

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD**

In re U.S. Patent No. 11,136,870

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Inventor(s): Joel N. Broussard, et al.

Assignee: U.S. Well Services, LLC

Title: System for Pumping Hydraulic Fracturing Fluid Using Electric Pumps

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I, Michael Nikolaou, make this declaration in connection with patent owner response submitted by Patent Owner for U.S. Patent No. 11,136,870. All statements made herein of my own knowledge are true, and all statements made herein based 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, under Section 1001 of Title 18 of the United States Code. Although I am being compensated for my time in preparing this declaration, the opinions expressed herein are my own, and I have no stake in the outcome of this proceeding or any related litigation or administrative proceedings.

Date: December 1, 2023

A handwritten signature in dark ink, appearing to read "Michael Nikolaou", is written above a solid horizontal line.

Michael Nikolaou, Ph.D.

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I. INTRODUCTION

1. I am making this declaration at the request of U.S. Well Services, LLC in the matter of the *Inter Parte* Review of U.S. Patent No. 11,136,870 (the “’870 patent”) to Broussard et al. (“Broussard”), assigned to U.S. Well Services, LLC (“Patent Owner” or “USWS”). I understand that Patent Owner has sued Petitioner Halliburton Energy Services, Inc. (“Petitioner”) in *Halliburton Energy Services et al. v U.S. Well Services, LLC, ProFrac Holding Corp.*, Case No. 6:22-cv-00906 (W.D. Tex.), where it has accused Petitioner of infringing the ’870 patent.

2. In the preparation of this declaration, I have reviewed the following documents:

Exhibit No.	Description
1001	U.S. Patent No. 11,136,870 by Joel Broussard et al. entitled “System for Pumping Hydraulic Fracturing Fluid using Electric Pumps” (“the ’870 Patent”)
1002	Declaration of Dr. Robert Durham
1003	File History for U.S. Patent No. 11,136,870
1004	File History for U.S. Patent No. 9,410,410
1005	U.S. Patent Publication No. 2012/0255734, Coli, <i>et al.</i> , “Mobile, modular, electrically powered system for use in fracturing underground formations,” (“ <i>Coli</i> ”) filed on April 6, 2012 and published on October 11, 2012.

Exhibit No.	Description
1006	Toshiba International Corporation, “G7 Adjustable Speed Drive Operation Manual,” Document No. 51546-009 (March 2005) (“ <i>Toshiba Manual</i> ”), available at: https://web.archive.org/web/20101207173900/http://www.toshiba.com/ind/data/tag_files/GX7%20Operation%20Manual_3886.pdf
1007	Declaration of Nathaniel E. Frank-White, custodian of records for Internet Archive regarding Toshiba documents (May 27, 2022)
1008	U.S. Patent Publication No. 2011/0241590, Horikoshi, et al., “Motor driving apparatus having fault diagnostic function,” (“Horikoshi”) filed on February 11, 2011 and published on October 6, 2011.
1009	U.S. Patent Publication No. 2010/0312415, Loucks, “Electrical Device Cooling Efficiency Monitoring,” (“Loucks”) filed on June 4, 2009 and published on December 9, 2010.
1010	U.S. Patent Publication No. 2011/0197988, Vliet, et al., “Fuel Delivery System and Method,” (“Vliet”) filed on February 16, 2011 and published on August 18, 2011.
1011	Gardner Denver, Inc., Well Servicing Pump, Model GD-2500Q, Quintuplex, Operating and Service Manual, 300FWF996 Revision C, (“Gardner”) published in April 2005, Tulsa, OK, USA.
1012	Declaration of Duncan Hall, custodian of records for Internet Archive regarding Gardner (June 7, 2021)
1013	U.S. Patent No. 8,997,904, Cryer et al., “System and method of powering a hydraulic pump,” (“Cryer”) filed on July 5, 2012 and issued on April 7, 2015.
1014	U.S. Patent Publication No. 2013/0306322, Sanborn et al., “System and process for extracting oil and gas by hydraulic fracturing,” (“Sanborn”) filed on December 7, 2012 and published on November 21, 2013.

Exhibit No.	Description
1015	K. Vidal, Memorandum regarding Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (June 21, 2022)
1016	Donald G. Fink, STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, 13th ed. (McGraw-Hill, New York: 1993), ISBN: 0-07-020984-7 (“Fink”)
1017	National Electrical Manufacturers Association (NEMA) Standards Publication ICS 61800-4-2004, Adjustable Speed Electrical Power Drive Systems, Part 4: General Requirements—Rating Specifications for a.c. Power Drive Systems above 1000 V a.c. and Not Exceeding 35 kV (National Electrical Manufacturers Association: 2004) (“ICS-61800-4”)
1018	Mark’s Standard Handbook for Mechanical Engineers, Eleventh Edition, McGraw-Hill Companies, New York, 2007.
1019	“Root Cause Failure Analysis for AC Induction motors in the Petroleum and Chemical Industry,” Austin H. Bonnet, Industry Applications Society 57th Annual Petroleum and Chemical Industry Conference, 2010.
1020	European Patent Specification 1,900,973, Salvaire et al., “Method of performing hydraulic fracturing and fracturing pump system,” (“Salvaire”) filed on September 9, 2006 and issued on June 23, 2010.
1021	D. Roethemeyer and D. Yankaskas, “Evolution of motor and variable frequency drive technology,” in ACEEE Summer Study Proceedings on Energy Efficiency in Industry, 1995, pp. 541-552.
1022	U.S. Patent No. 3,186,222, P.W. Martin, “Well Signaling System” (“Martin”) filed on July 28, 1960,” and issued on June 1, 1965.
1023	U.S. Patent No. 3,075,136, D.V. Jones, “Variable Pulse Width Parallel Inverters,” (“Jones”) filed on August 31, 1961, and issued on January 22, 1963.

Exhibit No.	Description
1024	U.S. Patent No. 3,262,036, C.D. Clarke et al., “Means for Smoothly Varying the Speed of a Star-Connected Polyphase Induction Motor,” (“Clarke”) filed on September 19, 1962, and issued on July 19, 1966.
1025	W. Shepherd and J. Stanway, “Unbalanced Voltage Control of 3-Phase Loads by the Triggering of Silicon Controlled Rectifiers,” IEEE Transactions on Industry and General Applications, vol. IGA-1, no. 3, pp. 206-216, 1965, doi: 10.1109/TIGA.1965.4180543 (“Shepherd”).
1026	H. N. Hickok, “Adjustable Speed---A Tool for Saving Energy Losses in Pumps, Fans, Blowers, and Compressors,” IEEE Transactions on Industry Applications, vol. IA-21, no. 1, pp. 124-136, 1985, doi: 10.1109/TIA.1985.349672.
1027	F. A. DeWinter and B. J. Kedrosky, “The application of a 3500 HP variable frequency drive for pipeline pump control,” Record of Conference Papers., Industrial Applications Society 35th Annual Petroleum and Chemical Industry Conference, Dallas, TX, USA, 1988, pp. 133-138, doi: 10.1109/PCICON.1988.22429.
1028	M. Perrin, G. Kohn, S. Mugford, and G. Seggewiss, “Induction motors, reciprocating compressors and variable frequency drives,” in Record of Conference Papers. IEEE Industry Applications Society 44th Annual Petroleum and Chemical Industry Conference, 15-17 Sept. 1997 1997, pp. 1-9, doi: 10.1109/PCICON.1997.648162.
1029	B. Lockley, B. Wood, R. Paes, and F. DeWinter, “IEEE Std 1566 - The Need for a Large Adjustable Speed Drive Standard,” in 2006 Record of Conference Papers - IEEE Industry Applications Society 53rd Annual Petroleum and Chemical Industry Conference, 11-15 Sept. 2006 2006, pp. 1-10, doi: 10.1109/PCICON.2006.359687 (“Lockley”).

Exhibit No.	Description
1030	U.S. Patent No. 2,533,001, E. Eberhard., “Flip-Flop Counter Circuit,” (“Eberhard”) filed on April 30, 1949 and issued on December 5, 1950.
1031	C. M. Chang, “An N-P-N high power fast germanium core driver transistor,” 1957 International Electron Devices Meeting, Washington, DC, USA, 1957, pp. 114-114, doi: 10.1109/IEDM.1957.187057 (“Chang”).
1032	F. B. Golden, “Liquid Cooling of Power Thyristors,” in IEEE Transactions on Industry Applications, vol. IA-8, no. 5, pp. 601-606, Sept. 1972, doi: 10.1109/TIA.1972.349789 (“Golden”).
1033	A. H. Iversen and S. Whitaker, “A uniform temperature, ultra high heat flux liquid cooled, power semiconductor package,” Conference Record of the IEEE Industry Applications Society Annual Meeting,, San Diego, CA, USA, 1989, pp. 1340-1347 vol.2, doi: 10.1109/IAS.1989.96817 (“Iverson and Whitaker”).
1034	Hilbert, C., S. Sommerfeldt, O. Gupta, and D. J. Herrell. 1990. “High performance air cooled heat sinks for integrated circuits,” IEEE Transactions on Components, Hybrids, and Manufacturing Technology, 13: 1022-31 (“Hilbert et al.”).
1035	Hefner, A. R. 1992. “A dynamic electro-thermal model for the IGBT.” In Conference Record of the 1992 IEEE Industry Applications Society Annual Meeting, 1094-104 vol.1 (“Hefner”).
1036	Jim Bentein, “Drying Out,” Oilweek vol. 64 no. 3 (Mar. 2013).
1037	TM2500+™ Mobile Gas Turbine Generator Fact Sheet, GE Power & Water (June 25, 2014), available at: https://web.archive.org/web/20140625063653/https://www.gedistributedpower.com/
1038	Declaration of Nathaniel E. Frank-White, custodian of records for Internet Archive regarding Ex. 1037 (June 21, 2022)

Exhibit No.	Description
1039	ASME Landmark “America’s First Power Generating Gas Turbine,” available at: https://www.asme.org/wwwasmeorg/media/resourcefiles/aboutasme/who%20we%20are/engineering%20history/landmarks/100-belle-isle-gas-turbine.pdf (last accessed on Feb. 6, 2023)
1040	“GTS Admiral W.M. Callaghan,” U.S. Department of Transportation, Maritime Administration, available at: https://maritime.dot.gov/multimedia/gts-admiral-wm-callaghan (last accessed on Feb. 6, 2023)
1041	GE TM2500+ Aeroderivative Mobile Gas Turbine Brochure (July 17, 2014), available at: https://web.archive.org/web/20140717215045/https://www.gedistributedpower.com/component/cck/?task=download&file=seb_media_document&id=13183
1042	Turbomachinery Systems For Oil and Gas Applications, Solar Turbines Caterpillar Company (November 2, 2006), available at: https://web.archive.org/web/20061102043710/http://mysolar.cat.com/cda/files/127587/7/bo&g.pdf
1043	Oil and Gas Industry Packages, Generator Sets, Solar Turbines: A Caterpillar Company (March 18, 2006), available at: https://web.archive.org/web/20060318215809/http://mysolar.cat.com/cda/layout?m=36056&x=7
1044	Fast and Easy Installation for Mobile Power, Solar Mobile Turbomachinery, Solar Turbines: A Caterpillar Company, available at: https://www.solarturbines.com/en_US/solutions/oil-and-gas/solar-mobileturbomachinery.html (last accessed on Feb. 6, 2023)

Exhibit No.	Description
1045	Toshiba Low Voltage Adjustable Speed Drives, Integrated Power Services, available at: https://www.ipsrpd.com/toshibadrives.html#:~:text=Toshiba%20International%20Corporation%20entered%20the%20North%20American%20adjustable,requirements%20for%20virtually%20any%20industry%2C%20application%2C%20and%20environment (last accessed on Feb. 6, 2023)
1046	Oil & Gas, Toshiba International Corporation, available at: https://www.toshiba.com/tic/oilgas#:~:text=Toshiba%27s%20oil%20and%20gas%20product%20offerings%20are%20packaged,environments%20while%20improving%20process%20control%20and%20system%20efficiency (last accessed on Feb. 6, 2023)
1047	GX7 Low Voltage Severe Duty Specialty, Toshiba (Nov. 23, 2012), available at: https://web.archive.org/web/20101123025808/http://www.toshiba.com/ind/pr oduct_display.jsp?id1=7&id2=601
1048	IPR2021-01033, Paper 41 (P.T.A.B. Jan. 4, 2023) Final Written Decision concerning U.S. Patent No. 8,789,601
1049	U.S. Patent No. 8,789,601, Broussard et al., “System for Pumping Hydraulic Fracturing Fluid Using Electric Pumps,” (“the ’601 Patent”) filed on February 26, 2014 and issued on July 29, 2014.
1050	Declaration of Robert Schaaf from U.S. Well Services, LLC v. Tops Well Services, LLC et al., No. 3:19-cv-00237, Dkt. 72-9 (S.D. Tex. Apr. 24, 2020)
1051	Deposition Transcript of Robert Schaaf taken in IPR2021-01033 (July 1, 2022)
1052	Deposition Transcript of Robert Schaaf taken in IPR2021-01032, -01034, -01036, -01038 (June 29, 2022)

Exhibit No.	Description
1053	Halliburton Energy Services, Inc., et al. v. U.S. Well Services, LLC, No. 6:22- cv-00906-ADA-DTG, Dkt. 50 (Feb. 8, 2023) (Joint Motion to Extend Scheduling Deadlines)
2001	Excerpt from Webster’s New World College Dictionary, 5 th ed. (2016)
2003	Deposition of Dr. Robert Durham
2004	Curriculum Vitae of Dr. Michael Nikolaou

3. In forming my opinions expressed below, I have considered the documents listed immediately above and my knowledge and experience based on my work in this area as described below.

