaration in this matter on behalf of Enercorp Sand Solutions Inc. (“Petitioner”) as an expert in wellsite equipment and phase separation and have rendered an opinion regarding the technological background and validity of the claims of U.S. Patent No. 8,945,256 (the “’256 patent”) (Ex. 1001).

208. I understand that Owner, Specialized Desanders Inc. (“Patent Owner”) has filed a response to the petition in this matter, which includes as an exhibit a declaration prepared by Harold E. McGowen III, P.E. (Ex. 2001). I have reviewed Patent Owner’s response and Mr. McGowen’s declaration testimony and its exhibits as referenced here, as well as the exhibits in the “List of Exhibits Considered” table above, and provide my opinions here regarding certain positions and statements taken by Patent Owner and Mr. McGowen. I continue to affirm my testimony contained in that declaration, and my testimony in the current declaration should be considered as merely supplementing the testimony in my first declaration, in rebuttal to Patent Owner and Mr. McGowen’s positions.

I. THE “INTERFACE LIMITATIONS”

209. I understand that Patent Owner identifies the following terms as the “Interface Limitations”:

“gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow” (Claim 1)

“a freeboard above the fluid outlet ... establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet” (Claim 9).

Patent Owner’s Response at 10-11. Patent Owner asserts that “the plain and ordinary meaning of the Interface Limitations is that the gas/liquid interface level is the boundary between the gas-filled freeboard portion of the vessel and the solid-and-liquid-filled belly portion of the vessel; and that this interface must be at the same level as the fluid outlet, not above or below the fluid outlet.” *Id.* at 11. Patent Owner cites to Mr. McGowen’s declaration (¶¶ 28-29) in support. Mr. McGowen testifies that he agrees “that the proper construction of these claim terms is that the dividing line between the belly portion of the vessel and the freeboard portion of the vessel is at the same elevation as the fluid outlet. ... The dividing line between the belly portion and the freeboard portion is the ‘gas/liquid interface’. ... The claim language itself requires that this gas/liquid interface be ‘at’ the fluid outlet, not above or below the fluid outlet.” Ex. 2001 ¶¶ 29-30.

210. I understand that Petitioner asserts that the Interface Limitations do not require the gas /liquid interface to be at the exact same location or elevation as the

fluid outlet, but merely close to or near the fluid outlet. I agree with Petitioner, and respectfully disagree with Patent Owner and Mr. McGowen. I agree that the gas/liquid interface level is the boundary between the gas-filled freeboard portion of the vessel, and the solid-and-liquid-filled belly portion of the vessel. However, I do not agree that anything in the specification or the prosecution history of the '256 Patent teaches or requires that this interface “must be at the same level as the fluid outlet, not above or below the fluid outlet.” In fact, in my opinion, the specification teaches that the gas/liquid interface need only be adjacent to, nor near the fluid outlet, and may certainly be below it. This understanding is also completely consistent with how a person of ordinary skill in the art would understand the desander to function.

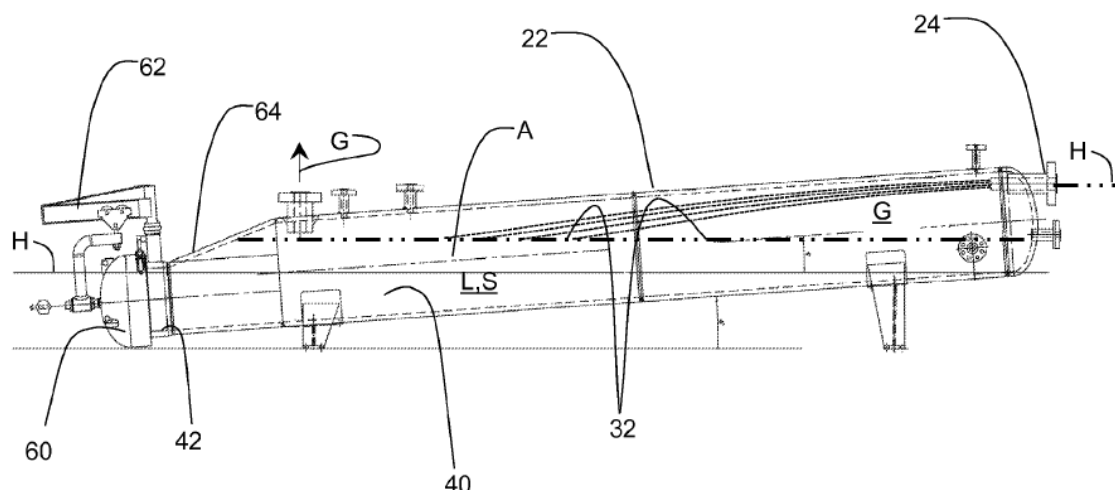
A. The claims indicate that “at the fluid outlet” means only close or near the fluid outlet, not at the exact same location.

211. Claim 10 requires the desanding system of claim 1, “wherein said gas/liquid interface is formed during operation, the gas/liquid interface extending horizontally from about the fluid outlet.” Claim 10 teaches that the gas/liquid interface can begin from “about the fluid outlet.” To a person of ordinary skill in the art, this does not mean “precisely at the same location as the fluid outlet,” but merely close by or near to the location of the fluid outlet.

212. Claim 9 requires “forming a freeboard above the fluid outlet” and “establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet.” Mr. McGowen testifies that these limitations require

the gas/liquid interface be formed at the fluid outlet, because “[o]therwise, the freeboard portion of the vessel would not be constrained to being above the fluid outlet, and the belly portion of the vessel would not be constrained to being below the fluid outlet.” Ex. 2001 ¶ 30. I disagree with Mr. McGowen’s premises. The claim language does not constrain the location of the freeboard and belly portion as he presupposes. All that is required is that the freeboard portion be formed above the fluid outlet, and the belly portion be formed below the fluid outlet. If this occurs, nothing in the claim language prohibits there also being a freeboard portion below the fluid outlet. In such a case, there is still freeboard formed above the fluid outlet and belly portion formed below the fluid outlet.

213. For example, Figure 7 of the ’256 Patent show that the interface 32 is below the opening of the fluid outlet:



Even though the gas/liquid interface 32 is below the fluid outlet, the freeboard is still above the fluid outlet, and the belly portion (the L, S section below the interface) is

still below the fluid outlet. Although there is also a portion of the freeboard section below the fluid outlet, claim 9 is still satisfied.

214. In my opinion, Claim 9 teaches that the gas/liquid interface can be below the gas/liquid interface. Claim 9 requires “establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet.” As previously discussed, and as Mr. McGowen agrees, the belly portion is the portion of the vessel below the gas/liquid interface, containing liquids and solids. *See* Ex. 2001 ¶ 29. Claim 9 states that the belly portion is formed below the fluid outlet, and that the interface itself is in the belly portion of the vessel. This phrasing indicates that the claim also includes operation where the gas/liquid interface is below the fluid outlet. Otherwise, the interface would not be established “in the belly portion of the vessel” (which is specified as being below the fluid outlet). Based on the foregoing, Claim 9 does not require the gas/liquid interface to be formed at the exact location of the fluid outlet, excluding elevations above or below it.

B. The written description portion of the specification indicates that the gas/liquid interface is only located close to or near the fluid outlet.

215. Figures 2 and 4 (which are quite similar, but differ in the angle of inclination) show that the interface begins at the same elevation as the fluid outlet. However, the written discussion of the figures indicates that these figures should not be interpreted as limiting how the desander operates. With regard to Figure 2, the

specification states that the interface “forms extending horizontally from about the fluid outlet 26.” Ex. 1001, 4:38-40. The interface is also taught as having a distal end 33 (the end farthest from the fluid inlet, i.e., the end near the fluid outlet) which is merely “adjacent the fluid outlet 26.” *Id.*, 4:50-55. Thus, the interface here is taught as only extending from “about” or “adjacent” the fluid outlet, which a person of ordinary skill in the art would understand to mean near or close to the fluid outlet, not necessarily at the exact same location as the fluid outlet.

216. Figure 4 is discussed with respect to different inclination angles of the vessel. The specification states that “The shallowest operating angle α is limited by the minimum requirement for a minimum 44 cross-sectional area adjacent the inlet 24 once the interface 32 builds to about the fluid outlet 26.” *Id.*, 5:62-65. Again, the level of the interface is not described as building to precisely the same level as the fluid outlet, but merely “to about the fluid outlet.”

C. A person of ordinary skill in the art would understand that during operation the liquid level is at best described as close or near the fluid outlet.

217. My interpretation of “at the fluid outlet” is also consistent with how a person of ordinary skill in the art would understand the liquid level in the ’256 Patent desander, as well as the Hemstock desander, to vary over time. Although the patents make several references to steady-state operation, a person of ordinary skill in the art would not understand either vessel to function for any extended length of time in

steady-state mode. “Steady-state,” as it is used in the ’256 Patent, refers to operation where the liquid level is neither rising nor falling, but the amount of liquid that is leaving the desander exactly equals the amount that is entering. *See* Ex. 1001, 5:1-5. If the amount of liquid coming into the desander suddenly increased by a large amount, the liquid level would rise. It could rise even above the fluid outlet, depending on the amount. In this situation any gas coming in the vessel would, for a very brief period of time, be unable to leave, and be compressed in the freeboard section to a pressure high enough such that it overcame the differential pressure necessary to push out of the fluid outlet. It would then form a chaotic path to and out the fluid outlet, entraining some volume of liquid with it out the fluid outlet. This would tend to lower the liquid level, but the level might not decrease, depending on the volume of liquid entering the vessel.

