UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ENERCORP SAND SOLUTIONS INC.
Petitioner

v.

SPECIALIZED DESANDERS INC.
Patent Owner

Inter Partes Review No. 2018-01748
U.S. Patent No. 8,945,256

DECLARATION OF HAROLD E. MCGOWEN III, P.E.

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I, Harold E. McGowen III, hereby declare as follows.

I. OVERVIEW

1. I am over the age of eighteen and otherwise competent to make this declaration.

2. I have been retained by Radulescu LLP on behalf of Specialized Desanders Inc. ("SDI") to serve as a technical expert and provide expert opinion in this *inter partes* review ("IPR") proceeding Case No. IPR2018-01748 before the United States Patent and Trademark Office regarding U.S. Patent No. 8,945,256 (the "'256 Patent"). Although I am being compensated for my time in connection with this IPR at my standard consulting rate, which is $500 per hour, no part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I understand that this proceeding was filed by Enercorp Sand Solutions Inc. ("Petitioner") and that the proceeding involves the '256 Patent (Ex. 1001). I understand that the application for the '256 Patent was filed on February 13, 2012, as U.S. Application No. 13/372,291. I understand that the '256 Patent issued on February 3, 2015.

4. I have been asked to consider the claim construction of "gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow" of claim 1 of the '256 Patent and "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" of claim 9 of the '256 Patent. I have also been asked to consider whether one of ordinary skill in the art of the '256 Patent would understand that certain references disclose or suggest the features recited in the claims of the '256 Patent, or otherwise render the claims obvious. My opinions are set forth below.

II. MY BACKGROUND AND QUALIFICATIONS

5. I hold a Bachelor of Science Degree in Mechanical Engineering from Texas A&M University ('82), I am a Registered Professional Engineering in the State of Texas and I have 36 years-experience in the upstream oil and gas industry. As part of the process of developing oil and gas fields over the span of my career I have studied, analyzed, implemented, inspected, monitored and/or inspected hundreds of oil and gas production facilities that included various separation and processing vessels. As both CEO and lead engineer at Navidad Resources, LLC I was involved in the design and trouble-shooting of a midstream gathering and processing system that included about fifty (50) production processing facilities (one per well), 100 miles of pipeline and two natural gas liquids extraction and natural gas processing plants. I have designed, implemented, monitored and analyzed hundreds of hydraulic fracturing treatments and flow-back operations which involved particle (sand, proppant and other solids) transport both during and

after treatment of the wellbore. As the lead engineer on numerous horizontal and vertical drilling operations, including managed pressured drilling or flow drilling operations, I have studied, analyzed and monitored particle transport (drill cuttings) in horizontal and vertical wellbores as well as surface separation of solids from drilling fluids. As the lead engineer on numerous post-frac composite bridge plug drill out operations, I studied, analyzed and monitored particle transport (removal of plug debris) in vertical and horizontal wellbores. At Signa Engineering I participated in a project to design a 4-Phase (oil/gas/water/solids) separation system for underbalanced drilling operations.

6. My additional contributions and experience in the field are set forth in my current *curriculum vitae* (Ex. 2002).

III. LIST OF DOCUMENTS CONSIDERED

7. In formulating my opinion, I have considered any documents cited in this declaration, specifically including the following documents:

Description
U.S. Patent No. 8,945,256 (the "'256 Patent") (Ex. 1001)
Declaration of David Simpson, P.E. (Ex. 1002)
File History of the '256 Patent (Ex. 1003)
U.S. Patent No. 6,983,852 ("Hemstock") (Ex. 1004)
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") (Ex. 1005)
U.S. Patent No. 1,458,234 ("Miller") (Ex. 1007)

Description
Engineering Data Book, Gas Processors Suppliers Association, Revised Tenth Edition 1994 (the "Data Book") (Sections 7 and 17) (Ex. 1008)
Engineering Data Book, Gas Processors Suppliers Association, Revised Twelfth Edition 2004 ("Section 7") (Ex. 2003)
Rhinesmith, R. Bret, Kimmitt, Russell P., and Root, Chris R., "Proven Methods for Design and operation of Gas Plant Liquid Slug Catching Equipment," 80th Annual Gas Processors Convention, San Antonio, Texas, March 12-14, 2001 ("Rhinesmith") (Ex. 2004)
Deposition Transcript of David Simpson ("Simpson Dep.") (Ex. 2005)
The American Heritage Dictionary of Science, 1986 (Ex. 2006)
McGraw-Hill Dictionary of Scientific and Technical Terms, Fourth Edition, 1989 (Ex. 2007)

IV. PERSON OF ORDINARY SKILL IN THE ART

8. I understand that a person of ordinary skill in the art is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. A person of ordinary skill in the art ("POSITA") would have had knowledge of the literature concerning the separation and collection of particles entrained in a wellbore fluid stream as of February 13, 2012.

9. Based on my review of the patent specification and file history, in my opinion, a POSITA would have at least (i) a bachelor of science degree in petroleum, mechanical or an equivalent engineering discipline with at least 3 years of oil and gas industry experience with the design and/or application of solids separation equipment in the upstream segment of the oil and gas industry (drilling,

completions or production operations), or (ii) the equivalent relevant oil and gas industry experience and training, for a person lacking a formal degree, which would be about 3-5 years in the upstream oil and gas industry. In addition, a POSITA would understand the basic principles underlying liquid-gas, liquid-liquid, and liquid-solids transportation and separation equipment and the corresponding basic legacy equipment designs for the application areas generally covered by the patents at issue. Finally, a POSITA would be familiar with hydraulic fracturing flow-back operations and issues related to separating particles from the fluid stream (sand or other proppant and possibly rock particles from a geologic formation).

10. Mr. Simpson states that in his opinion a person of ordinary skill in the art would have "at least a bachelor's degree in petroleum, chemical, or mechanical engineering, or equivalent experience and education." Ex. 1002 ¶ 40. While I disagree with Dr. Simpson's understanding of a person of ordinary skill in the art, none of my opinions would change under this definition.

11. Under either mine or Mr. Simpson's definition of a person of ordinary skill in the art, I would have been a person of ordinary skill in the art as of the filing date of the '256 Patent.

V. LEGAL STANDARDS

A. Claim Construction

12. I have been instructed by counsel on the law regarding claim construction.

13. I have been advised that in post-grant review proceedings before the U.S. Patent and Trademark Office, a patent claim receives the broadest reasonable construction in light of the specification of the patent in which it appears. I have also been advised that this means the claim terms are given their ordinary and customary meanings as would be understood by one of ordinary skill in the art at the time of the invention, unless that meaning is inconsistent with the specification of the patent.

14. I understand that a POSITA is deemed to read a claim term not only in the context of the particular claim in which the term appears, but also in the context of the entire patent, including the other claims, the specification, and the prosecution history, which is called the intrinsic evidence. I understand that claim terms must be construed in a manner consistent with the context of the intrinsic record. I further understand that the specification is highly relevant to claim construction and that, while claims are to be read in light of the specification, limitations should not be imported or read into the claims from the specification.

15. I understand that general purpose and scientific dictionaries, relevant scientific principles, references illustrating the meaning of technical terms, and the state of the art, known as extrinsic evidence, may also be relevant to claim construction. However, I understand that extrinsic evidence should not be considered divorced from the context of the intrinsic evidence.

B. Obviousness

16. I have been further instructed by counsel on the law regarding obviousness.

17. I have been advised that a patent claim may be invalid if the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention was made to a POSITA. I have also been advised that several factual inquiries underlie a determination of obviousness. These inquiries include the scope and content of the prior art, the level of ordinary skill in the field of the invention, the differences between the claimed invention and the prior art, and any objective evidence of non-obviousness.

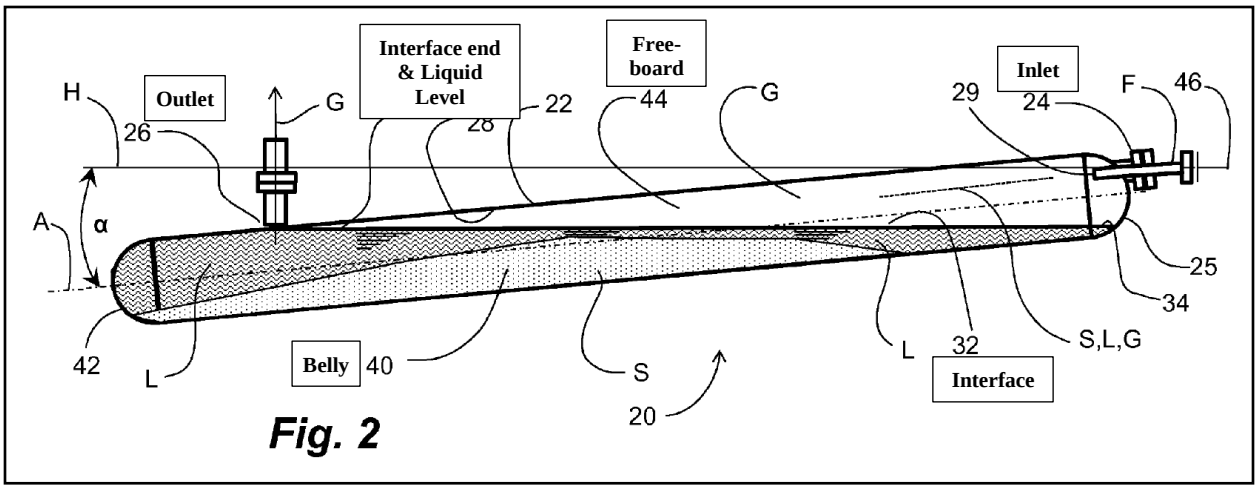
18. I have been advised that objective evidence of non-obviousness, known as secondary considerations of non-obviousness, may include: commercial success, satisfaction of a long-felt but unsolved need, failure of others, copying, skepticism or disbelief before the invention, and unexpected results.

19. In addition, I have been advised that the law requires a common sense approach to examining whether the claimed invention is obvious to a person skilled in the art. For example, I have been advised that combining familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

20. I have also been advised that a reference may be used as prior art for purposes of the obvious analysis only if it is analogous to the claimed invention. Prior art is analogous if it is from the same field of endeavor or if it is reasonably pertinent to the particular problem the inventor is trying to solve.

VI. OVERVIEW OF THE '256 PATENT

21. The '256 Patent is directed to a desanding system that makes use of an elongated vessel that is tilted at a non-zero inclination angle to remove entrained liquids and particulates from an inlet gas stream. '256 Patent (Ex. 1001), at Abstract. Figure 2 (copied below from page 3 of '256 Patent) illustrates a cross-sectional view exemplary desanding system according to the claims of the '256 Patent. '256 Patent (Ex. 1001), 3:4-49; Fig. 2.



'256 Patent (Ex. 1001), Fig. 2 (modified)

22. The desander of the '256 Patent is designed to be inserted between a wellhead and downstream equipment such as multiphase separators. '256 Patent (Ex. 1001), 3:64-67. The desanding vessel is inclined, such that a fluid inlet is at the upper end of the vessel and parallel to the longitudinal axis of the vessel, and a fluid outlet is spaced along the top of the vessel and spaced from the inlet. '256 Patent (Ex. 1001), 4:30-49. The fluid inlet receives a fluid stream from a wellhead comprising a combination of gas, some liquid, and entrained particles such as sand. '256 Patent (Ex. 1001), 4:32-35. The fluid stream travels in a "freeboard" top portion of the vessel, while liquid and particles fall out of the fluid stream and collect in the bottom, "belly" portion of the vessel.

23. One of the key features of the '256 Patent is the location of the "gas/liquid" interface within the vessel. This interface can be thought of as the boundary between: (1) the freeboard portion of the vessel where the fluid is flowing and (2) the belly portion of the vessel that contains only solids and liquids

that have fallen out of the fluid. ‘256 Patent (Ex. 1001), 3:22-25. In the ‘256 Patent, this gas/liquid interface has one end adjacent the fluid outlet, and extends horizontally toward the fluid inlet, ending at some location between the fluid outlet and the fluid inlet. ‘256 Patent (Ex. 1001), 4:50-55. By locating the gas/liquid interface at the fluid outlet, the output of vessel contains both the fluid (now free of sand particles), as well as other valuable liquids, such as oil, that have fallen out of the fluid stream. ‘256 Patent (Ex. 1001), 4:65-5:5. Unlike separator vessels, which aim to separate gas and liquid from a fluid stream, providing gas to one outlet and liquid to a separate outlet, the ‘256 Patent discharges both gas and liquid out of its fluid outlet. Additionally, by setting the minimum cross-sectional area of freeboard portion at the fluid outlet, and the maximum cross-sectional area of the freeboard portion adjacent the inlet (a result of locating the gas/liquid interface at the fluid outlet), the desander of the ‘256 Patent allows for maximum efficiency for dropping solids and liquids out of the fluid stream. ‘256 Patent (Ex. 1001), 5:17-39. This is because a fluid entering a vessel from a narrow inlet nozzle will slow down upon entering a volume with a cross-sectional area that is larger than the inlet nozzle: the larger the volume, the slower the fluid will flow. ‘256 Patent (Ex. 1001), 5:27-30. Specifically, for the desander of the ‘256 Patent, the volume is the cross-sectional area of the freeboard portion of the vessel, which does not include the belly portion of the vessel because fluid (and especially gas) cannot flow in the

belly portion of the vessel. Therefore, to create the greatest fluid velocity drop-off, and in turn the greatest drop-out efficiency for solid particulates, the vessel is inclined so that the greatest free-board is at the inlet portion of the vessel and the least amount of belly portion exists at the inlet portion of the vessel. '256 Patent (Ex. 1001), 5:27-30.

24. The '256 Patent teaches that it has a number of advantages over the prior desander vessel disclosed in the Hemstock reference. For example, and as explained above, by inclining the '256 Patent with the outlet lower than the inlet, the '256 Patent has a much larger free-board cross-sectional area adjacent to the fluid inlet than the horizontal Hemstock desanding vessel does; this decreases the velocity of the fluid flow in the '256 Patent compared to Hemstock, and in turn increases the drop-out efficiency of the particles in the fluid stream. '256 Patent (Ex. 1001), 5:31-39.