4. The earliest application that resulted in the issuance of the ’870 patent was filed on November 16, 2012. EX-1001, Cover. I am familiar with the technology at issue and am aware of the state of the art around this time. It is my opinion that, as of November 16, 2012, a person of ordinary skill in the art (“POSITA”) pertinent to the subject matter of the ’870 patent would have had at least (1) a bachelor of science in mechanical engineering, electrical engineering, petroleum engineering or an equivalent field and at least two years of academic or industry experience in the oil and gas industry, including well drilling, completion, or production; or (2) at least four years of industry experience in the oil and gas industry, including well drilling, completion, or production. Further, it is my opinion that someone with additional

education but less professional experience, and vice versa, may qualify as a POSITA. Based on this description, I qualified as a POSITA as of November 16, 2012. My analysis and opinions below are given from the perspective of a POSITA in this technological field in the relevant time frame, unless stated otherwise.

II. QUALIFICATIONS AND COMPENSATION

5. I am a Professor and Associate Chair of Chemical and Biomolecular Engineering in the Cullen College of Engineering at the University of Houston.

6. I graduated with a diploma in chemical engineering from the National Technical University in Athens, Greece in 1984. I then earned a Ph.D. in chemical engineering at the University of California, Los Angeles in 1989. Prior to coming to the University of Houston, I was an Assistant (and then Associate) Professor at Texas A&M University for eight years. After my promotion to Associate Professor and tenure at Texas A&M, I took a sabbatical leave as a Visiting Scientist at MIT. I have taught at the University of Houston for over 20 years.

7. In my role as a professor at the University of Houston I teach both undergraduate and graduate courses every year. At the undergraduate level, these courses include Analytical Methods for Chemical Engineers, Numerical Methods for Chemical Engineers, Plant Economics, Plant Design, Thermodynamics, Statistical Methods in Chemical Engineering, Statistical Quality Control Methods, and Chemical Process Control. At the graduate level, I teach Mathematical Methods

in Chemical Engineering, Advanced Process Control, and Natural Gas Engineering. I also routinely advise both undergraduate and graduate (master and Ph.D.) students.

8. I have extensive experience in process systems engineering and mathematical modeling. My research interests are in computer-aided systems engineering, i.e., development and use of computer-based methods for the design, optimization, monitoring, and automatic control of various kinds of systems, in a diverse array of industries, including the oil and gas industry.

9. In my 30 years of academic and industrial consulting experience I have worked on problems in several industries, including the oil and gas industry and oil refining and petrochemicals. Much of my work tackles fundamental research issues and is described in a number of publications, as discussed below. A substantial portion of my work is directed to concrete solutions to problems faced by industrial partners and has resulted in specific commercial products (e.g., for Lam Research, <https://www.lamresearch.com/>), patents, and the formation (by the corresponding project's managers) of a small company that was eventually bought by Schlumberger, a major global oilfield services company (http://www.slb.com/services/drilling/drilling_services_systems/directional_drilling/slider.aspx).

10. In addition to teaching, I have also served as a consultant for various oil and gas companies over the past 27 years, working with both major companies

and smaller, independent companies, both “upstream” (i.e., oil and gas exploration and production) and “downstream” (oil and gas transportation, oil refining, and chemicals). I have consulted on a variety of matters for ENI, Schlumberger, WildHorse / RotoSlide, Synergy Fluid Services, XGas/EPT, IQPC Oil & Gas, Intelligent Agents Corporation, Landmark, ECOPETROL, Lam Research, Shell Global Solutions, Noble Drilling, AspenTech, General Electric, Simulation Sciences, Bryan Research & Engineering, Frito-Lay, Shell Development, and Union Pacific Resources.

11. I have published over 150 peer-reviewed publications in journals and conference proceedings in the area of computer-aided systems engineering. My publications focus on applications to the design, optimization, monitoring, and automatic control of various kinds of systems, in oil and gas, oil refining and petrochemicals, snack food production, semiconductor manufacturing, and development and administration of antibiotics against resistant infections. Three of my refereed journal publications have been featured on the cover of high-impact journals (*AIChE Journal*, 2011; *IEEE Control Systems Magazine*, 2006; *PLoS Computational Biology*, 2011).

12. I have also presented my work as a speaker at numerous academic conferences, whether in regular sessions, invited sessions, or as a keynote speaker. As an example, I have been invited twice (in 1996 and 2011) to give presentations

in the flagship conference on Chemical Process Control, held every five years (CPC-V and CPC-VIII), and was a keynote speaker at the 2017 International Petroleum & Petrochemical Technology Conference (IPPTC) in Beijing, China. I have also published five book chapters on various aspects of computer-aided systems engineering. Finally, I serve regularly as a peer reviewer at several major engineering and scientific journals (including *Automatica*, *PLoS*, *AIChE Journal*, *SPE Journal*, *Journal of Process Control*, *Computers & Chemical Engineering*) as well as at federal and international funding agencies, including National Science Foundation (NSF), Petroleum Research Fund (PRF), National Institutes of Health (NIH), and the Qatar National Research Fund (QNRF).

13. I am a member of the American Institute of Chemical Engineers, the Society of Petroleum Engineers, and Omega Chi Epsilon. I serve as a co-organizer or co-chair of several major international conferences, including the AIChE Annual Meeting and the AIChE Spring Meeting.

14. I have received numerous teaching awards from both Texas A&M and University of Houston, including the Dow Excellence in Teaching Award, and the Cullen College of Engineering Teaching Award. I have also been named a Top Reviewer by *Automatica*, and, in 2007, I received the Computing & Systems Technology (CAST) Directors Award from the American Institute of Chemical Engineering. In 2017, I received the Abraham E. Dukler Distinguished Engineering

Faculty Award at the University of Houston, which is given to a faculty that has made significant contributions to society and whose accomplishments and careers have brought credit to the University of Houston Cullen College of Engineering. In 2019, I received the Fluor Corp. Faculty Excellence Award at the Cullen College of Engineering. This award is the highest distinction bestowed to faculty of this college.

15. My curriculum vitae, which includes a complete list of my publications, is included as EX-2004.

16. I have previously given testimony in the following cases:

a) *Eurecat United States, Inc. v. Soren Marklund, Douglas Wene, and Chem 32 LLC*, Trial Ct. Cause No. 2012-5700, Harris Cty. Ct. (Tex.).

b) *TDE Petroleum Data Solutions, Inc. v. AKM Enterprise, Inc. DBA Mobilize, Inc.*, Case No. 4:15-cv-01821 (S.D. TEX-2015).

c) *Arrona et al. v. Bluestone Natural Resources, LLC*, Case No. 4:15-cv-02680 (S.D. TEX-2017).

d) *Sunoco Partners Marketing & Terminals L.P. v. Powder Springs Logistics, LLC, et al.*, Case No. 1:17-cv-01390 (D. Del. 2017).

e) *Magellan Midstream Partners L.P. v. Sunoco Partners Marketing & Terminals*, Case No. IPR2019-00024 (U.S. Patent No. 9,494,948).

f) *Magellan Midstream Partners L.P. v. Sunoco Partners Marketing & Terminals*, Case No. IPR2019-00025 (U.S. Patent No. 9,606,548).

17. I am being compensated in this matter at my standard consulting hourly rate of \$700 per hour. My compensation is not dependent on the substance of my statements in this declaration.

18. I am over the age of 18 and am competent to write this declaration. I have personal knowledge, or have developed knowledge, of the technologies discussed in this declaration based upon my education, training, or experience with the matters discussed herein. It is my opinion that, in accordance with the above, I am qualified to provide opinions from the perspective of a POSITA.

III. RELEVANT LEGAL STANDARDS

A. Obviousness

19. I understand that obviousness is analyzed from the perspective of a POSITA at the time of the alleged invention. I also understand that a POSITA is presumed to have been aware of all pertinent prior art at the time of the alleged invention.

20. I understand that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention as a whole would have been obvious to a POSITA in view of the prior art and in light of the general knowledge of the art at the time the invention was made. I also understand that the invention may be deemed obvious when a POSITA would have reached the claimed invention through routine experimentation.

21. I understand that obviousness can be established by combining or modifying the disclosures of the prior art to achieve the claimed invention. It is also my understanding that where there is a reason to modify or combine the prior art to achieve the claimed invention, there must also be a reasonable expectation of success in so doing to render the claimed invention obvious. I understand that the reason to combine prior art references can come from a variety of sources, not just the prior art itself or the specific problem the patentee was trying to solve. I also understand that the references themselves need not provide a specific hint or suggestion of the alteration needed to arrive at the claimed invention; the analysis may include recourse to logic, judgment, and common sense available to a POSITA.

22. I understand that when there is some recognized reason to solve a problem, and there are a finite number of identified, predictable solutions, a POSITA has good reason to pursue the known options within his or her technical grasp. If such an approach leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense. In such a circumstance, when a patent simply arranges old elements with each performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, the combination is obvious.

23. I understand that when considering the obviousness of an invention, one should also consider whether there are any objective indicia that support the

non-obviousness of the invention. I further understand that objective indicia of non-obviousness, also known as “secondary considerations,” include failure of others, copying, unexpected results, information that “teaches away” from the claimed subject matter, perception in the industry, commercial success, and long-felt but unmet need. I also understand that for objective indicia of non-obviousness to be applicable, the indicia must have some sort of nexus to the subject matter in the claim that was not known in the art. I understand that this nexus includes a factual connection between the patentable subject matter of the claim and the objective indicia alleged. I also understand that an independently made invention that is made within a comparatively short period is evidence that the claimed invention was the product of ordinary skill.

24. Finally, I understand that patent examiners at the U.S. Patent and Trademark Office (“PTO”) rely upon certain exemplary rationales in reviewing patent applications to understand whether the subject matter of the claims is obvious. I understand that the following is the list of exemplary rationales relied upon by patent examiners at the PTO: (i) combining prior art elements according to known methods to yield predictable results; (ii) simple substitution of one known element for another to obtain predictable results; (iii) use of a known technique to improve similar devices (methods, or products) in the same way; (iv) applying a known technique to a known device (method, or product) ready for improvement to yield

predictable results; (v) “obvious to try”—choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and (vi) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art.

B. Construing the Meaning of Claim Terms

25. I understand that a inter partes review (“IPR”) is a proceeding before the PTO for evaluating the validity of issued patent claims. I understand that, in a IPR, a claim term is interpreted in a manner consistent with the standard used in patent litigation, as set forth in a case known as *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). That standard generally construes the claims according to their “ordinary and customary” meaning in view of the claim language, specification, file history, and, where applicable, relevant other evidence.

26. I understand that a patent’s “specification” includes all the figures, written descriptions, and claims within the patent. I understand that the PTO will look to the specification and prosecution history to see if there is a definition for a given claim term and, if not, will apply the ordinary and customary meaning from the perspective of a POSITA at the time in which the alleged invention was made.