218. If the phase composition of the inlet stream changed in the opposite direction (less liquid), the liquid level would fall below the fluid outlet. If this happened, liquid near enough to the level of the fluid outlet would still be entrained. Liquid would also evaporate, further lowering the liquid level. In this case, the desander would not only continue to function, but would actually be more efficient. This is because the freeboard section of the vessel would have an even larger cross-section, meaning a lower velocity, resulting in increased separation of solid particles from the fluid stream.

219. Although the figures in both the '256 Patent and in Hemstock depict a placid and calm (and even) liquid level, a person of ordinary skill in the art would understand these depictions to be mere devices for illustrating the vessels' general function. A person of ordinary skill in the art would not understand them as intending to illustrate the exact level of the liquid in the vessel at any point during actual operation. Rather, a person of ordinary skill in the art would expect the interior of the vessel, at least at the surface of the liquid, to be quite chaotic, almost like the surface of the ocean during a hurricane. There would be various waves, with solids and liquids alternatively falling out of the gas and being re-entrained, depending on the velocity profiles in the vessel, which would not be uniform. Thus, the liquid "level" inside the vessel would not be in a simple plane, like the surface of a calm lake, but rather would rise and fall continuously at various points in the vessel. To the extent one can even speak of a simple liquid level in the vessel, it would only be an average of the various actual liquid levels. Thus, a person of ordinary skill in the art would not describe the liquid level in the vessel as at any exact elevation; rather, the best that one could do would be to approximate its general location. Thus, a person of ordinary skill in the art would understand that "at the fluid outlet" is only an approximate indication of location, and would know that this description would include locations close to or near the fluid outlet.

D. Neither Hemstock's disclosure nor the expected operation of the Hemstock prior art desander supports Patent Owner's construction.

220. I understand that Patent Owner cites to differences between the Hemstock desander and the desander described in the '256 Patent as supporting its construction of the Interface Limitations. Essentially, I understand that Patent Owner argues that the '256 Patent desander is an improvement over the Hemstock desander because it dispensed with the need for a flow barrier or weir, which Patent Owner argues prevented the liquid in the prior art desander from reaching the fluid outlet, by "forcing fluid to go below the flow barrier such that it collects below the fluid outlet so that it can leave the vessel via the outlet." Response at 13. I further understand that Mr. McGowen testifies that Hemstock's flow barrier ensures that the freeboard portion of the vessel is maintained below the vessel's fluid outlet "so that gas can always escape through the fluid outlet." Ex. 2001 ¶ 33. I respectfully disagree.

221. The problem with Patent Owner's argument, and Mr. McGowen's analysis, is that neither Hemstock nor the '256 Patent actually teach that Hemstock's flow barrier/weir prevents the liquid level in the vessel from rising to the elevation of the fluid outlet. Hemstock does teach that (1) the flow barrier/weir maintains the freeboard portion of the vessel (Ex. 1004, 4:44-47); (2) the flow barrier/weir ensures that the liquid and sand level only reach a maximum depth (Ex. 1004, 4:44-47); (3)

the lower edge of the flow barrier/weir sets the maximum depth of the belly portion (Ex. 1004, 5:9-27); and (4) the fluid stream is forced under the lower edge of the flow barrier/weir before discharging from the vessel's fluid outlet (Ex. 1004, 5:9-27). Patent Owner and Mr. McGowen have extrapolated from these statements, and apparently Hemstock's figures, their basic assertion that the flow barrier/weir prevents the liquid level from reaching either the flow barrier or the fluid outlet. *See, e.g.,* Resp. at 7, 8, 13; Ex. 2001 ¶¶ 25, 33, 39. However, as I will explain further, neither Hemstock nor the '256 Patent expressly teach this, nor would a person of ordinary skill in the art understand this to be the case based on Hemstock's disclosure.

222. As mentioned, Hemstock teaches that the flow barrier, and specifically the bottom of the flow barrier, sets the maximum depth of the gas/liquid interface. Ex. 1004, 4:44-47 ("The freeboard portion 30 is maintained using means such as a depending flow barrier 40 to ensure that the collected liquids L and particulates S **only reach a maximum depth** in the belly portion 32...."); 5:9-38 ("The flow barrier 40 has a lower edge 41 **which sets the maximum depth of the belly portion 32.**"). Notably, Hemstock does not say that this maximum depth is below the flow barrier or even at the same elevation as the flow barrier, merely that the flow barrier sets the maximum depth.

223. On the contrary, Hemstock explains two different scenarios where the interface, during normal operation, actually rises above the bottom of the flow barrier. The first is when only the liquid level rises above the flow barrier, while the second is when the accumulated solids rise above the flow barrier.

224. Hemstock explains that:

All of the various flow barriers 40, 40a, 40b, 40c have a lower edge 41 which forces the fluid stream S thereunder before discharging from the vessel 11 at outlet 13. Accumulated levels L,S **encroaching above the lower edge 41 will result in high velocities and re-entrainment of liquids L and particulates S** from the area about the flow barrier 40, inherently resulting in a steady state maximum level of accumulation of the belly portion 32.”

Ex. 1004, 5:20-27. Elsewhere, Hemstock explains that:

Typically, **liquid L out of the fluid stream F accumulates in the belly portion 32 to a steady state level and then is re-entrained for discharge** with fluids exiting the outlet 13 without affecting the capability of the vessel 11 and belly portion 32 to continue to accumulate particulates S. . . . **However, should a maximum depth of particulates S be reached during operation and encroach on the freeboard portion 30**, operations may yet continue as if the vessel 11 were not even installed; **both incoming liquid L and particulates S being temporarily re-entrained with the fluid stream flowing from the vessel outlet 13** until the earliest opportunity to perform maintenance. Typically the belly portion 32

vessel 11 is periodically cleaned out or emptied of accumulated particulates and liquid at sufficient intervals to ensure that the maximum accumulated depth does not encroach on the freeboard portion 30.

Id., 4:55-5:7.

225. These passages teach that, during normal operation, it is expected that the liquid level will rise to some “steady-state” depth, whereupon any rise in the gas/liquid interface results in an increased velocity in the freeboard portion (due to the lower cross-section area available for fluid flow because of the rising liquid level) which will begin to re-entrain the liquid, carrying it out of the fluid outlet (and any reduction in the level of the gas/liquid interface results in a decrease in the freeboard velocity and reduced ability to entrain liquids). The only teaching in Hemstock that states where this maximum steady-state liquid level will be is from the first passage quoted above, “encroaching **above** the lower edge 41.” Thus, Hemstock teaches that the maximum level of accumulation is above the bottom of the flow barrier, not below it. When the liquid level rises above the bottom of the flow barrier, the higher velocity causes liquid re-entrainment to begin. This, in turn, results in a drop in the liquid level. When the liquid level falls sufficiently, re-entrainment necessarily stops because the primarily gas-phase stream may exit the vessel by passing over the liquid surface. This is what is shown in Figures 4a, 4b, and 4c. At this point, the liquid level begins to rise again, because no liquid is being re-entrained and liquid from the inlet

stream is accumulating. Once the liquid level encroaches above the lower edge of the flow barrier, the cycle begins again. Thus, the bottom edge of the flow barrier sets the steady state maximum level of accumulation of the belly portion, which is in fact slightly above the bottom edge. Thus, a person of ordinary skill in the art would not understand Hemstock to teach that there must be any freeboard below the fluid outlet in order for Hemstock to function properly; in fact, Hemstock teaches that the opposite is true. It is expected that the liquid level will rise above the bottom of the flow barrier (which, as discussed further below, may be the fluid outlet itself) periodically during normal operations.

226. The second scenario where the belly portion rises above the bottom of the flow barrier is when accumulated solids rise to this level. It is only in this situation that Hemstock teaches that desanding will fail. Again, Hemstock teaches that when the accumulated solids encroach above the bottom of the flow barrier, the velocity will increase and re-entrain the accumulated solids, and this results in a maximum steady-state level in the vessel. But Hemstock contrasts this scenario, where desanding will fail, with the normal and expected rise of liquids to the steady-state maximum level: “However, should a maximum depth of particulates S be reached during operation and encroach on the freeboard portion 30 [i.e., as compared to the accumulation of liquids to their steady state level], **operations may yet continue as if the vessel 11 were not even installed**; both incoming liquid L and

particulates S being temporarily re-entrained with the fluid stream flowing from the vessel outlet 13.” This indicates that, if when particulates accumulate high enough that they encroach above the bottom of the flow barrier, they will be re-entrained out of the fluid outlet, and the desander will cease to effectively function to remove sand from the production stream (until the solids are removed). Thus, Hemstock never teaches that the liquid level is prevented from reaching the bottom of the flow barrier itself. Hemstock actually teaches that the flow barrier ensures that the maximum liquid level is higher than the bottom of the flow barrier, at least temporarily (until re-entrainment lowers the level).

227. Notably, nothing in the foregoing discussion or in Hemstock’s teaching indicates that the bottom of the flow barrier be at an elevation below the level of the fluid outlet. However, Hemstock explicitly teaches that the flow barrier may be the fluid outlet itself:

In the embodiment shown in some detail in FIG. 4c, the outlet 13 itself acts as the flow barrier 40, which incorporates a tubular portion 43 protruding downwardly and depending through the freeboard portion 30. The tubular portion 43 also has a lower edge 41 spaced from the top of the vessel 11 which forces the fluid stream F to exit from a point nearer the vessel axis A.

Ex. 1004, 5:28-34. As Hemstock explicitly states that liquid levels during normal operation are expected to encroach above the top of the flow barrier, in the

embodiment shown in Figure 4c, Hemstock expressly anticipates that liquid levels will encroach above the lower edge of the fluid outlet. Hemstock does not teach or support Patent Owner's theory that the liquid level is somehow held below the bottom of the flow barrier.