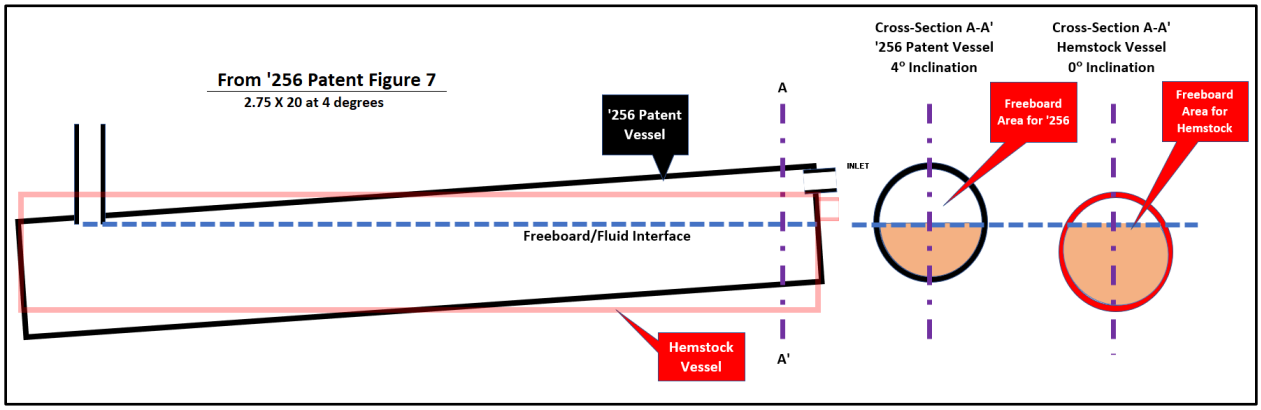


Figure 1 - Increase in Cross-Sectional Area in '256 Patent

25. The ‘256 Patent also teaches that by maintaining the gas/liquid interface with the fluid outlet, the ‘256 Patent no longer needs to make use of the downcomer (also known as a “flow barrier” or a “weir”), which is needed in the horizontal vessel to make sure the gas/liquid interface always remains below the fluid outlet in the Hemstock vessel. ‘256 Patent (Ex. 1001), 6:38-56. The gas/liquid interface needs to remain below the fluid outlet in the Hemstock vessel so that gas can continue to flow out of the fluid outlet; if the fluid level were to reach or exceed the level of the fluid outlet, only fluid would be able to exit the vessel. Because the ‘256 Patent inclines the vessel, as explained above, when the gas/liquid interface is at the fluid outlet, both gas and liquid can exit the vessel via the fluid outlet. ‘256 Patent (Ex. 1001), 5:1-4. Further, by allowing liquid to exit in this manner, the freeboard portion of the vessel can be maintained, thus eliminating the necessity of the downcomer. ‘256 Patent (Ex. 1001), 6:47-56.

26. Finally, the ‘256 Patent teaches that it improves the ability to clean the vessel of its solid particulates collected in the belly portion, as compared to the prior art Hemstock reference. ‘256 Patent (Ex. 1001), 2:22-29, 7:14-27. The ‘256 accomplishes this by again taking advantage of the inclination of the vessel. ‘256 Patent (Ex. 1001), 5:45-51. Because the vessel is inclined, sand and liquid are forced to the outlet side of the vessel. ‘256 Patent (Ex. 1001), 5:45-51. This process is increased as sand builds up, as with more solid in the belly portion, there

is less liquid, and the smaller amount of liquid causes the liquid to travel towards the outlet side of the vessel at a higher velocity. '256 Patent (Ex. 1001), 5:45-51. On the other hand, in the Hemstock vessel, particulates collect substantially along the entire length of the vessel, which the '256 Patent teaches "increase[es] the difficulty of periodic manual removal of such accumulat[ion] using scraper rods and the like." '256 Patent (Ex. 1001), 2:18-21. By causing the particulates to accumulate closer to the outlet side of the vessel, the '256 Patent teaches that the removal of these particles through the access port on the outlet side of the vessel is much easier. '256 Patent (Ex. 1001), 7:14-19.

27. In summary, claim one recites "[a] desanding system for receiving a gas stream containing entrained liquid and particulates." '256 Patent (Ex. 1001), 7:46-47. The vessel is elongated along its longitudinal axis and is inclined from a horizontal at a non-zero inclination angle at all times. The fluid inlet to the vessel is adjacent the first end of the vessel, and the fluid outlet is lower than the fluid inlet and spaced along the longitudinal axis from the fluid inlet. The gas/liquid interface is formed at the fluid outlet, such that the belly portion of the vessel is below the fluid outlet, the freeboard portion of the vessel is above the fluid outlet, and the freeboard portion decreases along the vessel from inlet to outlet.

VII. CLAIM CONSTRUCTION

28. I understand that the challenged claims must be given their plain and ordinary meaning in light of the specification of the '256 patent and its prosecution history. I have reviewed the construction of "gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow" of claim 1 of the '256 Patent and "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" of claim 9 of the '256 Patent proposed by the Patent Owner. In my opinion, I agree that Patent Owner's proposed constructions is supported by the specification, and I do not believe anything in the prosecution history alters my opinion on the claim constructions set forth below. In addition, I have relied on my education, experience, and knowledge of engineering practices and principles in the fields of mechanical and petroleum engineering and my understanding of the applicable legal principles described in this declaration.

29. Specifically, I agree 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 claims of the '256 Patent teaches that its vessel is divided into a "belly" portion and a "freeboard" portion. '256 Patent (Ex. 1001), 7:46-9:14. The belly portion of the vessel contains liquid and solids. '256 Patent (Ex. 1001), 4:40-41. The freeboard

portion contains gas, and is the portion of the vessel where the fluid from the inlet enters the vessel. '256 Patent (Ex. 1001), 4:40-43. The dividing line between the belly portion and the freeboard portion is the "gas/liquid interface" of the claims of the '256 Patent. '256 Patent (Ex. 1001), 4:40-43 ("A belly portion 40 is formed below the interface…A freeboard portion 44 is formed above the interface"), Figs. 2, 3A, 3B, 4 (all showing a belly portion containing solids and liquids below an interface 32, and a freeboard portion above interface 32).

30. The claim language itself requires that this gas/liquid interface be "at" the fluid outlet, not above or below the fluid outlet. '256 Patent (Ex. 1001), cl. 1. The remainder of the claim term provides further support for this construction, teaching that the belly portion is "below" the fluid outlet and the freeboard portion is "above" the fluid outlet, meaning the boundary between the belly portion and freeboard portion must be in line with the fluid outlet. Similarly, claim 9 requires that the "belly portion being formed below the fluid outlet" and "forming a freeboard portion above the fluid outlet." '256 Patent (Ex. 1001), cl. 9. A POSITA wound also understand from this claim limitation that if the belly portion were below the fluid outlet, and the freeboard portion were above the fluid outlet, then the boundary between the belly and freeboard portions—the gas/liquid interface—must be formed at the fluid outlet. Otherwise, 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.

31. The specification further supports this construction. For example, the '256 Patent teaches that the gas/liquid interface "32 has a distal end 33 adjacent the fluid outlet 26." '256 Patent (Ex. 1001), 4:52-53. This teaching informs a POSITA that the gas/liquid interface is at or near to the fluid outlet. As described above in paragraph 23, the gas/liquid interface is the boundary between the freeboard portion of the vessel, and the belly portion of the vessel. The '256 Patent provides additional clarification when it teaches that the "minimum inclination angle would be the condition where the inlet 24 is entirely in the gas phase of the freeboard portion 44 and the gas phase at the discharge 26 is of zero height." '256 Patent (Ex. 1001), 5:67-6:3. This condition is illustrated in Figure 2 below which shows a zoomed in cross-section of the vessel (22) where the interface (32) is at the very top of the fluid outlet (26). This portion of the specification teaches that the minimum angle of inclination of the vessel must be enough that the inlet is completely in the gas phase of the freeboard portion of the vessel, and that the liquid level raises to the level of the top of the outlet, such that the gas level (relative to the top of the vessel or the opening that forms the outlet) goes to zero at the fluid outlet. A POSITA would understand that having the interface "at" the outlet also means that at steady state conditions the liquid level may be at any level

in the fluid outlet between the top and the bottom of the fluid outlet such that any valuable oil and other liquids are re-entrained with the gas G exiting at fluid outlet.

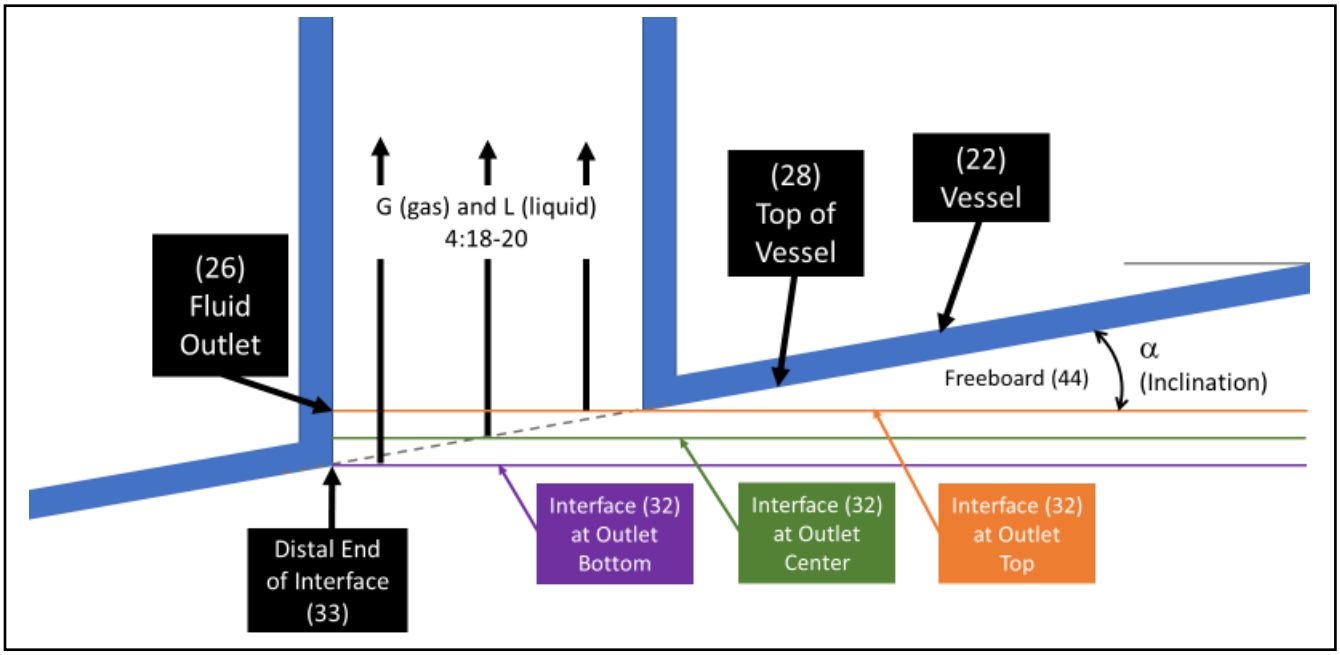


Figure 2 - Cross-Section at Fluid Outlet

This condition is illustrated in Figure 2 and is succinctly stated at '256 Patent (Ex. 1001), 4:65-5:3.

> 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.

32. The Figures of the '256 Patent also depict that Patent Owner's construction is correct. Figures 2 and 4 depict the liquid level 33 of the vessel to be at the same level as the fluid outlet 26. '256 Patent (Ex. 1001), Figs. 2, 4. This, compared to Figure 1 of the '256 Patent, depicting a prior art vessel, which shows

the liquid level of the vessel to be below, rather than at (or at the same level) as the fluid outlet 16.

33. The Figures of the ‘256 Patent and track the requirements of the liquid level in the ‘256 Patent compared to Hemstock. *Compare* ‘256 Patent (Ex. 1001) Fig. 1 with ‘256 Patent (Ex. 1001) Figs. 2, 4. As described above, the prior art Hemstock desander vessel requires a flow barrier to ensure that the freeboard portion of the vessel is maintained—and is maintained below the fluid outlet—so that gas can always escape through the fluid outlet. The flow barrier abruptly decreases the surface area of the freeboard portion of the vessel, causing the velocity of the fluid to substantially increase. When the fluid velocity increases, it causes fluid in the belly portion of the vessel to become entrained in the fluid. When additional liquid is introduced into the belly portion of the vessel, the velocity below the flow barrier is further increased, causing even more liquid to become entrained in the fluid, and causing the liquid level to decrease again. In this way, the flow barrier ensures that the liquid level in the belly portion of the Hemstock vessel does not reach either the flow barrier or the fluid outlet. *See* Hemstock (Ex. 1004), Figs. 4a, 4b, 4c, 5:14-26. Since the freeboard portion is below the fluid outlet in the prior art Hemstock vessel, and the gas/liquid interface is below the freeboard portion, the gas/liquid interface is necessarily below the fluid outlet in the Hemstock prior art (Figure 1 of the ‘256 Patent) in order for that

vessel to operate properly. The ‘256 Patent, rather than ***avoiding*** placing the gas/liquid interface at the fluid outlet, ***requires*** that the gas/liquid interface be at the fluid outlet in order for the vessel to operate properly. As described above in paragraph 25, by placing the gas/liquid interface at the fluid outlet, the flow barrier is no longer required, because the fluid outlet itself maintains the freeboard portion of the vessel. This positioning of the gas/liquid interface at the fluid outlet also allows for more efficient recovery of valuable liquid hydrocarbons that fall into the belly portion of the vessel, as the liquid level is at, rather than below, the fluid outlet.

VIII. OVERVIEW OF THE PRIOR ART

A. Hemstock

34. Hemstock is a substantially horizontal, cylindrical pressure vessel that is adapted to remove particulates, such as sand, from a fluid stream emanating from an oil well, and sending that desanded fluid downstream to other equipment, such as multiphase separators. Hemstock (Ex. 1004), 3:32-47. Hemstock identifies two prior art desanding systems, and describes problems with those systems. Hemstock (Ex. 1004), 1:51-2:21.

35. The first prior art system cited in Hemstock is a P-Tank, which collects the fluid output from a wellhead into a pressurized tank until the wellhead does not produce any more sand. Hemstock (Ex. 1004), 1:51-67. One limitation

of this system is that it is generally designed to provide a temporary solution while many wells may require extended use of a desander. Hemstock (Ex. 1004), 1:32-33. Moreover, the large size/diameter of the P-tank reduces the resistance to burst and therefore the maximum operating pressure is relatively low (1,000 to 2,100 kPa = 145 to 300 PSI). Hemstock (Ex. 1004), 1:51-67. This generally requires that a large pressure drop must be created upstream of the P-tank in order to protect the P-tank, which requires an increase in fluid velocity which in turn makes the particulate-laden fluid stream much more abrasive. Hemstock (Ex. 1004), 1:51-67. This is contrary to the purpose of the desander, which is to protect piping and equipment from damages by particulates.

36. The second prior art system consists of using a pressure vessel with a fiber-mesh filter bag in order to filter out sand particles. Hemstock (Ex. 1004), 2:1-4. Hemstock explains that this prior art system does not perform well in multiphase flow regimes such as are produced downstream from a wellhead. Hemstock (Ex. 1004), 2:5-7. In particular, filter bags do not work well with fluid streams coming from a wellhead, because oil and gas wells often produce unstable multi-phase (intermittent and/or random) fluid flow regimes (e.g. a predominantly gas fluid stream followed a predominantly liquid fluid stream, sometimes referred to as a slug). The repeated differential pressure drops across the filter bags caused

by these sudden slugs of fluid impacting the filter bags can cause the filter bags to fail. Hemstock (Ex. 1004), 2:8-15.

37. Hemstock teaches that the claimed desanding vessel overcomes the problems of both prior art systems. First it teaches that "the desander can be economically placed on a wellsite for long term sand production," and "with a pressure rating that allows the vessel to operate at the wellhead conditions" thus overcoming the problems inherent with the P-tank system. Hemstock (Ex. 1004), 6:19-22. Hemstock overcomes this issue by providing a vessel that operates at wellhead conditions with minimal pressure drop, and by removing sand from the fluid stream on a continual basis such that desanded fluid is provided at the fluid outlet. Hemstock (Ex. 1004), 6:16-29.

