Filed on behalf of Baker Hughes Incorporated

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BAKER HUGHES INCORPORATED.,
Petitioner

v.

LUBRIZOL SPECIALTY PRODUCTS, INC.,
Patent Owner

Case IPR2016- 00734
Patent No. 8,022,118

PETITION FOR *INTER PARTES* REVIEW

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PETITIONER'S EXHIBIT LIST

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1004	U.S. Patent No. 4,983,186 ("Naiman")
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1010	Material Safety Data Sheet for KOCH SURE SOL®-150 (2000)
1011	Barrufet, M. *et al.* (2003) "Reliable Heavy Oil-Solvent Viscosity Mixing Rules for Viscosities Up to 450 K, Oil-Solvent Viscosity Ratios Up to 4 x 10^5, and Any Solvent Proportion" *Fluid Phase Equilibria* 213:65-79
1012	Fetters, J. *et al.* (1999) "Chain Dimensions and Entanglement Spacings in Dense Macromolecular Systems" *J. Polym. Sci. B: Polym. Phys.* 37:1023-33
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1031	Martinez-Palou, R. *et al.* (2011) "Transportation of Heavy and Extra-Heavy Crude Oil by Pipeline: A Review" *J. Pet. Sci. Eng.* 75:274-82
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1034	Tait, P.J.T. *et al.* (1970) "Thermodynamic Studies on Poly(α-olefin)-Solvent Systems" *Polymer* 11:359-73
1035	*Polymers: A Property Database*, 2nd ed., Ellis, B. *et al.* (Eds.), CRC Press, Boca Raton, FL, 2009
1036	*Handbook of Thermoplastics*, 2nd ed., Olabisi, O. *et al.* (Eds.), CRC Press, Boca Raton, FL, 2016
1037	Sharp, D.G. *et al.* (1950) "Size and Density of Polystyrene Particles Measured by Ultracentrifugation" *J. Biol. Chem.* 185:247-53

I. INTRODUCTION

Baker Hughes Incorporated petitions for *inter partes* review of claims 1-11 of U.S. Patent No. 8,022,118 ("the 118 patent"; Ex. 1001). The claims of the 118 patent are directed to a method of treating heavy crude oil with a drag reducing polymer, thereby improving the flow of the oil through a pipeline. Claim 1 is representative:

> 1. A method comprising:
> introducing a drag reducing polymer, into a pipeline, such that such that [*sic*] the friction loss associated with the turbulent flow through the pipeline is reduced by suppressing the growth of turbulent eddies, into a liquid hydrocarbon having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;
> wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon and
> the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.

Ex. 1001 at 19:33-48.

The specification of the 118 patent describes the synthesis and testing of two purportedly novel drag reducing polymers, named "Polymer A" and "Polymer B,"

that are especially suited for use in heavy crude oil. *See* Ex. 1001 at 13:3-18:24 (Examples 1-5). But while the application that issued as the 118 patent included composition-of-matter claims to these drag reducing polymers, the patentee pursued and ultimately obtained broad claims to a method of treating virtually *any* heavy crude oil with virtually *any* effective drag reducing polymer.

The patentee was not the first, however, to effectively treat heavy crude oil with a drag reducing polymer. For example, U.S. Patent No. 6,015,779 (Ex. 1002; "Eaton"), which issued five years before the effective filing date of the 118 patent, describes the synthesis and successful testing of drag reducing polymers in heavy crude oil. Indeed, Eaton discloses each and every element of six claims of the 118 patent. Moreover, the elements of the remaining claims that are not disclosed in Eaton are disclosed in two other prior art references, "Strausz" and "Naiman" (Exhibits 1003 and 1004, respectively). Accordingly, there is at least a reasonable likelihood that each of claims 1-11 of the 118 patent is unpatentable over Eaton, either alone or in combination with Strausz and Naiman.

II. MANDATORY NOTICES

Real Parties-In-Interest: Baker Hughes Incorporated and Baker Petrolite LLC, are the real parties-in-interest.

Related Matters: The following judicial or administrative matters would affect or be affected by a decision in the proceedings:

1. *Lubrizol Specialty Products, Inc. v. Baker Hughes Inc.*, Case No. 4:15-cv-02915 (S.D. Tex.), filed October 5, 2015;

2. *Lubrizol Specialty Products, Inc. v. FLOWCHEM LLC*, Case No. 4:15-cv-02917 (S.D. Tex.), filed October 5, 2015); and

3. U.S. Patent Application No. 13/209,119, filed on August 12, 2011, which is pending and which claims benefit to and is a continuation in part of U.S. Patent Application No. 11/615,539.