228. Mr. McGowan testifies that the flow barrier maintains the freeboard portion "so that gas can always escape through the fluid outlet," and that as liquid even approaches the bottom of the flow barrier, the velocity increases to such an extent that it entrains liquid out of the vessel, thus "ensur[ing] that the liquid level in the belly portion of the Hemstock vessel does not reach either the flow barrier or the fluid outlet." Ex. 2001 ¶ 33 (citing Hemstock Figures 4a, 4b, 4c, 5:14-26). He further testifies that this is necessary for the vessel to operate properly. *Id.* Mr. McGowan is partially correct, but his testimony paints an incomplete picture of what a person of ordinary skill in the art would expect to occur in Hemstock's vessel, especially given Hemstock's disclosure that liquid levels are expected to encroach above the lower edge of the flow barrier. While it is true that the velocity in the freeboard section will rise with the liquid level, and that as the liquid level approaches the bottom of the flow barrier it will increase further, there is no mechanism by which the flow barrier itself could somehow stop the liquid level from increasing above the bottom of the barrier, assuming the amount of liquid coming into the vessel was higher than the amount leaving the vessel.

229. Further, while gas is forced under the flow barrier in order to exit the vessel, there is nothing in Hemstock that requires the gas to be able to escape through the fluid outlet at every instant during operation, as Mr. McGowen apparently presupposed when he prepared his declaration. I understand that, under cross-examination, Mr. McGowan admitted that gas can be stopped from leaving the vessel when the liquid level rises above the fluid outlet. Ex. 1011 at 42:19-45:17, 46:17-47:17. This is correct. Thus, as I previously explained and as expressly taught in Hemstock, the liquid level is expected to rise above the bottom of the flow barrier (which is the same as the fluid outlet in the Figure 4c embodiment) momentarily, which will then force the gas under the barrier, carrying or re-entraining liquid out of the vessel with it, and lowering the liquid level in the vessel. In my opinion, this is the only way in which Hemstock could be understood to operate based on its disclosure that the liquid level may encroach above the bottom of the flow barrier, resulting in high velocities and re-entrainment of any liquids L or particulates S in the area about the flow barrier, and inherently resulting in a steady state maximum level of accumulation in the vessel. Ex. 1004, 5:22-27.

230. The '256 Patent also does not support Patent Owner's position. Patent Owner and Mr. McGowen cite to the following passages from the '256 Patent in support of their position that it teaches that Hemstock's flow barrier ensured that the gas/liquid interface remained below the fluid outlet: 2:7-17, 2:44-47, 4:45-5:5, and

6:38-56. Resp. at 7; Ex. 2001 ¶ 25. I address each of these in turn below. None of these passages teach that Hemstock's weir or flow barrier ensured that the gas/liquid interface remained below the fluid outlet. In fact, none of these passages teach anything about the maximum liquid level in Hemstock's desander.

231. The passage at 2:7-17 states as follows:

In Canadian Patent Number 2,433,741, issued Feb. 3, 2004 and in Canadian Patent Number 2,407,554, issued Jun. 20, 2006, both assigned to the Applicant, a desander is disclosed having an elongate, horizontal vessel having an inlet at one end and an outlet at the other end, the outlet separated from the inlet by a downcomer flow barrier, such as a weir, adjacent the vessel's outlet or exit. The weir forms, and maintains, an upper freeboard portion having a cross-sectional area which is greater than that of the field piping from whence the fluid stream emanates for encouraging water and particulates to fall out of the freeboard portion.

Ex. 1001, 2:7-17. This states that the weir forms and maintains an upper freeboard portion. It does not state where the freeboard portion begins or that the weir maintains the liquid level below the fluid outlet.

232. The passage at 2:44-47 states as follows:

The freeboard portion is maintained through control of the angle of the desander, obviating the need for a downcomer of Applicant's own prior art horizontal desanders.

This passage merely states that the freeboard portion is maintained by controlling

the desander's angle and that this eliminates the need for the weir. It does not state either where precisely the freeboard is maintained or that the weir in the Hemstock desander maintained the gas/liquid interface in that device below the fluid outlet.

233. The passage at 4:45-5:5 states:

In one embodiment, the discharge 29 of the inlet 24 can be aligned parallel to the vessel axis A. The inlet 24 or discharge 29 can be oriented in other orientations including above the inclined axis A, or below the axis A.

The interface 32 is a generally obround, gas/liquid interface between the belly and freeboard portions 40,44. The obround interface 32 has a distal end 33 adjacent the fluid outlet 26 and a proximal end 34, the location of which is intermediate the fluid outlet 26 and fluid inlet 24 and varies with liquid level and inclination angle α . As a result of the desander 20 inclination, the trajectory of the fluid stream F, from inlet 24, converges with the interface 32. The trajectory for dropping sand S and liquid L into the belly portion 40 is foreshortened, reducing drop out time. The vessel 22 is long enough to space the fluid inlet 24 sufficiently from the interface 32 to minimize turbulence of the liquid L in the belly portion 40, that spacing being dependent upon various design factors including vessel inclination angle α , inlet fluid stream velocity and characteristics.

At a steady state, the maximum level of the interface 32, is controlled at the distal end 33, set by eventual liquid entrainment and discharge at the fluid outlet 26. Gas G discharges at the fluid outlet 26. At steady state, when the liquid level reaches the fluid outlet 26, any oil

and other liquids are re-entrained with the gas G exiting at fluid outlet 26. Particulates S continue to be captured in the belly portion 40 until its volumetric capacity is reached.

This passage makes several statements about where the gas/liquid interface is at in the '256 desander. Notably, it says nothing about where the interface was maintained in the prior art Hemstock desander.

234. The passage at 6:38-56 states:

In operation, various sizes of desanders are employed in the prior art for differing operational conditions. Prior art desanders 10, such as that described in U.S. Pat. No. 6,983,852 to Applicant, for different feed fluid streams F, might include one typical standard vessel 11 having a nominal 0.3 m (12 inch) diameter by 3.048 m (10 feet) long and another vessel 11 having 0.3 m (12 inch) diameter by 6.096 m (20 feet) long, both of which are fitted with a downcomer weir to set the freeboard portion.

Herein, in the inclined desander 20, the prior art downcomer flow barrier, such as a weir, can be eliminated by providing similar 0.3 m (12 inch) diameter vessels 22 and tilting the upper end 30 of the new desander 20 at about twice the prior art weir height so as to form the interface 32 at the fluid outlet 26. To mimic the minimum operating performance of the 3.048 m (10 feet) and 6.096 m (20 feet) prior art desanders, a 20 foot long inclined vessel 22 would only need to be inclined about $\frac{1}{2}$ the angle α of the 10 foot long inclined vessel 22. Performance can be adjusted by varying the angle.

This passage repeats the assertion that inclining the vessels can eliminate the weir

from the prior art vessels. It also does not state that the maximum liquid level in the Hemstock desander was below the fluid outlet.

E. The figures of the '256 Patent conclusively show that Patent Owner's construction is wrong.

235. I understand that Patent Owner and Mr. McGowen rely on the figures of the '256 Patent as proof of their assertion that the gas/liquid interface must be located “at the fluid outlet,” i.e., at the exact same location as the fluid outlet and neither above or below it. *See* Response at 8 (annotated version of Figure 2); Ex. 2001 ¶ 31 (citing Figure 2), ¶ 32 (asserting that “Figures 2 and 4 depict the liquid level 33 of the vessel to be at the same level as the fluid outlet 26”), ¶ 33 (“The Figures of the '256 Patent and [sic] track the requirements of the liquid level in the '256 Patent compared to Hemstock.”). Again, I respectfully disagree. Patent Owner and Mr. McGowen place too much emphasis on Figures 2 and 4, which a person of skill in the art would not understand to show precise details of the claimed invention. Notably, Patent Owner and Mr. McGowen also completely ignore Figure 7 in discussing the appropriate claim construction.

236. First, Figures 2 and 4 are clearly not intended as scale drawings. They are basic illustrations, which a person of ordinary skill in the art would not rely upon to show precise details of every aspect of the described embodiments, especially to the extent they contradict the written portion of the specification. There are several reasons for this. First, the illustrations do not show major aspects of the described

embodiments. Thus, while the drawings show inlet piping 46 and fluid inlet 24, and fluid outlet 26, they do not show any access or closure for use in removing accumulated sand from the lower end of the inclined vessel. This is not optional, at least as described in the specification, but a necessary feature. Sand must be removed or the desander will cease to properly function. Moreover, the drawings themselves are simplistic, what I would describe as “cartoons.” This can be seen for example, in Figure 2, where the outline of the fluid outlet 26 is not even actually connected to the outline of the desanding vessel, but “floats” just above it. I understand that Mr. McGowen himself agrees that these figures are only cartoons. Further, the specification itself provides no dimensions for these embodiments, which is required of a scale drawing.

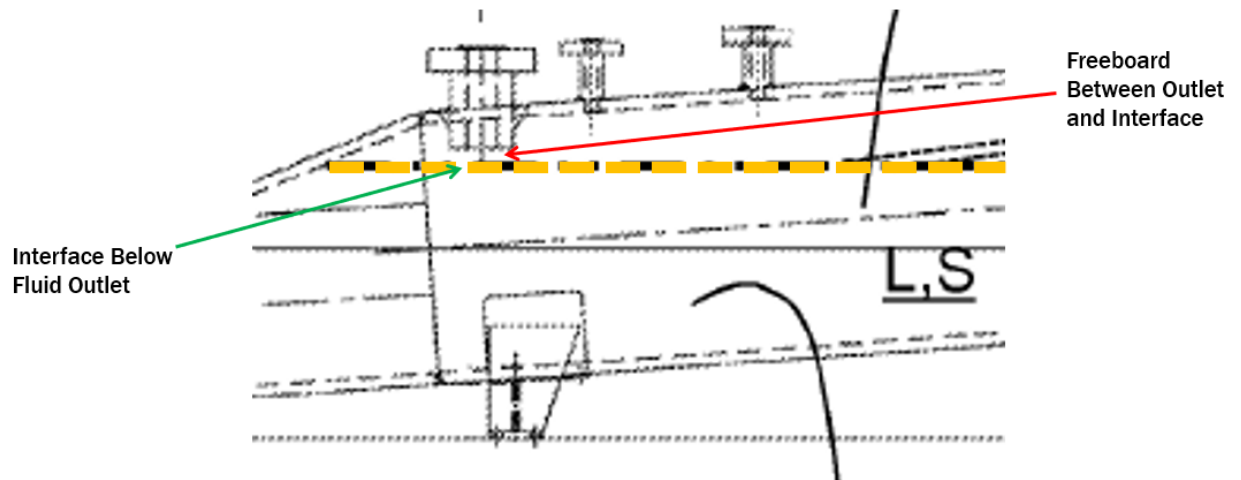
237. Thus, in my opinion, these drawings should not be used to divine the meaning of the claim terms, especially given that, at least when it comes to the location of the gas/liquid interface respective to the fluid outlet, they contradict the written portion of the patent, as I previously explained.