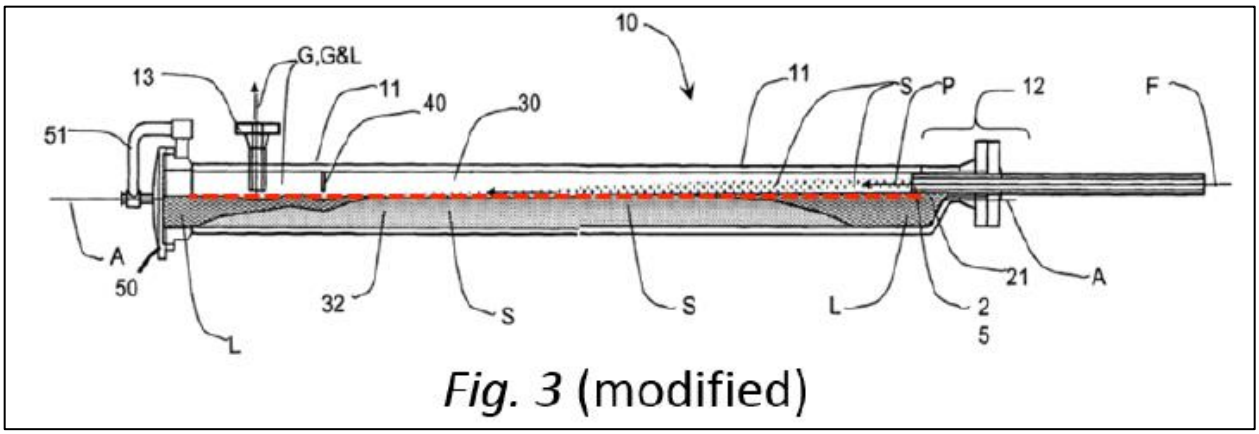
38. Second, it teaches that "the desander is capable of handling multiphase production," meaning it is capable of handling the multiphase flow, and associated slug flow, that would cause the filter bag systems to fail. Hemstock (Ex. 1004), 6:32-33. Hemstock overcomes this issue by not using a filter of any kind, and relying on its innovative design to cause sand to fall out of the fluid stream.

39. The mechanics of the sand falling out of the fluid stream in Hemstock are similar to the '256 Patent, with the important distinctions that Hemstock does not have an inclined vessel, and Hemstock does not have the gas/liquid interface at

the fluid outlet. Instead, Hemstock discloses a horizontal vessel connected to a wellhead via a fluid inlet, and connected to downstream equipment such as multiphase separators via a fluid outlet. Hemstock (Ex. 1004), 3:32-37. Hemstock relies on providing a larger cross-sectional area freeboard in the vessel for the fluid than the cross-sectional area of the fluid inlet, causing the velocity of the gas to slow, which causes sand to fall out of the fluid and into the belly portion. Hemstock (Ex. 1004), 4:15-43. The region of Hemstock containing the collected solids and liquids is the belly portion of the vessel, while the region above the belly is the freeboard portion, and these portions are separated by a gas/liquid interface. Hemstock (Ex. 1004), 4:15-43. Hemstock also contains a flow barrier, alternatively known as a downcomer or a weir, which is used to maintain the freeboard portion of the vessel so that the liquids and solids can only reach a maximum depth, a depth that is below the fluid outlet. Hemstock (Ex. 1004), 4:44-47. This flow barrier creates a temporary reduction in the cross-sectional area of the freeboard portion of the vessel, causing the velocity of fluid to increase. Hemstock (Ex. 1004), 5:9-15. This increase in velocity sweeps up any liquid near the flow barrier. Hemstock (Ex. 1004), 5:9-15. Thus, if the amount of liquid in the belly portion of the vessel were to increase, the flow barrier would cause the additional liquid to be re-entrained back in the fluid stream, causing the liquid level to remain where it is. Hemstock (Ex. 1004), 5:9-15. A POSITA would understand

that Hemstock maintains the freeboard portion below the fluid outlet, because if the liquid level were to rise to the level of the fluid outlet, the fluid flow would become unstable and the vessel would stop working as a desander, as it would result in "re-entrainment of liquids L and particulates S from the area about the flow barrier," which would allow particulates (e.g. sand) to exit the vessel. Hemstock (Ex. 1004), 2:37-39, 5:9-27.

40. Hemstock also discloses that the fluid outlet is above the fluid inlet. For example, Figure 3 shows the belly portion of the vessel rising all the way up to the level of the fluid inlet, but shows space between the fluid inlet and the fluid outlet. Hemstock (Ex. 1004), Fig. 3; Simpson Dep. (Ex. 2005), 15:15-23, 17:5-18. Figure 3 of Hemstock below (as modified by Mr. Simpson, Ex. 1002 at ¶ 68) provides a horizontal dashed red line to demonstrate that the fluid outlet is above the fluid inlet. Moreover, in a second embodiment of Hemstock, the fluid outlet is located at the top of the vessel, rather than protruding into the vessel like in Figure 3. Hemstock (Ex. 1004) at Fig. 4b, 5:16-27. In this embodiment, the fluid outlet is well above the fluid inlet, as it is at the top of the vessel, while the fluid inlet below the top of the vessel. Hemstock (Ex. 1004) at Fig. 4b.



Hemstock (Ex. 1004), Fig. 3 (modified)

B. Davis

41. Davis is a research paper focused on providing a review of recent developments in three specific fields of sedimentation. Davis (Ex. 1005) at 3. According to Davis, sedimentation is when "particles fall under the action of gravity through a fluid in which they are suspended." Davis (Ex. 1005) at 3; Simpson Dep. (Ex. 2005), 25:2-8. Therefore, a person of ordinary skill in the art would understand that the Davis article is only applicable to suspensions.

42. A suspension, as defined by the McGraw-Hill Dictionary of Scientific and Technical Terms is a "mixture of fine, nonsettling particles of any solid within a liquid or gas." Ex. 2007 at 3. In other words, solids that are in suspension with a liquid do not immediately fall to the bottom of the liquid, but rather they stay suspended within the liquid for a period of time. This understanding of "suspension" is further confirmed by the American Heritage Dictionary of Science, which defines "suspension" as "a mixture in which very small particles of a solid

remain suspended without dissolving." Ex. 2006 at 3. This dictionary further explains in its example that "the ingredients of which slowly separate on standing." Ex. 2006 at 3.

43. Davis gives blood as an example of a suspension. Davis (Ex. 1005) at 17. Blood consists of blood plasma, and red and white blood cells which are suspended in the plasma ("corpuscles" in Davis). Davis (Ex. 1005) at 17. It is generally understood that red and white blood cells do not settle out of blood very quickly—most people have witnessed a doctor or a scientist putting blood in a centrifuge in order to separate the blood cells out of blood plasma.

44. The Petitioner relies on Section 4 of Davis entitled ENHANCED SEDIMENTATION IN INCLINED CHANNELS in its Petition and related Declaration of Mr. Simpson. Davis (Ex. 1005) at 17.

45. Section 4 of Davis discusses a well-known phenomenon, that tilting a thin, vertical tube away from the vertical will increase the settling rate of a suspension. Davis (Ex. 1005) at 17-29. As Davis teaches, this is because "whereas particles can only settle onto the bottom in a channel with vertical walls, such particles can also settle onto the upward-facing wall in a tilted channel." Davis (Ex. 1005) at 17. In other words, Davis analyzes the effective surface area of the container the fluid is in that the solid can settle on when it moves in a downward direction. This analysis in Davis is performed on a simple tube or

channel with a bottom surface, two side walls, and no discussion of any gasses, any gas/liquid interface, any inlets, or any outlets. Davis (Ex. 1005) at 17-29, Fig. 4.

46. For a narrow vertical channel with a bottom, the only surface that is available for settling is the bottom surface of the channel, as shown in Figure 3 A) below. Once the narrow vertical channel is tilted, the inclination angle causes the lower side of the channel to become an additional surface for the particles to settle, as is shown in Figure 3 B) below. However, because the particles are travelling downward, and not perpendicular to the side surface, only the projection in the horizontal direction is considered, as can be seen by comparing the "available (or effective) surface area" notations in Figure 3.

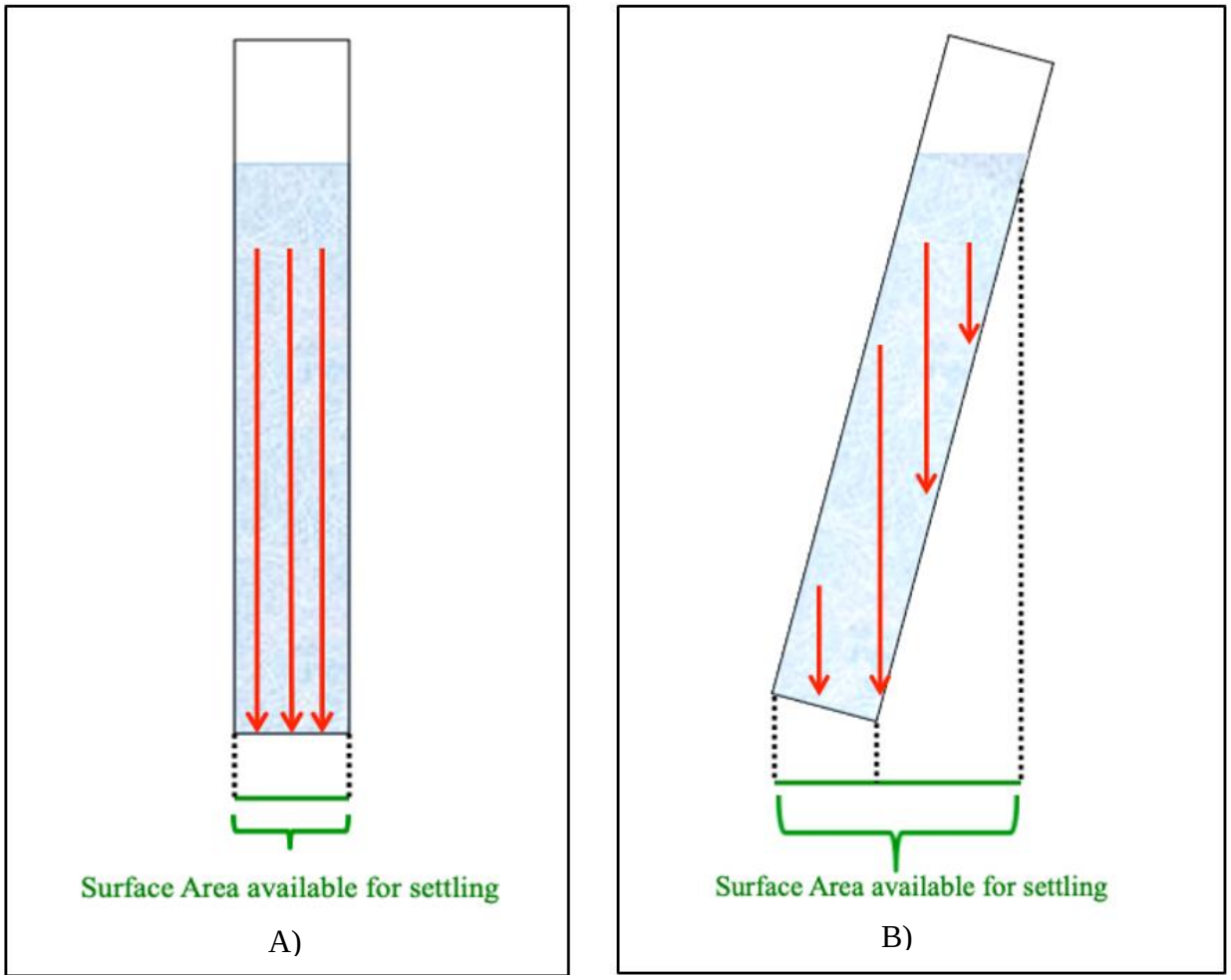


Figure 3 - Settling Surface Area

The settling surface area of a tilted channel with a base (or bottom) can be calculated based on the length of the base (b), the length of the channel wall available for settling (L), the width of the channel (W) and the tilting (or inclination) angle θ. A side-view cross-section of such a channel may be represented as shown in Figure 4 of Davis, reproduced below. For the purposes of comparing the relative surface area available for settling between identical channels oriented at different inclination angles, the width may be ignored because the channel surface projected in the horizontal plane will control the settling area.

The projection of b in the x dimension (B') is equal to b*cos(θ), and the projection of L in the x dimension (e') is equal to L*sin(θ). Therefore, the total surface for settling (Lpt) equals b*cos(θ) + L * sin(θ).

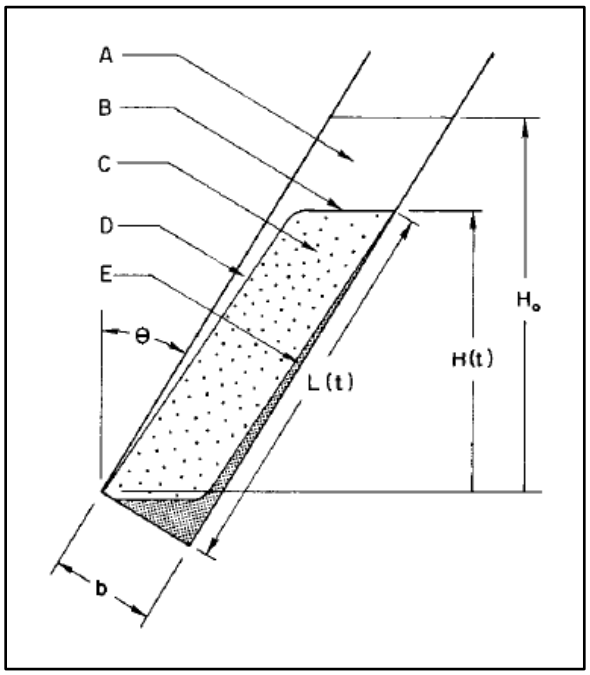


Figure 4 - Side View of Channel (Davis (Ex. 1005) Fig. 4 at 17)

47. Consistent with the equation I derived above, Davis teaches that the volumetric rate of production of clarified fluid or the efficiency in which solids are settled out of the fluid (hereinafter "settling efficiency") is calculated by multiplying the vertical settling velocity by the total horizontal surface available for settling. Davis (Ex. 1005) at 18-19 (Equation 4.1 and accompanying

discussion).[1] This can be verified by multiplying my equation above [b*cos(θ) + L * sin(θ)] by the vertical settling velocity v_0, and factoring out a b, which results in Equation 4.1 from Davis:

$$S^*(t) = v_0 b \left(\cos \vartheta + \frac{L}{b} \sin \vartheta \right),$$

(From Davis (Ex. 1005) at 19 (Eq. 4-1))

48. The vertical settling velocity of Equation 4-1 is particulate and suspension fluid dependent. Davis (Ex. 1005) at 19-20. Therefore, when comparing the settling efficiency of two containers that contain the same fluid and particulates, the vertical settling velocity can be considered to be the same for both containers. I will now provide an example for how to use Equation 4-1 to compare the relative settling efficiency of identical narrow channels with bottoms at different inclination angles.