27. As discussed above and detailed in my curriculum vitae, I was very familiar with hydraulic fracturing processes at both the individual well and oil-field

level, as well as control systems for such processes and well treatment methods, technologies and was aware of the state of the art as of the earliest claimed priority date of the '870 patent. I believe that I would qualify as understanding the knowledge and skill of a POSITA as of November 16, 2012, and I have a sufficient level of knowledge, experience, and expertise to provide an expert opinion in the field of the '870 patent.

IV. BACKGROUND OF THE TECHNOLOGY

28. The following paragraphs regarding hydraulic fracturing are based on the '870 patent. For purposes of this declaration, I have been asked to assume that the earliest priority date of the '870 patent is November 16, 2012.

29. The '870 Patent regards hydraulic fracturing of underground formations in an oil or gas well to extract oil or gas from the formation. EX-1001, Abstract. In particular, this technology related to pumping fracturing fluid into an oil or gas well using pumps powered by electric motors. *Id.*, 1:23–26.

30. In hydraulic fracturing operations, fracture fluid is pumped into a wellbore at very high pressure. *Id.*, 1:39–40. Typically, this pumping is performed by large diesel-powered pumps. *Id.*, 1:40–42. Diesel-powered pumps can pump fracturing fluid into a wellbore at a high enough pressure to crack a formation, but have drawbacks including being very heavy, requiring heavy duty trailers for transport thus making their use expensive and inefficient, requiring a relatively high

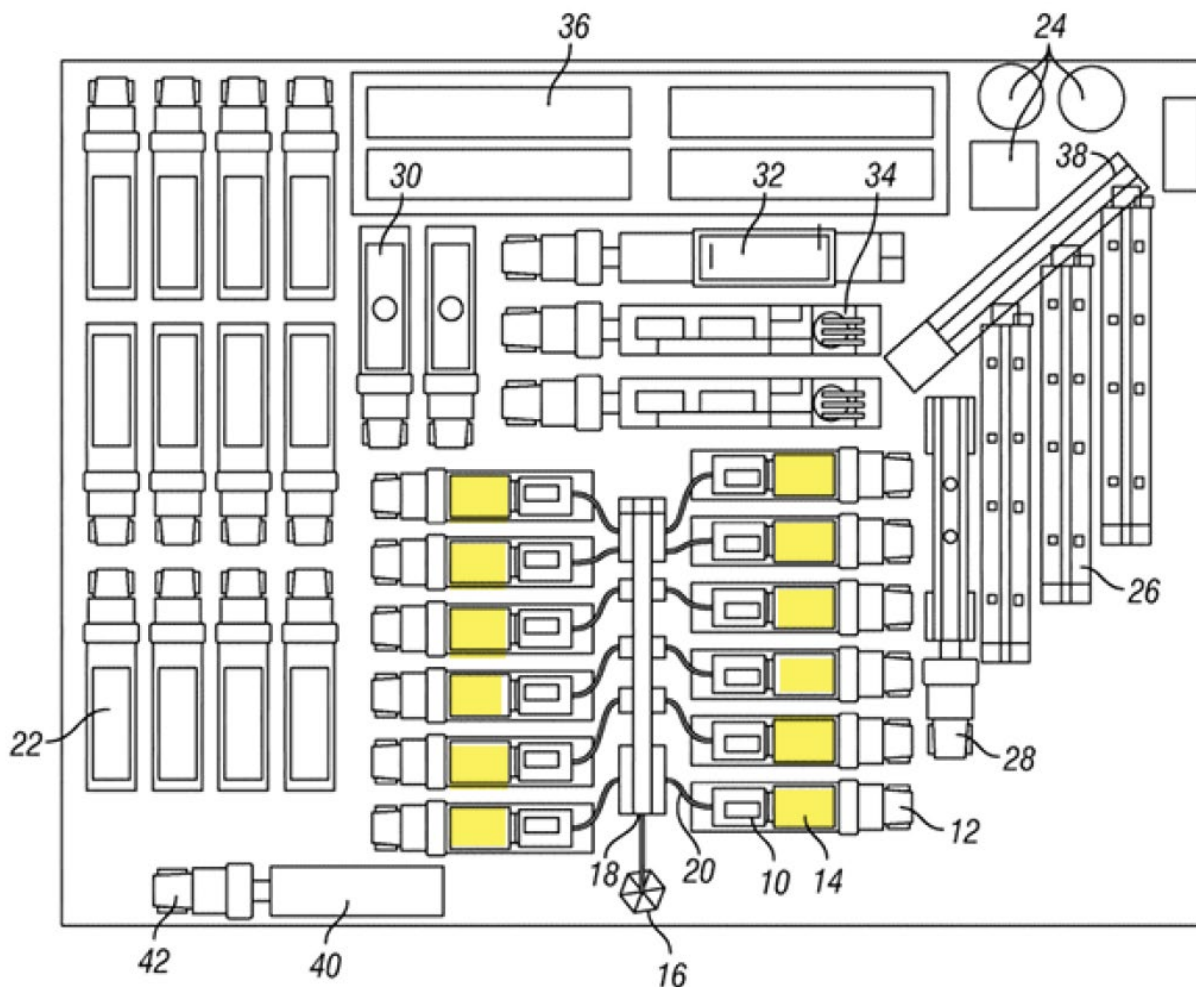
level of expensive maintenance, and having an increasing operational cost as the cost of diesel fuel is much higher than in the past. *Id.*, 1:42–51. There has been a need in the industry for a pump system with hydraulic fracturing fluid that overcomes the problems associated with diesel pumps. *Id.*, 1:52–54.

V. U.S. PATENT NO. 7,931,870

31. In this Section, I consider the disclosure in the '870 patent along with relevant information from the prosecution history of the '870 patent.

A. Background

32. To overcome these problems in the background technology, the '870 patent discloses a fracturing system and method that uses electric motors controlled by a variable frequency drive. EX-1001, 1:62–2:8. Figure 1 depicts an exemplary system and method using electric motors 14 (in yellow) equipped with variable frequency drive (not shown) below:



EX-1001, Fig. 1 (annotated); 3:59–62 (“In addition, each electric motor 14 can be equipped with a variable frequency drive (VFD), and an A/C console, that controls the speed of the electric motor 14, and hence the speed of the pump 10.”). The ’870 patent further explains that the variable frequency drive also “frequently perform[s] electric motor diagnostics to prevent damage to the electric motor if it becomes grounded or shorted.” *Id.*, 2:36–39. The challenged patent also explains that a variable frequency drive may include “power semiconductor heat sinks having one

or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat.” *Id.*, 2:39–42.

B. The Prosecution History

33. The Examiner allowed the challenged claims over the prior art of record because the claims recited one of two novel features: (i) “wherein the variable frequency drive performs electric motor diagnostics to prevent damage to the one or more electric motors,” or (ii) “wherein the variable frequency drive has one or more power semiconductor heat sinks having thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.” See EX-1003, 94 (stating dependent claims 3, 9, and 18 that recited one of these two features would “be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.”); *id.*, 168–70 (showing dependent claims 3, 9, and 18). It is my understanding that Petitioner does not dispute that the examiner found these two limitations were key to allowing the challenged claims to issue over the cited prior art. Pet. at 6 (“Based on the above, the point of purported novelty of independent claims 1, 4, and 7 of the ’870 Patent lies in the variable frequency drive (“VFD”) performing [electric motor] diagnostics and heat sinks having thermal sensors to prevent damage to the motor.”)

C. The Challenged Claims

34. I understand that for purposes of this proceeding, Petitioner is challenging the validity of claims 1–16 of the '870 patent.

35. Claim 1 of the '870 patent is shown below:

1. A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

a trailer for attachment to a truck;

two or more pumps attached to the trailer and fluidly connected to the well, the pumps configured to pump fluid into the wellbore;

one or more electric motors attached to the pumps to drive the pumps, the electric motors attached to the trailer; and

a variable frequency drive connected to the electric motor to control the speed of the motor, **wherein the variable frequency drive performs electric motor diagnostics to prevent damage to the one or more electric motors.**

EX-1001, 7:45–60 (emphasis added). The claims depending from claim 1 add further limitations including a skid to which at least one of the pumps and the one or more electric motors are attached (claim 2) and a natural gas powered generator for connection to the electric motor that provides electric power to the electric motor (claim 3). *Id.*, 8:1–7.

36. Claim 4 of the challenged patent is shown below:

4. A method of hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the method comprising:

pumping fluid into the wellbore using hydraulic fracturing pumps;

powering the hydraulic fracturing pumps using an electric motor; and

controlling the speed of the motor using a variable frequency drive, **wherein the variable frequency drive performs electric motor diagnostics to prevent damage to the electric motor.**

EX-1001, 8:8–20 (emphasis added). Dependent claim 5 adds the further limitation of powering the electric motor using a generator, and claim 6, which depends from claim 5, adds the further limitation that the generator of claim 5 be powered using natural gas. *Id.*, 8:21–24.

37. Claim 7 of the challenged patent is shown below:

7. A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

a pump fluidly connected to the well; and an electric motor to power the pump;

the pump configured to pump fluid into the wellbore; and

a variable frequency drive connected to the electric motor to control the speed of the motor and having **one or more power semiconductor heat sinks having thermal**

sensors monitored by a microprocessor to prevent damage caused by excessive heat.

EX-1001, 8:25–37 (emphasis added).

VI. CLAIM CONSTRUCTION

38. I agree with Patent Owner proposed construction: “*electric motor diagnostics*” means “diagnostics for the electric motor alone.” See EX-2001, Webster’s New World College Dictionary, 5th ed. (2016) at 406 (“diagnostic. . . 3. Comput. a routine for testing a piece of hardware or for locating an error in a program”).

39. When asked about this term at his deposition, Dr. Durham explained:

Q: The terms electric motor in front of diagnostic,. . .
how does that limit the claim?

A: It limits by saying the variable[] frequency drive has
to perform a diagnostics or analysis on the electric motor
detecting a problem with the electric motor at least.

EX-2003, 35:10-15. I agree with Dr. Durham that the diagnostics are limited by the qualifier “electric motor.” Without limiting the errors, failures, or performance issue to the motor, a POSITA would effectively give the prefix “electric motor” no meaning in “electric motor diagnostics.” Thus, a POSITA would have understood that the claimed “diagnostics” in the '870 must be for the electric motor alone.

40. For purposes of this declaration, I will apply the plain and ordinary meaning for every term to all terms. However, I reserve the right to supplement my

opinions if Petitioner offers a construction of any term in the '870 patent, or if the Board decides to apply a construction of any term in the '870 patent.

VII. ASSERTED PRIOR ART

A. Toshiba Manual (EX-1006)

41. *Toshiba Manual* is an operation manual for a G7 True Torque control Adjustable Speed Drive (“ASD”), EX-1006, 1–2. I understand that, and agree with, Petitioner that the Toshiba Manual’s ASD is a variable frequency drive. Toshiba’s ASD is a “solid-state AC drive” and uses a “Vector Control Algorithm [that] enables the motor to develop high starting torque and provide compensation for motor slip.” *Id.*, 2. The G7 also includes a “user-friendly Electronic Operator Interface (EOI)” to access “many monitoring and programming features of the G7.” *Id.*

42. These monitoring features include alarms and ASD fault codes displayed on the EOI during the operation of the G7 ASD. See EX-1006, 180–86. Alarms for the ASD include, for example, communication errors (*id.*, 180), overheat (*id.*), and timer (*id.*). *Toshiba Manual* lists 46 fault codes for the ASD that occur for various reasons, such as “CPU Fault” (*id.*, 183), “RAM” or “ROM Fault[s]” (*id.*, 185), ASD Overload (*id.*, 182) and “communication error” (*id.*). As I explain further below, none of the fault codes or alarms disclosed in *Toshiba Manual* satisfy the claimed “*electric motor diagnostics*.”

43. For example, one such alarm code is “overheat” (*id.*, 180), which is triggered whenever the “**ASD ambient temperature** is excessive.” *Id.* (emphasis added). Notably, this alarm code refers to when the VFD is overheating—not the electric motor. *Toshiba Manual* explains that this alarm code may be triggered for five various reasons, such as when the “[c]ooling fan is inoperative” or when the “[i]nternal thermistor is disconnected.” *Id.* To help dissipate heat, *Toshiba Manual*’s G7 ASD also includes a heat sink. *Id.*, 14 (“heat sink and other components may become extremely hot to touch”); 204 (“cooling capacity of the heatsink”). Although *Toshiba Manual* includes both a heat sink and thermistor (i.e., temperature sensor), nothing in *Toshiba Manual* (EX-1006) describes that the thermistor is located on the heat sink as the claims require—that is, “heat sinks having thermal sensors.”