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Service Information: Petitioner consents to service by email at: BakerHughes118IPR@mcandrews-ip.com.

III. GROUNDS FOR STANDING

The 118 patent is available for *inter partes* review, and Petitioner is not barred or estopped from requesting an *inter partes* review challenging claims 1-11 of the 118 patent on the grounds identified in this Petition.

IV. IDENTIFICATION OF CHALLENGE

Petitioner identifies the following grounds of unpatentability:

Ground 1: Claims 1, 3, 4, 6, 7, and 11 are anticipated by U.S. Patent No. 6,015,779 ("Eaton"; Ex. 1002).

Ground 2: Claims 1-7 and 11 are obvious over Eaton in view of Strausz et al., *The Chemistry of Alberta Oil Sands, Bitumens and Heavy Oils*, Alberta Energy Research Institute, Calgary, 2003 ("Strausz"; Ex. 1003).

Ground 3: Claims 8-10 are obvious over Eaton in view of Strausz and U.S. Patent No. 4,983,186 ("Naiman"; Ex. 1004).

V. THE 118 PATENT

A. The Subject Matter of the 118 Patent

The 118 patent "relates generally to high molecular weight drag reducers for use in crude oils." Ex. 1001 at 7-8. More specifically, the 118 patent "relates to high molecular weight drag reducing polymers for use in crude oils having an

asphaltene content of at least about 3 weight percent and an API gravity of less than about 26°." *Id.* at 1:9-12. The 118 patent refers to such crude oil as "heavy crude oil." *See id.* at 2:4-9. *See also* Ex. 1024 at ¶ 9 ("The limitations put forth by our patent application of a liquid hydrocarbon [having] an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° place the liquid hydrocarbon in the range of 'heavy crude oils' as known by one skilled in the art.").

As the 118 patent explains, "[w]hen fluids are transported by a pipeline, there is typically a drop in fluid pressure due to friction between the wall of the pipeline and the fluid. Due to this pressure drop, for a given pipeline, fluid must be transported with sufficient pressure to achieve the desired throughput." Ex. 1001 at 1:15-19. The 118 patent further teaches, in the Background of the Invention:

> To alleviate the problems associated with pressure drop, many in the industry utilize drag reducing additives [also referred to as drag reducing agents ("DRAs")] in the flowing fluid. When the flow of fluid in a pipeline is turbulent, high molecular weight polymeric drag reducers can be employed to enhance the flow. A drag reducer is a composition capable of substantially reducing friction loss associated with the turbulent flow of a fluid through a pipeline. The role of these additives is to suppress the growth of turbulent eddies, which results in higher flow rate at a constant pumping pressure. Ultra-high molecular weight polymers are known to function well as drag

> reducers, particularly in hydrocarbon liquids. In general, drag reduction depends in part upon the molecular weight of the polymer additive and its ability to dissolve in the hydrocarbon under turbulent flow. Effective drag reducing polymers typically have molecular weights in excess of five million.

Id. at 1:28-43.

Thus, the 118 patent recognizes that several limitations of claims 1-11 were known in the prior art. Specifically, the patent acknowledges that:

(1) DRAs were known in the art;

(2) the mechanism of action of DRAs—i.e., "substantially reducing friction loss associated with the turbulent flow of a fluid through a pipeline [by] suppress[ing] the growth of turbulent eddies")—was known in the art;

(3) ultra-high molecular weight polymers ("typically hav[ing] molecular weights in excess of five million") were known to function as drag reducers; and

(4) it was known in the art that "drag reduction depends in part upon [the] ability [of the DRA] to dissolve in the hydrocarbon under turbulent flow."

In addition, the 118 patent acknowledges that the equations and methods for determining solubility parameters (recited in claims 6, 7, and 11) were known in the prior art. For instance, the 118 patent states, "[t]he solubility parameter for the liquid hydrocarbon is determined in accord with the above equation [$\delta_2=[(\Delta Hv-RT)/V]^{1/2}$] and the description found on pages 465-467 of [Strausz; Ex. 1003]."

Ex. 1001 at 4:20-33. Likewise, the 118 patent states, "[t]he solubility parameter of the drag reducing polymer is determined according to the Van Krevelen method of the Hansen solubility parameters. This method of determining solubility parameters can be found in [Brandrup; Ex. 1007]." *Id.* at 11:47-60.