49. I will analyze a settling container that is 3 inches wide, and 10 inches tall. Equation 4-1 teaches that if this settling container is exactly vertical, θ will

[1] Although the discussion on Pages 18-19 is for parallel-plate geometry, Davis teaches that settlers may be composed either of a narrow tube inclined from the vertical or of a large tank containing severally closely spaced tilted plates.

equal 0, b will equal 3” and L will equal 10”. The settling efficiency is then equal to: v_0*3” * [cos(0) + 10”/3” * sin(0)] = **3” * v_0.**

50. If the same container is tilted by 25 degrees, θ will equal 25, b will equal 3” and L will equal 10”. The settling efficiency is then equal to v_0 * 3” * [cos(25) + 10”/3”sin(25)] = **6.94” * v_0.**

51. Comparing the result of 0-degree tilt to 25-degree tilt, the efficiency has improved from 3 to 6.94 times the vertical settling velocity, or over 100% increased efficiency. This shows the enhanced sedimentation effect of a tilted channel with a bottom relative to a vertical channel with a bottom that Davis discusses in Section 4.

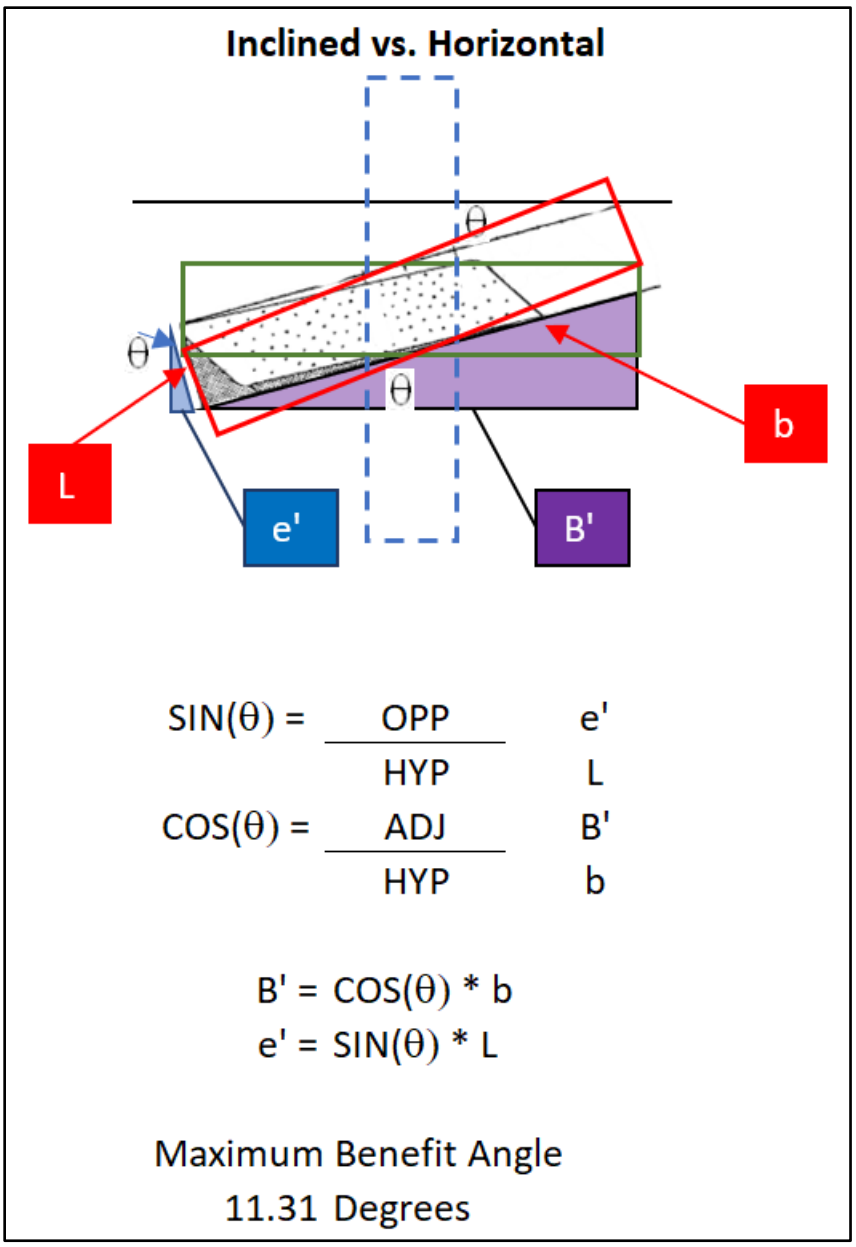
52. Davis and Equation 4-1 teaches that this effect only produces a significant benefit when a narrow channel or closely spaced plates are inclined ***from the vertical***. Davis (Ex. 1005) at 17. A POSITA would understand that Equation 4-1 was derived specifically for and is primarily relevant to narrow vertical containers (that are much taller than they are wide). The results produced by Equation 4-1 makes this clear. In order to illustrate this point, I will use the Davis Equation 4-1 approach to compare the Settling Efficiency of an inclined horizontal vessel, such as the one described in the ‘256 Patent to that of a non-inclined horizontal vessel, such as the one that is described in the Hemstock Patent.

53. The ‘256 Patent describes a prior art vessel that is 12 inches (1 foot) in diameter, and 10 feet long, and another prior art vessel that is 12 inches (1 foot) in diameter and 20 feet long. ‘256 Patent (Ex. 1001), 6:38-46.

54. For the first prior at vessel of the ‘256 Patent, b will equal 10 feet, and L will equal 1 foot. With 0 degrees of tilt, the first prior art vessel will have a settling efficiency of v_0 * 10’ * [cos(0) + 3’/10’sin(0)] = **10’ * v_0.** That same vessel, tilted 20 degrees, will have a settling efficiency of v_0 * 10’ * [cos(20) + 3’/10’sin(20)] = **9.74 * v_0.** Thus, inclining the first prior art vessel by 20 degrees results in only 97.4% of the settling efficiency of the non-inclined vessel, and actually decreases the settling efficiency of the container.

55. The results of this same calculation are shown in Table 1 below, which uses the same prior art horizontal vessel, but for various angles of inclination. The vessel in the example will have a negligible increase in efficiency, and for angles over about 11.3 degrees, performance will worsen[2].

[2] For a horizontal vessel the maximum angle where a settling surface increase occurs can be found by taking the inverse tangent of the ratio of the height of the vessel divided by ½ the length of the vessel. This is the angle where the upper corner of the downdip side of the inclined vessel reaches the x,y coordinate of the lower corner of the same side of the same vessel at zero degrees inclination.



Note: The Figure above depicts a horizontal vessel inclined from a horizontal plane at various angles. As explained previously, for the purposes of this analysis, the surface area components of Equation 4-1 (*see* Davis (Ex. 1005) at 19) have been designated by two variables, e' and B'.

Table 1 - Settling Surface Analysis of Prior Art Example (b=10, L=1)

Inclination	Vessel Dimensions		Dimensions of Settling Surface		Total Length of Settling Surface	Change in Settling Efficiency
Theta (Degrees)	b (ft)	L (ft)	B' (ft)	e' (ft)	Lpt = B'+e' (ft)	% Increase in SA relative to Horizontal
0	10	1.00	10.00	-	10.00	0.00%
1	10	1.00	10.00	0.02	10.02	0.16%
2	10	1.00	9.99	0.03	10.03	0.29%
3	10	1.00	9.99	0.05	10.04	0.39%
4	10	1.00	9.98	0.07	10.05	0.45%
5	10	1.00	9.96	0.09	10.05	0.49%
6	10	1.00	9.95	0.10	10.05	0.50%
7	10	1.00	9.93	0.12	10.05	0.47%
8	10	1.00	9.90	0.14	10.04	0.42%
9	10	1.00	9.88	0.16	10.03	0.33%
10	10	1.00	9.85	0.17	10.02	0.22%
11	10	1.00	9.82	0.19	10.01	0.07%
12	10	1.00	9.78	0.21	9.99	-0.11%
13	10	1.00	9.74	0.22	9.97	-0.31%
14	10	1.00	9.70	0.24	9.94	-0.55%
15	10	1.00	9.66	0.26	9.92	-0.82%
16	10	1.00	9.61	0.28	9.89	-1.12%
17	10	1.00	9.56	0.29	9.86	-1.45%
18	10	1.00	9.51	0.31	9.82	-1.80%
19	10	1.00	9.46	0.33	9.78	-2.19%
20	10	1.00	9.40	0.34	9.74	-2.61%
30	10	1.00	8.66	0.50	9.16	-8.40%
40	10	1.00	7.66	0.64	8.30	-16.97%
50	10	1.00	6.43	0.77	7.19	-28.06%
60	10	1.00	5.00	0.87	5.87	-41.34%
70	10	1.00	3.42	0.94	4.36	-56.40%
80	10	1.00	1.74	0.98	2.72	-72.79%
90	10	1.00	0.00	1.00	1.00	-90.00%

As can be seen in Table 1 above, between an inclination of zero degrees and the maximum relative benefit inclination of about 11.3 degrees, the inclined vessel offers an increase in Settling Efficiency of 0.5% or less, which is not substantial

enough to motivate a POSITA to incorporate inclination into the design of an upstream application horizontal desander.

56. This effect is even more pronounced for the second prior art vessel. That vessel will have a b of 20 feet, and an L of 1 foot. With 0 degrees of tilt, the first prior art vessel will have a settling efficiency of v_0 * 20' * [cos(0) + 3'/10'sin(0)] = 20' * v_0. That same vessel, tilted 20 degrees, will have a settling efficiency of v_0 * 20' * [cos(20) + 3'/20'sin(20)] = 19.14' * v_0. Thus, inclining the second prior art vessel by 20 degrees results in only 95.78% of the settling efficiency of the non-inclined vessel, and actually decreases the settling efficiency of the container.

57. The results of this same calculation are shown in Table 2 below, which uses the same second prior art vessel, but for various angles of inclination. At very small inclination angles, the vessel will have a negligible (less than 0.2%) increase in efficiency, and for angles over 5.7 degrees, performance will worsen.

Table 2 – Eq. 4-1 Results for b=20 and L=1

Inclination	Vessel Dimensions		Dimensions of Settling Surface		Total Length of Settling Surface	Change in Settling Efficiency
Theta (Degrees)	b (ft)	L (ft)	B' (ft)	e' (ft)	Lpt = B'+e' (ft)	% Increase in SA relative to Horizontal
0	20	1.00	20.00	-	20.00	0.00%
1	20	1.00	20.00	0.02	20.01	0.07%
2	20	1.00	19.99	0.03	20.02	0.11%
3	20	1.00	19.97	0.05	20.02	0.12%
4	20	1.00	19.95	0.07	20.02	0.11%
5	20	1.00	19.92	0.09	20.01	0.06%
6	20	1.00	19.89	0.10	19.99	-0.03%
7	20	1.00	19.85	0.12	19.97	-0.14%
8	20	1.00	19.81	0.14	19.94	-0.28%
9	20	1.00	19.75	0.16	19.91	-0.45%
10	20	1.00	19.70	0.17	19.87	-0.65%
11	20	1.00	19.63	0.19	19.82	-0.88%
12	20	1.00	19.56	0.21	19.77	-1.15%
13	20	1.00	19.49	0.22	19.71	-1.44%
14	20	1.00	19.41	0.24	19.65	-1.76%
15	20	1.00	19.32	0.26	19.58	-2.11%
16	20	1.00	19.23	0.28	19.50	-2.50%
17	20	1.00	19.13	0.29	19.42	-2.91%
18	20	1.00	19.02	0.31	19.33	-3.35%
19	20	1.00	18.91	0.33	19.24	-3.82%
20	20	1.00	18.79	0.34	19.14	-4.32%
30	20	1.00	17.32	0.50	17.82	-10.90%
40	20	1.00	15.32	0.64	15.96	-20.18%
50	20	1.00	12.86	0.77	13.62	-31.89%
60	20	1.00	10.00	0.87	10.87	-45.67%
70	20	1.00	6.84	0.94	7.78	-61.10%
80	20	1.00	3.47	0.98	4.46	-77.71%
90	20	1.00	0.00	1.00	1.00	-95.00%

C. The Data Book

58. The Data Book is a general reference book that is published by the Gas Processors Suppliers Association "as a service to the gas processing and related process industries." Data Book (Ex. 1008) at 2. Petitioner includes two

chapters of the Data Book in Exhibit 1008. The Data Book defines a "separator" as a "vessel used to separate a mixed-phase stream into gas and liquid phases that are 'relatively' free of each other." Data Book (Ex. 1008) at 3. The Data Book defines a "filter separator" as having two compartments: the first "contains filter-coalescing elements" that causes liquid particles to "flow out of the filter elements into the center core;" the second contains "a vane-type or knitted wire mesh mist extractor" where larger droplets are removed.

59. Chapter 7 of the Data Book first relates to "Separators and Filters." Data Book (Ex. 1008) at 3. It provides equations useful to understand how to separate liquids from gases. Data Book (Ex. 1008) at 4-5. It also includes a section on "Separator Design and Construction." Data Book (Ex. 1008) at 5. The Data Book teaches there are three types of separators, 1) vertical separators, 2) horizontal separators, and 3) spherical separators. Data Book (Ex. 1008) at 5-7. Finally, the Data Book includes a number of additional features, such as mist extractors and filter packs, that can help with separation of liquids and gases. Data Book (Ex. 1008) at 9-17.

60. Chapter 7 of the Data Book does not teach or suggest a single separator vessel design that is inclined, nor does it explain any potential benefit to inclining a separator vessel.

61. Chapter 17 of the Data Book relates to "Fluid Flow and Piping." Data Book (Ex. 1008). This section generally relates to how fluid flows in a pipe, including fluid properties such as friction (p. 23), single phase flow (p. 24), low pressure gas flow (p. 27), and two-phase flow (p. 31). Figure 17-14 depicts different flow regimes for two phase flow, including slug flow. Data Book (Ex. 1008) at 36.

62. One portion of Chapter 17 deals with slug catchers. Data Book (Ex. 1008) at 41-42. The Data Book defines "slug catcher" as a "particular separator design able to absorb sustained in-flow of large liquid volumes at irregular intervals. [. . .] A slug catcher may be a single large vessel or a manifolded system of pipes." Data Book (Ex. 1008) at 3.

63. Because the Data Book uses the term "separator" as defined above in the definition of "slug catcher," it would be understood to a POSITA that a slug catcher separates mixed-phase streams into gas and liquid phases that are "relatively free of each other." Data Book (Ex. 1008) at 3. This means that gas coming out of a slug catcher will be relatively free of liquid, and liquid coming out of a slug catcher will be relatively free of gas. The definition of "slug catcher" also indicates that slug catchers may be made of pipes or of a large vessel. The Data Book provides examples of each, the slug catcher made of pipes shown in Figure 17-21 (p. 41) (also called a "harp-type slug catcher") and the slug catcher made of

a vessel shown in Figure 17-22. Data Book (Ex. 1008) at 42. The Data Book teaches that a pipe-type slug catcher may be inclined but provides no such teaching for vessel-type slug catchers. Data Book (Ex. 1008) at 41-42.

64. The Data Book also teaches how to improve slug capacity for horizontal and vertical separators. For vertical separators, the Data Book teaches that the "ability to handle liquid slugs is typically obtained by increasing height. Level control is not critical and liquid level can fluctuate several inches without affecting operating efficiency. Data Book (Ex. 1008) at 5. For horizontal separators, the Data Book teaches that "[i]ncreased slug capacity is obtained through shortened retention time and increased liquid level." Data Book (Ex. 1008) at 7. The Data Book does not teach to incline a separator vessel for increased slug capacity.