B. *Coli* (EX-1005)

44. *Coli* relates to hydraulic fracturing in hydrocarbon-bearing wells. EX-1005, [0003]. *Coli* recognizes drawbacks of the diesel motors typically used in such drilling. *Id.*, [0005]; [0008]. *Coli* purports to improve upon known fracturing systems by using electric motors and generators powered by natural gas to drive the pumps. *Id.*, [0009]–[0011]; [0038]. *Coli* purports that this use of electric components beneficially reduces the amount of infrastructure, makes control safer and easier, facilitates syncing the equipment within the system, and reduces costs. *Id.*, [0039]; [0066]; [0071]; [0073].

45. Figure 3 is a schematic plan view of *Coli's* fracturing trailer and is reproduced below.

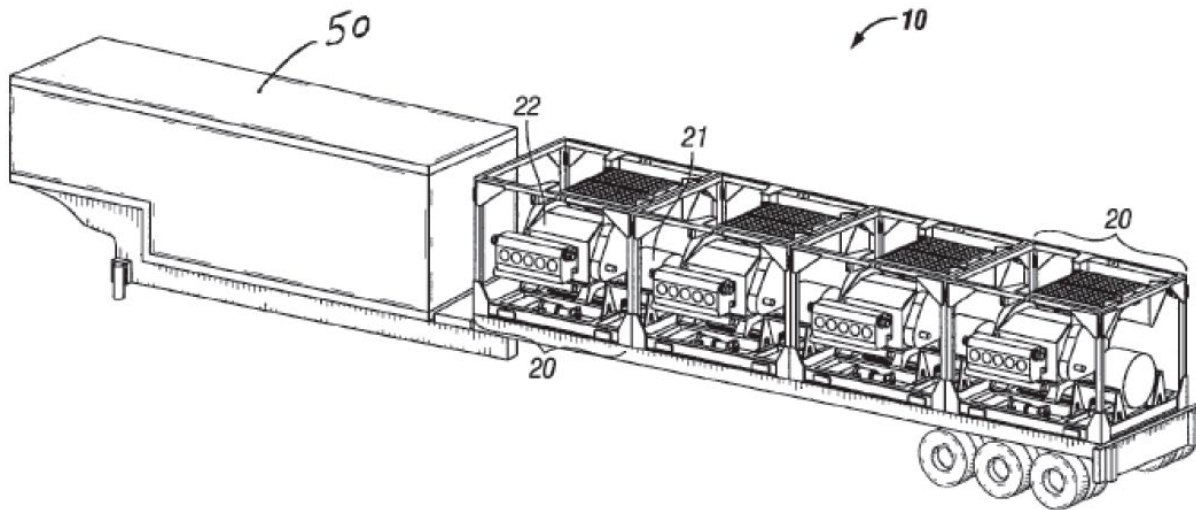


FIG. 3

Figure 3 is a schematic diagram of trailer 10 housing four fracturing modules 20. EX-1005, [0040]. Each fracturing module 20 includes electric motor 21 coupled directly to fluid pump 22. *Id.*, [0040]; [0052]. The trailer housing also includes an electrical transformer and drive unit 50 to step down the power voltage from turbine generator 30 (not shown) to electric motor 21. *Id.*, [0047]. The “[f]racturing modules 20 utilize electric power from turbine generator 30 to pump the fracturing fluid directly to the wellbore.” *Id.*, [0040]. I understand that, and agree with, Petitioner takes the position that *Coli's* drive unit 50 does not perform “electric motor diagnostics” or includes “heat sinks having thermal sensors.”

C. *Horikoshi* (EX-1008)

46. *Horikoshi* “relates to a motor driving apparatus having a fault diagnostic function.” EX-1008, [0002]. *Horikoshi* recognizes that typical driving apparatus include a DC/AC converter having only two current sensors to reduce cost, resulting in circumstances where an overcurrent due to a ground fault cannot be detected and, if an overcurrent is detected, it cannot be determined whether the cause is a ground fault or a short circuit. *Id.*, [0004]–[0005]. *Horikoshi* purports to improve upon known driving apparatus by including a fault diagnostic function capable of detecting a ground fault and a short circuit. EX-1008, [0011]. The motor driving apparatus includes an AC/DC converter that converts supplied three-phase AC power into DC power output into a DC/AC converter that converts the DC power into frequency-variable three-phase AC power. *Id.*, [0027]. The driving apparatus includes a zero-phase current detector at the supply input of the AC/DC converter and current sensors to detect two of the three-phase AC currents output from the DC/AC converter. *Id.*, [0028]. A determining unit uses signals input from these components to determine whether a detected overcurrent is a short circuit or a ground fault. *Id.*, [0029]. *Horikoshi* discloses only one electric motor diagnostic, not multiple “electric motor diagnostics” required by the claims. Nor does *Horikoshi* expressly disclose a variable frequency drive used in hydraulic fracturing, let alone one that includes “*heat sinks having thermal sensors.*”

D. Loucks (EX-1009)

47. *Loucks* is related to measuring changes in cooling performance for server IT equipment. See EX-1009, Fig. 1; Abstract. Figure 1 of Loucks depicts the cooling operation in an equipment room in a typical data center 100:

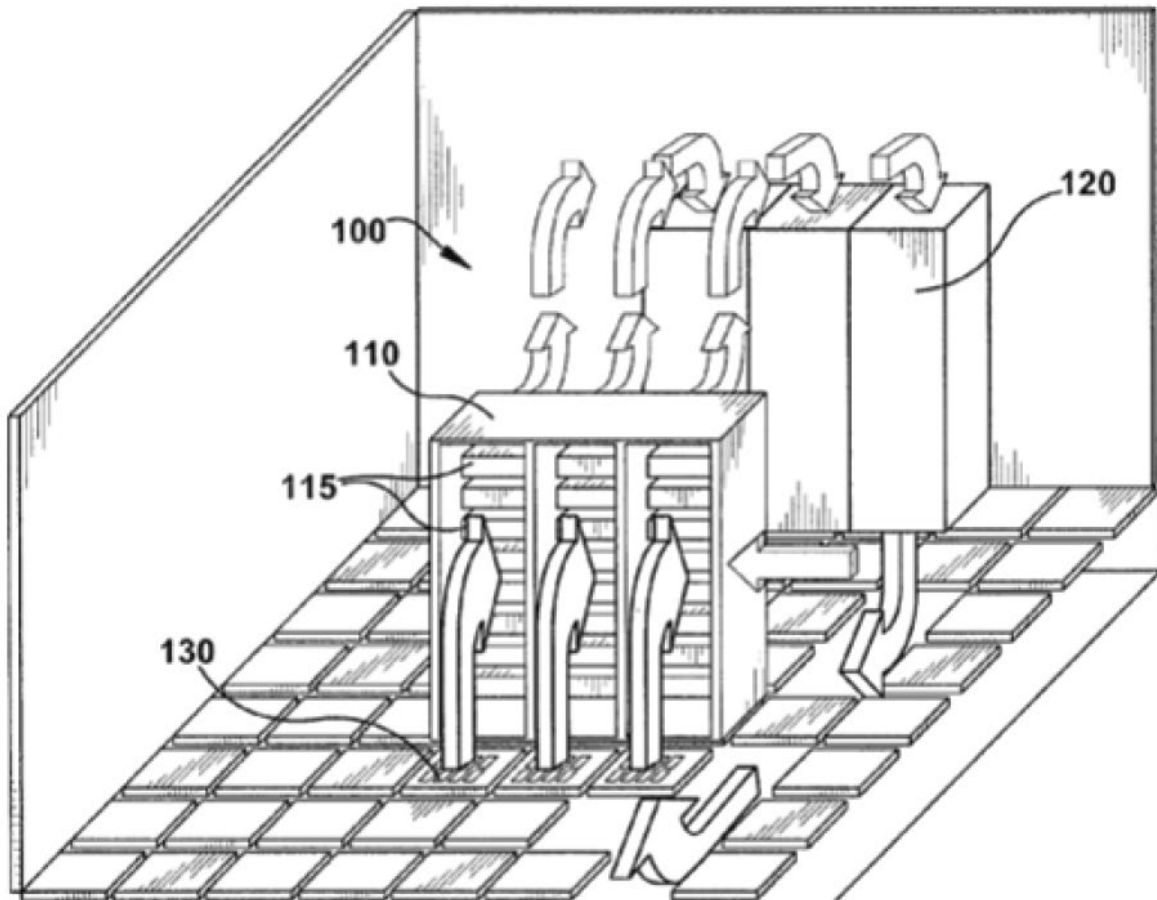


Fig. 1

EX-1009, Fig. 1; [0025] (“data center 100 houses multiple racks or enclosures 110 of IT equipment 115, such as servers, routers, switches, and circuit protection devices.”) As shown above, “[a] computer room air conditioner 120 intakes heated

air from the room, cools it, and circulates the cooled air through the room as shown by the arrows.” *Id.* *Loucks* discloses a method for monitoring the “operating cooling efficiency” of such equipment based on “a ratio between equipment electrical power consumption and a temperature differential between the equipment and an ambient temperature.” EX-1009, Abstract. *Loucks* briefly mentions “a variable frequency drive,” but those drives have many different uses beyond those for an electric pump motor. *Loucks* discloses neither “electric motor diagnostics” nor a variable frequency drive including a “heat sink having thermal sensors,” as I explain further below.

E. *Vliet* (EX-1010)

48. *Vliet* discloses a fuel-delivery system for use in a fracturing operation that is portable and transportable to various well sites. EX-1010, [0014]. For example, the fuel delivery system may be contained on a single wheeled or skidded trailer. *Id.* I understand that Petitioner does not, however, contend that *Vliet* discloses a variable frequency drive that performs “electric motor diagnostics” or includes “heat sinks having thermal sensors.”

F. *Gardner* (EX-1011)

49. *Gardner* is an operating and service manual published by *Gardner* Denver. EX-1011, 1. The manual is for a well servicing pump, model GD-2500Q Quintuplex. *Id.* The GD-2500Q is a quintuplex pump with a stroke length of 8.0

inches and a variety of plunger diameters, including 4.5 inches. *Id.*, 20. The GD-2500Q has an input power of 2200 or 2500 bhp and a rated brake horsepower of 2500 bhp. *Id.* But the Petition does not contend that *Gardner* discloses a VFD that performs “electric motor diagnostics” or includes “heat sinks having thermal sensors.”

VIII. A POSITA WOULD NOT HAVE FOUND THE CLAIMS OBVIOUS FOR THE REASONS DISCUSSED IN THE PETITION

A. *Toshiba Manual*’s faults do not satisfy the claimed “electric motor diagnostics”

50. I understand that Dr. Durham maps *Toshiba Manual*’s variable frequency drive faults to the “*electric motor diagnostics*.” These faults are not “diagnostics” for an “electric motor.” I disagree that those faults alone can satisfy electric motor diagnostics.

1. The claims and specification shows the claimed “*diagnostics*” must be for the “*electric motor*,” not the “*variable frequency drive*”

51. Challenged independent claims 1 and 4 require a “variable frequency drive [that] performs electric motor diagnostics.” EX-1001, claims 1 and 4. The claims and specification show that the electric motor and variable frequency drive are separate and distinct components of the claimed hydraulic fracturing system. Both the specification and claims are clear that the claimed “diagnostics” must be for the claimed “electric motor,” not the “variable frequency drive.”

52. The claims recite the “electric motor” and “variable frequency drive” as different components of the claimed system. Claim 1, for example, recites that the variable frequency drive is connected to the “electric motor,” showing that the claimed VFD and electric motor cannot be the same:

1. A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

. . . **one or more electric motors** ... and

a variable frequency drive connected to the electric motor to control the speed of the motor, wherein the variable frequency drive performs electric motor diagnostics to prevent damage to the one or more electric motors.

