

U.S. WELL SERVICES, LLC (PATENT OWNER)

IPR2023-00558

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

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DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

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Summary of Grounds

Ground	Claims Challenged	35 U.S.C. § ²	References
1	1–16	103	Coli, Toshiba Manual
2	1–6	103	Coli, Horikoshi
3	7–16	103	Coli, Loucks
4A	12, 13	103	Coli, Toshiba Manual, Vliet
4B	12, 13	103	Coli, Loucks, Vliet
5A	14, 15	103	Coli, Toshiba Manual, Gardner
5B	14, 15	103	Coli, Loucks, Gardner

Roadmap

- Claims 7-16: Prior art does not render obvious “*a variable frequency drive*” “*having heat sinks having thermal sensors*”
 - Ground 1 is deficient because the Petition failed to show that *Toshiba* inherently discloses a VFD having a heat sink having a thermal sensor
 - Ground 3 is deficient for two reasons:
 - Petitioner failed to prove one would combine *Coli* and *Loucks*.
 - Petitioner’s proposed combination does not render obvious “*a variable frequency drive*” “*having heat sinks having thermal sensors*”
- Claims 1-6: Prior art does not render obvious “*electric motor diagnostics*”
 - Grounds 1 and 2: None of the prior art discloses multiple “electric motor diagnostics”
 - Ground 1: A POSITA would not have combined *Coli* and *Toshiba*
- Dependent Claims
 - Claim 13: Prior art does not render obvious “*truck having 5 or more axles*”
 - Claims 15-16: Prior art does not render obvious “*maximum continuous [horsepower/torque]*”

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Claims 7-16: *Grounds 1 and 3*

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Claim 7: “heat sink having thermal sensors”

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.

Claims 7-16: *Coli + Toshiba (Ground 1)*

Toshiba Manual is Silent Regarding Heat Sink Having A Thermal Sensor

Claim Language

"heat sinks having thermal sensors"

Toshiba Manual

The heat sink and other components may become extremely hot to the touch. Allow the unit to cool before coming in contact with these items.

EOI Display	Function	Description	Possible Causes
*OH	Overheat	ASD ambient temperature excessive.	- ASD is operating at an elevated temperature. - ASD is too close to heat-generating equipment. - Cooling fan vent is obstructed (see Mounting the ASD on pg. 18). - Cooling fan is inoperative. - Internal thermistor is disconnected.

Toshiba Manual (EX-1006 at 14 (top) and 180 (bottom)); PO Resp. at 14.

Petitioner Argued Only That This Feature was Inherent in Toshiba Manual (EX-1006)

Claim Language	
"heat sinks having thermal sensors"	
Petition	Dr. Durham Declaration (paragraph 186)
A POSITA would have understood that the heat sink would necessarily have sensors (e.g., thermistors) to report the temperature measurements to the CPU (i.e., microprocessor). Ex. 1002, ¶186.	A POSITA would further understand that in order to protect against overheating, the heatsink would necessarily have sensors which would report to the CPU (microprocessor) temperature data.

The Board Rejected Petitioner’s Inherency Argument

Claim Language	Institution Decision
"heat sinks having thermal sensors"	However, we are unable to discern any express disclosure in the Toshiba Manual pages cited by Petitioner of “<i>heat sinks having thermal sensors</i>,” as recited in claim 7 (emphasis added). <i>See</i> 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. <i>See id.</i>

Loucks Teaches Thermal Sensors in Various Locations

Claim Language	Loucks
"heat sinks having thermal sensors"	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.
	Nikolaou Declaration Based on this disclosure, a POSITA would have understood that thermal sensors may be placed in various internal locations of a electrical component.

Loucks (EX-1009 at [0003]); Nikolaou Dec. (EX-2002 at ¶68); PO Resp. at 16.

Petitioner’s New Obviousness Arguments are Untimely

Claim Language	
"heat sinks having thermal sensors"	
Petition	Petitioner Reply
A POSITA would have understood that the heat sink would necessarily have sensors (e.g., thermistors) to report the temperature measurements to the CPU (i.e., microprocessor). Ex. 1002, ¶186.	To the extent the Board maintains that <i>Toshiba Manual</i> does not disclose that its heat sink has thermal sensors, a POSITA would have deemed that obvious.

Petitioner’s New Obviousness Arguments are Untimely

Ground	Claims Challenged	35 U.S.C. § ²	References
1	1–16	103	Coli, Toshiba Manual
2	1–6	103	Coli, Horikoshi
3	7–16	103	Coli, Loucks

Name	Reference	Exhibit No.
Toshiba Manual	Toshiba Int’l Corp., <i>G7 Adjustable Speed Drive Operation Manual</i> , Doc. No. 51546-009 (Mar. 2005)	1006

Petitioner's New Obviousness Arguments are Untimely

Claim Language

"heat sinks having thermal sensors"

Petitioner Reply

Although PO disagrees with Dr. Durham's testimony as "conclusory," at least two pieces of evidence support it. First, the "standard specifications" for *Toshiba Manual's* GX7 VFD—published at the same website as *Toshiba Manual*—expressly refer to the only "Overheat" function of that system as "***Heatsink*** Overheat." Ex.1007pt.1, 15, 23; Ex.1002, ¶¶122, 186

Petitioner’s New Obviousness Arguments are Untimely

Moreover, the drawings and equipment list for Toshiba’s VFD refer to the only thermistor in that device as the “*heatsink* thermistor.”

PAGE No.	DEVICE	DESCRIPTION	TYPE FORM
8	(1) MCCB1	MOLDED CASE SWITCH	SQD P JL36000S12-RE10
	8FU1, 2	CPT1 PRIMARY FUSE	CRF ATQR 6
	8FU3	CPT1 SECONDARY FUSE	GLD TRM 12
	FR, FS, FT	SEMICONDUCTOR FUSE	CRF 6,9URD33TTF0700
	BFI	BLOWN FUSE INDICATOR	CRF MS3V1-5BS
	CPT1	CNTL. PWR. TRANSFORMER	GTI
	ACL1~3	OUTPUT LINE REACTOR	TCI KDRG1C
	HCTU, V, W	HALL CT	LEM HAX1000-S
9	MS1	SOFT START CONTACTOR	TMQ LC1F4004U7
	MS2	CAP DISCHARGE CONTACTOR	CLK 7001-5150-21
	OH1T~3T	T-STAT 75°C FIXED N.C.	TKN OHD3-75B
	OH1B~3B	T-STAT 90°C FIXED N.C.	TKN OHD3-90B
	THR1	HEATSINK THERMISTOR	FEN 590-32BP01-203
	R1	SOFT START RESISTOR	PWO WR33
	R2	CAP DISCHARGE RESISTOR	PWO SXR2-500
	REC1M~6M, 1A~6B	DIODE PACK	EUP DD600N16K
	SA1~3	SURGE SUPPRESSOR	EPC B40K750

Ex.1007pt.2, 251 (excerpt highlighted above), 264, 279-80; see also Ex.1002, ¶120.