D. Laminar vs Turbulent flow

65. The Data Book introduces the concepts of laminar flow and turbulent flow. Data Book (Ex. 1008) at 22.

66. Laminar flow in the context of fluid flow occurs when fluids flow at low velocities. Data Book (Ex. 1008) at 22. When fluids are in laminar flow, the molecules and any accompanying particles carried by the molecules move in a straight line, and do not interfere with one another. Data Book (Ex. 1008) at 22. Mr. Simpson testified that laminar flow is almost never present in real systems.

Simpson Dep. (Ex. 2005), 50:16-23. I agree. In my experience, there are virtually no examples of laminar flow in a production stream emanating from an oil or gas wellhead in a situation where desanding equipment would be required.

67. Turbulent flow occurs when fluids flow at increased velocities. Data Book (Ex. 1008) at 22. When fluids are in turbulent flow, the fluid particles will show a random motion transverse to the direction of flow, meaning the fluid particles will be travelling in many different directions, cause mixing. Data Book (Ex. 1008) at 22. The flows in Hemstock, the '256 Patent, the separation vessels described in the Data Book section 7, and the slug catchers of section 17 will all involve turbulent flows. One of the primary purposes of desanding equipment is minimizing erosion of equipment downstream of the desander to the point of catastrophic failure. '256 Patent (Ex. 1001), 1:25-35. The erosion rate due to produced particles is highly dependent on the particle impact velocity and the particle impact velocity will be close to the velocity of the fluid carrying the particle. Therefore, erosion is likely to be worst where the fluid flow velocity is the highest. The fluid velocity required to carry the kind of particles that desanders are designed to remove (such as sand) up a wellbore and through a wellhead with sufficient impact to cause erosion during production operations must necessarily be "increased", that is to say, very high, which means that the fluid stream must be in

substantially turbulent flow. The only example of laminar flow I've seen in the record is the sedimentation experiments of Davis. Davis (Ex. 1005) at 17-20.

E. Miller

68. Miller is a patent from 1922 that has little to do with desanding vessels. Miller does not disclose separating sand from a fluid production stream. Instead, it looks at mud-laden water (also known as drilling mud) which is used to "clean drill bits" during the process of drilling oil and gas wells. Miller (Ex. 1007), 1:24-31. Once of the functions of drilling mud is to carry the rock cuttings generated by the drill bit ("drill cuttings") up the annulus between the drill pipe and the borehole wall (the "annulus") up and out of the borehole. Miller (Ex. 1007), 1:24-31. The drilling mud that returns to the surface up the annulus contains some solids that are purposely added to increase the weight of the mud and some solids that were generated by the drill bit ("drill cuttings") and some solids that fall off or are knocked off the borehole walls by the drill pipe and bottom hole assembly.

69. In Miller, the returning drilling mud fills the separating vessel to capacity, then air is pumped through the holes in the nozzle. This causes "pulsating currents" to be built up causing a concentration of the heavier particles (drill cuttings), to migrate towards the lower end of the separating vessel by gravity, while the cleaned mud liquid (drilling mud with weighting solids) flows

over the baffle at the upper end of the vessel and out through the outlet, and is then ready to be re-circulated through the well. The concentrated heavier particles (drill cuttings) together with some liquid then pass out from the lower end of the separating vessel through the discharge pipe. Miller (Ex. 1007), 2:88-3:27.

70. A POSITA would perceive that Miller does not teach separating solids from liquids, it teaches only removing the heaviest particles from a mixture of solids and liquids, while allowing the remaining (presumably desirable) solids to remain in the liquid. Miller (Ex. 1007), 3:2-21. Further, Miller has two outlets, outlet 13 for the mud-liquid, and outlet pipe 8 for the heavier particles. Miller (Ex. 1007), 2:62-75. Miller is designed so that the mud-liquid (drilling mud) travels up the vessel, while the heavier solids travel down the vessel. Miller (Ex. 1007), 3:2-21. Technically, this process is called elutriating, which may be defined as a process for separating particles based on their size, shape and density, using a stream of gas or liquid. The stream of gas or liquid is usually flowing in a direction opposite to the direction of gravity sedimentation. Elutriation is a process of separating and/or sizing particles by means of an upward current of fluid, usually water or air. The process is the reverse of gravity sedimentation, and Stokes' law typically applies[3]. This is a completely different process than the separation of solids from a production stream emanating from a wellhead through a

[3] https://www.sciencedirect.com/topics/engineering/elutriation

reduction in fluid velocity and gravity sedimentation that is substantially perpendicular to the flow direction of the fluid stream as is found in the '256 Patent.

IX. HEMSTOCK IN VIEW OF DAVIS DOES NOT RENDER ANY OBVIOUS CHALLENGED CLAIM

71. Mr. Simpson states that a "[POSITA] would have been motivated to modify the teachings of Hemstock by inclining the desander, as taught or suggested by Davis's teaching that an inclined tube or channel would achieve more rapid separation between the solid and liquid phases." Ex. 1002 ¶ 167. I disagree.

72. In my opinion, the combined teachings of Hemstock and Davis would not have rendered obvious any of the challenged claims—including claims 1-8, 9-11, 13 and 16—to a POSITA.

A. Davis Is Not Analogous Art

1. Different Field of Endeavor

73. I understand that a prior art reference must be analogous art to be available for supporting obviousness. In my opinion, Davis is not analogous to the claimed invention because it is not from the same field of endeavor as the '256 Patent, or reasonably pertinent to the particular problem the inventor of the '256 patent is trying to solve.

74. I understand that the field of endeavor is determined by consulting the structure and function of the claimed invention as perceived by one of ordinary

skill in the art. The '256 expressly states its field of invention, stating, in a section titled "Field of the Invention," that the "present invention relates to a system and apparatus for the removal of particles, such as sand, from fluid streams produced from a well, while minimizing abrasion of the involved equipment." '256 Patent (Ex. 1001), 1:5-8. A POSITA would understand that the entire specification of the '256 Patent is directed at this field of endeavor, as the entire invention is related to removing sand from a fluid stream produced from a well, and all of the claims are directed to this field as well. '256 Patent (Ex. 1001). Mr. Simpson acknowledges a field of endeavor similar to the description in the patent, stating that the "'256 Patent is concerned with the control and separation of solids from oil and gas well production streams." Ex. 1002 ¶ 43.

75. Although Davis states in its introduction that sedimentation takes place in the chemical and petroleum industries, the rest of Davis does not describe the chemical and petroleum industries, nor does it ever mention fluid streams produced from a well or removing sand from such streams. Davis (Ex. 1005). Additionally, as explained above, Davis limits its discussion of sedimentation to solids in ***suspension*** with a liquid. Davis (Ex. 1005) at 4. However, neither Hemstock nor the '256 Patent teach that the sand is in ***suspension*** with the liquid in the belly portion of the vessel. Simpson Dep. (Ex. 2005), 13:22-24 ('256 Patent), 19:25-20:7 (Hemstock). Instead, a POSITA would understand that when

sand from the fluid stream impinges on the liquid in the belly portion of the vessel for the ‘256 Patent, that sand falls substantially straight to the bottom of the belly portion of the ‘256 vessel. Similarly, when the trajectory of the sand intersects the liquid in the belly portion of the vessel for Hemstock, that sand also falls substantially straight to the bottom of the belly portion of the Hemstock vessel. This fact is evidenced by the Figures of both patents, which depict the sand in the belly portion of the vessel as separate and distinct from the liquid in the belly portion of the vessel. ‘256 Patent (Ex. 1001), Figs. 1, 2, 4; Hemstock (Ex. 1004), Figs. 3, 4a, 4b, 4c. Therefore, assuming the same liquid in the belly of the ‘256 Patent and in Hemstock, the sand in the belly portion of the vessel will fall to the bottom of the vessel in the ‘256 Patent and in Hemstock at the same velocity, regardless of whether the vessel is tilted or not, because the sand is not in suspension, and therefore, methods such as Davis to increase sedimentation of solids in suspension in a vertical channel will not apply to Hemstock or the ‘256 Patent.

76. In my opinion, because Davis only applies to solids in suspension with a liquid, and neither Hemstock nor the ‘256 Patent disclose solids in suspension with a liquid, Davis is not in the same field of endeavor as either Hemstock or the ‘256 Patent. Further, in my opinion, there is no rational reason to

apply a method for increasing sedimentation rate in a suspension to a vessel that does not make use of a suspension in a vessel.

77. Mr. Simpson relies only on the enhanced sedimentation portion of Davis, which teaches inclining a narrow vertical channel. Ex. 1002 ¶ 63. Mr. Simpson acknowledges that this section of Davis has no description indicating that any fluid flow is a fluid stream produced from an oil well. Simpson Dep. (Ex. 2005), 31:12-15. Moreover, Davis is clear that it's enhanced sedimentation teaching only applies to fluid conditions where "flow in the channel remains laminar." Davis (Ex. 1005) at 19. As Mr. Simpson acknowledges, fluid flow in the '256 patent will not be laminar, it will be turbulent. Simpson Dep. (Ex. 2005), 50:16-23, 51:7-11. Davis teaches that non-laminar flow "limits the efficiency of the inclined settling process" because the "fluid that has already been clarified is remixed with the suspension." Davis (Ex. 1005) at 19. It is my opinion that a POSITA working in the field of the '256 Patent, specifically removing particulates from a fluid stream produced from a well, would not consult a paper that is limited to laminar flow regimes, because laminar flow regimes are virtually never present in fluid streams produced from a well where a continuous operation desander such as the '256 Patent is required. Therefore, in my opinion, Davis is not in the same field of endeavor as the '256 Patent.

2. Inapplicability of Davis to Upstream Post-Hydraulic Fracturing Flow-back

78. A major weakness of Davis as prior art relative to the '256 Patent is that Davis deals with a situation where the fluid flow in the "vertical channel" is static. That is, there is no flow through the vertical channel from one end to the other. In the application for which the '256 Patent is designed, there must necessarily be continuous high velocity flow through the channel. A continuous operation desander (such as is required for the application contemplated by the '256 Patent) is not shut in periodically for the purpose of allowing the solids to settle to the bottom of the vessel. As a result, a POSITA would not be motivated to look to static settling solutions like Davis.

79. A huge problem with the idea that a POSITA would apply the concepts encapsulated in Equation 4-1 of Davis as prior art relative to a desander such as the one disclosed by the '256 Patent is that Davis clearly teaches that Equation 4-1 is only valid for **Laminar Flow**.[4] For example Davis states: "**The enhancement in the settling rate predicted by (4.1) holds true only so long as the flow in the channel remains laminar."** Davis (Ex. 1005), at 19. As discussed in paragraph 67 above, a POSITA would know that a fluid stream emanating from a wellbore, through a wellhead and into a desander adjacent to the

[4] For a discussion of laminar and turbulent flow, *see* paragraphs 62-64 above.

wellhead would generally not be in laminar flow. A POSITA would know that the multi-phase (intermittent and/or random) fluid flow regimes (e.g. a predominantly high velocity gas fluid stream followed a predominantly liquid fluid stream, sometimes referred to as a slug) would tend to create chaotic and therefore turbulent flow within the desander vessel. Hemstock (Ex. 1004), 2:8-15.

80. Sediment transport can be defined as the movement of particles in a flowing fluid. That movement depends on the carrier fluid, and gravity forces acting on the particles (e.g., sand or proppant). In pipeline or horizontal wellbore applications, it is desirable to prevent the formation of sediment beds in the pipe. In order to prevent this problem fluid flow must be above the critical transport velocity. In a desander application, the designer desires to create a sediment bed in order to remove the solid particles from the fluid stream. Therefore, a POSITA working on a desander design for use in an upstream application would primarily be concerned with reducing the velocity of the flow stream below the minimum velocity required to transport the flow-back particles (such as sand) through the desander while also being concerned with creating a vessel geometry that minimizes the time for a given particle to reach a settling surface and provides for sufficient storage capacity to accommodate the particles between periodic vessel clean-out operations.

81. Given that a POSITA would be concerned with designing a desander that takes into account the behavior of particles being carried in a moving fluid such that the velocity of the particle falls below the minimum transport velocity, a POSITA would be concerned with the factors that control the critical or minimum transport velocity.

82. While analysis of the transport of particles such as proppant starts with Stokes' Law as described below, this equation only takes into account the settling velocity of a single particle in a Newtonian Fluid. This is generally not the situation in a high-rate fracturing flow-back application (for example).

$$V_s = 1.74\sqrt{\frac{g(\rho_p - \rho_f)d_p}{\rho_f}}$$

Where:

d_p = Average particle diameter, m

g = Gravitational velocity, m/s^2

V_s = Minimum particle settling velocity, m/s

ρ_f = Density of the fluid carrier, g/cm^3

ρ_p = Density of the particle, g/cm^3

Wasp (Wasp, et al. 1977; Turian and Yuan 1977; Poirier 2000) derived an equation for minimum transport velocity that includes a correction to the Durand Equation (1953) to account for the influence of particle size. The first work of Durand (Durand 1953; Poirier 2000) was done mostly for vertical pipe while Wasp modified it for horizontal pipes:

$$V_s = F[2g(s-1)D]^{\frac{1}{2}}\left(\frac{d_P}{D}\right)^{\frac{1}{6}}$$

V_s = Minimum particle settling velocity, m/s

d_P Average particle diameter, [L], m

D Pipe inner diameter, [L], m

g Gravitational velocity, $[LT^{-2}]$, m/S^2

s Ratio of particle and fluid densities, [dimensionless], unitless

F Dimensionless group, [dimensionless], unitless

The particles in the post-hydraulic fracturing flow back fluids or other high-rate well stream have momentum and inertia when they enter the desander. The design of the desander must overcome this momentum and inertia in order to reduce the velocity of the particle to a point that it will settle to the bottom of the vessel.

3. Different Problem

83. I understand that a reference is reasonably pertinent to the problem with which the inventor was concerned only if it logically would have commended itself to an inventor's attention in considering his problem.

84. As Mr. Simpson acknowledges, the primary problem faced by the inventor of the '256 Patent was an improvement in separation efficiency of the desander disclosed in Hemstock. Ex. 1002; '256 Patent (Ex. 1001), 2:24-26. As Mr. Simpson admits, this separation efficiency is directed to sand falling out of the fluid stream in the freeboard portion of the desanding vessel, and not to the settling

efficiency of the sand once it's within the belly (liquid) portion of the desander. Simpson Dep. (Ex. 2005), 82:5-18.; '256 Patent (Ex. 1001), 5:17-39 ("maximizing the efficiency of that freeboard portion for particulate drop out"). Also, as described above, and as Mr. Simpson admits, the fluid flow in the freeboard portion of the desanding vessel will not be a laminar flow, it will be turbulent flow. Simpson Dep. (Ex. 2005), 50:16-23, 51:7-11. Thus, Davis does not attempt to solve how to increase the settling efficiency of sand falling from a fluid stream.

85. Davis does not teach a way to increase the separation efficiency of a solid from a turbulent flow; indeed, as described above, Davis teaches away from using an inclined vessel with turbulent flow because turbulent flow "limits the efficiency of the inclined settling process." Davis (Ex. 1005) at 19. Instead, Davis teaches how to increase the settling efficiency of a solid in suspension with a liquid.