EX-1001, Claim 1 (emphases added); see *Id.*, Claim 4 (also separately requiring an “electric motor” and a “variable frequency drive”). The claims also require that these components perform different functions—that is, the “electric motor” powers the claimed “pumps,” whereas the “variable frequency drive” “control[s] the speed” of the “electric motor.” EX-1001, claim 1; claim 4. Based on the claim language alone, the “electric motor” and “variable frequency drive” must be different claim components.

53. Claims 1 and 4 further require that the claimed “diagnostics” are for the “electric motor”—not the “variable frequency drive.” These independent claims specifically recite “electric motor diagnostics.” EX-1001, claim 1 (“wherein the

variable frequency drive performs electric motor diagnostics to prevent damage to the one or more electric motors”); claim 4 (“wherein the variable frequency drive performs electric motor diagnostics to prevent damage to the electric motor.”) (emphasis added). Notably, neither claim recites diagnostics (or faults) for the system generally or specifically for the variable frequency drive. Claims 1 and 4 further require that the claimed diagnostics are used “to prevent damage to the one or more electric motors,” which confirms that the diagnostics must be for the “electric motor” and not the “variable frequency drive.” Accordingly, the plain reading of the claim requires that the claimed “diagnostics” are for “electric motor” alone.

54. Moreover, the ’870 patent specification distinguishes “electric motor diagnostics” from other system faults. The specification recites both electric motor diagnostics along with VFD and general fault indicators, but does not equate the diagnostics and faults. EX-1001, 2:36–39 (“In another embodiment, variable frequency drive can frequently perform electric motor diagnostics to prevent damage to the electric motor if it becomes grounded or shorted.”); *Id.*, 5:42–46 (“Other pump control and data monitoring equipment can include pump throttles, a **pump VFD fault indicator** with a reset, a **general fault** indicator with a reset, a main estop, a programmable logic controller for local control, and a graphics panel.”) (emphases added). By not saying the claimed electric motor diagnostics with other system faults

are the same, a POSITA would have understood that the claimed “electric motor diagnostics” in the ’870 patent must be different from faults related to other system components (e.g., system faults or VFD faults) expressly mentioned in the specification.

55. For the above reasons, a POSITA would have understood that both the claims and specification are clear in describing the claimed “diagnostics” must be for the claimed “electric motor” and not for “variable frequency drive.”

2. *Toshiba Manual’s* VFD fault conditions represent errors in the VFD

56. *Toshiba Manual’s* VFD faults cannot satisfy the claimed “diagnostics” for an “electric motor,” especially under the plain and ordinary meaning or construction “diagnostics for the electric motor alone.”

57. Dr. Durham listed the following exemplary faults as satisfying the claimed “electric motor diagnostics” without explanation:

Toshiba Manual discloses numerous examples of electric motor diagnostics. Toshiba Manual expressly discloses that the Electronic Operator Interface (EOI) (a touchscreen interface, shown in green above) “may be used to monitor system functions, input data into the system, or perform diagnostics.” Ex. 1006 at 43. The diagnostics includes a “fault screen” that “identifies the active Fault.” Ex. 1006 at 182–186 (Table 12, containing a list of 5 pages of faults that are diagnosed). Examples of motor diagnostics used to protect the connected motor disclosed in Toshiba Manual include:

- Overload protection (Ex. 1006 at 19)
- Over-current protection (Ex. 1006 at 22)
- Electronic Thermal Protection (Ex. 1006 at 160)
- Overcurrent Stall Level (Ex. 1006 at 160)
- Motor 150% OL Time Limit (Ex. 1006 at 161)
- Short Circuit Test (Ex. 1006 at 162)
- Over-torque trip (Ex. 1006 at 163)
- Earth Fault Trip (Ex. 1006 at 166)

These diagnostic functions result in an alarm or trip condition on the ASD.

EX-1002, ¶117, *id.*, ¶166 (“*Toshiba Manual* further discloses a variable frequency drive that performs electric motor diagnostics to prevent damage to the electric motor, including protecting against overload, overcurrent, overtorque, short circuit, and earth faults.”). I disagree that these faults alone satisfy the claimed “*electric motor diagnostics*.” I also note that Dr. Durham provided no additional explanation of how each of these faults would satisfy the claimed “electric motor diagnostics.”

58. *Toshiba Manual*’s VFD fault conditions, listed above, represent faults in the VFD—not the electric motor. Consequently, *Toshiba Manual*’s VFD fault conditions cannot satisfy “electric motor diagnostics” as these fault conditions are

for a claim limitation different from the electric motor—that is, the “variable frequency drive.” *See* EX-1001, claim 1 (reciting the “variable frequency drive” and “electric motor” as separate and distinct components). Moreover, and as I explained above, the intrinsic evidence distinguishes VFD faults from electric motor diagnostics and does not equate them. EX-1001, 2:36–39; 5:42–46. Fault conditions merely represent that an error condition occurred. The claimed “diagnostics,” in contrast, determine the underlying cause of the problem or error to prevent damage to a motor. EX-1001, 4:20–23 (“motor diagnostics can be performed frequently (e.g., on the application of power, or with each start) to prevent damage to a grounded or shorted electric motor.”). This understanding is consistent with the proposed construction for “electric motor diagnostics”: diagnostics for the electric motor alone.” Based on the claims and specification of the ’870 patent, a POSITA would have understood that *Toshiba Manual’s* VFD faults cannot satisfy the claimed “electric motor diagnostics.”

59. Further, the VFD faults identified by Dr. Durham as satisfying “electric motor diagnostics” have another problem. These faults have possible causes (emphasized below) unrelated to an electric motor:

Fault Screen Display	Possible Causes [of Fault]
Overload (EX-1006, 184)	• V/f setting needs to be adjusted. • Motor is locked. • <i>Continuous operation at low speed.</i> • Load requirement exceeds ability of the motor. • <i>Startup frequency setting adjustment required.</i>
Overcurrent (EX-1006, 184)	• V/f setting needs to be adjusted. • Restart from a momentary power outage. • The ASD is starting into a rotating motor. • ASD/Motor not properly matched. • Phase-to-phase short (U, V, or W). • <i>Accel time too short.</i> • <i>Voltage Boost setting is too high.</i> • Motor/machine jammed. • <i>Mechanical brake engaged while the ASD is running.</i> • <i>ASD current exceeds 340% of the rated FLA on ASDs that are 100 HP or less during acceleration. On ASDs that are greater than 100 HP, this fault occurs when the ASD current exceeds 320% of the rated FLA during acceleration.</i> • <i>Deceleration time is too short.</i> • Load fluctuations. • <i>ASD is operating at an elevated temperature.</i>
Overtorque (EX-1006, 185)	• A torque requirement by the load in excess of the setting of F616 or F617 for a time longer than the setting of F618. • <i>The ASD is improperly matched to the application.</i> • <i>The load is obstructed.</i>

Fault Screen Display	Possible Causes [of Fault]
Short Circuit (EX-1006, 186)	• <i>Low impedance at the U lead of the ASD output.</i> • <i>Low impedance at the V lead of the ASD output.</i> • <i>Low impedance at the W lead of the ASD output.</i>
Earth Faults (EX-1006, 186)	• Ground fault at the motor. • <i>Ground fault at the output of the ASD.</i> • <i>Current leakage to Earth Ground.</i>

Given that these faults have causes unrelated to the electric motor, they do show that these faults are “diagnostics” for the “electric motor” alone. Because Dr. Durham failed to provide any explanation about how any of Toshiba’s VFD faults operate, he has failed to show that the above VFD faults satisfy performing the claimed “electric motor diagnostics,” especially given that these faults can occur without any problem with the electric motor.

60. For the above reasons, the *Toshiba Manual’s* VFD faults satisfy the claimed “electrical motor diagnostic.”

B. *Horikoshi* Also Fails to Show Multiple “Electronic Motor Diagnostics”

61. Claims 1 and 4 require “electric motor diagnostics” (plural). *Horikoshi*, however, discloses only a single, electric motor diagnostic to detecting a ground fault and a phase-to-phase short circuit by distinguishing one from the other.” EX-1008, Abstract, [0011], [0012]. Specifically, *Horikoshi* refers to a single fault diagnostic for an electric motor:

- Motor driving apparatus having fault **diagnostic** function, EX-1008, Title;
- The present invention relates to a motor driving apparatus having a fault **diagnostic** function, EX-1008, [0002]; and
- Accordingly, it is an object of the present invention to achieve, while minimizing an increase in cost, a motor driving apparatus having a fault **diagnostic** function capable of detecting during operation a ground fault and a phase-to-phase short circuit by distinguishing one from the other, EX-1008, [0011].

Based on the above disclosures, a POSITA would have understood that Horikoshi discloses a single fault diagnostic—not multiple. Because the claims require multiple “electric motor diagnostics,” the proposed combination Coli and Horikoshi fails to render obvious the claimed “electric motor diagnostics” (plural).

C. Neither *Coli* nor *Toshiba* discloses “heat sinks having thermal sensors” as required by claims 7–16

62. Claim 7 recites “one or more power semiconductor heat sinks having thermal sensors.” EX-1001, claim 7. Claims 8–16 depend from claim 7. *Id.*, claims 8–16. Dr. Durham appears to concede that Coli does not disclose this feature, *see* EX1002, ¶¶165-166. Instead, he appears to rely on *Toshiba Manual’s* internal thermistor and *Loucks’s* power electronics heat sink temperature sensor to satisfy the claimed “thermal sensor.”

1. Dr. Durham relies on no evidence to support his argument that Toshiba’s internal thermistor is located on a heat sink

63. Although I agree with Dr. Durham that *Toshiba Manual* discloses both a heat sink, EX-1006, 14, and an internal thermistor, EX-1006, 180, I disagree that

a POSITA would have understood that the heat sinks “would necessarily have sensors (e.g., thermistors) to report the temperature measurements.” The internal thermistor could be placed in various internal locations of *Toshiba Manual*’s GX7, one of which may be located on the heat sink. But, at least in view the disclosure of Loucks, it is not always “necessarily true” that the internal thermistor is located on the heat sink for the reasons I explain below.

2. *Coli* or *Toshiba Manual* do not expressly disclose “heat sinks having thermal sensors” as required by claim 7

64. Claim 7 requires that the claimed VFD have “one or more power semiconductor heat sinks having thermal sensors[.]” EX-1001, claim 7. Claims 8–16 depend from claim 7. *Id.*, claims 8–16. Dr. Durham appears to concede that *Coli* does not disclose this feature, see EX-1002, ¶¶ 184-186, and instead relies on *Toshiba Manual*’s internal thermistor to satisfy the claimed “thermal sensor.” Dr. Durham, however, does not show that *Toshiba*’s thermistor is located on the claimed “heat sink” or advance any argument about why it would be obvious for the “heat sink” to have a “thermal sensor.” In my opinion that, having reviewed *Toshiba Manual* in its entirety, *Toshiba Manual* does not disclose that its internal thermal sensor is necessarily located on a heat sink. Accordingly, the combination of *Coli* and *Toshiba Manual* does not render obvious “one or more power semiconductor heat sinks having thermal sensors.”

65. Dr. Durham’s unsupported expert testimony fails to render this limitation obvious. In paragraph 120, he appears to map *Toshiba Manual*’s heat sink as the claimed “heat sink,” and the internal thermistor to the claimed “thermal sensor.” See EX-1006, 14, 180, 184–185. He also notes that Toshiba mentions an “overheat error,” which occurs when the “ASD ambient temperature is excessive.” EX-1002, ¶122 (citing EX-1006 at pp. 2, 42–43, 180); see EX-1002, ¶186. I have reviewed these disclosures and do not see conclusively that *Toshiba Manual*’s internal thermistor is located on its heat sink. The limited *Toshiba Manual* disclosures cited by Dr. Durham never say that the internal thermistor is located on the heat sink as required by the claim (i.e., one or more power semiconductor heat sinks having thermal sensors). Further, having reviewed *Toshiba Manual* in its entirety, I have not seen where the internal thermistor is located on the heat sink.

66. Dr. Durham’s testimony stating that a POSITA would have understood that the heat sinks “would necessarily have sensors (e.g., thermistors) to report the temperature measurements” is unsupported and incorrect. EX-1002, ¶186. Dr. Durham offered no cited disclosure from *Toshiba Manual* to support his opinion that Toshiba’s thermal sensor would necessarily be placed on the heat sink. Instead, he merely concluded that it was so. See EX-1002, ¶186 (“A POSITA would further understand that in order to protect against overheat, the heatsink would necessarily have sensors which would report to the CPU (microprocessor) temperature data.”).