Claims 7-16: *Coli + Loucks (Ground 3)*

A POSITA Would Not Have Combined *Coli* and *Loucks*

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Petitioner Bears the Burden to Show Prior Art is Analogous

Institution Decision

We agree with Patent Owner's position that Petitioner bears the burden of persuasion to establish that Horikoshi is analogous art.

***In re Bigio*, 381 F. 3d 1320, 1325 (Fed. Cir. 2004).**

Two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed and, (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved.

The PTAB Correctly Determined That *Loucks* Fails the Field of Endeavor Test

Institution Decision

(i) *Whether Loucks is From the Same Field of Endeavor as the '870 Patent*

Based on the present record, we agree with Patent Owner's position that the field of endeavor of the '870 patent is hydraulic fracturing operations in oil and gas wells. *See* Prelim. Resp. 34; Section III.E.2(ii) *supra*.

Petitioner's Argument is Unsupported by Evidence

Petitioner's Reply

The '870 Patent addresses implementing VFDs and electric motors in the field of hydraulic fracturing. Ex.1001, 1:24-26, 2:5-7, 4:8-25; Ex.1002, ¶¶ 40-41. Prior art techniques for implementing VFDs and electric motors in other fields, including those of Loucks, would have been reasonably pertinent to **that problem**.

Durham Declaration (EX-1002 at ¶ 40) (annotated).

40. The '870 Patent acknowledges the well-understood **“problems associated with diesel pumps”** and re-states what was already known in the art—i.e., the **problems associated with diesel pumps** can be overcome by “using pumps powered by electric motors.” Ex. 1001, 1:52–54; 1:25–26.

Petitioner's Reply at 17 (top) (annotated); Durham Dec. (EX-1002 at ¶40) (below) (annotated);
PO Sur-Reply at 7–11

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Dr. Nikolaou's Testimony for Why *Loucks* is Non-Analogous Stands Unrebutted

Nikolaou Declaration (EX-2002 at ¶¶ 101 & 102) (annotated).

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.**

Coli Teaches Away From Using Loucks' Cooling Technique In Combination

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Coli + Loucks Uses Loucks' Cooling Efficiency Monitoring Technique

Claim Language

“thermal sensors monitored by a microprocessor **to prevent damage caused by excessive heat.**”

Loucks provides further details regarding the protection of electrical devices, including protecting VFDs from damage due to excessive temperatures, and a POSITA would have employed the thermal management techniques of *Loucks* to enhance the VFD of *Coli* to prevent “over-temperature” and ensuing “equipment damage.” *Id.*, [0018], [0060]; Ex. 1002, ¶235-237.

Particularly in view of *Loucks*' applications to VFDs, a POSITA would have been motivated to look to *Loucks*' heat sinks and temperature sensors and employ *Loucks*' cooling efficiency monitoring techniques to “detect problems” with *Coli*'s VFD “before temperatures reach alarm limits” and to ensure that it does not “malfunction” or suffer from “accelerated equipment degradation and early failure.” Ex. 1009, [0018]; Ex. 1002, ¶¶235-237.

Coli Teaches Away From Combination With *Loucks*

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.

Dr. Nikolaou (EX-2002, ¶95)

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].

Coli Teaches Away From Combination With Loucks cont.

Previous IPR Decision	Petitioner’s Reply
Although Dr. Durham acknowledges Stark’s use of a refrigerant to cool its heat sink, he does not explain how such refrigerant would be provided in the modified Coli variable frequency drive. . . . Petitioner does not explain how such coolers necessarily include the use of a refrigerant or how any such refrigerant would be used with the variable frequency drives.	There, Petitioner sought to combine Coli with U.S. Patent No. 6,116,040 (“Stark”), which involved a VFD for a refrigerator compressor and included a heat sink cooled by fluid refrigerant flowing through internal flow channels. Ex.1048, 17.

Coli + Loucks does not disclose a VFD having “*a heat sink having thermal sensors monitored. . . to prevent damage caused by excessive heat.*”

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Loucks Does Not Disclose A VFD Having A Heat Sink

Claim Language

a VFD “having one or more power semiconductor heat sinks having heat sink thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.”

[0036] 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. Thus a percentage value is assigned to this heat conversion rate and called it delta ‘ δ ’. Since this conversion rate may vary based on percentage loading of the equipment (e.g., I^2R losses from transformers) or other effects, the conversion rate variable 6 is written as being a function of one or more external parameters grouped and written as the variable ‘x’, with the resultant conversion rate written as $\delta(x)$.

[0060] 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. The cooling efficiency techniques and systems described herein may be also be used to monitor groups or systems of electrical devices such as data centers, wiring closets, and electrical rooms. A change in the cooling efficiency indicator may be used to detect changes to the cooling system performance of any of these devices or systems long before over-temperature limits are reached.

Coli + Loucks is Flawed

Claim Language	Nikolaou Declaration
“thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.”	Loucks does not expressly disclose that its power electronics heat sink temperature sensor 510 monitors alarms for high temperature limits.

Coli + Loucks is Flawed

Claim Language

“thermal sensors monitored by a microprocessor **to prevent damage caused by excessive heat.**”

Particularly in view of *Loucks*’ applications to VFDs, a POSITA would have been motivated to look to *Loucks*’ heat sinks and temperature sensors and employ *Loucks*’ cooling efficiency monitoring techniques to “detect problems” with *Coli*’s VFD “before temperatures reach alarm limits” and to ensure that it does not “malfunction” or suffer from “accelerated equipment degradation and early failure.” Ex. 1009, [0018]; Ex. 1002, ¶¶235-237.