86. Further, Davis teaches how to increase the settling efficiency of a vertical vessel with fluid in laminar flow inclined from the vertical, while the '256 Patent relates to a horizontal vessel inclined from the horizontal in turbulent flow. As described above in Section VIII(B), under laminar flow conditions, Davis would have taught a POSITA that inclining elongated vessels from the vertical significantly increases settling efficiency, while inclining elongated vessels from the horizontal actually decreases their settling efficiency for large angles and only

negligibly increases setting efficiency for small angles. This is because a POSITA would know that, in general, an elongated horizontal vessel where the length of the vessel is much greater than the height would inherently have much greater surface area for settling and would require less time for particles to reach a settling surface than an elongated vertical vessel. As a result, a POSITA would not be motivated to look to prior art concerning vertical or near vertical configurations, in laminar flow or otherwise, when designing a desander designed for use in production emanating from a wellhead desanding applications. Results from the Davis Equation 4-1 found in Table 1 show that when a horizontal vessel approaches a vertical orientation the Settling Efficiency drops dramatically. Thus, Davis and the '256 Patent are directed at improving separation efficiencies in different types of vessels under very different conditions. The methodology for improving vertical vessels such as Davis does not apply to a horizontal desander such as the '256 Patent. Moreover, the methodology for improving particle settling in vertical vessels where fluids remain static or in laminar flow provided by Davis does not apply to a horizontal desander where fluids are necessarily in turbulent flow such as in the '256 Patent.

87. To the extent Mr. Simpson implies that the '256 Patent is concerned with the problem of increasing separation efficiency of sand in the liquid portion of the vessel (the belly portion) (e.g. Ex. 1002 ¶ 168), I disagree. As Mr. Simpson

admits, neither the ‘256 Patent nor Hemstock ever discuss the settling efficiency of sand in the liquid portion of the vessel. Simpson Dep. (Ex. 2005), 13:22-24 (‘256 Patent), 19:25-20:7 (Hemstock). Further, Hemstock teaches that any liquid at the fluid outlet is already substantially particle free, meaning that no additional separation efficiency for solids in the liquid is necessary. Hemstock (Ex. 1004), 4:55-59. Additionally, as described above, Davis teaches increasing the sedimentation rate in a suspension, and the sand and liquid do not form a suspension in the belly portion of the ‘256 Patent.

88. Therefore, in my opinion, a POSITA trying to increase the separation efficiency of the Hemstock desander would not have logically looked to Davis, as Davis acknowledges that it does not apply to turbulent flow, Davis has no applicability to horizontal vessels such as Hemstock and the ‘256 Patent, and Davis (which only applies to suspensions) would have no application to liquids and solids in the belly portion of the vessel like those in the ‘256 Patent which are not in suspension.

B. The Combined Teachings of Hemstock and Davis Do Not Disclose a “Gas/Liquid Interface Formed at the Fluid Outlet Having a Belly Storage Portion Formed Therebelow” of Claim 1 or “Establishing a Liquid Interface in a Belly Portion of the Vessel, the Belly Portion Being Formed Below the Fluid Outlet”

89. I have reviewed Mr. Simpson’s Declaration, and it does not appear that Mr. Simpson has the opinion that either Hemstock or Davis disclose the

limitations "gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow" or "establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet." '256 Patent (Ex. 1001), cls. 1 and 9. I agree. Mr. Simpson appears to believe that these limitations are coextensive (Ex. 1002 ¶ 123), and I also agree with that implication—both limitations require a gas/liquid interface that is located at, rather than below, the fluid outlet. This is consistent with Patent Owner's claim construction, as described above in paragraphs 28-33.

90. While Hemstock discloses a gas/liquid interface, that interface is located below the fluid outlet, not at the fluid outlet. For example, Figures 3, 4a, 4b and 4c all depict the gas/liquid interface as below the fluid outlet, rather than "at" the fluid outlet. Hemstock (Ex. 1004), Figs. 3, 4a, 4b, 4c. Hemstock teaches that this space between the gas/liquid interface and the outlet is intentional. For example, Hemstock teaches that a "downcomer flow barrier" is used to maintain the freeboard portion of the vessel such that a maximum level of accumulation of solids and liquids can occur in the belly portion of the vessel. Hemstock (Ex. 1004), 5:16-27. As Hemstock further explains, maintaining this gas filled portion between the fluid outlet and the gas/liquid interface is important, because if the liquid level were to reach the outlet, it would result in "re-entrainment of liquids L and particulates S from the area about the flow barrier", which would allow liquid

and particulates (e.g. sand) to exit the vessel, defeating the purpose of the desander. Hemstock (Ex. 1004), 2:36-39, 5:9-27.

91. Davis does not disclose a gas/liquid interface, because Davis does not disclose a gas. Davis (Ex. 1005) at 17; Simpson Dep. (Ex. 2005), 31:4-15. Therefore Davis does not disclose the limitation "gas/liquid interface formed at the fluid outlet."

92. If a POSITA were to combine the teachings of Hemstock and Davis (which as I explain below they would not), they would rely on the teachings of Hemstock that the gas/liquid interface should be maintained below the fluid outlet, rather than at the fluid outlet. Nothing in Davis provides any reason to change this configuration, as Davis does not discuss any relevance of the position of any gas/liquid interface.

93. Therefore, in my opinion, none of Hemstock, Davis, or Hemstock modified based on Davis discloses the limitation "gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow" of claim 1 or "establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet" of claim 9 of the '256 Patent.

C. The Combined Teachings of Hemstock and Davis Do Not Disclose "said vessel being inclined…such that the fluid outlet is lower than the fluid inlet"

94. As described above in paragraph 40, Hemstock does not disclose a vessel where the "fluid outlet is lower than the fluid inlet." As described above in paragraph 45, Davis does not disclose a fluid inlet or a fluid outlet; thus Davis cannot disclose a relationship between a fluid inlet and a fluid outlet. It is my opinion that a POSITA would not be motivated to incline Hemstock based on the teachings of Davis. As explained above, Davis teaches how to increase sedimentation in a vertical vessel with fluids in laminar flow, not in a horizontal vessel with a fluid stream in turbulent flow. Application of Equation 4-1 shows that inclining a vertical vessel with fluids in laminar flow confers substantial settling efficiency, while inclining a horizontal vessel with fluids in laminar flow confers an insignificant increase in settling efficiency and for most angles of inclination actually reduces the efficiency. More importantly, Davis teaches the POSITA nothing about the impact on settling efficiency of inclining a horizontal vessel with an inlet fluid stream in turbulent flow, which is the environment in which the '256 Patent must operate. However, even if a POSITA were to incline Hemstock based on Davis, he would not incline the vessel such that the fluid outlet were lower than the fluid inlet.

95. To the extent Mr. Simpson intends to rely on the less than 0.5% increase of efficiency for small angles of inclination, that increase of efficiency would not be conferred in a Hemstock vessel tilted as Mr. Simpson implies. First, as Mr. Simpson admits, Hemstock does not teach that the sand in the belly portion of the vessel is in suspension. Simpson Dep. (Ex. 2005), 19:25-20:7. Rather, Hemstock teaches that sand collects in the belly portion, for example as shown in Figure 3. '256 Patent (Ex. 1001), 4:40-42; Fig. 3.

96. As I describe above, 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. Hemstock teaches that all of the sand has settled out of the fluid prior to reaching the outlet. Hemstock (Ex. 1004), 4:34-37. This means that, to the extent that any sand that is in suspension (again, in my opinion there is not), this sand would be in suspension in the liquid that is close to the inlet, and there would not be sand in suspension with the liquid close to the outlet.

97. Because there can only be sand in suspension with the liquid near 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. This is because there would be no sand in suspension near the wall past the fluid outlet, meaning if the

vessel wall near the fluid outlet was provided for additional settling, it would not make a difference, because no sand is in that portion of the liquid to settle.

98. Therefore, to the extent a POSITA would incline Hemstock at all based on the teachings of Davis, it would do so in a manner that would provide the wall closest to the inlet for settling. The only way in which to accomplish this would be to incline the vessel so that the fluid outlet was higher than the fluid inlet, as depicted below in Figure 3 below. This is because, if Hemstock were inclined such that the outlet was higher than the inlet, the extra surface area available for settling, on the left hand side of the vessel, will be below liquid that is taught not to have any sand in it. Without sand, there can be no additional sand settling.

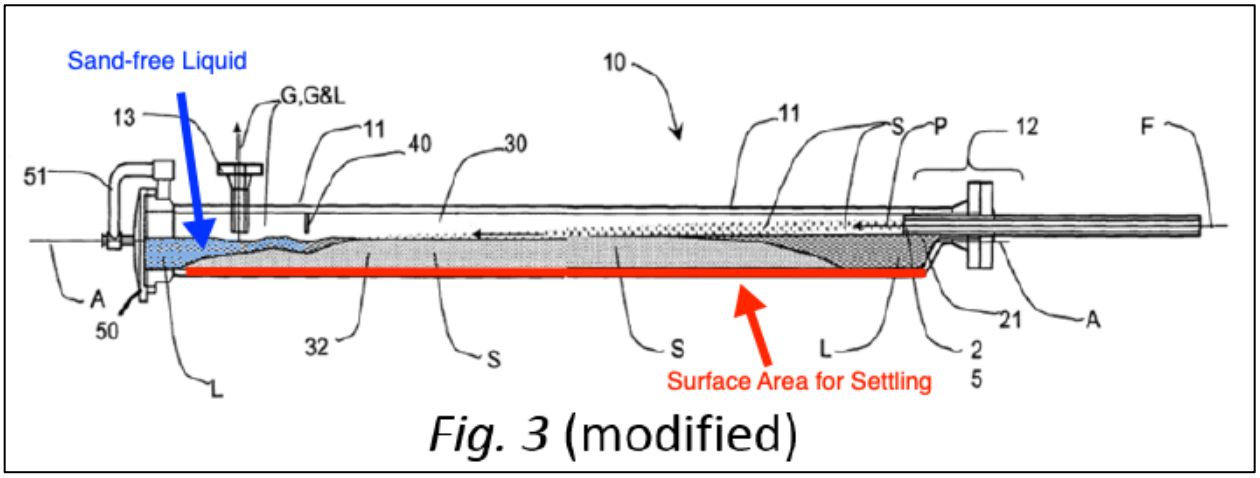


Figure 3 – Non-inclined Hemstock, bottom surface available for settling

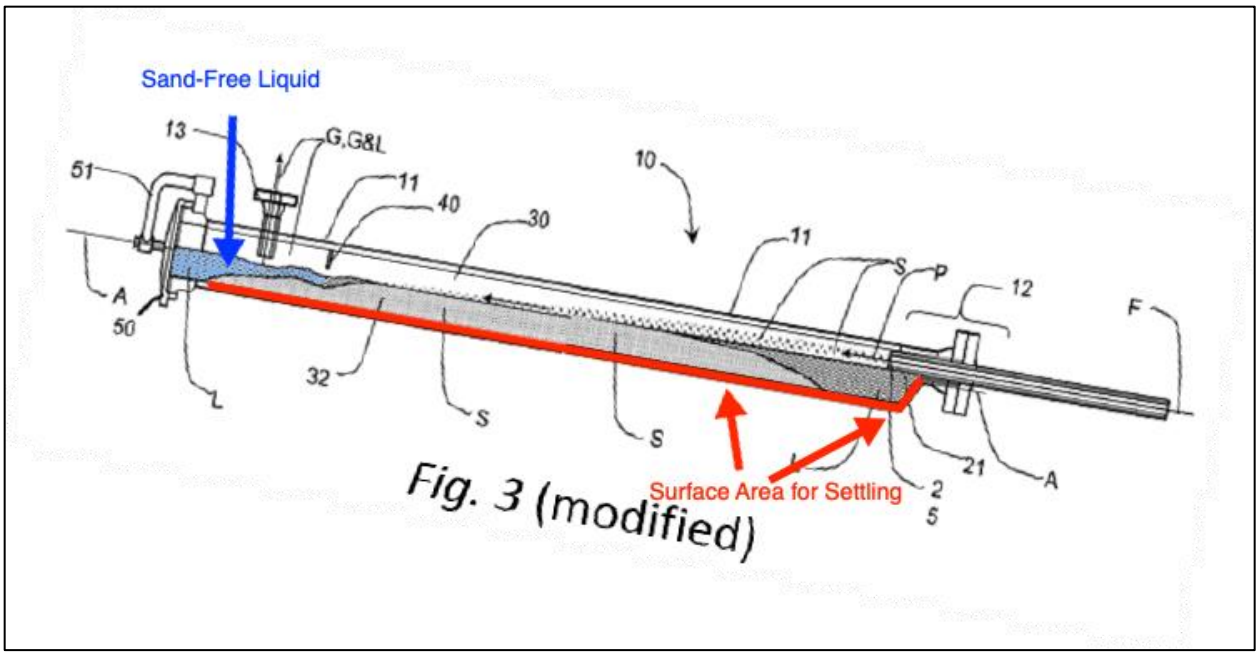


Figure 3 – Inclined Hemstock, inlet lower than outlet, extra surface available for settling

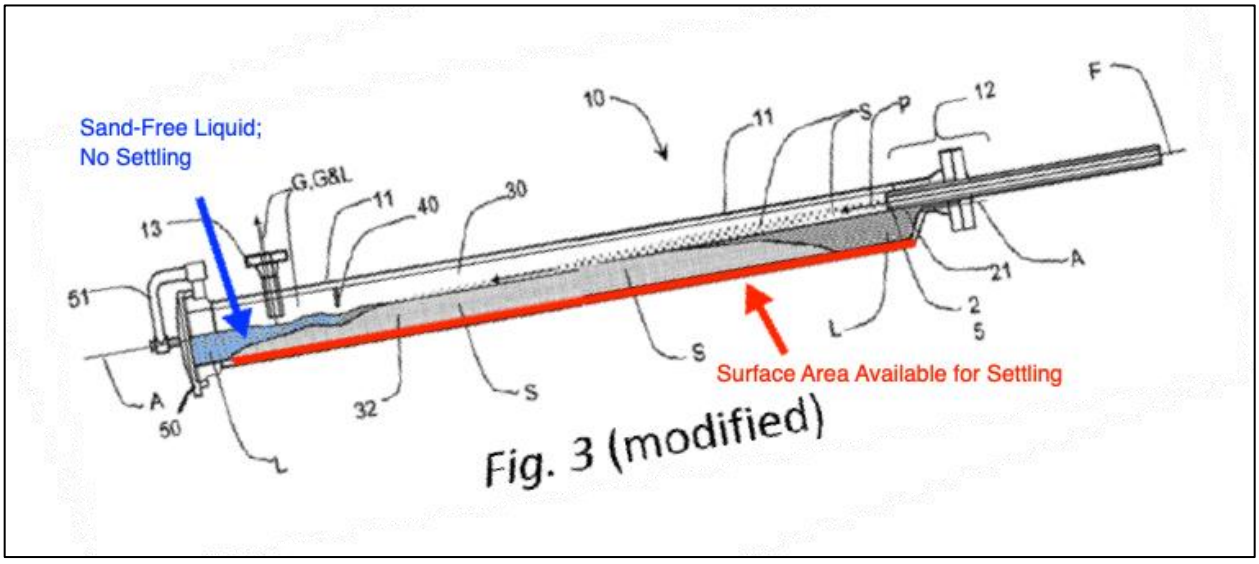


Figure 3 – Inclined Hemstock, outlet higher than inlet, no extra surface available for settling because no sand in liquid on the left

99. However, if Hemstock were inclined such that the outlet were higher than the inlet, the only possible suggestion based on the teachings of Davis, then that combination does not meet the claim limitation "said vessel being

inclined…such that the fluid outlet is lower than the fluid inlet." Therefore, in my opinion, the combination of Hemstock and Davis does not teach the claim limitation "said vessel being inclined…such that the fluid outlet is lower than the fluid inlet" as required by claims 1 and 9 of the '256 patent.