In addition, and based on my review of *Toshiba Manual* (EX-1006), I did not see any disclosure that stated *Toshiba Manual's* internal thermistor must necessarily be located on the heat sink.

67. This opinion testimony lacks sufficient technical detail, explanation, or statements supporting why the heat sink would necessarily have sensors. Without an explanation, it is unclear why a POSITA would place a thermal sensor on the heat sink in particular. It is my opinion that, in light of the above, that a POSITA would not have been motivated to always place a thermal sensor specifically on the sink.

68. Moreover, *Loucks* (EX-1009) contradicts Dr. Durhams's conclusory testimony by showing that thermal sensors typically have a variety of internal locations in a system:

Traditional methods of detecting these problems include monitoring rotational velocity of fans, measuring air flow rates with damper switches or pressure sensors or **heated sensors, and measuring the temperature of inlet air, exhaust air, heat sinks, or other areas of equipment.**

EX-1009, [0003] (emphasis added). Based on this disclosure, a POSITA would have understood that thermal sensors may be placed in various internal locations of a electrical component. *Loucks* thus supports that *Toshiba Manual's* internal thermistor may be located at other places besides only on the heat sink. Given that Dr. Durham cites no disclosure for his conclusion that a "heat sink would necessarily have [thermal] sensors," and other disclosure that he relied on shows this is not

always true, I disagree with this opinion that heat sinks “would necessarily have sensors (e.g., thermistors) to report the temperature measurements.”

69. Further, *Toshiba Manual*’s internal thermistors are used to measure ambient temperature, and the other internal placements mentioned in Loucks are better situated for doing so than on the heat sink. Dr. Durham testified that the internal thermistors measure when the “ASD ambient temperature is excessive.” EX-1002, ¶186 (citing EX-1006, 2; 42–43; 180). Other internal placements of the thermistor, such as at the inlet or exhaust air, would measure ASD ambient temperature much more accurately than a thermistor located on a semiconductor heat sink. EX-1006, 180; EX-1009, [0003]. Dr. Durham also testified that the internal thermistor might become disconnected. EX-1002, ¶186 (citing EX-1006, 185); *see* EX-1006, ¶180. But this scenario contradicts his other testimony that internal thermistors are typically soldered on heat sinks so they cannot be disconnected. *See*, e.g., EX-1002, ¶93 (“Hilbert monitored the internal temperature of the heat sink by use of a type T (copper-constantan) thermocouple located inside a hole drilled into the solder interface between the chip and heat sink at the center of the heat sink base[.]”) (internal quotes omitted); *Id.*, ¶94 (describing, in the background, a TTC1406 heatsink with thermal sensors); EX-1035, 10 (stating that “[t]he thermal component models are connected to the IGBT thermal terminal to form electro-thermal networks.”). The other locations for *Toshiba Manual*’s thermistor suggested

by Loucks are more consistent with *Toshiba Manual's* disclosures than Dr. Durham's opinion that the thermistor would necessarily be on the heat sink.

70. Given that another exhibit contradicts Dr. Durham's unsupported testimony, I disagree with him that *Toshiba Manual* discloses "one or more power semiconductor heat sinks having thermal sensors."

D. Loucks similarly does not disclose that a "variable frequency drive" has "heat sinks having thermal sensors" as required by claim 7.

71. *Loucks* discloses a VFD and a "power electronics heat sink temperature sensor 510," but never discloses that the VFD includes such a sensor. Figure 5 is an example of *Loucks's* cooling efficiency monitoring system, see EX-1009, [0061], where *Loucks* discloses multiple temperature sensors, including "a power electronics heat sink temperature sensor 510." EX-1009, [0063]. Nothing in the description of Figure 5 or in that Figure, itself, mentions or illustrates a variable frequency drive. See EX-1009, [0063], Fig. 5.

72. *Loucks* provides only two disclosures about a VFD. But neither disclosure, shown below, mentions that the VFD includes a heat sink:

As electrical equipment converts electrical energy to heat, the amount of heat produced will be related to the electrical energy consumed by the equipment. Certain equipment (such as computers) convert essentially 100% of the electrical energy into heat. Other devices such as transformers, circuit breakers, uninterruptible power supplies (UPSs) or *variable frequency drives (VFDs)* are more efficient

consumers of electrical energy, a certain percentage of energy consumed is converted into heat.

Id., [0036]

The cooling efficiency techniques and systems described herein may be used on any device that consumes electrical energy and exhausts waste heat. Examples of such devices include: circuit breakers (open or enclosed), fuses and fused switches, ***variable or adjustable frequency drives***, reduced voltage soft starters, uninterruptible power supplies, transformers, electrical assemblies and structures including switchboards, switchgear and motor control centers and components such as switched mode power supplies providing power to servers, networking equipment, programmable logic controllers, storage devices, and telephone systems.

Id., [0060] (emphasis added). *Loucks* 's limited disclosures of VFD, shown above, provide no express disclosure from *Loucks* describing a “*variable frequency drive. . . having one or more power semiconductor heat sinks having thermal sensors.*”

73. Even if *Loucks* discloses VFDs with heat sinks having thermal sensors, those thermal sensors are not “*monitored by a microprocessor to prevent damage caused by excessive heat.*” *Loucks* 's high temperature limits and alarms described in paragraph 18 of *Loucks*, shown below:

The large number of issues and causes of air flow problems means that fully instrumenting each device that may affect cooling performance can become cost prohibitive. However, since electrical or electronic equipment can malfunction due to over-temperature, detecting these problems is important.

Unfortunately, for a variably loaded system, simply waiting for a ***high temperature limit to be reached may result in equipment damage that occurs in the time it takes to resolve the cooling problem. Thus it is desirable to detect problems before temperatures reach alarm limits.*** Also, for devices that are externally cooled through refrigeration, insufficient cooling due to blocked air flow can result in the refrigeration system moving to a lower temperature set point as it attempts to reduce the temperature of the protected equipment. This results in wasted energy if a better solution of fixing the airflow exists. Finally, if the temperature of the equipment does rise above previous levels, the consequences of not cooling equipment properly may result in accelerated equipment degradation and early failure.

EX-1009 [0018] (emphasis added). Nothing in the above passage mentions that these alarms or high temperature limits are measured by Loucks power electronics heat sink temperature sensor 510. Given that Loucks describes multiple temperature sensors, *see* EX-1009, [0063], any of these other temperature sensors may be used to monitor for these alarm and high temperature limits—not only the heat sink temperature sensor 510. Thus, Loucks does not expressly disclose that its power electronics heat sink temperature sensor 510 monitors alarms for high temperature limits.

74. Further, Loucks high temperature limits and alarms are not part of its cooling efficiency monitoring technique shown in Figure 2 and incorporated into *Loucks* VFD. Specifically, the only passage mentioning these two alarms (and shown above), does not mention them being part of *Loucks* cooling efficiency monitoring technique. And, in describing *Loucks*'s cooling efficiency monitoring technique, *Loucks* does not mention these high temperature limits and alarms:

FIG. 2 is a flow diagram that illustrates an example embodiment of a method 200 that monitors cooling efficiency with respect to electrical equipment. At 210, a baseline cooling efficiency is established in kWh/degree, or other analogous units. The baseline cooling efficiency may be established by receiving a baseline rate of heat transfer with respect to the monitored electrical device and converting the baseline rate of heat transfer to a baseline cooling efficiency indicator that is ratio of input electrical power to the monitored electrical device and a temperature differential across the monitored electrical device. At 220 an amount of electrical power consumed by the monitored electrical device is determined. At 230 a monitored electrical device temperature and an ambient temperature proximate the monitored electrical device are determined to compute a temperature differential between the temperature of the monitored electrical device and the ambient temperature.

At 240 an operating cooling efficiency indicator is calculated based, at least in part, on a ratio of the electrical power consumed by the monitored electrical device and the computed temperature differential. At 250 the operating cooling efficiency indicator is compared with the baseline cooling efficiency and at 260 if the difference in cooling efficiencies exceeds a threshold, a notification that communicates results of the comparison between the operating cooling efficiency and the baseline cooling efficiency is provided.

EX-1009 [0048]-[0049]. Without the above description of *Loucks's* cooling efficiency method mentioning these high temperature limits and alarms, it is my opinion that *Loucks's* cooling efficiency monitoring technique does not include these limits or alarms.

75. I understand that, and agree with, Dr. Durham admitted that high temperature limits and alarms that are supposedly measured are not part of *Loucks's* cooling efficiency monitoring technique shown in Figure 2 and incorporated into *Loucks* VFD:

Q: Okay. So the alarm limits and a high temperature limit described in paragraph 18 [of Loucks] are not the same limits or are even disclosed in Figure 2 of Loucks. Is that correct?

A: They're completely different. They're complete different units. You can't compare temperature alarm limits to the baseline minus operating greater than threshold in Figure 2. They're just different.

Q: And when you say they're different, is it because the units that they measure are temperature units and degrees of Celsius or Fahrenheit? Is that correct?

A: Temperature limits would be more likely than not a degree measurement. Nothing in Figure 2 is in units of degrees.

EX-2003, 65:4–20; *see id.*, 59:8–15 (admitting that Figure 2 illustrates *Louck's* cooling efficiency monitoring technique). Without these high limits or alarms being incorporated in Loucks' VFDs, the combination of *Coli* and *Loucks* does not disclose a “*variable frequency drive. . . having one or more power semiconductor heat sinks having thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.*”

E. Dr. Durham fails to offer a sufficient reason for why a POSITA would have combined *Coli* with *Toshiba Manual*

76. I understand that Dr. Durham has proposed that a POSITA would have combined *Coli* with *Toshiba Manual*. I disagree. It is my opinion that a person of ordinary skill in the art would not have combined *Coli* with *Toshiba Manual* because

the technology disclosed in *Toshiba Manual* lacks sufficient power output to work in conjunction with the technology of *Coli*.

1. One of skill in the art would not have substituted the VFD described in *Toshiba* for *Coli*'s VFD because *Toshiba* lacks sufficient power output for *Coli* fracturing operations.

77. I understand that Dr. Durham has provided multiple to combine *Coli* and *Toshiba* in paragraphs 152-156 of his declaration. *See* Ex. 1002, ¶¶152-156. I disagree that these reasons show a POSITA would have been motivated to combine the *Coli* and *Toshiba* references.

78. First, he explains that a POSITA would have been motivated to simply substitute the VFD of *Coli* for a single VFD of *Toshiba* that has the diagnostic functionality and temperature monitoring to prevent damage, without affecting the other functionalities of *Coli*. However, the Toshiba G7 VFD only provides a maximum of around 800 horsepower to an electric motor and pump. Ex. 1047, 1. This 800-horsepower maximum is insufficient to power the “present system” in *Coli* that requires “2500 hp” delivered directly to each pump. *See* Ex. 1005, ¶49.

79. It is my opinion that a person having ordinary skill in the art would not combine *Coli* with *Toshiba Manual* because the device disclosed in *Toshiba*, the GX7 Toshiba VFD, would not meet the power output requirements for *Coli*. One cannot use a single *Toshiba* GX7 VFD to power *Coli*'s hydraulic fracturing

operation because its power output is insufficient to meet the higher power needs of hydraulic fracturing pumps.

80. Coli explains that that its “present system” can deliver 2,500 horsepower to each pump. Ex. 1005, [0049]; *see also* Ex. 2003, 74:19-22 (“Q: So in Coli’s system, it explains that the present system can deliver 2,500 horsepower to each pump. Is that correct? A: Yes.”). But the GX7 Toshiba VFD only has a maximum horsepower output between 500 and 800 horsepower. *See* Ex. 1006, 22, 199; *see also* Ex. 2003, 78:19-79:3 (“Regarding the spec sheet for the GX7 Toshiba VFD disclosed in *Toshiba*: “Q: There is a line here for maximum horsepower. Now, there’s a range here between 500 and 800 horsepower. Is that the maximum horsepower output that the VFD can have? A: That’s the maximum horsepower output for continuous operation of this particular specified VFD can have as a standalone unit.”). Based on these documents describing the Toshiba GX7, a single VFD cannot have an output power higher than 800 horsepower. Dr. Durham agreed as much. Ex. 2003, 80:10-14 (“Q: So can an electric motor powered by only a single Toshiba GX7 have an output power higher than 800 horsepower? A: No, not if you limit it to a single GX7 as specified on this sheet. Then its limited to 800 horsepower.”).