In describing the problem that the 118 patent addresses, the patent states:

> Conventional polymeric drag reducers, however, typically do not perform well in crude oils having a low API gravity and/or a high asphaltene content. Accordingly, there is a need for improved drag reducing agents capable of reducing the pressure drop associated with the turbulent flow of low API gravity and/or high-asphaltene crude oils through pipelines.

Id. at 1:46-49. The 118 patent purports to fill this need. And the 118 patent inventors may perhaps have invented such "improved drag reducing agents"—e.g., polymers A and B of Example 1. But, as demonstrated below, they certainly were not the first to practice the methods that are broadly claimed in the 118 patent.

B. Prosecution History of the 118 Patent

The 118 patent was filed as U.S. Patent Application No. 11/615,539 ("the '539 application") on December 22, 2006. The 118 patent does not claim priority to any earlier-filed application, and therefore the effective filing date of the 118 patent is December 22, 2006.

As originally filed, the '539 application contained 75 claims, including many that recited drag reducing polymers having a specific chemical structure. A preliminary amendment brought the total number of claims up to 92, including composition-of-matter and method-of-use claims. Ex. 1013. Following a restriction requirement, the applicants elected 77 claims, all of which claimed methods of use, but many of which recited drag reducing polymers having a specific chemical structure. Ex. 1014.

The first Office Action rejected all of the pending claims under sections 112, 102, and/or 103. Ex. 1015. In a second Office Action, all of the pending claims were rejected again, but this time on new grounds under section 103. Ex. 1016. In response, the applicants amended the independent claims to include a "weight average molecular weight" limitation of the drag reducing polymer and argued that the claims were not obvious because a "weight average molecular weight of at least 1 x 10^6 g/mol is outside the scope of the current references." Ex. 1017 at 32. In the same response, however, in support of their argument that a prior art reference did not teach effective drag reduction, the applicants admitted that "[i]t is well known in the art that to be an effective drag reducer, in liquid hydrocarbon with the properties currently claimed, ultra-high molecular weights are required." *Id.* at 33.

Prior to the third Office Action, a new examiner was assigned to the '539 application. In that third Office Action (an Advisory Action), the new examiner informed the applicants that the claim amendments, including the amendments adding the weight average molecular weight limitation, were not entered because they raised new issues. Ex. 1018 at 2. In their response (filed with an RCE), the applicants stated:

> In direct response to the Advisory Action, attached is an article from Zakin, J.L., and Hunston, D.L., "Effect of Polymer Molecular Variables on Drag Reduction," J. Macromol. Sci. Phys. B18(4), p. 795-814 (1980). *In this article Jacques Zakin of the Ohio State University and Donald Hunston of the Naval Research Laboratory state that drag reduction is enhanced by high molecular weight and that in their experiments the minimum molecular weight necessary to observe drag reduction was* $M_{w,\,min}$ *1 x* 10^6.

Ex. 1019 at 2 (emphasis added).

In the fourth Office Action, the examiner withdrew the previous grounds of rejection and rejected all of the pending claims based on new grounds under sections 102 and 103. Ex. 1020. In response, the applicants cancelled all of the pending claims and submitted new claims 97-125—of which claims 113-125 are early versions of issued claims 1-11. Ex. 1021. For example, claim 113 was filed as follows:

113. A method comprising:

introducing a drag reducing polymer into a liquid hydrocarbon;

wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon.

Id. at 4.

In the fifth Office Action, all of the new claims were rejected under sections 102 and 103 based on new grounds. Ex. 1022. In response, the applicants withdrew claims 97-112 and amended the independent claims (113, 124, and 125) by adding limitations reciting a specific asphaltene content and API gravity of the liquid hydrocarbon. Ex. 1023. For example, claim 113 was amended as follows:

113. A method comprising:

introducing a drag reducing polymer into a liquid hydrocarbon <u>having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer</u>;

wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon.

Id. at 4.