D. The Combined Teachings of Hemstock and Davis Lack a Motivation to Combine the References to Derive the Claimed Invention

1. Motivation to Combine Hemstock and Davis based on Erroneous Interpretation of Hemstock

100. Mr. Simpson states that a POSITA would have been motivated to combine Hemstock and Davis because they "would have desired more rapid sand settling in the liquid in order to prevent, to the maximum extent possible, re-entrainment of the solid particulates with the liquid stream leaving via outlet 13." Ex. 1002 ¶ 168. I disagree that a person of ordinary skill would have been motivated to increase sand settling time in Hemstock.

101. Hemstock teaches that the sand leaving via outlet 13 is substantially particle free. Hemstock (Ex. 1004), 5:34-36 ("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."). Hemstock teaches that the desander continues to accumulate sand particles, even in the situation where the liquid level is at its highest and liquid is re-entrained for discharge. Hemstock (Ex. 1004), 4:55-59. For example, after installation of a preferred vessel of the Hemstock

invention was installed to provide desanding, it produced effectively particulate free liquid. Hemstock (Ex. 1004), 6:6-12 ("Applied to problem wells in several exceptional cases, using no [desander] 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."). Therefore, a POSITA would have understood that the liquid exiting Hemstock via outlet 13 is already particulate free and would not be motivated to find ways to increase settling efficiency.

2. Hemstock and Davis Work on Different Principles

102. Even if a POSITA wanted to increase the settling efficiency of the sand in the liquid portion of the vessel (which as explained above they would not), they would not consult Davis to do so. This is because Hemstock and Davis work on very different physical principles.

103. First, Davis teaches settling efficiency for a solid that is in suspension with a liquid. Davis (Ex. 1005) at 17, Fig. 4; *see also* Davis (Ex. 1005) at 3 ("Sedimentation, wherein particles fall under the action of gravity through a fluid in which they are suspended"). On the other hand, Hemstock does not teach that the sand, once it is in the belly portion of the vessel, is ever in suspension with the liquid. Instead, the sand is disclosed as simply falling through the liquid to the

bottom of the vessel. Hemstock (Ex. 1004), 4:40-43 ("The particulates S deposit and accumulate over time in the belly portion 32"). This statement in Hemstock teaches a POSITA 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. Therefore, because Hemstock does not teach that sand is in suspension with the liquid in the belly portion of the vessel; if a POSITA wanted to increase the settling efficiency of the sand through the liquid portion of Hemstock, that person would not look to articles that describe solids in suspension with a liquid, including articles such as Davis that teach only how to increase sedimentation rates for a suspension.

104. Second, as explained above, Davis is directed to liquids that are operating in laminar flow range. Davis (Ex. 1005) at 19 ("The enhancement in the settling rate predicted by (4.1) holds true only so long as the flow in the channel remains laminar."). Laminar flow generally refers to very slow moving liquids with no turbulence in it. Davis goes on to teach that even the turbulence caused by solids settling too quickly through a suspension may cause liquid that has become solid-free to become mixed back in to the suspension. Davis (Ex. 1005) at 19. Hemstock, as Mr. Simpson admits, includes very turbulent flow caused by the fluid flow in the freeboard portion of the vessel. This turbulent fluid flow will cause the liquid to also become turbulent, at least because of frictional forces between the

fluid flow and the liquid. Therefore, a POSITA would understand that the teachings of Davis, which restricts itself to suspensions with laminar flow regimes, would not be applicable to Hemstock, which uses turbulent flow regimes.

105. Third, as explained above, to the extent Davis is directed at inclining a vessel, Davis limits its analysis to narrow channels. Davis (Ex. 1005) at 17 ("These settlers 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."). Narrow, in this context, is referring to the distance between the vertical walls of the non-tilted vessel. Davis (Ex. 1005) at 17. However, the example vessels in Hemstock are disclosed as being 10 feet and 20 feet long respectively. Hemstock (Ex. 1004), 6:13-15. A POSITA would not consider a vessel that is 10 or 20 feet wide to be a "narrow channel." Thus, if for some reason a POSITA were to consult Davis to determine how to increase sedimentation rate, ignoring the problems I address above, then that person would be motivated to use the other disclosed embodiment of Davis, the inclined plates inside of a large tank. This would not result in a POSITA tilting the Hemstock vessel, and therefore would not be a motivation to combine Hemstock and Davis in a way that results in the claimed invention. An example of a real world large tank settler with inclined plates is shown below, taken from the website

https://www.monroeenvironmental.com/water-and-wastewater-treatment/plate-settlers/.

Example of a large tank with inclined plates for sedimentation

Example of parallel plates for sedimentation

106. Fourth, as explained above, Davis teaches inclining vessels from the vertical to increase settling efficiency. Davis (Ex. 1005) at 17. In this context, vertical vessels are vessels that are taller than they are wide. By inclining a vertical vessel, more surface area becomes available for settling, thus allowing sedimentation of a suspension to increase. Davis (Ex. 1005) at 17. For example, using Equation 4.1, as shown above, a vertical vessel with a base of three inches and a height of ten inches that is inclined by 25 degrees will increase its settling efficiency by over 100%. Hemstock, on the other hand, does not disclose a vertical vessel, it discloses a horizontal vessel, much wider than it is long. Hemstock (Ex. 1004), 6:13-15. A POSITA would understand, by way of Equation 4.1, that for most angles, inclining a horizontal vessel would decrease settling efficiency, not increase setting efficiency. For example, if the Hemstock ten-foot vessel were inclined by 25 degrees, as described above its settling efficiency would decrease by 3%. Thus, Mr. Simpson's statement that Davis teaches "an inclined tube or channel would achieve more rapid separation between the solid and liquid phases" is incorrect. Ex. 1002 ¶ 167. Moreover, as explained above, for very small angles (less than 10 degrees), Equation 4-1 suggests for the ten-foot Hemstock vessel an improvement of less than 0.5%. However, as discussed above, Equation 4-1 assumes that the solid in suspension will be well mixed throughout the liquid, but in Hemstock the liquid on the far end of the vessel will be substantially solid free.

Davis (Ex. 1005) at 17; Hemstock (Ex. 1004), 5:34-36. Therefore, a POSITA would not apply Davis's teachings to Hemstock, because that person would understand that no benefit to settling efficiency of the sand in the liquid would result by inclining Hemstock, and instead a decrease of settling efficiency would occur.

X. HEMSTOCK IN VIEW OF THE DATA BOOK DOES NOT RENDER OBVIOUS ANY ASSERTED CLAIM

107. Mr. Simpson states that "[b]ased on the Data Book's teaching that an inclined device is desirable for absorbing the fluctuating liquid inlet flow rates through liquid level fluctuation, a POSITA would have been motivated to modify Hemstock by inclining the desander." Ex. 1002 ¶ 171. I disagree.

A. Normal Operation of Slug Catchers

108. Mr. Simpson bases his obviousness opinions regarding the Data Book based on how a POSITA would understand the slug catcher in Figure 17-21. For example, Mr. Simpson's opinion regarding the Data Book for limitation 1.5 is entirely based on what a POSITA would understand about the slug catcher in Figure 17-21. However, Mr. Simpson's view in his Declaration of how a slug catcher normally operates is incorrect. For example, Mr. Simpson describes three "modes of operation," two (a steady-state mode and a liquid flooded mode), of which would have liquid and gas being emitted from the gas outlet because the gas/liquid interface would be at or above the gas outlet. Ex. 1002 ¶ 104. However,

slug catchers operating in their designed manner would not have a gas/liquid interface that begins at the fluid outlet, because, as Mr. Simpson concedes, slug catchers are designed to operate such that the gas/liquid interface is well below the fluid outlet. Simpson Dep. (Ex. 2005), 48:9-13. This is consistent with the nomenclature of the Data Book, which explains that a slug catcher is a "particular separator design" and that a separator is a vessel which is "used to separate a mixed-phase stream into gas and liquid phases that are 'relatively' free of each other." Data Book (Ex. 1008) at 3. These definitions inform a POSITA that the slug catcher will be designed such that the gas outlet will emit gas, which will be relatively free of liquid. Therefore, a POSITA would understand that the slug catcher of Figure 17-21 in the Data Book would operate with a gas/liquid interface well below the gas outlet (Mr. Simpson's third "mode of operation" Ex. 1002 ¶ 104).

109. The version of the Data Book on which Mr. Simpson relies is the Tenth Edition from 1987, revised in 1994. Data Book (Ex. 1008) at 2. Attached, I have included Section 7 from the Twelfth Edition, dated in 2004 ("Section 7"). Ex. 2003. I include this version, because on page 20 it includes a very short description of slug catchers. Importantly, it states "Reference 13 provides design details and an example of slug catcher design." Section 7 (Ex. 2003) at 20. Reference 13 is "Rhinesmith, R. Bret, Kimmitt, Russell P., and Root, Chris R.,

"Proven Methods for Design and Operation of Gas Plant Liquid Slug Catching Equipment," 80th Annual Gas Processors Convention, San Antonio, Texas, March 12-14, 2001." ("Rhinesmith"). Ex. 2004. Attached, I have included Rhinesmith as evidence of what a POSITA would have understood about slug catchers at the time of the invention.

110. As explained in the 12th Edition of the Data Book, Rhinesmith is a paper presenting the design details and an example of a slug catcher design. As Rhinesmith explains, its purpose is to "take the veil away from the mysteries of slug catcher design and operation." Rhinesmith (Ex. 2004) at 2. Rhinesmith first gives some background information on flow, and beings teaching "Slug Catcher Design" on page 14. Rhinesmith (Ex. 2004) at 14. This section explains that the "slug catcher must be designed so the outlet gas flow is not impeded by the arriving liquid flow." Rhinesmith (Ex. 2004) at 15. This teaching informs a POSITA that when slugs of liquid enter the slug catcher, the catcher must have enough volume in it so that gas can continue to exit even during a large liquid event such as a slug. This in turn informs a POSITA that the level of liquid must be well below the gas outlet to avoid having excessive entrained liquid exit the slug catcher and continue downstream with the gas. Rhinesmith (Ex. 2004) at 20 ("The goal of a level control system for a slug catcher is to keep the normal liquid level in the vessel as low as possible so that more volume is available for liquid

slug handling.”). This allows a slug of liquid to enter the slug catcher, flow past the gas outlet, and be stored in the portion of the slug catcher below the gas outlet. This is what is meant by catching a slug. Below I have annotated Figure 11 from Rhinesmith to depict a slug catcher in two states: 1) during normal operation where there are no slugs, and 2) immediately after a slug has been “caught.”

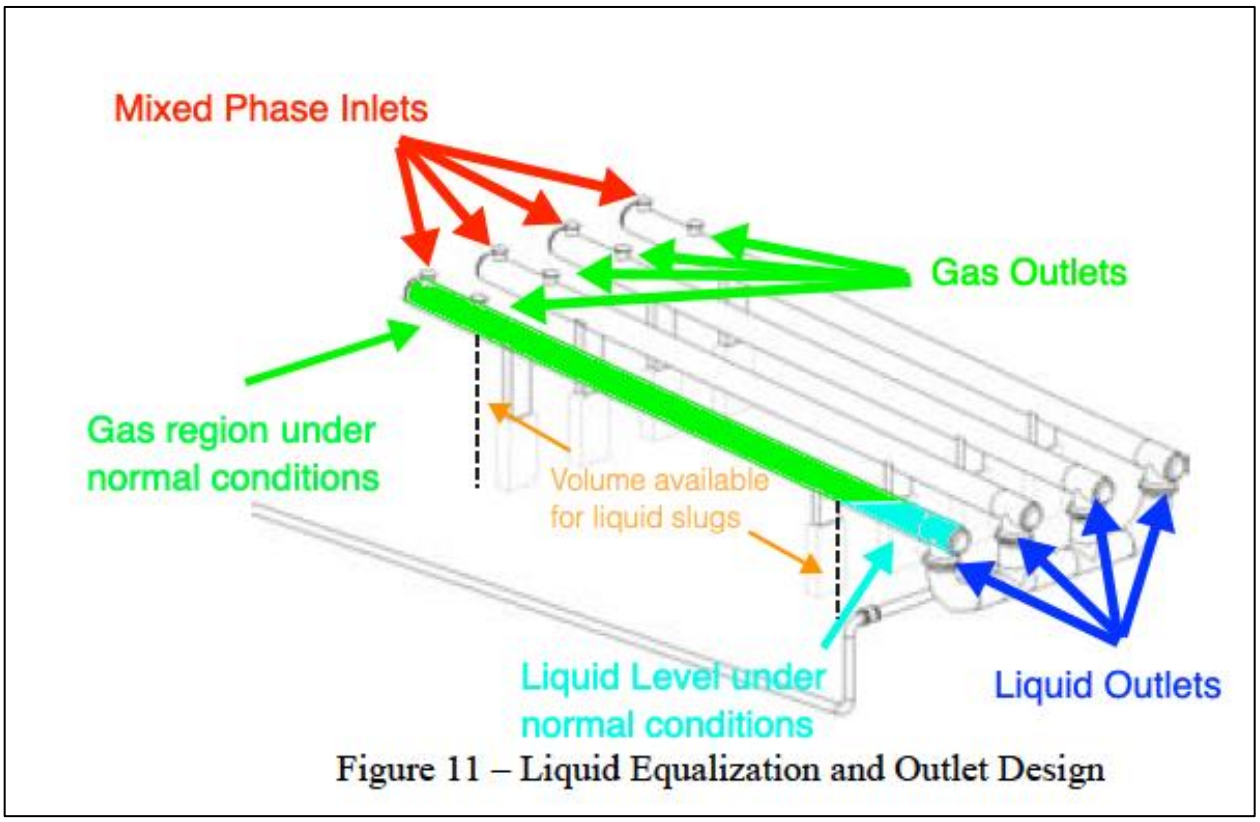


Figure 11 – Liquid Equalization and Outlet Design

Slug catcher in normal conditions, i.e., absent any slugs

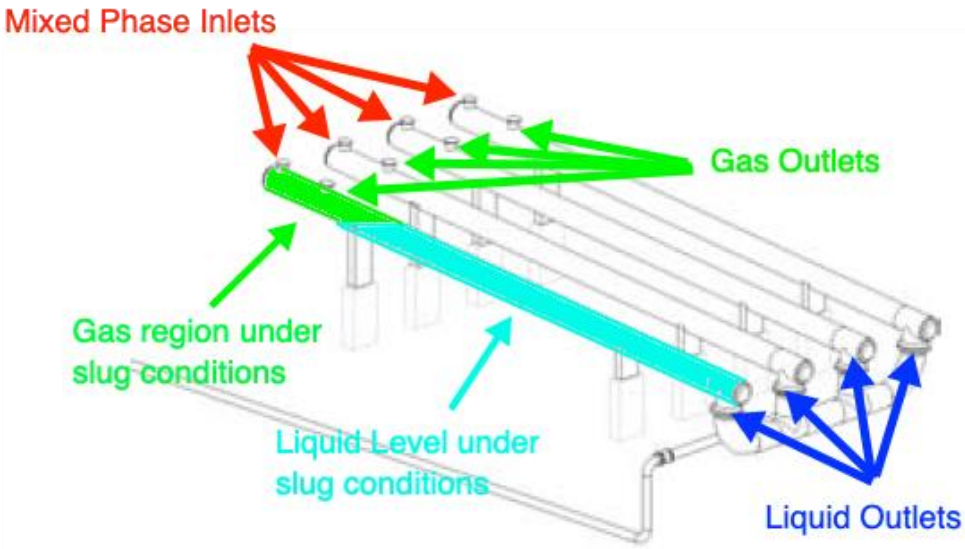


Figure 11 – Liquid Equalization and Outlet Design

Slug catcher immediately after "catching" a slug

111. Next, Rhinesmith describes vessel slug catchers. Rhinesmith (Ex. 2004) at 15. Rhinesmith explains that vessel slug catchers "usually" horizontal, and that some slug catchers can also be vertical for cramped areas or if surplus vertical vessels are available. Rhinesmith then goes on to describe various characteristics of horizontal vessel slug catchers, and vertical vessel slug catchers. Rhinesmith (Ex. 2004) at 15-16. Rhinesmith does not describe a single example of a vessel-type slug catcher that is inclined. Rhinesmith (Ex. 2004) at 15-16.