Loucks' Cooling Efficiency Monitoring Technique

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,

Dr. Durham's Deposition Transcript (EX-2003, 59:12-15)

Q I would like to turn your attention to Figure 2. Figure 2 illustrates Loucks' cooling efficiency monitoring technique. Is that correct?

A Yes, but the software side, not the physical side.

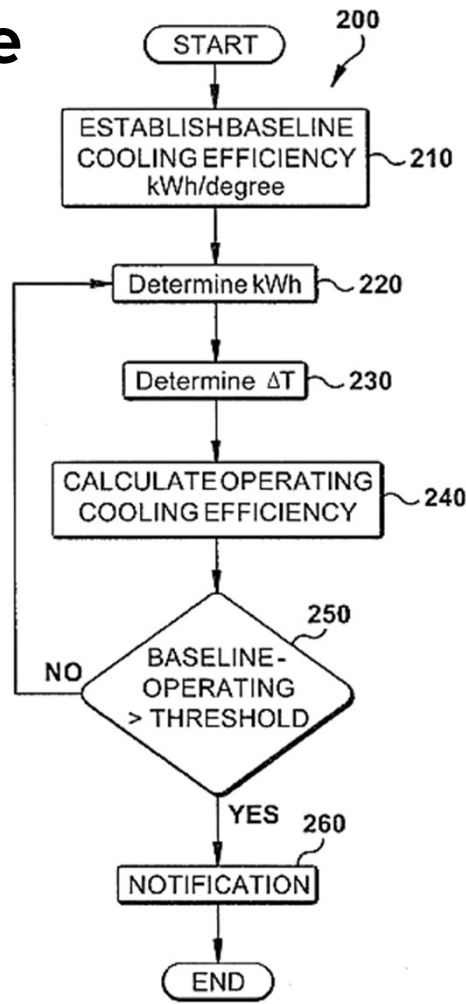


Fig. 2

Dr. Durham Admits That Alarm Limits Are Not Included in *Loucks*' Cooling Efficiency Monitoring Technique

Claim Language

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

Dr. Durham's Deposition Transcript (EX-2003, 65:4-20) (annotated).

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

MS. FLANNERY: Object to form.

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

BY MR. HOPKINS:

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.

Without Limits or Alarms, *Coli* + *Loucks* does not render obvious Claim

Claim Language	
“thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.”	
Nikolaou Declaration	Loucks
Further, Loucks high temperature limits and alarms are not part of its cooling efficiency monitoring technique shown in Figure 2 and incorporated into <i>Loucks</i> VFD. . . . EX-1009 [0048]-[0049].	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.

Nikolaou Declaration (EX-2002 at ¶74) (annotated); *Loucks* (EX-1009 at [0049]) (annotated); PO Resp. at 20.

Claims 1-6: *Grounds 1 & 2*

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Claims 1-6:

Toshiba Manual (Ground 1)

Claim 1: “variable frequency drive perform[ing] electric motor diagnostics”

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.

Claim Construction

Claim Language	
“electric motor diagnostics”	
Petition	Patent Owner’s Construction
The claim’s plain language does not require “electric motor diagnostics” to identify problems only with the electric motor. Dr. Durham opined that “electric motor diagnostics” do not exclude diagnostics on the electric motor and on something else.	Diagnostics for an electric motor alone.

The Petition Provides No Explanation For How VFD Faults Satisfy “Electric Motor Diagnostics”

Claim Language

“variable frequency drive performing electric motor diagnostics”

Toshiba Manual further discloses that the variable frequency drive performs electric motor diagnostics to prevent various types of damage to the electric motor, including protecting against overload, overcurrent, overtorque, short circuit, and earth faults.

- 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. *Toshiba Manual* describes alarms and trips:

Dr. Nikolaou Explains that *Toshiba’s* VFD Faults Are Not “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]
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>
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>

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>

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Dr. Nikolaou Explains that *Toshiba's* VFD Faults Are Not “Electric Motor Diagnostics” cont.

Claim Language

“variable frequency drive performing electric motor diagnostics”

Nikolaou Declaration (EX-2002 at ¶58) (annotated).

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.”

Challenged Patent Confirms VFD Faults Are Different Than “Electric Motor Diagnostics”

Claim Language

“variable frequency drive performing electric motor diagnostics”

'870 Patent

For example, 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 14. The electric motor diagnostics can be disabled, if desired, when using, for example, a low impedance or high-speed electric motor.

For example, the pump control and data monitoring equipment 40 can include an A/C console that controls the VFD, and thus the speed of the electric motor 14 and the pump 10. 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. The graphics panel can include, for example, a touchscreen interface.

A POSITA Would Not Have Combined *Coli* and *Toshiba*

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***Toshiba Manual* “Substitution” Argument**

Petition	Durham Declaration
A POSITA would have been motivated to use the VFD described in Toshiba Manual as the variable frequency drive in Coli, or to enhance the Coli VFD with the features taught by Toshiba Manual. Ex. 1002, ¶¶148-158.	In my opinion, a POSITA would have been motivated to simply substitute the VFD of Coli for the VFD of Toshiba Manual that has the diagnostic functionality and temperature monitoring to prevent damage, without affecting the other functionalities of Coli.

The “Substitution” Argument is Flawed

Patent Owner Response	Nikolaou Declaration
[D]uring his deposition, Dr. Durham admitted that a POSITA could not simply substitute Coli’s VFD for the VFD described in the Toshiba Manual. Toshiba’s VFD lacks the necessary horsepower requirements for Coli’s pump—that is, a “true 2500 hp” to each pump.	[T]he Toshiba G7 VFD only provides a maximum of around 800 horsepower to an electric motor and pump. This 800-horsepower maximum is insufficient to power the “present system” in Coli that requires “2500 hp” delivered directly to each pump.

PO Resp. at 22; Nikolaou Dec. (EX-2002 at ¶78) (internal citations omitted).

The “Substitution” Argument is Flawed

For example, a conventional diesel powered fluid pump is rated for 2250 hp. However, due to parasitic losses in the transmission, torque converter and cooling systems, diesel fueled systems typically only provide 1800 hp to the pumps. In contrast, the present system can deliver a true 2500 hp directly to each pump **22** because pump **22** is directly coupled to electric motor **21**.