The applicants argued that the amended claims were novel and nonobvious over the prior art because no drag reducing additives had, prior to 2006, been used in heavy crude oil having the asphaltene content (at least 3 weight percent) and

API gravity (less than 26°) recited in the claims. For example, the applicants argued:

> The specific species of heavy crude oil presents special challenges compared to the production, transportation, and refining of compared to [*sic*] genus of crude oil. *Prior to applicant's invention, one skilled in the art would not have transported applicant's liquid hydrocarbon via pipelines due to challenges such as the high viscosity and asphaltene content of heavy crude oil.*
>
> * * *
>
> As established by the affidavit by Ray L. Johnston, *one of ordinary skill in the art would not have previously thought it was possible to impart a drag reducing polymer into the specific genus of heavy crude oil.* When one typically hears that a drag reducing polymer is introduced into a crude oil, the immediate assumption by one skilled in the art would be that the drag reducing polymer would only work in light or medium crude oils.

Ex. 1023 at 8-9 (emphasis added). The affidavit of Ray L. Johnston, referenced in the applicants' response, is provided as Exhibit 1024. Mr. Johnston stated, in relevant part:

> 15. Prior to the invention of ConocoPhillips ExtremePower™ drag reducer, in 2006, heavy crude oil was scientifically thought to be impossible to effectively drag reduce in pipelines due to the high viscosity and asphaltene content and resultant lack of sufficient turbulence within the pipeline.

> 16. One skilled in the art, prior to 2006, would not have considered any drag reducer capable of operating in heavy crude oil. Therefore, any mention of effective crude oil drag reduction prior to 2006 only meant use of a drag reducer in light or medium crude oil.

Ex. 1024 at ¶¶ 15-16.[1]

In the sixth Office Action, however, the examiner continued to reject the claims under sections 102 and 103. Ex. 1025. In particular, the examiner stated that heavy crude oil:

> is a species in the genus of "crude oil" and [the prior art] teaches adding the polymer to crude oil. As the genus of "crude oil" contains only three species, light, medium, and heavy, one of ordinary skill in the art would be able to "at once envisage" the specific species claimed (heavy crude oil). Because the class of species is sufficiently limited, the genus of "crude oil" anticipates the claimed species "heavy crude oil."

Id. at ¶ 6 (pp. 2-3) (internal citations omitted); *see also id.* at ¶¶ 9-10 (p. 3) (internal citations omitted).

[1] Applicants' assertions that they were the first to effectively use a drag reducing agent in heavy crude oil are belied by their own marketing materials. *See* Exhibits 1028, 1029, and 1030 (promoting ConocoPhillips drag reducing agents for use in heavy crude oil). Moreover, such assertions are proven wrong by Eaton (Ex. 1002), as discussed in detail below.

In response, the applicants again amended the independent claims, this time adding two limitations: (1) a limitation relating to the mechanism by which the drag reducing polymer acts to reduce drag; and (2) an element reciting the concentration of drag reducing polymer that is added to the heavy crude oil. Ex. 1026. For example, claim 113 was amended as follows:

> 113. A method comprising:
>
> introducing a drag reducing polymer, between two pump stations capable of reducing friction loss associated with the turbulent flow through a pipeline by suppressing the growth of turbulent eddies, into a liquid hydrocarbon having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;
>
> wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon and
>
> the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.

Ex. 1026 at 2.

The applicants provided arguments as well, but they were largely repeated from their prior response. In addition, the applicants cited a "peer reviewed article" as evidence of "secondary considerations":

> As described in the peer reviewed article "Transportation of heavy and extra-heavy crude oil by pipeline" the only method currently known or described that can be a drag reducer in heavy crude oil is our current patent application. Properties of drag reducers such as reducing friction loss associated with the turbulent flow through a pipeline by suppressing the growth of turbulent eddies have been added to applicants independent claims.
>
> * * *
>
> As secondary consideration please note that the peer reviewed journal article "Transportation of heavy and extra-heavy crude oil by pipeline" describe[s] that the only true drag reducer ever thought about or conceived to be feasible with the heavy crude oil is applicants own patent application. Reconsideration of the rejection is respectfully requested.

Ex. 1026 at 6-7.[2]

The next Office Action was a Notice of Allowance. Ex. 1027. Although the examiner provided Reasons for Allowance, (*see id.* at 10-11), those reasons do not

[2] A copy of the article cited in applicants' response is provided as Exhibit 1031. While the article discusses the '539 application, (*see* Ex. 1031 at 280), it does not support the applicants' assertion that the article "describe[s] that the only true drag reducer ever thought about or conceived to be feasible with the heavy crude oil is applicants own patent application."

explain how the applicants' amendments and arguments submitted in their last response placed the claims in condition from allowance.