112. Rhinesmith also addresses pipe-type slug catchers, explaining that this is the preferred method when one wants to "[use] the pipeline itself as a slug catcher." It is in this instance that a slug catcher may be inclined, and only if "the

site topography allows for a long gentle downward slope." Rhinesmith (Ex. 2004) at 16.

B. The Combined Teachings of Hemstock and the Data Book Do Not Disclose a "Gas/Liquid Interface Formed at the Fluid Outlet Having a Belly Storage Portion Formed Therebelow" of Claim 1 or "Establishing a Liquid Interface in a Belly Portion of the Vessel, the Belly Portion Being Formed Below the Fluid Outlet"

1. Neither Hemstock Nor the Data Book Disclose this Limitation

113. As explained above with respect to the combination of Hemstock and Davis, it is my opinion that Hemstock does not disclose the limitations "gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow" or "establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet." This is because Hemstock discloses a gas/liquid interface that is located below the fluid outlet, not at the fluid outlet. This is consistent with Patent Owner's claim construction, as described above in paragraphs 28-33.

114. Mr. Simpson relies on the sloped harp slug catcher on page 41 of the Data Book for this limitation of his obviousness theory combining Hemstock and the Data Book. Ex. 1002 ¶¶ 102-104. The harp slug catcher on page 41 of the Data Book does not disclose any gas/liquid interface, much less the location of any gas/liquid interface. Data Book (Ex. 1008) at 41. Therefore, in my opinion, neither Hemstock nor the Data Book disclose this claim limitation. Further, as

explained above, Mr. Simpson is incorrect that in normal operation of a slug catcher, the gas/liquid interface will necessarily be at the fluid outlet. Instead, as taught by Rhinesmith, a slug catcher is designed to keep the gas/liquid interface as low as possible, and well below the gas outlet. Rhinesmith (Ex. 2004) at 20.

115. Moreover, the primary function of the multiple inclined pipes of the harp slug catcher is to provide a method to drain as much liquid out of the flow path of the gas as possible before the next slug arrives at the slug catcher. The multiple pipes provide multiple drains out of the perpendicular horizontal vessel or pipe that manifolds these multiple pipes together. The combined cross-sectional area of these pipes minimizes back-pressure and the incline merely acts to further accelerate removal of the liquid slug before the next slug arrives.

C. The Combined Teachings of Hemstock and the Data Book Lack a Motivation to Combine the References to Derive the Claimed Invention

1. Motivation to Combine Hemstock and the Data Book based on Erroneous Interpretation of Hemstock

116. Mr. Simpson states that a POSITA would have been motivated to combine Hemstock and the Data Book to "maximize the desander's ability to handle liquid slugs, as Hemstock itself explains that the expected multiphase flow from the wellhead was unstable and that 'large slugs of fluid followed by a gas mist' were common." Ex. 1002 ¶ 171. I disagree that a POSITA would have been motivated to improve Hemstock to handle slug flow.

117. First of all, a desander is not a slug catcher. A desander only needs to be able to tolerate slug flow, not eliminate it by continuously catching and draining off slugs for further processing as is the ideal functionality of a slug catcher. A POSITA would be focused on maximizing the sand separation capabilities of Hemstock, not converting Hemstock to a slug catcher. Further, Hemstock does not provide a single example for how to catch slugs, nor does it provide any indication that an ability to catch slugs in its desander vessel would in any way be desired. Hemstock (Ex. 1004). Therefore, in my opinion, a POSITA would not have been motivated to improve Hemstock to better handle slug flow.

118. Hemstock teaches that slug flow, while present in multi-phase flow, is a problem only for certain prior-art desanders: specifically desanders that include a filter bag. Hemstock (Ex. 1004), 2:1-19. Hemstock teaches that filter bags in particular are not effective for separating out solids (like sand) in a slug flow regime, because slugs cause sudden, large and often repeated pressure differentials across the filter bags which often cause the filter bags to fail. Hemstock (Ex. 1004), 2:9-11. Hemstock improves over this prior art, as Mr. Simpson admits, by not using a filter bag. Simpson Dep. (Ex. 2005), 18:2-23. Further, Hemstock specifically teaches that the claimed desander is capable of handling multiphase production, meaning Hemstock is designed such that multiphase flow (oil, water and gas) passes through the Hemstock desander, and as Mr. Simpson admits, the

slugs that are a part of multiphase flow. Because Hemstock does not rely on filter bags and was designed such that multiphase flow (oil, water and gas) may pass through the vessel, Hemstock was not sensitive to slug flow. Therefore, in my opinion, a POSITA would not have been motivated to improve Hemstock to better tolerate slug flow.

2. The Data Book Does Not Teach that Inclining Horizontal Vessels Improves Slug Capacity

119. Even if Mr. Simpson were correct that a POSITA would want to improve slug capacity for the Hemstock desander (which, as I describe above, he is not), the Data Book does not teach that the way to do so is through inclining the vessel. Hemstock discloses a horizontal vessel. Hemstock (Ex. 1004), 3:32-37, Fig 3. The Data Book includes a section on horizontal separators. Data Book (Ex. 1008) at 7. The section also includes a statement regarding how to increase slug capacity, "Increased slug capacity is obtained through shortened retention time and increased liquid level." Data Book (Ex. 1008) at 7. The Data Book, including this section, does not teach that inclining a horizontal vessel will increase its slug capacity. Thus, a POSITA, applying the disclosure of the Data Book, would only be motivated to shorten retention time and increase liquid level in the Hemstock vessel to increase slug capacity, he would not be motivated to incline the vessel.

120. In practice, the pipe type slug catchers described in the Data Book have a relatively large foot-print and are generally used for handling slug flow

related to pipelines. The ‘256 Patent is specifically designed to be placed directly downstream of a wellhead during production. Space is at a premium on many well sites. A POSITA designing a desander vessel, where one of the objectives is to reduce the equipment foot-print, would not be motivated to incorporate the features of a large foot-print pipe style slug catcher.

121. Further, if a POSITA were to avoid the separator section (Chapter 7) of the Data Book, and go to the piping section of the Data Book (Chapter 14) (which it would not, because Hemstock is a horizontal separator, not a pipe), the Data Book teaches that there are two types of slug catchers, pipe type slug catchers and vessel-type slug catchers. Here again, with regard to vessel-type slug catchers, the Data Book does not teach that inclining the vessel will improve performance. Data Book (Ex. 1008) at 41-42. Although the Data Book teaches that some components of certain pipe-type slug catchers are often inclined, there is no reason for a POSITA to understand that this teaching applies to horizontal vessels as well, especially considering the Data Book expressly discusses how to improve slug capacity for horizontal separators. Data Book (Ex. 1008) at 7, 41. This is further supported by the fact that the Data Book does not provide a single disclosure of a pressure vessel that is inclined for any reason. Data Book (Ex. 1008). Therefore, in my opinion, if a POSITA were to use the Data Book to increase slug capacity in Hemstock (which he would not), he would use the teachings relating to horizontal

vessels, or vessel-type slug catchers, and would not look at unrelated pipe-type slug catchers. Therefore, a POSITA would not be motivated to tilt Hemstock based on the teachings of the Data Book.

122. In my opinion, if a POSITA really believed that slugs in the Hemstock desander continued to be a problem, they would install a slug catcher before the Hemstock desander. This is because the Hemstock desander is not designed to catch slugs at all. Hemstock teaches that liquid that comes in the inlet is later discharged via the outlet, and that the purpose of the vessel is to remove the solids such as sand. Hemstock (Ex. 1004), 4:44-59. Further, Hemstock distinguishes between the desander itself, and later downstream separation devices, further evidencing that separation between the liquid and gas phases is not the intention of the desander. Hemstock (Ex. 1004), 2:25-29. Therefore, a POSITA wanting to reduce the presence of slugs in the Hemstock desander, would either use known slug catching techniques, such as adding a liquid vessel as shown in Figure 17-22 of the Data Book, or would install a separate slug catching device prior to the Hemstock desander. However, as explained above, Hemstock teaches that it is capable of handling multiphase flow, and does not use a filter, so avoidance of slugs is no longer a concern for the Hemstock vessel.

3. Hemstock and the Data Book Work on Different Principles

123. In my opinion, a POSITA would not be motivated to apply the principles of a pipe-type slug catcher to the desander disclosed in Hemstock, because the references work on very different principles.

124. As Mr. Simpson admits, slug catchers are designed such that the liquid level is well below the gas outlet. Simpson Dep. (Ex. 2005), 48:9-13. This design is to ensure that the slug catcher is acting as a separator, which means making sure the gas phase is relatively free of the liquid phase at the outlet. Data Book (Ex. 1008) at 3. The inclined pipe slug catcher accomplishes this separation by providing extra volume beyond the gas outlet for the liquid to collect. The liquid has a separate outlet, so that liquid, relatively free of gas, can be processed separately. The incline to the pipe encourages the liquid to flow past the outlet into the storage portion of the slug catcher.

125. Hemstock on the other hand teaches a fluid flow that allows both liquid and gas to exit via the outlet. Hemstock (Ex. 1004), 4:55-59. There is no separate outlet designed to drain liquid flow for processing later; in fact Hemstock teaches that downstream separators will accomplish this task. Hemstock (Ex. 1004), 2:25-29.

126. Because both Hemstock and the pipe-type slug catcher of the Data Book make use of a gas/liquid interface that is below the fluid outlet, in my

opinion a POSITA were to apply the disclosure of the pipe-type slug catcher to the vessel of Hemstock would logically be motivated to also set the gas/liquid interface below the fluid outlet.

XI. HEMSTOCK IN VIEW OF MILLER AND DAVIS OR THE DATA BOOK DOES NOT RENDER OBVIOUS ANY CHALLENGED CLAIM

127. Mr. Simpson describes Ground 3 as the combination of Hemstock and Davis with Miller, rendering obvious claims 8, 12, 14, and 15. Ex. 1002 ¶¶ 33-34. Mr. Simpson also describes Ground 4 as the combination of Hemstock, the Data Book and Miller, rendering obvious claims 14, and 15. Ex. 1002 ¶ 35. Because each of claims 8, 12, 14 and 15 depend directly or indirectly from claim 1, I understand that claims 8, 12, 14 and 15 incorporate by reference the limitations of claim 1. With respect to these claims, Mr. Simpson does not attempt to cure the deficiencies of Hemstock in combination with Davis, or the deficiencies of Hemstock in combination with the Data Book. Thus, it is my opinion that the combined teachings of Hemstock, Miller, and either Davis or the Data Book would not have rendered obvious any of the challenged claims, including claims 8, 12, 14 and 15, to a POSITA.

128. Further, claim 14 requires "said vessel has a smaller diameter downstream of the fluid outlet than the diameter of other portion of the vessel." '256 Patent (Ex. 1001), cl. 14. Mr. Simpson cites only Miller to support this

limitation being met. Ex. 1002 ¶ 148; *see also* Simpson Dep. (Ex. 2005), 62:10-63:24 (explaining that only the first sentence of ¶ 148 is directed to claim 14). Mr. Simpson identifies outlet pipe 8 as meeting this limitation. Ex. 1002 ¶ 148. However, as Mr. Simpson admits, the identified pipe is not "downstream of the fluid outlet" as required by the claim; the fluid outlet 13 is on the opposite side of the vessel 5. Miller (Ex. 1007), Fig. 1; Simpson Dep. (Ex. 2005), 64:10-19. Therefore, in my opinion, neither Hemstock nor Miller disclose the limitation "said vessel has a smaller diameter downstream of the fluid outlet than the diameter of other portion of the vessel." '256 Patent (Ex. 1001), cl. 14.

129. Claim 15 requires the "desanding system of claim 14 wherein second end of the vessel is an eccentric end." '256 Patent (Ex. 1001), cl. 15. Mr. Simpson does not allege that either Hemstock, Davis, the Data Book, or Miller meet this claim limitation. Ex. 1002 ¶ 148. Instead, Mr. Simpson only argues that Miller's disclosure of a vessel with an output as a pipe suggests to a POSITA that the pipe could be incorporated into the vessel itself. Ex. 1002 ¶ 148. I disagree. Mr. Simpson does not provide a single example of a vessel of any kind which includes a smaller, eccentric end that is located after a fluid outlet, as required by the combination of claims 14 and 15. Mr. Simpson provides 6 example photographs in his declaration, but none show this limitation being met, much less in an inclined vessel. Ex. 1002 ¶ 193. Mr. Simpson focuses on his photographs 5 and 6 in

paragraph 193, arguing that these "pig receivers" are "single-phase separators with large solids components." Ex. 1002 ¶ 195. However, as Mr. Simpson admits, these vessels show an output after a fluid outlet that is getting larger, not smaller as required by the claim. Simpson Dep. (Ex. 2005), 65:19-66:13 ("Q. And so the -- although, it's labeled eccentric reducer, the volume of it or the cross-section of the pipe is actually increasing in this example [Picture 5 and 6]? A. That is correct."). Thus, Mr. Simpson's statement that using smaller diameter ends for quick-release cleanouts is "common for such quick-opening fittings, because such closures on pressure vessels are increasingly expensive as the closure size increases, and it is common to try to reduce this cost by reducing the vessel size at the closure" is disproven by Mr. Simpson's own examples. Ex. 1002 ¶ 196. Further, Miller does not discuss any benefit to decreasing the size of a pressure vessel at its end, Mr. Simpson's motivations do not come from Miller at all. Further, the Data Book, with its entire section on horizontal and vertical separators, contains no discussion about replacing a small diameter pipe with a smaller diameter portion of a vessel. Data Book (Ex. 1008) at 1-17. Nor does Davis or the Data Book teach that it is cost effective to fit pressure vessels with small diameter coverings, and that modifications to the pressure vessel accomplish this goal. Therefore, in my opinion, there would be no motivation to modify Hemstock to reduce the diameter of the end of the vessel based only on Miller and the Data Book or Davis.

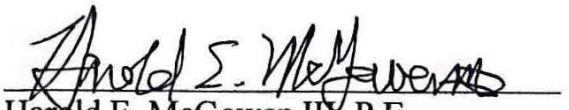
XII. CONCLUSION

130. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

131. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: May 22, 2019

Respectfully submitted,



Harold E. McGowen III, P.E.