The “Substitution” Argument is Flawed

Specifications	Manuals	Brochures	Drawings	Setup Software	Support
GX7 Standard Specifications					
Voltage Class	600 VAC				
Maximum HP	500 HP	600 HP	700 HP	800 HP	
Drive Rating (A)	481 A	601 A	698 A	770 A	
Dimensions	95"H x 32"W x 30.5"D				
Power Requirements					
Output Frequency	0 to 299 Hz				
Control Power	DC Bus Control Power				
Tolerance	Voltage: $\pm 10\%$; Frequency: $\pm 2\%$				
Control Specifications					
Control Method	Sine Wave PWM System; Flux Field Current Vector Control				
V/Hz Control	Constant Torque, Variable Torque, Open-Loop Vector, Auto or Manual Torque Boost, 5-Point V/Hz Custom Curves				
Overload Rating	130% for 120 Seconds; 110% Continuous				

Dr. Durham Admits Substitution Fails

Durham Deposition Transcript (EX-2003, 92:18-93:8) (annotated)

BY MR. HOPKINS:

Q So you could use a motor providing 2400 true horsepower with a Toshiba GX7, with a single GX7 ASD. Is that correct?

MS. FLANNERY: Object to form.

A We don't have enough data to answer your question the way you asked it.

BY MR. HOPKINS:

Q Let's turn back to paragraph 155. Do you have enough data to determine whether a POSITA would have been motivated to simply substitute the VFD in Coli for a single VFD of Toshiba in the Toshiba Manual?

A No.

Durham Declaration (EX-1002 at ¶ 155) (annotated).

155. In my opinion, a POSITA would have been motivated to simply substitute the VFD of Coli for the VFD of *Toshiba Manual* that has the diagnostic functionality and temperature monitoring to prevent damage, without affecting the other functionalities of Coli.

Dr. Durham Admits Substitution Fails

Durham Deposition Transcript; (EX-2003, 89:13-20) (annotated).

Q So the example provided in Coli that requires the present system to deliver a true 2500 horsepower directly to each pump could not be used with a single Toshiba GX7 described in Exhibit 1006 and 1047. Is that correct?

A Yes, that specific embodiment and limited the GX7 to a single one as specified in 1047 and 1006, they would not work.

Toshiba Teaches Away From Coli + Toshiba

Toshiba

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

Nikolaou Declaration

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.

New Coli + Toshiba Argument is Untimely

Petition	Petitioner’s Reply
A POSITA would have been motivated to use the VFD described in Toshiba Manual as the variable frequency drive in Coli, or to enhance the Coli VFD with the features taught by Toshiba Manual. Ex. 1002, ¶¶148-158.	A POSITA would understand how to combine the references’ teachings without focusing on whether a single Toshiba VFD could be used with Coli’s 2500-hp pump. And a POSITA would understand how to run multiple Toshiba VFDs in parallel to achieve the desired horsepower.

Petition at 23 (annotated); Petitioner’s Reply at 9 (annotated)
PO Sur-Reply at 19–21.

Petitioner’s Reply Not Responsive

Patent Owner’s Response	Petitioner’s Reply
Given this warning in Toshiba Manual, a POSITA would have understood that the <i>Toshiba Manual</i> teaches away from simply substituting the VFD of Coli for the VFD of <i>Toshiba Manual</i> . EX-2002, ¶ 84.	A POSITA would understand how to combine the references’ teachings without focusing on whether a single Toshiba VFD could be used with Coli’s 2500-hp pump. And a POSITA would understand how to run multiple Toshiba VFDs in parallel to achieve the desired horsepower.

PO Resp. at 25 (annotated); Petitioner’s Reply at 9 (annotated)
POR Sur-Reply at 19–21.

Toshiba Manual “Features” Argument

Petition

A POSITA would have been motivated to use the VFD described in Toshiba Manual as the variable frequency drive in Coli, **or to enhance the Coli VFD with the features taught by Toshiba Manual**. Ex. 1002, ¶¶148-158.

Durham Declaration

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.

The “Features” Argument is Unsupported

Patent Owner Response

By making **conclusory statements**, Dr. Durham’s expert testimony provides little to no probative value beyond Petitioner’s attorney argument.

Nikolaou Declaration

But Dr. Durham cites little to no evidence in most of the above rationales so I cannot understand his basis for making such statements. . . . **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.

Claims 1-6: *Horikoshi (Ground 2)*

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DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

“[E]lectric motor diagnostics” is Plural

Claim Language

“variable frequency drive performing electric motor diagnostics”

Institution Decision

We therefore presently conclude that Toshiba Manual teaches performance of **electric motor diagnostics (plural)** as recited in claim 1.

Petitioner Admits That *Horikoshi* Discloses a Single “Diagnostic”

Claim Language

“variable frequency drive performing electric motor diagnostics”

Petitioner’s Reply

Horikoshi also discloses “plural” “electric motor diagnostics” because it discloses performing its electric motor diagnostic multiple times. *Horikoshi* performs its “fault diagnostic function” “during operation,” Ex.1008, ¶11, so *Horikoshi* must perform the fault diagnostic more than once over the life of the VFD, Ex.1002, ¶¶86, 129, 215-217.

Claim Construction: “*electric motor diagnostics*”

Claim Language	Institution Decision
“variable frequency drive performing electric motor diagnostics”	We therefore presently conclude that Toshiba Manual teaches performance of electric motor diagnostics (plural) as recited in claim 1.

- There is no dispute that “*electric motor diagnostics*” is plural
- The parties dispute what constitutes what satisfies the claimed “*electric motor diagnostics*”
 - Patent Owner: Multiple “*electric motor diagnostics*”
 - Petition: A single “*electric motor diagnostic*” performed multiple times

Claim Construction: “*electric motor diagnostics*”

Claim Language

“variable frequency drive performing electric motor diagnostics”

Petitioner’s Reply

11. PO half-heartedly argues that *Horikoshi* does not disclose plural “electric motor diagnostics.” POR, 44. But PO fails to clarify what it means by “more than one diagnostic” or how *Horikoshi* fails to disclose it. PO suggests that “electric motor diagnostics” requires multiple different types of diagnostics simply because the word “diagnostics” is plural. But the record does not support this narrow interpretation.