C. Person of Ordinary Skill in the Art

As Prof. Epps explains, in 2005, a person of ordinary skill in the art relating to the subject matter of the 118 patent would have had a Bachelor of Science degree in chemical engineering, polymer science and engineering, or a closely related field, and at least two years of work experience or three years of further academic experience with drag reducing polymers or with polymer flow properties in solution for any fluid. Ex. 1005 at ¶ 18.

Such a person would have been familiar with and routinely utilized basic principles relating to polymers and polymer synthesis, such as chemical composition of monomers and polymers, the common types of polymerization processes, types of polymerization catalysts, and solubility properties of polymers. He or she would have regularly consult standard reference materials in the field, such as Brandrup et al., *Polymer Handbook*, 4th ed., John Wiley & Sons, Inc., 1999 (Ex. 1007; "Brandrup"). Ex. 1005 at ¶ 14.

Further, such a person would have been aware of and consulted technical and scientific publications specifically directed to drag reducing polymers and to the study of polymer flow properties in solution. Representative of such publications are Strausz, O.P. and Lown, E.M., *The Chemistry of Alberta Oil*

Sands, Bitumens and Heavy Oils, Alberta Energy Research Institute, Calgary, 2003. (Ex. 1003; "Strausz"); Zakin, J.L. and Hunston, D.L., *Effect of Polymer Molecular Variables on Drag Reduction*, J. Macromol. Sci.-Phys., B18(4), 795-814 (1980) (Ex. 1008); and Mowla, D. and Naderi, A., *Experimental study of drag reduction by a polymeric additive in slug two-phase flow of crude oil and air in horizontal pipes*, Chemical Engineering Science 61, 1549-1554, available online as of November 4, 2005 (Ex. 1009). Ex. 1005 at ¶ 15.

Thus, such a person would readily have been able to determine the solubility parameters of polymers, including by such well-known techniques as group contribution theory calculations, enabling him or her to identify polymers that would be suitable for use as drag reducing additives in any target fluid. Ex. 1005 at ¶ 16.

D. Claim Construction

Petitioner submits that the Board need not construe any claim terms to determine whether to institute *inter partes* review of the 118 patent. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("only those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy"). Depending on how the matter proceeds, Petitioner may propose a claim construction at a later stage.

VI. SUMMARY OF THE ASSERTED PRIOR ART

A. Eaton

Eaton (U.S. Patent No. 6,015,779) issued on January 18, 2000. Ex. 1002. Therefore, Eaton is prior art to the 118 patent under 35 U.S.C. § 102(b). Eaton was not cited by the applicants or considered by the examiner during prosecution of the 118 patent.

Eaton discloses the addition of a polymeric drag reducing agent to a hydrocarbon, particularly viscous crude oil, flowing through a pipeline to improve the hydrocarbon flow. Ex. 1002 at 1:66-2:9. According to Eaton, the polymeric drag reducing agents "interact with the turbulent flow processes and reduce frictional pressure losses such that the pressure drop for a given flow rate is less . . . ." *Id.* at 1:29-33. More particularly, Eaton explains that the polymeric drag reducing agents "reduce the impact of turbulence through direct interaction and absorption of some or most [frictionally generated] energy bursts thus improving flow characteristics in the conduit." *Id.* at 5:8-23.

Eaton describes the drag reducing polymers as being "ultra-high molecular weight," which, according to Eaton, corresponds roughly to a molecular weight of at least 10 or 15 million g/mol. *Id.* at 6:15-32. Preferably, the ultra-high molecular weight polymers of Eaton have molecular weights of greater than 25 million g/mol.

Id. at 6:32-34. Eaton also states that the polymers should have a narrow molecular weight distribution. *Id.* at 6:34-36.

According to Eaton, flow can be improved when a drag reducing polymer is added to a liquid hydrocarbon at a concentration as low as 1 part per million by weight. *Id.* at 2:6-9. More particularly, Eaton teaches that the drag reducing polymers should be added to a pipeline having viscous crude oil at a concentration of from about 1 to about 250 ppm by weight, and more preferably from about 25 to 150 ppm by weight. *Id.* at 2:32-39.

Eaton describes the polymeric drag reducing agents as overcoming the problems with commercially available polymers, which "are deficient when used with *highly viscous* crude oil, where the need may be the greatest." *Id.* at 1:48-52 (emphasis added). Similarly, Eaton describes the improved polymeric drag reducing agents as being particularly effective for incorporation into *viscous* crude oil flowing through pipelines. *Id.* at 1:66-2:9 (emphasis added).