238. I also note that Patent Owner and Mr. McGowen have failed to include Figure 7 in their claim construction analysis in any way. In my opinion, Figure 7 alone proves that Patent Owner’s position is incorrect.

239. First, Figure 7 differs markedly from the other figures in the patent. It has the appearance of a scale drawing, and specifically an engineering schematic,

such as might be used during vessel fabrication. No important detail is left out, including the access at the lower end. Even minor details such as ports for pressure safety valves and other connections are included, even though the specific purpose of each is never discussed in the patent. See Ex. 1001, 7:39-42. Most importantly, the written portion of the specification provides dimensions for the drawing: a diameter (in the main portion) of 36 inches with a 33 inch internal diameter; a horizontal spacing between inlet 24 and the inside wall of the vessel at “about 1.5 feet”; a 4 degree incline; a length of “about 20 feet”; an eccentric portion length of 3 feet; an eccentric portion diameter of “about 18 inches” for fitting an 18 inch clean out. Id., 7:7-13, 7:34-38. Thus, unlike the other figures, Figure 7 appears intended to show precise details of the claimed invention.

240. Notably, in Figure 7, the gas/liquid interface 32 is shown at a level below the fluid outlet. I have included a close-up of the portion of Figure 7 showing the fluid outlet below, which includes annotations calling out the interface level and noting the freeboard below the outlet above the gas/liquid interface:



I note that this depiction of the fluid outlet and the relative location of the gas/liquid interface is identical to Figure 4c in Hemstock, which used the fluid outlet as its flow barrier. This depiction is entirely consistent with my analysis of the specification above, as well as how one of ordinary skill in the art would understand the desander to work.

241. There is nothing in the specification of the '256 Patent which indicates that Figure 7 shows an embodiment not operating in the normal, expected fashion, the same as all of the other figures in the patent. It is described as simply another embodiment that illustrates some additional optional characteristics. Ex. 1001, 6:66-7:13. These characteristics relate to the orientation of the fluid inlet and the angle of discharge of the fluid stream into the vessel. *Id.* There is nothing in the written description indicating that Figure 7's depiction of the gas/liquid interface is atypical in any way, or that it was not intended to show the interface "at the fluid outlet." It is entirely consistent with the discussions of other figures in the patent, which teach

that the interface is located adjacent or about the fluid outlet, or that it builds to about the fluid outlet. *See, e.g.,* Ex. 1001, 5:62-65: I know of no reason to simply not consider it when analyzing the meaning of the claim terms, or to construe the claims to exclude the embodiment it discloses.

242. I also note that Mr. McGowen’s declaration includes a rendering of Figure 7, somewhat similar to Figure 6, which he provided to illustrate the cross-sectional area in the freeboard portion:

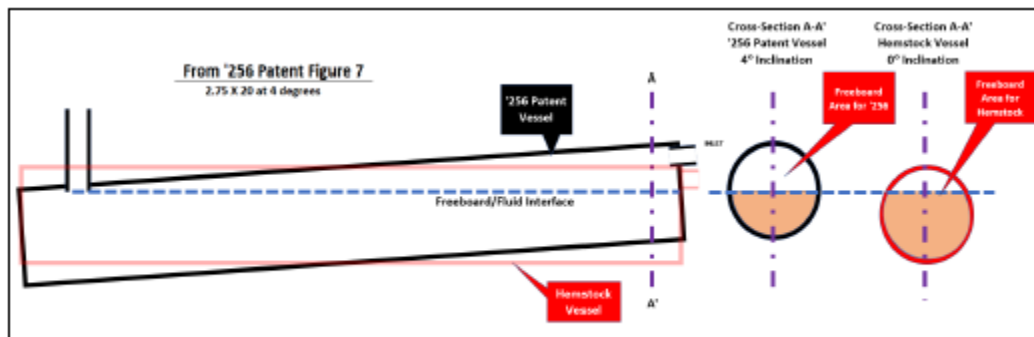


Figure 1 - Increase in Cross-Sectional Area in '256 Patent

Ex. 2001 ¶ 24. Although he has drawn the gas/liquid interface at the same location as would be required by Patent Owner’s construction, this is not what is actually shown in Figure 7 itself. In any event, Mr. McGowen failed to address Figure 7 in his claim construction analysis.

243. Figure 7 clearly contradicts Patent Owner’s claim construction position. Even if there were nothing else in the specification indicating that “at the fluid outlet” was only intended to mean near or close to the fluid outlet, this figure would compel that interpretation to one of ordinary skill in the art. This is so

especially given how such a person would interpret the liquid level in the vessel as fluctuating during operation, as previously explained.

II. THE COMBINATION OF HEMSTOCK AND DAVIS

A. A person of ordinary skill in the art would have been motivated to combine Hemstock with Davis.

244. Petitioner asserts that a person of ordinary skill in the art would have been motivated to improve, to the maximum extent possible, how fast sand settled in Hemstock's liquid-filled belly portion, so that there would be less sand in the liquid that is re-entrained out the fluid outlet. Pet. at 48. Patent Owner and Mr. McGowan make several assertions to the effect that a person of ordinary skill in the art would not have been motivated to achieve this, nor to incline Hemstock's vessel as suggested by Davis. These assertions are based on faulty conclusions regarding the teachings of both Hemstock and Davis, and how a person of ordinary skill in the art would have understood both. I address each assertion in turn.

1. A person of ordinary skill in the art would not have understood that the fluid stream leaving Hemstock's vessel was free of all particulates.

245. Patent Owner and Mr. McGowan assert that the fluid leaving Hemstock's fluid outlet 13 was particulate free, and therefore there was no reason to improve Hemstock as suggested by Petitioner, and Petitioner is merely relying on a "non-existent problem." Resp. at 28; Ex. 2001 ¶ 101. Mr. McGowan cites several passages in Hemstock to support his assertion that a person of ordinary skill in the

art “would have understood that the liquid exiting Hemstock via outlet 13 is already particulate free.” Ex. 2001 ¶ 101. I have reviewed these passages in view of the rest of Hemstock’s disclosure, and I respectfully disagree.

246. Mr. McGowan concludes that any liquid leaving Hemstock’s fluid outlet is particulate free based on three passages in Hemstock, which I address in turn:

[Referring to the embodiment shown in Fig. 4c] Particulate-free fluid, typically being gas G and some liquid L, is collected about the axis A for discharge through the discharge tubing 40 and outlet 13.

Ex. 1004, 5:34-36. This passage does use the phrase “particulate-free” fluid, with respect to both gas and liquid phases. In my opinion, a person of ordinary skill in the art would not conclude from this that the gas and liquid leaving the embodiment are completely particulate-free, leaving no room for improvement. This is because the balance of the specification explicitly states, in multiple places, that the fluid leaving the vessel is not particulate free:

In a broad aspect, desanding apparatus vessel for removal of particulates from a fluid stream containing particulates comprises: . . . wherein the fluid stream at the fluid outlet is *substantially free* of particulates. Ex. 1004, 2:40-61;

The fluid stream emanating from the fluid outlet 13 is typically liquid L and gas G, with a *substantial portion of the particulates* being captured by the desander 10. Ex. 1004, 3:37-42.

Substantially particulate-free means there are still particulates leaving the fluid outlet. Thus, there is still room for improved separation.

247. Second, a person of ordinary skill in the art would simply not understand that Hemstock's vessel achieves perfect separation over any and all operating conditions and particle size distributions. For instance, if certain particles are small enough, with all other conditions equal, they would remain entrained in Hemstock's freeboard portion instead of falling out into the belly portion. Hemstock itself teaches that at least some particulates will remain entrained in the freeboard section until they impact the flow barrier. Ex. 1004, 4:29-43 (explaining that not all particulates will fall out of the suspension in the freeboard phase, and that if the length of the vessel is insufficient the particulate will impinge the vessel internals). Of course, the flow barrier may be the fluid outlet itself, as in Fig. 4c. *Id.*, 5:16-27. Particulates striking the fluid outlet/flow barrier would most probably fall into the liquid in the belly portion in the area immediately around the flow barrier—the very same liquid that could be re-entrained with the gas leaving the vessel. *Id.*, 4:55-59. Any sand falling into this liquid, assuming it does not settle out immediately (which it would not as discussed below), would be re-entrained. Thus, a person of ordinary skill in the art would understand that Hemstock does not achieve perfect separation, and that the “particulate-free” fluid (either liquid or gas-phase) leaving the vessel is at best substantially particulate-free.

248. The next passage relied upon by Mr. McGowan is:

Typically, liquid L out of the fluid stream F accumulates in the belly portion 32 to a steady state level and then is re-entrained for discharge with fluids exiting the outlet 13 without affecting the capability of the vessel 11 and belly portion 32 to continue to accumulate particulates S.