81. Based on the above, it is my opinion that a POSITA would not have been able to substitute the VFD of *Coli* for a single VFD of *Toshiba* because the

VFD lacks the horsepower range to drive the higher output needs of the motors and pumps in *Coli*.

82. Dr. Durham appears to agree that both VFDs and electric motors need to have matching horsepower requirements. For example, he said that a Toshiba G7 is typically used to “drive any motor that is operating within the horsepower range of the G7 drive.” Ex. 2003, 17:19-18:1. Dr. Durham also agrees that “the need of the process or what you’re trying to drive determines what size electric motor you have, and the size of the electric motor determines what size VFD you would select.” *Id.*, 16:16-19. “What has to match is what is driving, the output of the drive versus what load is required on the motor.” *Id.*, 18:14-16.

83. Further, *Toshiba* specifically teaches away from using the G7 ASD with a motor, like the one in *Coli*, that has a power rating higher than the rated output:

Do not use an ASD with a motor that has a power rating
that is higher than the rated output of the ASD.

Ex. 1006, 24; *see* Ex. 2003, 18:21-19:5. It is my opinion that a POSITA would have understood such a warning to teach against using Toshiba’s VFD with *Coli*’s electric motor and pump.

84. I understand that Dr. Durham, when asked about this warning at his deposition, repeatedly answered that he lacks sufficient information or data to answer the questions about combining *Coli* and *Toshiba*. EX 2003, 92:7-93:8. But, based on the evidence that I described above, it is my opinion that a single Toshiba

GX7 VFD could not provide the necessary 2400 true horsepower required by Coli's fracturing operation, *See* EX1005, [0049]. Without being able to do so, and with the warning from Toshiba, a POSITA would have understood that the *Toshiba* manual teaches away from substituting the VFD of *Coli* for the VFD of the *Toshiba* manual.

85. Accordingly, a POSITA would not have considered the disclosure of *Toshiba* for combination with *Coli* because the technology disclosed in *Toshiba* lacks sufficient power output to activate and operate the technology disclosed in *Coli*. A POSITA would have only considered the disclosure of VFDs with sufficient power output.

2. Dr. Durham's remaining reasons to combine by Coli and Toshiba are unsupported by the cited evidence, or evidence at all.

86. I understand that Dr. Durham advances several other reasons for combining Coli and Toshiba. Those additional reasons are shown below:

153. A POSITA would have been motivated to combine Toshiba Manual with Coli for Toshiba Manual's express disclosure of VFD control and monitoring of parameters of the electric motor in Coli, such as current, voltage, speed, temperature, torque, and load, and use the diagnostic functionality of Toshiba Manual (e.g., the alarms and fault trips) in order to prevent damage to the electric motor. Ex. 1006 at 179; see Ex. 1006 at 182-85 (Table 12, listing trips from diagnostics). The results of the combination would have been predictable and obvious to a POSITA.

154. Furthermore, a POSITA would have been motivated to combine Toshiba Manual with Coli to include the power semiconductor heat sinks having thermal sensors in order to prevent overheating of the IGBT power electronics. The results of the combination would have been predictable and obvious to a POSITA.

156. Alternatively, a POSITA would have been motivated to enhance the VFD of Coli with the diagnostic and temperature monitoring/protection functionality of Toshiba Manual because such an improvement represents the mere application of a known technique (i.e., the fault detection and temperature monitoring/protection including heat sinks of Toshiba Manual) to predictably improve a similar system (i.e., the VFD of Coli) in the same way.

87. But Dr. Durham cites little to no evidence in most of the above rationales so I cannot understand his basis for making such statements. In Paragraph 153, Dr. Durham cites only two pieces of evidence that show Toshiba's faults prevent damage to the VFD—not the “electric motor” are required by the claim. EX1006, 182 (“Trip is a safety feature that disables the ASD system in the event that a subsystem of the ASD is malfunctioning.”). There is no evidence cited that, as Dr. Durham suggests, shows these faults “prevent damage to the electric motor.” For the remaining paragraphs, Dr. Durham cites no evidence nor provides any explanation.

88. Dr. Durham also contends that, based on the above reasons, a POSITA would have been motivated to combine *Coli's* VFD with *Toshiba's* teaching of a

power semiconductor heat sink having thermal sensors. *See* Ex. 1002, ¶¶154, 156. I disagree because Dr. Durham cites no disclosure that the internal thermistor in Toshiba G7 is located on the heat sink. Instead, he simply states that “[a] POSITA would further understand that in order to protect against overheat, the heatsink would necessarily have sensors which would report to the CPU (microprocessor) temperature data.” Ex. 1002, ¶186. As I explained above, however, nothing in Toshiba manual discloses that the heat sink has temperature sensors located on it.

89. In its institution decision, I understand that the Board noted, and I agree with, that the Toshiba manual did not have any express disclosures showing the heat sinks have thermal sensors and that *Loucks* explains that the internal thermal sensors may be in various locations inside an electronic component:

Patent Owner finally asserts that “the Petition includes no rationale explaining why a [person of ordinary skill in the art] would have found it obvious to place a thermistor on a heat sink.” *Id.* at 16, 24, 28. Based on the present record, we agree with Patent Owner’s argument. The Toshiba G7 VFD has a heat sink. *See* Ex. 1006, 14 (“The heat sink and other components may become extremely hot to the touch.”), 204 (“[T]he heat generated by the [Dynamic Braking Resistor] will affect the cooling capacity of the heatsink[.]”). The Toshiba G7 VFD also has an internal thermistor to monitor the temperature of the VFD and thereby prevent overheating. *See Id.* at 58 (describing a “Cooling Fan Control”); *Id.* at 180, 185 (identifying an “Overheat” control parameter and fault condition that determine when the VFD’s ambient temperature is excessive, as might be caused by the VFD “operating at an elevated temperature” or when an “[i]nternal thermistor is disconnected”). However, we are unable to discern any

express disclosure in the Toshiba Manual pages cited by Petitioner of “heat sinks having thermal sensors,” as recited in claim 7 (emphasis added). See Ex. 1006, 2, 14, 42–43, 36, 180, 184–85, 163, 204. Instead, based on the present record, we find that the Toshiba Manual does not specify a particular location within the VFD for the thermal sensors to be located. See *Id.*

...

In this case, Loucks suggests that measuring the temperature of electrical equipment in order to provide a controlled cooling of the equipment may be accomplished by “measuring the temperature of inlet air, exhaust air, heat sinks, or other areas of” the equipment. Ex. 1009 ¶¶ 1–3. Thus, based on the present record, Petitioner’s assertion that Toshiba Manual inherently associates its heat sinks with its thermal sensors is not supported by the evidence.

Paper 7, 25-26. Because the two rationales advanced by Dr. Durham are flawed, he has not advanced any reason for why a POSITA would have been motivated to combine the teachings of the *Coli* and *Toshiba* reference. For the reasons expressed above, it is my opinion that Dr. Durham has failed to provide a sufficient explanation as to whether a POSITA would have combined *Coli* and *Toshiba* or not.

F. Dr. Durham fails to offer a sufficient reason why a POSITA would have combined *Loucks* and *Coli*

90. Dr. Durham offers two proposed combinations of Loucks and Coli, Ex. 1002, ¶¶ 235-237, as follows: 1) adding power semiconductor heat sinks and associated temperature sensors to the VFD of Coli and (2) employed the cooling efficiency monitoring technique (or thermal management technique) of Loucks to

enhance the VFD of Coli. I disagree with his reasoning that a POSITA would be motivated to make such combinations to arrive at the claim invention for two reasons.

91. First, Loucks does not disclose that the “power semiconductor heat sink temperature sensor 510” is, as claim 7 requires, “*monitored by a microprocessor to prevent damage caused by excessive heat.*” Rather, Loucks discloses this temperature sensor, among numerous other temperature sensors, EX1009, [0063], are used in its cooling efficiency monitor system to “calculate the cooling efficiency indicator”:

Multiple temperature sensors are utilized, including a breaker trip unit temperature sensor 530, a power electronics heat sink temperature sensor 510, and a microprocessor temperature sensor 520 that are installed within the enclosure, as well as an ambient temperature sensor 540. ***Each temperature sensor within the enclosure is matched with an ambient sensor external to the enclosure*** and this, along with the kW input to the enclosure ***can be used to calculate the cooling efficiency indicator.***

EX1009, [0063] (emphasis added). The cooling efficiency indicator, however, is not the “alarm” or “high temperature limit” mentioned in Coli that “may result in equipment damage” if reached. *See id.*, [0018]. Based on paragraph 18 being the only passage in Loucks that discusses this limit, Loucks does not disclose that the “power semiconductor heat sink temperature sensor 510” are used to monitor a

high temperature limit, especially given that Loucks discloses multiple other temperature sensors. EX1009, [0063]. Without an express statement describing that Loucks heat sink temperature sensor 510 is responsible for monitoring the temperature of this alarm, a POSITA would not know that to be necessarily true. Thus, the proposed combination of *Coli* and *Loucks* does not teach “*one or more power semiconductor heat sinks having thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.*”

92. Dr. Durham’s proposed combination of employing the thermal management techniques of *Loucks* in the VFD of *Coli* is similarly flawed. Dr. Durham admitted in his deposition, and I agree with, that the both the “alarm” or “high temperature limit” are not included in *Loucks*’s cooling efficiency monitoring technique:

Q: Okay. So the alarm limits and a high temperature limit described in paragraph 18 [of Loucks] are not the same limits or are even disclosed in Figure 2 of Loucks. Is that correct?

A: They’re completely different. They’re complete different units. You can’t compare temperature alarm limits to the baseline minus operating greater than threshold in Figure 2. They’re just different.

Q: And when you say they’re different, is it because the units that they measure are temperature units and degrees of Celsius or Fahrenheit? Is that correct?

A: Temperature limits would be more likely than not a degree measurement. Nothing in Figure 2 is in units of degrees.

EX-2003, 65:4–20; *see id.*, 59:8–15 (admitting that Figure 2 illustrates *Loucks*’s cooling efficiency monitoring technique). Because the combination proposed by Dr. Durham would not include either the *Loucks*’s alarm or high temperature limit by using *Loucks*’s cooling efficiency monitoring technique in *Coli*’s VFD.

Without these alarms or limits, the Petition’s combination of *Loucks* and *Coli* does not include *Loucks*’s alarm for “a high temperature limit to be reached may result in equipment damage that occurs in the time it takes to resolve the cooling problem.” EX1009, [0018]. Without such an alarm, the proposed combination of *Coli* and *Loucks* does not include “one or more power semiconductor heat sinks having thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.”

93. For the reasons expressed above, it is my opinion that Dr. Durham has not shown why a person of ordinary skill in the art would have combined *Loucks* with *Coli*.

1. *Coli* teaches away from combining *Coli* and *Loucks*

94. It is my opinion that *Coli* teaches away from implementing *Loucks*’ cooling system and technique in the system of *Coli*.

95. *Coli* explains:

Notably, the setup of FIG. 2 requires significantly less infrastructure than the setup shown in FIG. 1, while providing comparable pumping capacity. Fewer trailers 10 are present in region B of FIG. 2 than the trucks 6 and trailers 5 in region A of FIG. 1, due to the lack of need for a constant diesel fuel supply. Further, each trailer 10 in FIG. 2 does not need a dedicated truck 6 and operator as in FIG. 1. Fewer chemical handling skids 7 are required in region B of FIG. 2 than in region A of FIG. 1, as the skids 7 in FIG. 2 can be electrically powered. ***Also, by removing diesel prime movers, all associated machinery necessary for power transfer can be eliminated***, such as the transmission, torque converter, clutch, drive shaft, hydraulic system, etc. . . . , ***and the need for cooling systems, including circulating pumps and fluids, is significantly reduced***. In an illustrative embodiment, the physical footprint of the on-site area in region B of FIG. 2 is about 80% less than the footprint for the conventional system in region A of FIG. 1.