In Example 1, Eaton provides a description and data showing that the polymeric drag reducing agents are in fact effective when introduced into highly viscous crude oil. Specifically, Eaton describes a comparative test between two polyalphaolefin drag reducing agents made in accordance with the description (compositions "A" and "B") and two commercially available drag reducing compositions (compositions "C" and "D"). *Id.* at 13:55-14:5. Each of the four

compositions was introduced into Bow River crude oil, and the percent flow increase was measured. *Id.* at 14:33-36.

Eaton describes Bow River crude oil as a "highly viscous" crude oil. *Id.* at 14:36-38. And, as demonstrated by Table 1 of the 118 patent, Bow River crude oil has an asphaltene content between 10.3 and 11.4 weight percent and an API gravity of about 21.8°, within the scope of the 118 patent claims. Ex. 1001 at 14:51-15:18 (Table 1). The two drag reducing agents prepared by Eaton (compositions "A" and "B"), were found to reduce the frictional pressure loss associated with the turbulent flow of the Bow River crude oil, resulting in percent flow increases of 3.0% and 5.5%, respectively, when added at a concentration of 4.6 ppmw. Ex. 1002 at 15:1-12 (Table I).

B. Strausz

Strausz (Strausz, O.P. and Lown, E.M., *The Chemistry of Alberta Oil Sands, Bitumens and Heavy Oils*, Alberta Energy Research Institute, Calgary) was published in 2003. Ex. 1003. Accordingly, Strausz is prior art to the 118 patent under 35 U.S.C. § 102(b). Strausz is cited in the specification of the 118 patent (at col. 4, lines 20-33, for the method for determining the solubility parameter of a liquid hydrocarbon, as noted above), but it was not considered by the examiner during prosecution.

Strausz describes the use of solubility parameters in the context of heavy crude oil, particularly through an examination of asphaltene solubility (asphaltene plays a principal role in determining the boundaries of heavy crude oil solubility characteristics). For example, Strausz explains that "[t]he ability of a solvent to solubilize asphaltene or, in general, to dissolve a solid or to form a homogenous solution with another liquid, may be expressed in terms of solubility parameters." Ex. 1003 at 465. According to Strausz, "the correlation between the solubility of asphaltene and solvent solubility parameter is quite good for nonpolar and low-polarity solvents." *Id.* at 466. Indeed, Strausz describes a study of the correlation between asphaltene solubility and solubility parameters, which demonstrates that "the solvation energy of the solvents with [a solubility parameter] in the 17.1–22.1 $MPa^{1/2}$ range is sufficiently large to overcome the cohesion energy of asphaltene and cause solubilization." *Id.* at 467. In other words, for asphaltene to be completely soluble in a material, Strausz teaches that the material should have a solubility parameter between 17.1 and 22.1 $MPa^{1/2}$, i.e., a solubility parameter within about 2.5 $MPa^{1/2}$ of the solubility parameter of asphaltene, which, according to Strausz, is about 19.6 $MPa^{1/2}$. *Id.*

C. Naiman

Naiman (U.S. Patent No. 4,983,186) issued on January 8, 1991. Ex. 1004. Therefore, Naiman is prior art to the 118 patent under 35 U.S.C. § 102(b). Naiman

was apparently considered by the examiner during prosecution of the 118 patent, as it is listed on the face of the patent, but it was not the basis of any claim rejections.

Naiman describes his invention as relating to pressure loss as a result of friction in the flow of hydrocarbons, and particularly hydrocarbon fuels, through conduits, and to additives for the reduction of such frictional pressure loss. Ex. 1004 at 1:7-12. Specifically, for example, Naiman describes the problems associated with frictional pressure loss during the long distance transport of crude oil extracted from Alaskan reserves through pipelines. *Id.* at 1:14-27.

To reduce this frictional pressure loss, Naiman describes utilizing a drag reducing polymer made up of styrene, an alkyl acrylate, and a carboxylic acid (which then may be reacted with a polyamine). *Id.* at Abstract. The styrene component is said to increase the molecular weight of the polymer while the alkyl acrylate is said to provide the polymer with improved oil solubility. *Id.* at 2:56-62. Alkyl acrylates contain oxygen heteroatoms. Ex. 1005 at ¶ 99.