Claim Construction: “*electric motor diagnostics*”

Claim Language

“variable frequency drive performing electric motor diagnostics”

'870 Patent

For example, **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 14. The **electric motor diagnostics** can be disabled, if desired, when using, for example, a low impedance or high-speed electric motor.

Dr. Nikolaou Confirms That *Horikoshi* Discloses a Single Diagnostic

Claim Language	Nikolaou Declaration
“variable frequency drive performing electric motor diagnostics”	61. Claims 1 and 4 require “electric motor diagnostic ^s ” (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

***Horikoshi* “Multiple Performance” Argument Untimeliness**

Claim Language

“variable frequency drive performing electric motor diagnostics”

Petitioner Reply

Horikoshi also discloses “plural” “electric motor diagnostics” because it discloses performing its electric motor diagnostic multiple times. *Horikoshi* performs its “fault diagnostic function” “during operation,” Ex.1008, ¶11, so *Horikoshi* must perform the fault diagnostic more than once over the life of the VFD, Ex.1002, ¶¶86, 129, 215-217.

Petitioner's Construction is Inconsistent with Specification

Claim Language

“variable frequency drive performing electric motor diagnostics”

'870 Patent

For example, 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 14.

Claim 13

Claim 13

13. The system of claim 12, wherein the vehicle is a truck having at least five axles.

Petitioner Mapped Coli's Truck-Trailer to the Claimed “Truck”

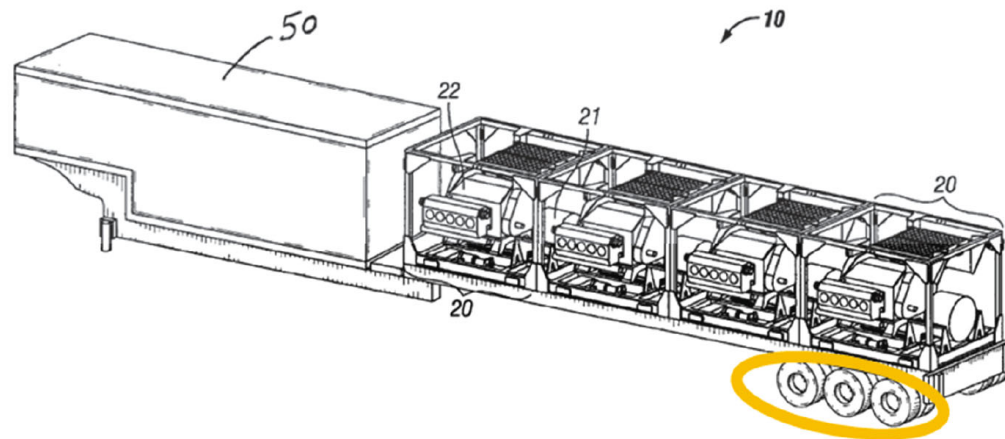


FIG. 3

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. Ex. 1002, ¶198. Accordingly, *Coli* discloses a vehicle that is truck-trailer configuration with a total of 5 axles. *Id.*, ¶198.

A Claimed “Truck”

13. The system of claim 12, wherein the vehicle is a truck having at least five axles.

What is claimed is:

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;

Claim Language: “a truck”

Nikolaou Declaration (EX-2002 at ¶¶ 104, 107) (annotated).

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.

* * *

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.

Petitioner's Remaining Obviousness Rationales for the Claimed "Truck" are Deficient

Additionally, a "unitary" truck with five axles would have been obvious to a POSITA in view of this disclosure of a three axle semi-trailer intended to be attached to and pulled by a tractor (commonly referred to collectively as a "tractor-trailer truck," a "semi-trailer truck," and a "semi-truck") because a POSITA would have known that the semi-trailer portion could be permanently attached to the tractor portion of the truck instead of as a detachable trailer, as is done with many commercial trucks.

Petitioner’s Remaining Obviousness Rationales for the Claimed “Truck” are Deficient

Petition	Durham Declaration
Furthermore, a POSITA would have understood that the number of axles used on a vehicle is a simple design choice, with the number of axles to use being determined based on the amount of load that is supported by the axles. Ex. 1002, ¶200.	200. Furthermore, a POSITA would have understood that the number of axles used on a vehicle is a simple design choice, with the number of axles to use being determined based on the amount of load that is supported by the axles. I further understand that the Board found a substantially similar claim of the ’601 Patent to be disclosed by Coli. Ex. 1048 at 43. Accordingly, Coli discloses or at least renders obvious claim 13.

Petition at 42–43; Durham Dec. (EX-1002 at ¶200); PO Resp. at 48–49.

Claims 15 & 16

Claims 15 & 16

15. The system of claim 7, wherein the electric motor has a **maximum continuous power** output of about 1750 brake horsepower or more.

16. The system of claim 7, wherein the electric motor has a **maximum continuous torque** of about 8750 lb-ft or more.

Petitioner's Evidence for *Coli* Teaching Claims 15 and 16

In contrast, the present system can deliver a true 2500 hp directly to each pump 22 because pump 22 is directly coupled to electric motor 21.

[0011] In certain illustrative embodiments, the electric motor can be an AC permanent magnet motor and/or a variable speed motor. 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. The pump can be a triplex or quintiplex plunger style fluid pump.

“Maximum” is not “maximum continuous”

Specifications	Manuals	Brochures	Drawings	Setup Software	Support
GX7 Standard Specifications					
Voltage Class	600 VAC				
Maximum HP	500 HP	600 HP	700 HP	800 HP	
Drive Rating (A)	481 A	601 A	698 A	770 A	
Dimensions	95"H x 32"W x 30.5"D				
Power Requirements					
Output Frequency	0 to 299 Hz				
Control Power	DC Bus Control Power				
Tolerance	Voltage: $\pm 10\%$; Frequency: $\pm 2\%$				
Control Specifications					
Control Method	Sine Wave PWM System; Flux Field Current Vector Control				
V/Hz Control	Constant Torque, Variable Torque, Open-Loop Vector, Auto or Manual Torque Boost, 5-Point V/Hz Custom Curves				
Overload Rating	130% for 120 Seconds; 110% Continuous				

Claim Language

“maximum continuous power” “maximum continuous torque”

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

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.