EX-1005, [0039]. The above disclosure would persuade a POSITA to not modify *Coli* to incorporate *Loucks*'s cooling efficiency monitoring system because such a combination to implement a cooling system, like the one in *Loucks*, in *Coli*'s fracturing operations which would require a larger on-site footprint and increased infrastructure. Such a modification would be similar to the one that *Coli* specifically warns against. *See* Ex. 1005, [0039].

G. A POSITA would not have considered *Loucks* as prior art because it is not analogous art

96. It is my understanding that only “analogous” prior art references may be used to support an obviousness reference. It is further my understanding that a prior art reference is analogous to a challenged patent if (1) it is from the same field

of endeavor as the challenged patent; or (2) it is reasonably pertinent to the particular problem with which the inventor(s) of the challenged patent were involved.

97. Dr. Durham’s declaration does not offer any opinion as to the field of endeavor for the ’870 patent or any problem addressed by it. It is my opinion that neither Horikoshi nor Loucks is analogous art to the ’870 patent, as I explain below.

98. If Dr. Durham includes any additional explanation in supplemental declaration, I reserve the right to supplement my declaration to address this new explanation. Dr. Durham fails to include any argument showing how Horikoshi and Loucks are analogous to the challenged patent.

99. Dr. Durham thus fails to show how *Loucks* is analogous art to the challenged patent.

1. *Loucks* is not analogous art to the claimed invention

i. *Loucks* is not from the same field of endeavor as the ’870 Patent

100. *Loucks* is also not in the field of hydraulic fracturing operations—that is, the field of art for the ’870 patent. *See* EX-1001, 1:23–26; *see also* Pet. at 4 (“The ’870 Patent relates to hydraulic fracturing operations.”). Rather, *Loucks* is drawn to the field of endeavor of measuring changes in cooling performance for server IT equipment. *See* EX-1009, Fig. 1; Abstract. *Loucks* is thus not in the same field of endeavor as the ’870 patent.

ii. *Loucks* is not reasonably pertinent to the problem addressed by the '870 Patent

101. Dr. Durham fails to identify any problem facing the inventor by the '870 patent addressed by *Horikoshi*. Dr. Durham contends that the '870 Patent is drawn to overcoming “problems associated with diesel pumps” by “using pumps powered by electric motors.” Ex. 1002, ¶40 (citing Ex. 1001, 1:52–54; 1:25–26). I agree with Dr. Durham’s characterization of this being a particular problem with which the inventor(s) of the '870 Patent was involved. To the extent that one argues this is not the only particular problem facing the inventors of the '870 patent, any additional problem would be limited to those problems when implementing a portable VFD. *See* EX-1001, Fig. 1, 1:40–51, 3:38–63.

102. Loucks does not address either of the above problems. Rather, Loucks addresses the problem of detecting cooling problems in the environment in room and/or data centers. EX-1009, [0018]; [0024]; [0026]. Because *Loucks* does not describe any portable equipment, it is my opinion that an inventor considering the problem addressed in the '870 patent would not be motivated to turn to Loucks at the time of the invention, particularly given that *Loucks* addresses a fundamentally different problem (detecting cooling problems in an environment for room containing electrical equipment, such as server IT equipment) than the problem addressed in the '870 Patent (problems associated with portable VFDs and electric motors replacing portable diesel-powered pumps). An inventor considering these

problem addressed in the '870 patent would not be motivated to turn to *Loucks* at the time of the invention, especially given it is directed how adjust the environment in a room with electrical equipment without any mention of mobile electrical equipment. Therefore, *Loucks* is not reasonably pertinent to any problems addressed by the '870 patent.

H. Claim 13 is not obvious

103. Claim 13 claims, “[t]he system of claim 12, wherein the vehicle is a truck having at least five axles.” EX-1001, 8:50–51. Claim 13 does not claim a “truck-trailer configuration,” but rather “wherein the vehicle is **a truck** having at least five axles.” *Id.*

1. A “truck-trailer configuration” is not a truck

104. In understanding what a “truck” is, it is my understanding that one must read claim terms in light of the other claims and the specification. It is my understanding that the Petitioner, Patent Owner, and Board have each not proposed a claim construction for the word “truck.” Accordingly, I understand “truck” to have its plain and ordinary meaning.

105. I understand Dr. Durham contends that *Coli* discloses “wherein the vehicle is a truck having at least five axles” because it discloses “[e]ach trailer 5 is attached to a truck 6.” EX-1002, ¶¶ 198-200 (citing Ex. 1005, [0037]; [0007]; [0039]; [0078]). To support his claim that a POSITA would have understood that

any truck pulling the trailer in *Coli* would have at least two axles, Dr. Durham opines:

Figure 3 of *Coli* clearly depicts a trailer 10 with three axles “for housing one or more fracturing modules,” wherein “[e]ach fracturing module” includes “an electric motor 21 and a fluid pump 22 coupled thereto.” Ex. 1005, [0040], Fig. 3. Further, *Coli* discloses “[e]ach trailer 5 is attached to a truck 6.” Ex. 1005, [0037]; [0007]; [0039]; [0078]. A POSITA would have understood that any truck pulling the trailer in *Coli* would have at least two axles. Accordingly, *Coli* discloses a vehicle that is truck-trailer configuration with a total of 5 axles.

Ex. 1002, ¶198.

106. “Truck” is a claim term in both claim 1 and claim 13. Ex-1001, 7:51, 8:51–52. In claim 1, a “trailer” is attached to a “truck,” indicating that a trailer is separate from a truck in order to need to be attached. *See Id.*, 7:51. No such trailer is recited nor required for claim 13. *Id.*, 8:51–52.

107. Dr. Durham contends that “truck” has a different meaning in claim 1 and claim 13. EX-2003, 55:10–56:4 (“Q: So Claim 13 specifically recites, ‘A vehicle is a truck having at least five axles.’ Is that correct? A: Yes. Q: And if we look to claim 1, it recites, ‘a trailer attachment to a truck.’ Is that correct? A: Correct, yes. Q: Does truck mean something different in Claim 1 than truck means in Claim 13? A: I think it can, yes. Q: So a claim term can have different meanings in different claims? A: Yes.”) (objection omitted). Specifically, Dr. Durham thinks that a trailer is read into the word truck because claim 13 is not dependent on claim 1, but rather

from claim 7. EX-2003, 53:15–54:2 (“Q: Claim 1 specifically recites a trailer. Is that correct? A: Correct. Q: Okay. Let’s turn to Claim 13. A: Okay. Q: Does Claim 13 recite a trailer? A: I think it – yes, you could read a trailer into the word truck. Claim 13 is not dependent in Claim 1. It depends from Claim 7.”) (objection omitted), 54:9–13 (“Q: What do you mean by a trailer can be part of a truck in Claim 13? A: A tractor trailer is referred to as a truck, and there’s nothing that I recall in the ’870 Patent that excludes that.”). I disagree that a truck means something different in claim 1 than what it does in claim 13. It is my understanding that the same phrase in different claims of the same patent should have the same meaning is a strong one, overcome only if it is clear that the same phrase has different meanings in different claims, such as with inherently contradictory claim context.

I. Claim 15 is not obvious

108. Claim 15 requires, “the system of claim 7, wherein the electric motor has a maximum continuous power output of about 1750 brake horsepower or more.” EX-1001, 8:55–58.

109. Dr. Durham contends that *Coli* discloses the limitation of claim 15 solely based on this one sentence of disclosure. *See* Ex. 1002, ¶203. The entirety of Dr. Durham’s analysis and opinion for this claim is as follows:

Coli discloses that the motor “can deliver a true 2500 hp directly to each pump 22 because pump 22 is directly coupled to electric motor 21.” Ex. 1005, [0049]. Accordingly, a POSITA at the time the ’870 Patent was

filed would have recognized that Coli discloses the “electric motor has a maximum continuous power output of about 1750 horsepower or more.” I further understand that the Board found a substantially similar claim of the ’601 Patent to be disclosed by Coli. Ex. 1048 at 41.

Ex. 1002, ¶203. I disagree. Upon review of the evidence, it is my opinion that this does not disclose the “maximum *continuous* power” of *Coli*’s motor, but rather only the maximum instantaneous power, or peak power. The word “continuous” is not present in the above sentence, and there is a difference between maximum horsepower and maximum *continuous* horsepower.

110. Dr. Durham agrees that there is a difference between maximum horsepower and maximum continuous horsepower:

Q: I would like to turn to the – or draw your attention to the next paragraph. It says, “However, the ASD may be operated at 110 percent of the specified output-current range continuously or at 150 percent for a limited amount of time as indicated.” Is there a difference between running the ASD continuously at a certain amount versus what appears to be its maximum at 150 percent for a limited amount of time? A: Well, yes.

A: Power is – your horsepower is your instantaneous power that’s being used or delivered. Energy is the amount of energy you use over time. They relate to each other by time.

Q: Does an ASD have a maximum current range that’s different for continuous operation versus a maximum current range generally?

A: There are, just like motors, this particular ASD has different current ranges for different amount of times.

“Q: So would motors have similar limits on how much they could run continuously versus how much they could run as a maximum?” A: Yes.”

EX-2003, 42:4–14, 44:9–12, 42:17–43:1 (objection omitted), 44:15–18.

111. These limits are, as Dr. Durham himself explains, are functions of input current. EX-2003, 43:19–21 (“it’s i²t, current squared times time. If you have a higher current, you can only run that higher current for a shorter period of time.”). Dr. Durham also admits that the instantaneous horsepower and continuous horsepower would have different values:

“Q: Does an electric motor have a limit on its input current for continuous operation that is different than a limit or a instantaneous or short time period operation?

A: Yes, sir, it does.

Q: Okay. So using those different limits applied to the same electric motor, would there be a difference in horsepower at the continuous limit and the limit for a shorter period of time?

A: All else being equal, those are likely to be different horsepowers.”

EX-2003, 46:8–18.

112. While a maximum continuous power is available for a long period of time, Dr. Durham also explained that a maximum power is only available for a short period of time. *See* EX-2003, 88:10–16 (“A: We know, for example, in the GX7 that an 800 horsepower GX7 can power a 1200 horsepower pump at least for a period of

time. Q: Can it power that pump continuously? A: No. Q: I believe the GX7 mentioned a period of time for about 120 seconds on Exhibit 1047.”).

113. Based on his deposition testimony, I agree with Dr. Durham that there is a difference between maximum horsepower and maximum continuous horsepower.

114. The sentence cited relied on by Dr. Durham only addresses maximum horsepower and says nothing about maximum continuous horsepower. Without additional evidence, I do not know what the “maximum continuous horsepower” of the motor in *Coli* would be.

115. For the above reasons, the cited evidence from *Coli* does not disclose a motor with a “maximum continuous power output of about 1750 brake horsepower or more.”

J. Claim 16 is not obvious

116. Claim 16 provides, “[t]he system of claim 7, wherein the electric motor has a maximum continuous torque of about 8750 lb-ft or more.” EX-1001, 8:58–59.

117. Like the distinction between peak power and maximum continuous power, a POSITA would have understood the distinction between peak torque and maximum continuous torque.

118. Dr. Durham’ entire argument that claim 16 is disclosed by *Coli* is as follows:

Coli discloses that the “electric motor can be capable of operation in the range of up to 1500 rpms and up to 20,000 ft/lbs of torque.”⁴ Ex. 1005, [0011]. Accordingly, a POSITA at the time the ’870 Patent was filed would have recognized that Coli discloses an “electric motor has a maximum continuous torque of about 8750 ft-lb or more.”

EX-1002, ¶ 204. I disagree. Upon review of the evidence, it is my opinion that this does not disclose the “maximum *continuous* torque” of *Coli*’s motor, but rather only the maximum instantaneous torque, or peak torque. The word “continuous” is not present in the above sentence, and there is a significant difference between maximum torque and maximum *continuous* torque.

119. Like power, torque is a function of input current. Dr. Durham agrees. EX-2003, 47:10–11 (“Assuming a constant speed and all else being equal, yes, the torque would increase as current increase.”).

120. The sentence cited by Dr. Durham only addresses maximum torque and says nothing about maximum continuous torque. Without such evidence, I do not know what the “maximum continuous torque” of the motor in *Coli* would be.

121. For the above reasons, the cited evidence from *Coli* does not disclose a motor with a “maximum continuous torque of about 8750 lb-ft or more.”

IX. CONCLUSION

122. For the reasons above, it is my opinion that each of Patent Owner’s claims are not obvious.