Ex. 1004, 4:55-59. This passage does not state that the liquid leaving the vessel is particulate-free. It states that liquid is re-entrained, without affecting the desander's ability to accumulate particulates. But this is true regardless of whether there is sand in the liquid leaving the vessel; sand may still accumulate in the belly portion even if a portion of the sand entering the vessel is re-entrained with the liquid leaving the vessel. This passage does not teach one of ordinary skill in the art that there are no particulates in the liquid being re-entrained.

249. The final passage relied upon by Mr. McGowan is:

Applied to problem wells in several exceptional cases, using no vessel at all, one prior art wellhead, piping and equipment experienced four breaches and in another case, seven breaches. After installation of a preferred vessel of the present invention, no further breaches were experienced. In one case, the resulting collection of particulates, as sand, was about 5 liters per day.

Ex. 1004, 6:6-12. This passage relates to a successful test of the Hemstock vessel at one specific well. A person of ordinary skill in the art would never conclude from a successful test, or even many successful tests, that the vessel in question was perfect

and could not be improved. Operating conditions and particulate size distributions change from well to well. Furthermore, there is no explanation, exactly, for what is meant by “breaches” in this passage. I understand this to refer to the abrasive fluid/solid mixture wearing away the pipe wall and creating a path to the atmosphere. Again, however, this does not mean that the Hemstock vessel achieved a perfect, particulate-free fluid outlet stream, but only that it reduced the particulates in the outlet stream to such an extent that the abrasive action was insufficient to cause the pipe to fail.

250. Based on the foregoing, in my opinion a person of ordinary skill in the art would not have considered the fluid, either gas or liquid, leaving Hemstock’s vessel to be “particulate-free” and therefore requiring no improvement, but would have been motivated to improve how fast sand settled in the liquid contained in Hemstock’s belly portion.

2. A person of ordinary skill in the art would have considered Hemstock’s vessel to contain a suspension of sand in liquid.

251. Patent Owner also asserts that a person of skill in the art would not have been motivated to combine Hemstock with Davis because Davis applies to suspensions, and Hemstock does not teach that sand is in suspension with the liquid. Resp. at 29-30; Ex. 2001 ¶ 103. I cannot disagree more strongly.

252. According to Patent Owner and Mr. McGowen, Hemstock does not describe sand as being in suspension because “sand that falls out of the fluid flow

simply falls through the liquid to the bottom of the vessel, and does not become suspended.” Resp. at 29 (citing Ex. 2001 ¶ 103). This conclusion is premised on Mr. McGowen’s declaration, as well as the following passage from Hemstock (which also forms the basis for Mr. McGowen’s analysis): “The particulates S deposit and accumulate over time in the belly portion 32.” Ex. 1004, 4:40-43; Ex. 2001 ¶ 103. From this, Mr. McGowen concludes that “sand simply accumulates on the bottom of the belly portion of the vessel, not that sand first becomes *suspended* in the belly portion and then later settles out through sedimentation.” Ex. 2001 ¶ 103 (emphasis in original). Mr. McGowen’s conclusion is completely wrong.

253. First, the cited passage actually suggests there is a suspension: “The particulates S deposit and accumulate **over time** in the belly portion 32.” This suggests that the particulates do not “simply accumulate,” but rather settle over some period of time to the bottom of the vessel. This is a suspension. Second, to the extent that this suggestion of a suspension is disregarded, the cited passage says nothing else about *how* the particles deposit and accumulate in the belly portion. There is absolutely nothing in Hemstock supporting Mr. McGowen’s assertion that all of the sand simply “falls through the liquid to the bottom of the vessel” without becoming suspended (Ex. 2001 ¶ 103) or “falls substantially straight to the bottom.” (Ex. 2001 ¶ 75). In fact, a person of ordinary skill in the art could not possibly conclude that the sand particles in Hemstock fall straight down to the bottom of the vessel after

entering the liquid in the belly portion. One of ordinary skill in the art would understand that, due at least to the horizontal velocity of both sand particles and the liquid itself in the belly section, there is a suspension.

254. Hemstock teaches that particulates that enter the vessel that fall out of suspension in the freeboard portion fall along a downwardly curved trajectory into the liquid. Ex. 1004, 4:18-43. This means that the particles are traveling both horizontally and vertically. When these particles intersect with the liquid level, the majority will still retain some forward horizontal velocity. Due to the particles' momentum and velocity, they will tend to continue in the same direction, even after they strike the liquid surface (although the liquid will slow them down). Thus, the particles can be expected to have at least some horizontal velocity.

255. Further, there is essentially always going to be a horizontal liquid velocity (varying dependent on depth) in the belly portion. That is, liquid will be traveling at some speed from the fluid inlet end of the vessel to the fluid outlet end of the vessel. This is because fluid is continuously entering the vessel at the fluid inlet end and is leaving the vessel at the fluid outlet end (assuming a steady-state or near steady-state mode).

256. Given that there is both a particle and a liquid velocity, a person of ordinary skill in the art would understand that there is certainly a suspension in the liquid. Speaking in layman's terms, the settling of particles in a liquid is a function

of the particle size and the fluid velocity, and the particle settling velocity. As fluid velocity increases, the size of a particle that can remain suspended increases. Thus, a particle that would settle in a still fluid can remain suspended in even a slowly moving stream. As stream velocity increases above the particle's fluid settling velocity, it will tend to carry the particle. Thus, even very large objects can be suspended in a moving fluid; this is why one often sees cars, boulders, and similar objects being carried along in a flash flood. In Hemstock's vessel, separating very small particles (Hemstock states that a "worst case scenario" consists of particles of "about 100 mesh", Ex. 1004 at 6:5, which is a standard measurement and means there are no particles greater than 146 μm), the fluid velocity would not need to be very great to suspend sand particles in the liquid.

257. Moving beyond a general description, Stokes' law describes the settling rate of a solid of a given size in a given still fluid (having a Reynolds Number less than 0.1). The Stokes' law velocity, i.e., the velocity at which the particle will settle in a still fluid, is given by:

$$u^{(0)} = \frac{2a^2(\rho_s - \rho)g}{9\mu}$$

Where " $u^{(0)}$ " is the settling velocity, " a " is the particle radius, " μ " is the fluid dynamic viscosity, and " ρ " is density (ρ is fluid density and ρ_s is particle density). As particles get smaller and smaller, the velocity of the particle approaches zero and the combination of the tiny particles in the fluid is called a "colloidal mixture" where

the solids will not settle in real time. Desanding a raw well stream does not include consideration of colloidal mixtures and Hemstock sets the minimum particle size at “about 100 mesh”, Ex. 1004 at 6:5.

258. Assuming a 100 mesh sand particle in clean water, the Reynolds number in still water will be 1.18 at Stokes’ Law velocity (which is calculated at 0.018 feet per second). Note that this is the Reynolds number of the particle, not the fluid. I would expect the horizontal fluid velocity in Hemstock’s vessel to exceed this number at one or more points along the liquid’s velocity profile which would result in an x-axis velocity for the particle. Thus, it would not simply fall straight to the bottom but would have a horizontal velocity and thus take time to settle, or in other words, it would be suspended.

259. Furthermore, the forces on a real particle in a real fluid include more than just gravity, but also buoyancy and viscous drag. These forces are calculated using the following expressions:

$$F_d = \frac{\pi}{8} C_d \rho_{fluid} (v_{fluid} * r_{particle})^2 \quad \text{Viscous Drag Force}$$

$$F_b = (\rho_{particle} - \rho_{fluid}) * V_{particle} * g \quad \text{Buoyant Force}$$

As can be seen, the forces are a function of (among other things) the fluid velocity, both directly (v_{fluid}) and indirectly (drag coefficient “ C_d ” is a function of the fluid Reynolds number, which is a function of the fluid velocity). In essence, a person of ordinary skill in the art would understand that the sand particles falling through the

liquid in Hemstock's vessel are not simply going to fall straight to the bottom, but these forces will tend to suspend the particles (that is, make them settle over time).

260. Accordingly, in my opinion, there are multiple reasons to conclude there is indeed a "suspension" of sand in Hemstock's belly portion. Therefore, a person of ordinary skill in the art would have considered Davis' teachings applicable to Hemstock.

3. A person of ordinary skill in the art would have expected laminar flow in Hemstock, and Davis is not limited to laminar flow.

261. Patent Owner argues that a person of ordinary skill in the art would not consider Davis applicable to Hemstock because its teaching regarding enhanced sedimentation is limited to laminar flow. Resp. at 30; Ex. 2001 ¶ 104. Patent Owner and Mr. McGowen reason that, because Hemstock has turbulent flow in the freeboard portion of the vessel, Davis' teachings do not apply to Hemstock at all. *Id.*

262. As I previously testified (Ex. 2005 at 51:8-11), I agree that the fluid in Hemstock's freeboard portion would probably never be in laminar flow. However, the Reynolds number of the substantially gas phase fluid in the freeboard portion has absolutely nothing to do with the Reynolds number in the belly portion of the vessel, and the corresponding flow regime of the primarily liquid phase fluid. Given that Davis is applicable to settling in liquids, not gases, this is the appropriate inquiry.

263. Again, as I testified at my deposition, the liquids may or may not be laminar flow, depending on the particular velocities. I would expect that there will be times and areas in Hemstock's vessel where there is laminar flow. I agree with Mr. McGowan, who testified that a person of ordinary skill in the art would expect a velocity profile in the vessel, such that the liquid velocity near the surface is high and the flow regime turbulent, and which decreases even to zero as one descends to the bottom of the vessel. Ex. 1011 at 86:17-88:7, 134:16-137:20, 218:11-219:19. Thus, there will be places in the liquid portion of the vessel in a turbulent flow regime; other places in a laminar flow regime; and still other places that are nearly quiescent (still).