Conclusion

- Claims 7-16: Prior art does not render obvious “*a variable frequency drive*” “*having heat sinks having thermal sensors*”
 - Ground 1 is deficient because the Petition failed to show that *Toshiba* inherently discloses a VFD having a heat sink having a thermal sensor
 - Ground 3 is deficient for two reasons:
 - Petitioner failed to prove one would combine *Coli* and *Loucks*.
 - Petitioner’s proposed combination render Petitioner’s proposed combination does not render obvious “*a variable frequency drive*” “*having heat sinks having thermal sensors*”
- Claims 1-6: Prior art does not render obvious “*electric motor diagnostics*”
 - Grounds 1 and 2: None of the prior art discloses multiple “electric motor diagnostics”
 - Ground 1: A POSITA would not have combined *Coli* and *Toshiba*
- Dependent Claims
 - Claim 13: Prior art does not render obvious a “*truck having 5 or more axles*”
 - Claims 15-16: Prior art does not render obvious “*maximum continuous [horsepower/torque]*”

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

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Extra Slides

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

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Petitioner’s New Electric Motor Damage Argument

Claim Language	
“variable frequency drive performing electric motor diagnostics”	
Petition	Petitioner Reply
The diagnostics includes a “ fault screen ” that “identifies the active Fault.” Id. at 182–186 (Table 12, containing a list of 5 pages of faults that are diagnosed).	He lists several examples of the diagnostics, including overload and over-current protection, and the possible causes of each fault relating to preventing damage an electric motor.

Nikolaou’s Opinion re Inherency Argument is Unrebutted

Claim Language	
"heat sinks having thermal sensors"	
Nikolaou Declaration	Durham Declaration
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 <i>Toshiba Manual</i> in its entirety, <i>Toshiba Manual</i> does not disclose that its internal thermal sensor is necessarily located on a heat sink.	In order for the CPU to control the cooling fans of the VFD in “automatic” mode, it would be necessary to have temperature data supplied to the microprocessor so it could determine when to turn the fans on (supply additional cooling) or off (conserve energy when not needed).

***Apple Inc. v. Andrea Elecs. Corp.*, 949 F.3d 697, 705-06 (Fed. Cir. 2020).**

Therefore, in determining whether [Petitioner] appropriately advanced its arguments . . . we must consider: [1] whether the petitioner's reply brief is responsive to arguments originally raised in its petition; or [2] whether the reply arguments are responsive to arguments raised in the patent owner's response brief.

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

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***Netflix, Inc. v. DivX, LLC*, 84 F.4th 1371, 1381 (Fed. Cir. 2023).**

“Petitioner never raised this potential argument in its petition, and the Board correctly declined to assume that such an argument had been raised.”

New Obviousness Argument is Not Responsive

Claim Language	
"heat sinks having thermal sensors"	
Patent Owner's Response	Petitioner Reply
Petitioner identifies no evidence that Toshiba's thermistor is located on the heat sink. Instead, it cites only Dr. Durham's conclusory testimony in asserting that the heat sinks "would necessarily have sensors (e.g., thermistors) to report the temperature measurements."	To the extent the Board maintains that <i>Toshiba Manual</i> does not disclose that its heat sink has thermal sensors, a POSITA would have deemed that obvious.

Toshiba New Table Evidence is Untimely

Claim Language	
"heat sinks having thermal sensors"	
Institution Decision	Petitioner's Reply
Toshiba Manual was publicly accessible from the Toshiba website at least by December 7, 2010, the date it was archived by the Internet Archive Wayback Machine. Ex. 1007, (Internet Archive Decl.) at 1, 25 (sponsoring Exhibit 1006).	Moreover, the drawings and equipment list for Toshiba's VFD refer to the only thermistor in that device as the "heatsink thermistor." * * * Ex.1007pt.2, 251 (excerpt highlighted above), 264, 279-80; see also Ex.1002, ¶120.

Petitioner’s New Obviousness Argument is Faulty

Claim Language	
"heat sinks having thermal sensors"	
Petitioner Reply	Patent Owner Sur-Reply
that dissipate heat. Ex.1054, 74:5-76:20. Regarding the location of the thermal sensor, Dr. Nikolaou also conceded that a POSITA would have understood that <i>Toshiba Manual</i> ’s thermistor could be located on the heat sink (Ex.2002, ¶63), but	(emphasis added). As the PTAB explained, “[a]n assertion that something could be done does not articulate a reason why something would be done . . . rais[ing] a specter of impermissible hindsight bias in an obviousness analysis.” <i>Nautilus Hyosung Inc. v. Diebold Self-Service Systems Division of Diebold</i> , IPR2016-00633, Paper 9, 21 (PTAB Aug. 22, 2016) (emphasis added).

Petitioner’s Reply at 16 (annotated); PO Sur-Reply at 5–6.

Loucks is Not Analogous Art

Petition

Loucks teaches techniques for improved “cooling efficiency” and applies those techniques to “any device that consumes electrical energy and exhausts waste heat” including “variable or adjustable frequency drives.”

Petitioner’s Reply

The ’870 Patent addresses implementing VFDs and electric motors in the field of hydraulic fracturing. Ex.1001, 1:24-26, 2:5-7, 4:8-25; Ex.1002, ¶¶ 40-41. Prior art techniques for implementing VFDs and electric motors in other fields, including those of Loucks, would have been reasonably pertinent to that problem.

Petitioner’s Argument is Unsupported by Evidence

Patent Owner’s Response	Petitioner’s Reply
Because Loucks does not describe any portable equipment, Dr. Nikolaou explains that that an inventor considering the problem addressed in the ’870 patent would not be motivated to turn to Loucks...	The ’870 Patent addresses implementing VFDs and electric motors in the field of hydraulic fracturing. Ex.1001, 1:24-26, 2:5-7, 4:8-25; Ex.1002, ¶¶ 40-41. Prior art techniques for implementing VFDs and electric motors in other fields, including those of Loucks, would have been reasonably pertinent to that problem.

Petitioner's Argument is Unsupported by Evidence

Durham Declaration (EX-1002 at ¶¶ 132, 234-235) (annotated).

132. *Loucks* teaches that the cooling calculations are applied to various electrical equipment including “transformers, circuit breakers, uninterruptible power supplies (UPSs) or variable frequency drive.” . . . Accordingly, in my opinion, a POSITA would have understood that *Loucks* teaches a method for preventing damage to electrical equipment due to overheat.

234. *Loucks* teaches that its cooling efficiency calculation method is directly applicable to electrical equipment such as “transformers, circuit breakers, uninterruptible power supplies (UPSs) or variable frequency drives (VFDs).” Ex. 1009, [0036]. . . . As would have been well known to a POSITA, “cooling problems . . . can contribute to electrical equipment malfunction or accelerated degradation since overheated equipment does not operate as effectively as equipment operating at acceptable temperature limits.” Ex. 1009, [0003]; *see also supra* Section VIII.C

235. . . . [I]t was well understood that power semiconductor components of a VFD require cooling to prevent damage caused by overheating, a problem addressed by the use of heat sinks long before the '870 Patent. *See supra* Section VIII. Particularly in view of *Loucks*' applications to VFDs, a POSITA would have been motivated to look to *Loucks*' heat sinks and temperature sensors and employ *Loucks*' cooling efficiency monitoring techniques to “detect problems” with *Coli*'s VFD “before temperatures reach alarm limits” and to ensure that it does not “malfunction” or suffer from “accelerated equipment degradation and early failure.” Ex. 1009, [0018].

'870 Patent's Problem Is Not Implementing VFDs

Durham Deposition Transcript (EX-2003, 10:13-11:4) (annotated)

Q And did I hear you correctly that you said it was a 3 horsepower variable frequency?

A Yes, yes. And I would clarify that that's the smallest one that I've done where it was an individual ASD. You almost can't buy an appliance anymore without a direct drive variable frequency drive on it.

Q What kind of appliances have ASDs and variable frequency drives?

A Washers, dryers, refrigerators, freezers, air conditioners, pool pumps. You can go down the list Almost all appliances now that have motors have at least as an option a direct drive pulse-width modulated variable frequency drive.

'870 Patent (EX-1001 at 4:10-16)

For example, as far as hardware is concerned, the VFD can include packaging receiving a high rating by the National Electrical Manufacturers Association (such as nema 1 packaging), and power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat.

Loucks is Not Analogous Because it is Not Portable

Nikolaou Deposition (EX-1054, 118:22-120:2) (objection omitted)

Q Okay. All right. Does the '870 patent say that the pumps or the motors or the VFDs have to be portable?

A There was reference to these things. And frankly, I would have to go through the patent again in detail to tell whether something is portable or not. For example, a moment ago you asked me about portability of equipment and what this meant, using the trailer and there are other places where this issues touched upon. So I can answer that if given enough time to go through all the details of this, what is portable or what is not. But the basic idea for having a trailer attached to a truck and having ways to move things around is essential in this patent.

Loucks is Not Analogous Because it is Not Portable

Nikolaou Deposition (EX-1054, 178:20-179:19).

Q Does Loucks state whether the equipment that was shown in Figure 1 and Figure 5 that we looked at a few minutes ago, does that state whether that equipment is portable?

A Let me look again really quickly, if I may. (Reviewing.)

Q Just let me know what portion of Loucks your reading.

A Talking about which equipment being portable, the one we looked at in Figure 5.

Q Figure 1 and Figure 5 is particularly what I am interested in.

A Figure 1 is the room and it's -- everything is there in the room, all that equipment. So this is not something that is easily portable. Of course, you can always, with enough effort, move things around. So that is the thing there. Mainly, this is not designed for portability.

'870 Patent's Problem Is Not Implementing VFDs

Institution Decision

... and one particular aspect of that problem was **how to use a VFD to drive the electric motors**. See Ex. 1001, 1:24–26, 1:52–54, 2:5–7, 2:21–22, 4:8–25. Loucks is reasonably pertinent to those problems, because it discusses the need to cool VFDs and provide methods for doing so.

Durham Declaration

73. **By the early 2000s**, installations of large ASDs in petroleum and chemical operations became **so ubiquitous** that industry recognized a need for standardization.

***SAS Institute, Inc. v. Iancu*, 138 S. Ct 1348 at 1356**

[T]he petitioner's petition, not the Director's discretion, is supposed to guide the life of the litigation.

New Loucks Theory is Not Responsive

Claim Language	
“thermal sensors monitored by a microprocessor to prevent damage caused by excessive heat.”	
Patent Owner’s Response	Petitioner’s Reply
But, Petitioner’s Expert Dr. Durham, admitted under cross examination that Loucks high temperature limits and alarms are not part of its “cooling efficiency monitoring technique” as shown in Figure 2 and incorporated into its VFD:	Thus, paragraph 18 simply confirms that Loucks’ methods monitor the sensor 510 to prevent damage that could result from excessive heat if the alarms or limits were reached.

117. *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:

- [Bulleted list of faults]

...

These diagnostic functions result in an alarm or trip condition on the ASD. *Toshiba Manual* describes alarms and trips:

[quote describing alarm and trip condition
functionality]

Ex. 1006, at 179.

150. *Toshiba Manual*, entitled “G7 Adjustable Speed Drive Operation Manual,” contains a description and details regarding the functionality, and schematics of a quintessential VFD. Ex. 1006. *Toshiba Manual* provides numerous examples of electric motor diagnostics, including overload protection, over-current protection, electronic thermal protection, overheat, overcurrent stall level, motor 150% OL time limit, short circuit test, over-torque trip, and earth fault trip. Ex. 1006 at 19, 22, 160, 161, 162, 163, 166, 180. The diagnostics further includes a “fault screen” that “identifies the active Fault.” Ex. 1006 at 182-186 (Table 12). *Toshiba Manual* further discloses the use of alarms to indicate that “a Fault is imminent if existing operating conditions continue unchanged.” Ex. 1006 at 179.