264. Given that a person of ordinary skill in the art would expect there to be laminar flow in at least a portion of Hemstock's liquid, in my opinion a person of ordinary skill in the art would consider would consider Davis' teachings regarding enhanced sedimentation in inclined channels as applicable to Hemstock's desander.

265. Furthermore, I note that Davis is not limited to laminar flow regimes. While Equation 4.1 in Davis is limited to laminar flow regimes (Ex. 1005 at 19), Davis is not limited to Equation 4.1. For example, Davis states that "many investigators have studied the phenomenon [enhanced sedimentation in inclined channels] for a variety of suspensions and have reported a severalfold increase in the sedimentation rate could indeed be achieved." Ex. 1005 at 17. In my opinion, even

if Davis' liquid phase were not expected to include the laminar flow regime, a person of ordinary skill in the art would still have been motivated to incline Hemstock based on this teaching, and would have considered there to be a reasonable expectation of success in the combination.

266. Finally, I understand that Patent Owner argues that Davis does not actually teach that its principles apply to the flow of a fluid stream. Resp. at 38 (“Davis focuses on . . . the rates at which those solids settle out of **suspension**, *not a fluid stream, which is not present in Davis.*”). (bold in original, italics added). But nothing in Davis limits its principles to quiescent settling. In fact, as Patent Owner and Mr. McGowan repeatedly note, even equation 4.1 in Davis is stated to apply to laminar **flow**. Therefore, a person of ordinary skill in the art would still consider Davis applicable to flowing fluid streams such as those in Hemstock.

4. A person of ordinary skill in the art would have considered Davis' teachings applicable to Hemstock's vessel because it is a narrow channel.

267. Patent Owner and Mr. McGowan further argue that Davis does not apply to Hemstock because it is only applicable to narrow vertical channels or plates within a large tank, and Hemstock would not be considered a narrow vertical channel due to its dimensions of 12" high by 10 or 20 feet long. Resp. at 21; Ex. 2001 ¶ 105. I disagree.

268. First, Hemstock discloses even more narrow desanders, including those having only a six inch diameter. Ex. 1004, 5:62-64.

269. Second, Davis is not limited to “narrow vertical channels” or plates in a large tank. Davis states that there are commercial devices “which may be composed either of a narrow tube or channel inclined from the vertical or of a large tank containing several closely spaced tilted plates.” Ex. 1005 at 17. But these are given only as examples of commercial vessels used to achieve increased sedimentation rates, and nowhere does Davis limit its principles to such devices. *See id.*

270. Finally, the term “narrow” is a relative term. For example, if we are talking about the Gulf Stream in the Atlantic Ocean, then the 60-mile nominal width of the stream is “narrow” relative to the 3500-mile distance from the New York coast to the European coast. For a particle settling in a still fluid, if it is more than a few particle diameters from a pipe wall, it sees no interference from the wall, and thus (for example) 100 mm becomes equivalent to infinity. In the sense of a particle settling in a dead-leg (e.g., represented by the belly portion of Hemstock’s vessel) a person of ordinary skill in the art would consider it “narrow” if interactions between the particles and the vessel wall were common. Since the purpose of the vessel is to accumulate solids on the vessel walls and end, it can safely be said that both Hemstock, and the ’256 Patent are “narrow channels.”

271. Thus, in my opinion, Hemstock does disclose a channel that is sufficiently narrow that a person of ordinary skill in the art would consider Davis as applicable.

5. A person of ordinary skill in the art would have considered Davis applicable even though Hemstock is a horizontal vessel.

272. Patent Owner also argues that a person of ordinary skill in the art would not have considered Davis' teachings applicable to Hemstock because the latter discloses a horizontal vessel, and Davis only teaches that inclining a vertical vessel would increase settling rates. Resp. at 31-33. Patent Owner's arguments are based again on Mr. McGowan's analysis of Davis, and specifically Equation 4.1 of Davis. Ex. 2001 ¶¶ 52-57, 106.

273. However, as Patent Owner has noted, equation 4.1 is limited to laminar flow. Given that a person of ordinary skill in the art would not necessarily expect Hemstock's liquid portion to be entirely laminar, it does not make sense to apply equation 4.1 in an attempt to determine how that person would expect inclining Hemstock would impact settling rates.

274. However, even using Equation 4.1, Mr. McGowan himself proved that there was, in fact, an expected increase in settling rate after inclining vessels having dimensions similar to those disclosed in the prior art. Ex. 2001 ¶¶ 54-57. Although the increase Mr. McGowan calculated was only for limited angles (up to 11.3 degrees and 5.7 degrees for the two vessels), these angles fall within the claimed

inclination angles in the '256 Patent. And, although the calculated increase in “settling efficiency,” (in reality, the surface area) per Mr. McGowan, is small, there is still an increase. *Id.* Thus, even based on Mr. McGowan’s testimony, there was a motivation for a person of ordinary skill in the art to incline Hemstock, based on Davis’ teaching.

275. However, even without applying Mr. McGowan’s calculations, I believe that a person of ordinary skill in the art would still have been motivated to apply Davis’ teachings regarding enhanced sedimentation to Hemstock’s horizontal vessel. The Hemstock vessel is a batch process. By this, I mean that it must occasionally be taken out of service so that solids may be emptied out of the vessel. The device, as designed, is intended to bring in a mixture of gases, liquids, and solids, and send a fluid consisting of gases and entrained, hopefully clarified liquids out of the vessel’s fluid outlet, with some portion of solids. The substantial portion of solids are intended to remain behind for later batch removal.

276. Likewise, Davis describes an essentially batch process for settling of solids out of a liquid, and specifically describes enhancing the rate at which solids settle in a liquid by using an inclined channel. Davis’ discussion of enhanced settling in an inclined vessel—even one that starts out as from a vertical orientation—would have caused a person of ordinary skill in the art to consider whether it might be advantageous to incline Hemstock’s vessel, in order to improve the settling rate

therein and thereby improve the solid retention rate of the vessel. A person of ordinary skill in the art would have understood that even in a horizontal vessel, there would be increased surface area for enhancing the rate of settling. This is true despite the fact that a person of ordinary skill in the art would have recognized that there was an even bigger increase in surface area to be had when inclining a vertical vessel. Thus, such a person would still have been motivated to apply Davis' teachings and incline Hemstock as asserted by Petitioner.

B. A person of ordinary skill in the art would have been motivated by Davis to incline Hemstock such that the fluid inlet is higher than the fluid outlet.

277. I understand that Patent Owner argues that a person of ordinary skill in the art motivated to incline Hemstock based on Davis "would be motivated to tilt Hemstock such that the outlet were *higher* than the outlet [sic], not lower." Resp. at 26 (emphasis in original). I understand from Patent Owner's argument that Patent Owner asserts that a person of ordinary skill in the art would be motivated to tilt Hemstock such that the outlet is higher than the inlet, or in the opposite direction from the way in which Petitioner asserts the references would be combined.

278. Patent Owner's argument is based on the testimony of Mr. McGowen, who testifies that "Davis teaches that inclining a vessel provides increased sedimentation rates because it allows for more surface area of the vessel to be available for downward settling of solids in suspension." Ex. 2001 ¶ 96. Mr.

McGowen further testifies that Hemstock teaches that “all of the sand has settled out of the fluid prior to reaching the outlet.” *Id.* Mr. McGowen cites the following portion of Hemstock for this assertion: “Preferably, to avoid impingement-type erosion, the length of the vessel is sufficient to permit the particulates to fall out of suspension before impinging internals of the vessel 11.” Ex. 1004, 4:34-37. Mr. McGowen then concludes that this means that “there would not be sand in suspension with the liquid close to the outlet.” Ex. 2001 ¶ 96. Therefore, according to Mr. McGowen, as the only location in Hemstock’s vessel where any sand could be in suspension is at the fluid inlet, “the only side wall available in Hemstock to provide additional surface area for settling would be the side wall closest to the inlet. *Id.* ¶ 97. Thus, he concludes that a person of ordinary skill in the art would only incline Hemstock in a way that “would provide the wall closest to the inlet for settling,” that is, “to incline the vessel so that the fluid outlet was higher than the fluid inlet.” *Id.* ¶ 98. This is because, according to Mr. McGowen, inclining the vessel in the manner asserted by Petitioner (with the fluid outlet lower than the fluid inlet), would not make the “extra surface area available for settling [i.e., the end wall of the vessel past the fluid outlet] because it “will be below liquid that is taught not to have any sand in it. Without sand, there can be no additional sand settling.” *Id.* Mr. McGowen includes the below modified version of Figure 3 to illustrate his logic. *Id.*

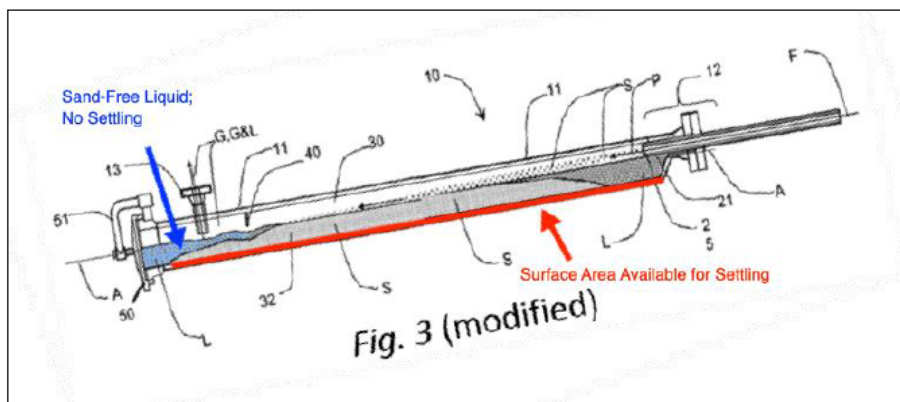


Figure 3 – Inclined Hemstock, outlet higher than inlet, no extra surface available for settling because no sand in liquid on the left

279. I respectfully disagree with Mr. McGowen’s reasoning at almost every single point of his analysis. First, Hemstock does not teach that all of the sand has settled out of the fluid prior to reaching the outlet. The passage Mr. McGowen relies upon in support of this proposition merely states that the vessel would preferably be of sufficient length such that **most** of the particulates—not all—will fall out of suspension *in the freeboard portion* of the vessel, so as not to impinge the vessel internals such as the flow barrier. Ex. 1004, 4:27-31 (explaining that a lesser fraction of particulates remains entrained and does not fall out of suspension in fluid stream F); 4:34-40 (teaching that the vessel is preferably of sufficient length such that the greater fraction of particulates “eventually fall from the freeboard portion 30” and preferably will not impinge and thereby erode vessel internals). This passage relates to particulates in suspension in the primarily gas-phase freeboard portion, not the primarily liquid-phase belly portion.