118. As discussed above, certain diagnostic actions result in a trip. Table 12 from Ex. 1006 shows several trip conditions and possible causes. Included in this table as it relates to preventing damage to an electric motor are the following:

Fault Screen Display	Possible Causes
Earth Fault	Ground Fault at the motor
Load Drooping	Load requirement is in excess of the capabilities of the motor
Motor Overload	Motor is locked Load requirement exceeds ability of the motor Continuous operation at low speed
Overcurrent During Acceleration	Accel time too short Motor / machine jammed Mechanical brake engaged while the ASD is running
Overcurrent During Deceleration	Motor / machine jammed Mechanical brake engaged while the ASD is running
Overtorque	A torque requirement by the load in excess of the setting of the motor (specific settings)
U phase Short Circuit	Low impedance at the U lead of the ASD output (at the motor or in cable to motor)
V phase Short Circuit	Low impedance at the V lead of the ASD output (at the motor or in cable to motor)
W phase Short Circuit	Low impedance at the W lead of the ASD output (at the motor or in cable to motor)

Ex. 1006, at 82–84 (Table 12).

119. The majority of the diagnostics that would result in a trip of the drive to protect the motor are conducted on a continuous basis as the motor is being run. Some diagnostics, such as the “Short Circuit Test,” are specifically conducted “every run” or “every power up” (Ex. 1006, at 162), which meets the definition of frequently, as used in this proceeding.

166. As discussed above, Toshiba Manual likewise discloses an “Adjustable Speed Drive” or VFD used to control the speed of a motor. Ex. 1006 at 2. Toshiba Manual further discloses operating a VFD with the ability to “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). 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. Toshiba Manual further explains that its VFD controls a motor that, in turn, may power a pump. See Ex. 1006. at 13 (“[t]he output terminals of the ASD . . . must be connected to the motor that is to be controlled”); Ex. 1006 at 71 ((describing prevention of “motor overload trips when used on fans, blowers, pumps, and other centrifugal loads which require less torque at lower frequencies”).

Durham Declaration (EX-1002 at ¶ 166) (annotated).

166. As discussed above, *Toshiba Manual* likewise discloses an “Adjustable Speed Drive” or VFD used to control the speed of a motor. Ex. 1006 at 2. *Toshiba Manual* further discloses operating a VFD with the ability to “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). *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. *Toshiba Manual* further explains that its VFD controls a motor that, in turn, may power a pump. See Ex. 1006. at 13 (“[t]he output terminals of the ASD . . . must be connected to the motor that is to be controlled”); Ex. 1006 at 71 ((describing prevention of “motor overload trips when used on fans, blowers, pumps, and other centrifugal loads which require less torque at lower frequencies”).

Petition (Paper 1 at 31)

As discussed above, *Toshiba Manual* likewise discloses an “Adjustable Speed Drive” or VFD used to control the speed of a motor. Ex. 1006 at 2, 44; Ex. 1002, ¶166. *Toshiba Manual* further discloses operating a VFD with the ability to “perform diagnostics.” Ex. 1007 at 43. The diagnostics includes a “fault screen” that “identifies the active Fault.” *Id.* at 182–186 (Table 12, containing a list of 5 pages of faults that are diagnosed). *Toshiba Manual* further discloses that the variable frequency drive performs electric motor diagnostics to prevent various types of damage to the electric motor, including protecting against overload, overcurrent, overtorque, short circuit, and earth faults. Ex. 1007 at 162; Ex. 1002 ¶¶117, 150, 166. *Toshiba Manual* further explains that its VFD controls a motor that, in turn, may power a pump. See Ex. 1006 at 23 (“[t]he output terminals of the ASD . . . must be connected to the motor that is to be controlled”); *id.* at 71 (describing prevention of “motor overload trips when used on fans, blowers, pumps, and other centrifugal loads which require less torque at lower frequencies”).

Petitioner’s New Theory is Unsupported

Claim Language	
“variable frequency drive performing electric motor diagnostics”	
Petitioner Reply	Durham Declaration
He lists several examples of the diagnostics, including overload and over-current protection, and the possible causes of each fault relating to preventing damage an electric motor.	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).

Horikoshi does not disclose plural “electric motor diagnostics”

Claim Language	Nikolaou Declaration
“variable frequency drive performing electric motor diagnostics”	61. Claims 1 and 4 require “electric motor diagnostic <u>s</u> ” (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

“[T]rue [] hp” v. “*Maximum continuous power*”

Petition

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.” Ex. 1002, ¶203; Ex. 1048 at 41.

Durham Declaration

203. 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.

Claim Language

“maximum continuous power”

Durham Deposition (EX-2003 at 46:8–18) (annotated).

Q Does an electric motor have a limit on its input current for **continuous operation** that is different than a limit for 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**.

Claim 15 Merits

Claim Language	
“maximum continuous power”	
Nikolaou Declaration	Coli
I disagree. Upon review of the evidence, it is my opinion that this does not disclose the “maximum <i>continuous</i> power” of <i>Coli</i> ’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 <i>continuous</i> horsepower.	For example, a conventional diesel powered fluid pump is rated for 2250hp. However, due to parasitic losses in the transmission, torque converter and cooling systems, diesel fueled systems typically only provide 1800 hp to the pumps. In contrast, the present system can deliver a true 2500 hp directly to each pump 22 because pump 22 is directly coupled to electric motor 21.

“up to . . . of torque” v. “*Maximum continuous torque*”

Petition

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.” 6 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; Ex. 1048 at 41-42.

Durham Declaration

204. 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.” I further understand that the Board found a substantially similar claim of the ’601 Patent to be disclosed by Coli. Ex. 1048 at 41-42.

Claim Language

“maximum continuous torque”

Durham Declaration (EX-2003 at 47:1-11) (annotated).

Q Would you suspect that they'd have different torques?

MS. FLANNERY: Object to form.

A It depends on how it's being operated. At a constant speed, an increase in horsepower changes the available torque, but it's that constant speed that's kind of a kicker.

BY MR. HOPKINS:

Q Assuming a constant speed for both?

A Assuming a constant speed and all else being equal, yes, the torque would increase as current increase.

Claim 16 Merits

Claim Language	
“maximum continuous torque”	
Nikolaou Declaration	Coli
I disagree. Upon review of the evidence, it is my opinion that this does not disclose the “maximum <i>continuous</i> torque” of <i>Coli</i> ’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 horsepower and maximum <i>continuous</i> horsepower.	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. The pump can be a triplex or quintiplex plunger style fluid pump.

***In re Varma*, 816 F.3d 1352, 1363 (Fed. Cir. 2016)
(citing *Fin Control Sys. Pty, Ltd. v. OAM, Inc.*, 265 F.3d 1311, 1318 (Fed. Cir. 2001))**

[T]he principle 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.