280. Furthermore, I find nothing in Hemstock detailing where sand is or is not settling in the belly portion. The only possible support for Mr. McGowen’s premise is Hemstock’s figures, which he has annotated to indicate “Sand-Free Liquid; No Settling.” There is no support for this assertion in Hemstock. I do not believe the indications of where sand accumulates shown in Hemstock’s figures to be reliable indicators of where sand will settle in this vessel under any and all operating conditions, stream compositions, and particulate sizes. Figure 3, for instance, is not drawn to scale, and there is nothing indicating that its depictions of sand accumulation are intended to be all-encompassing. A person of ordinary skill in the art would not rely on these depictions to determine where sand is or is not settling in the liquid-phase portion of this vessel, as that would be expected to vary widely depending on the particle size distribution, liquid and gas present in the stream, and fluid velocities in the vessel. In my opinion, and as discussed further in section II.A.2, there will be sand in suspension in the belly portion of the vessel, immediately below and even past the fluid outlet. Thus, the very premise of Mr. McGowen’s analysis is simply unfounded.

281. Second, even if there were no sand in the liquid beneath Hemstock’s fluid outlet in its *horizontal* position, it would not mean—as Mr. McGowen testifies—that *inclining* the vessel (in the manner suggested by Petitioner) would not make any extra surface area available for settling. This is because of the obvious

effects of gravity on the contents of the vessel, which Mr. McGowen completely ignores in his analysis and his tilted version of Hemstock's Figure 3. A person of ordinary skill in the art would have understood that tilting Hemstock such that the fluid outlet is lower than the fluid inlet would cause the liquid and solid contents of the vessel to pool or accumulate towards the lowest part of the vessel—the far wall past the fluid outlet. Therefore, in this inclined position, the liquid would indeed have sand in it, and the wall would provide additional surface area for sedimentation. Mr. McGowan's analysis completely fails to account for the impact of gravity, which would have been considered by a person of ordinary skill in the art when considering whether and how to modify Hemstock in view of Davis.

282. There is also an additional reason that a person of ordinary skill in the art would have inclined Hemstock in the manner suggested by Petitioner, and not as suggested by Patent Owner and Mr. McGowan. If Hemstock's vessel were inclined such that the fluid outlet was higher than the fluid inlet, as suggested by Patent Owner (Resp. at 27; Ex. 2001 ¶ 98), the desander would not retain any ability to separate solids from the incoming fluid stream. This is because the liquids and solids would pool, due again to the effects of gravity, at the fluid inlet end of the vessel. This would completely destroy the vessel's intended manner of operation (providing a larger cross-sectional area in the freeboard section than the inlet piping, thus lowering the velocity and causing the entrained particulates to fall from the stream)

because the fluid would enter the vessel beneath any accumulated liquid and sand, not in a substantially gas-filled freeboard portion. Not only would there be no separation of particulates and liquids entering the vessel (via gravity separation), accumulated liquids and solids covering the fluid inlet would be re-entrained back into the fluid stream and any vapor space in the vessel, from which they would be carried out of the fluid outlet. In essence, there would most likely be a continuous cycling of gas and liquid slugs, including entrained solid particulates in both phases, flowing out of the fluid outlet. Of course, this would defeat the vessel's purpose by allowing large amounts of solids to leave the fluid outlet, from which they could cause damage to downstream systems. Overall, no one of any skill in the art would ever consider inclining the vessel as suggested by Patent Owner and Mr. McGowan.

III. THE COMBINATION OF HEMSTOCK AND THE DATA BOOK

A. The Data Book discloses inclined slug catchers which a person of ordinary skill in the art would understand as including single-phase separators having a gas/liquid interface at the fluid outlet.

283. I understand that Patent Owner argues that the inclined slug catchers disclosed in the Data Book do not disclose the Interface Limitations, which Patent Owner construes as a gas/liquid interface at (but not above or below) the fluid outlet. Resp. at 41-43. Patent Owner asserts that, because I testified that such slug catchers have three different modes of operation, only one of which (steady state) has a

gas/liquid interface at the fluid outlet, that the slug catchers do not necessarily have a gas/liquid interface at the fluid outlet. *Id.* I respectfully disagree.

284. I previously testified that a person of skill in the art would have understood that the inclined harp-style slug catchers described in the Data Book include what I described as a “single phase separator.” Ex. 1002 ¶ 104. As I explained:

46. Although there are no rigid definitions with regard to terminology, separators are often distinguished by reference to the phases or species separated. A “single phase” separator is generally understood as one having a single outlet that does not require manual intervention (i.e., the unit may separate multiple species, but at the outlet any species that is not retained in the vessel will be recombined). A “two phase” separator will separate the phases of a multiple phase inlet stream into two separate streams, while a “three phase” separator will separate an inlet stream into three separate phase streams. In short, some numerical value in front of the word “phase” refers to the number of unique outlet paths from the vessel that function without manual intervention, not the number of species of fluids combined in the vessel inlet stream. Obviously, a separator may have other outlets that may be opened manually, on batch basis and outside of normal steady-state operation, but the presence of such outlets does not change whether a particular separator is considered a single, two, or three phase separator.

Ex. 1002 ¶ 46. Hemstock’s vessel is also a single phase separator.

285. Because such devices only have a single outlet during normal operation, the liquid level in the devices cannot be prevented from fluctuating, and as I previously testified will have three modes of operation. These modes relate to the liquid level: below (liquid starved), above (liquid flooded), or at (steady-state) the gas/liquid outlet. A person of ordinary skill in the art, as I testified, would understand and expect that all three modes of operation will occur at different times during the vessel's operation. Thus, Patent Owner is mistaken when it asserts that, because other modes of operation are also expected, that the steady-state mode will not necessarily occur. Resp. at 42-43. It will. Although the preferred normal mode of operation of any slug catcher is liquid starved, with the liquid level below the fluid outlet, a person of ordinary skill in the art would understand that a liquid slug event will cause this level to rise and reach the gas-liquid outlet, and that the slug catcher would (as designed) necessarily enter the other two modes of operation for at least some period of time.

286. When the amount of liquid coming in equals the amount leaving the vessel via the gas-liquid outlet, the vessel is in steady state mode, just like the Hemstock desander, and the gas/liquid interface is located at the fluid outlet. This mode of operation is necessarily going to be present for at least some periods of time in a slug catcher placed in its intended service.

B. A single-phase slug catcher does not operate in the same way as the two-phase slug catchers described in the 2004 Data Book and Rhinesmith.

287. I understand that Patent Owner, relying on Mr. McGowan's testimony, asserts that certain slug catchers described in a paper by Rhinesmith (Ex. 2004) and referenced in a 2004 edition of the Data Book (Ex. 2003) would not operate as I have explained. Resp. at 43-45 (citing Ex. 2001 ¶¶ 108-112). This is because these devices, as described, are not single phase slug catchers, but two phase slug catchers.

288. As I previously testified, a two phase separator is one which will separate the phases of a multiple phase inlet stream into two separate streams via two unique outlet paths that function without manual intervention. For example, a mixed gas/liquid inlet stream will be separated into two outlet streams, a gas stream and a liquid stream, which can leave the vessel via operation of open lines or lines having automatic control valves (i.e., no manual intervention).

289. The vessels described by Patent Owner and Mr. McGowan have automatic liquid level controllers, which attempt to regulate the level of liquid in the vessel at all times at a certain target. *See* Ex. 2004 at 20 (explaining the goal of the level control system). Thus, when the liquid level rises, the controller will open (without manual intervention) the valve on the liquid outlet, allowing liquid to leave the vessel and tending to lower the level in the vessel.

290. A slug catcher with a liquid level controller such as those discussed above may be capable of completely “catching” a liquid slug, as Mr. McGowan defines that term. Ex. 2001 ¶ 110. Even this, however, is not guaranteed, and is dependent on whether the amount of liquid leaving the vessel via the liquid outlet is more than enough to prevent the liquid from rising to and exiting the gas outlet. However, this is not necessarily the purpose of a single phase slug catcher, as I previously testified.

291. A single-phase slug catcher, versus a two-phase slug catcher, will be expected at times to have insufficient liquid surge volume to prevent liquid from leaving the vessel’s gas outlet. As I have previously testified (Ex. 1002 ¶ 104), in this situation the slug catcher converts a short duration liquid slug event into a long duration event that is much easier for the downstream production equipment to handle.

292. I note that Rhinesmith itself discusses the design of such slug catchers, which are not necessarily designed to completely “catch” every liquid slug so as to permanently separate gas and liquid, but are intended to merely convert the slug flow in the pipeline into a different, more manageable type of multiphase flow. Rhinesmith explains that

While many primary separation applications are designed to allow the carryover of a droplet not bigger than 100 to 150 micron diameter particles and secondary devices such as mesh pads or mist

eliminators may be used to reduce droplet size to approximately 10 to 50 microns, **slug catcher design often sets a much less demanding goal of establishing stratified flow to separate the gas and liquid phases, particularly if additional downstream separation is adequate.**

Ex. 2004 at 15. A person of ordinary skill in the art would understand this passage to mean that slug catcher design often differs from the design of primary separators (such as those described in Chapter 7 of the Data Book) in that they are not necessarily designed to completely separate gas and liquid phases (absent carryover of small droplets). Instead, they are designed to transform the multiphase flow regime in the pipe from slug flow (which is understood to be potentially damaging) to stratified flow, especially if there is additional downstream separation which would be relied on to perform the gas/liquid separation. Therefore, the slug catcher receives a liquid slug in its inlet, but sends stratified flow to its gas phase outlet. “Stratified flow” is one of the five two phase flow regimes detailed in Figure 17-14 of the Data Book. Ex. 1008 at 36. Stratified flow is much more desirable than slug flow. *See id.* at 37. This discussion is completely consistent with my testimony regarding converting slug flow events into longer duration froth events. Ex. 1002 ¶ 104.

293. I note that Patent Owner and Mr. McGowan also argue that my understanding of the Data Book’s slug catcher operation as a single-phase separator

is incorrect, based on the Data Book’s definition of “separator.” Resp. at 43-44; Ex. 2001 ¶ 108. However, a person of ordinary skill in the art would not limit the term “separator” as Patent Owner and Mr. McGowan attempt to do, nor does the Data Book even support their conclusion.

294. First, the cited definition appears in the “Nomenclature” section of Chapter 7 of the Data Book. Ex. 1008 at 3. Each section of the Data Book, including section 17 which contains the discussion of inclined harp-style slug catchers, has its own “Nomenclature” section. Section 17 does not have any definitions of separators or slug catchers. *See id.* at 21-22.

295. Second, the cited definition itself states that a separator is used to “separate a mixed-phase stream into gas and liquid phases that are ‘relatively’ free of each other.” Ex. 1008 at 3. The issue is, what does “relatively” mean? The answer is that it depends on the application. As stated in Rhinesmith, sometimes this means removal of all liquid droplets larger than 10 microns from the gas phase, but at other times—for slug catchers, especially—this may simply mean converting the slug phase flow regime into a different flow regime. Ex. 2004 at 15.

296. Finally, a person of ordinary skill in the art would be familiar with the design and operation of separators and slug catchers and would not view the Data Book’s discussion of separators and slug catchers by rigid adherence to definitions in the nomenclature section. A person of ordinary skill in the art would instead base

his assessment of the Data Book's disclosure on his general knowledge. And, as I previously testified, a person of ordinary skill in the art would know that "separator" has no rigid definition in the industry. Ex. 1002 ¶ 46.

C. A person of ordinary skill in the art would have been motivated to combine Hemstock and the Data Book.

1. A person of ordinary skill in the art would understand Hemstock to teach that liquid slugs are common in desanding service and that a desanding vessel should be capable of handling them.

297. I understand that Patent Owner argues that a person of ordinary skill in the art would not have been motivated to improve Hemstock's ability to handle liquid slugs because it would have been expected to "handle the expected multiphase flow," based on an excerpt from my testimony under cross-examination and testimony from Mr. McGowan. Patent Owner's argument does not reflect how a person of ordinary skill in the art would understand Hemstock, and misconstrues my testimony.

298. Hemstock teaches that it was known that there would be large slugs of fluid followed by a gas mist in oil and gas operations, and specifically in desanding service. Ex. 1004, 2:7-9. Although this was mentioned in Hemstock in the context of a desander using filter bags, Hemstock does not state that slug flow only occurs when filter bags are used, nor would a person of ordinary skill in the art reach this conclusion. A person of ordinary skill in the art would have understood from

Hemstock (as well as being aware of the fact independently) that slug flow was expected to occur in oil and gas desanding service, no matter what type of desander is use.

299. Patent Owner thus states that I testified that Hemstock would have been able to handle “the expected multiphase flow” including any liquid slugs. Resp. at 47. This is not what I said. I was asked whether the Hemstock vessel “can handle multiphase flow,” to which I replied, “Yes.” Ex. 2005 at 83:1-10. Of course, there is no question that Hemstock’s vessel can handle multiphase flow; this is its intended design. However, I was not asked, nor did I “concede,” that Hemstock could handle “**the expected** multiphase flow,” nor did I state that Hemstock could handle slug flow, nor did I state that Hemstock could handle slug flow no matter the volume of liquid.

300. Given that a person of ordinary skill in the art would have understood that Hemstock’s desander would experience slug flow, there is simply no question that a person of ordinary skill in the art would have been motivated to modify Hemstock’s design in any way possible to improve its ability to handle such flow. This is because, if Hemstock did not handle such flow adequately, it would mean that large volumes of liquid would be expected to partially or completely fill the desander, flowing out of the fluid outlet and carrying large volumes of the

accumulated sand particles with it. Of course, this would defeat the stated purpose of the desander.

2. A person of ordinary skill in the art would have looked to the Data Book's teaching on inclined-pipe desanders because Hemstock's desander may be a modified pipe.

301. I understand that Patent Owner asserts that a person of ordinary skill in the art would not have considered the inclined-pipe slug catchers taught by the Data Book, because they are constructed of pipe and are not vessels like the Hemstock desander. Resp. at 47-49. In my opinion, however, a person of ordinary skill in the art would consider the Data Book's disclosures regarding slug catchers made of pipe, because the "vessel" disclosed in Hemstock may itself be constructed of a pipe.

302. Hemstock teaches that

A typical vessel according to the present invention, . . . can be a 6" or 8" diameter. Using an 8" diameter, schedule 160 shell for the vessel 11 can result in a fluid stream capacity of about 8 million cubic feet of gas per day. A 2" schedule 160 inlet nozzle extends about 1" beyond an eccentric inlet 12 and into the vessel 11.

Ex. 1004, 5:62-6:1. The references in this passage to "schedule 160" refer to Schedule 160 pipe.

303. As can be seen, for example, in the Data Book, pipe comes in standard pipe sizes, referred to as the "nominal pipe size." *See* Ex. 1008 at 45. The nominal pipe size, however, only corresponds to the pipe's nominal diameter. Thus, an 8"

nominal size steel pipe always has an outer diameter of 8.625 inches. *Id.* However, the inner diameter of a pipe having an 8” nominal size will vary depending on the pipe’s schedule. The pipe schedule is a designation used to identify the wall thickness. Thus, an 8” Schedule 40 (“S40”) has a wall thickness of 0.322 inches; Schedule 80 has a wall thickness of 0.500 inches; and Schedule 160 a wall thickness of 0.906 inches. *Id.* As can be seen, the thickness, and therefore the effective pressure rating, goes up as the schedule increases. *See id.*

304. Because pipe schedules are not used to refer to pressure vessels, Hemstock’s references to a Schedule 160 shell for its vessels indicates they are indeed fabricated from pipe. This is not uncommon, as it is often cheaper to use pipe in a given service than to fabricate an equivalent pressure vessel by rolling steel plate due to code requirements, as long as the pipe is adequate for the intended service.

305. Because a person of ordinary skill in the art would have known that Hemstock’s desanders could be constructed of pipe, he would have every reason to consider the slug catchers disclosed in the Data Book that were also constructed from pipe, and to incline Hemstock based on the Data Book’s teachings.

306. Finally, I understand that Patent Owner and Mr. McGowen argue that a person of ordinary skill in the art would not incline Hemstock’s vessel based on the teaching of the Data Book because would have understood that the vessels did not operate on the same principles and would have “set the level” such that the

gas/liquid interface was below the fluid outlet. Resp. at 49-50. These arguments are based on the manner of operation of two phase slug catchers that meet Patent Owner's interpretation of the Data Book's definition of "separator," and are mistaken as I discussed in section III.B above. On the contrary, a person of ordinary skill in the art would have understood that Hemstock and the Data Book's harp-style slug catchers operated in exactly the same manner.

IV. COMBINATIONS WITH MILLER

307. I understand that Patent Owner argues, relying on Mr. McGowan's testimony, that a person of ordinary skill in the art "would not understand an outlet pipe to be disclosure of a smaller diameter portion of a pressure vessel." Resp. at 52 (citing Ex. 2001 ¶ 129).

308. Mr. McGowan himself states that he disagrees with my testimony that "Miller's disclosure of a vessel with an output as a pipe suggests to a person of ordinary skill in the art that the pipe could be incorporated into the vessel itself." Ex. 2001 ¶ 129. He then states that I "do not provide a single example of a vessel . . . which includes a smaller, eccentric end that is located after a fluid outlet." *Id.* However, I never argued that any of the smaller, eccentric ends on the examples I provided were "located after a fluid outlet." The examples I gave were provided merely to show that it was well known to use smaller diameter eccentric ends on pressure vessels. Ex. 1002 ¶ 193.


309. Mr. McGowan further asserts that my examples disprove my contention that it was common to use smaller diameter ends for quick release clean-outs. Ex. 2001 ¶ 129. However, his discussion only addresses two of my examples (pictures 5 and 6). *Id.* For example, as I testified at my deposition, picture 1 shows a reduced diameter section with quick closure. Ex. 2005 at 66:22-67:4, 69:4-70:1; Ex. 1014.

V. CONCLUSION

310. I reserve the right to revise or supplement my opinions after I have had the opportunity to review any new testimony, or other additional documents or information that may be brought to my attention, or in response to any critiques of my testimony.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on this 21st day of August, 2019

A handwritten signature in blue ink, appearing to read "David A. Simpson", is written over a horizontal line.

David A. Simpson, P.E