The drag reducing polymer of Naiman is said to have both sufficient molecular weight and sufficient solubility to be effective in the hydrocarbon fluid. Ex. 1004 at 2:6-14. In fact, because "the effectiveness of the polymer increases with its oil-solubility," preferred polymers are described as being oil-soluble, even at concentrations that are significantly higher than those encountered in drag-reducing applications. *Id.* at 3:56-62. Additionally, the polymer of Naiman is said

to have a molecular weight of about 3 million g/mol to about 5 million g/mol (prior to any polyamine salt formation). *Id.* at 3:47-49. According to Naiman, superior results are achieved when the drag reducing polymer is added to hydrocarbon fuel, such as crude oil, at a concentration of from about 3 ppm to about 35 ppm by weight. *Id.* at 4:12-21.

Naiman also states that the polymer may be combined with a polyamine to form an oil-soluble salt of higher effective molecular weight, resulting in an especially effective high-molecular-weight, oil-soluble drag reducing agent. Specifically, Naiman teaches that a carboxylic acid may be introduced into the polymer and then the acidic polymer and a basic polyamine may be reacted to form a salt. Naiman reports that doing so increases the molecular weight of the drag reducing polymer beyond that achieved through the polymerization reaction alone (between 3 g/mol and 5 million g/mol) without causing a significant decrease in solubility. *Id.* at 4:31-37.

In Example 2, Naiman demonstrates that the disclosed polymers are effective at reducing frictional pressure losses in hydrocarbon liquids, whether used alone or in combination with a polyamine. For instance, Naiman reports the results of an experiment in which various (a) polymers and (b) combinations of polymer and polyamine were introduced into kerosene, and the percentage of drag reduction (% D.R.) achieved over the untreated fluid was measured. *Id.* at 5:21-55.

Tables I and II demonstrate that, when added to kerosene at a concentration of 100 ppm, polymers consisting of about 62-63 wt.% 2-ethyl-hexyl acrylate (EHA) and about 37-38 wt.% styrene (St.) achieved a drag reduction of about 21-26%. *Id.* at 5:9-17 (Table I), *id.* at 5:43-52 (Table II) (*see* Polymers 1 and 5). When similar polymers were rendered acidic and reacted with a polyamine, they were able to achieve a drag reduction between 19% and about 39%. *Id.* at 5:43-52 (Table II).

VII. EATON ANTICIPATES CLAIMS 1, 3, 4, 6, 7, AND 11

A. Claim 1

Claim 1 can be divided into five elements, 1 through 5. As explained in detail below and summarized in the claim chart at the end of this section, Eaton discloses each and every element of claim 1.

> **Claim 1, element 1:** ***A method comprising: introducing a drag reducing polymer, into a pipeline, such that such that the friction loss associated with the turbulent flow through the pipeline is reduced by suppressing the growth of turbulent eddies,***

Eaton describes the introduction of a drag reducing polymer into a pipeline to reduce the frictional pressure loss associated with the turbulent flow through the pipeline by suppressing the growth of turbulent eddies. For example, according to Eaton:

> The present invention is directed to methods of improving the flow of hydrocarbons through conduits, particularly viscous crude oil flowing through pipelines. Surprisingly, it has been discovered that a drag reducing agent (DRA) made in accordance with the methods of this invention can produce as much as about thirty percent (30%) or greater flow improvement when added to a hydrocarbon flowing through a conduit.

Ex. 1002 at 1:66-2:6. Moreover, Eaton states that DRAs "interact with the turbulent flow processes and reduce frictional pressure losses such that the pressure drop for a given flow rate is less, or the flow rate for a given pressure drop is greater." *Id.* at 1:30-33. Eaton further teaches:

> A preferred aspect of the present invention is directed to 'flow increase' or 'drag reduction.' As discussed below, drag reducing agents reduce drag and increase the flow rate of hydrocarbons passing through conduits, particularly crude oil or refined hydrocarbons passing through pipelines. In at least one aspect, *the DRA can be introduced into the conduit to improve flow conditions by reducing frictional pressure losses, or frictionally generated energy bursts, associated with movement of fluid within the conduit. These frictionally generated energy bursts typically emanate from throughout the turbulent core of the flowing hydrocarbons and include lateral turbulent microbursts generated from or near the conduit walls.* More simply stated, the DRAs tend to reduce the impact of turbulence through direct interaction and absorption of

> some or most of these energy bursts thus improving flow characteristics in the conduit.

Id. at 5:8-23 (emphasis added).

Based on the foregoing disclosures in Eaton, Prof. Epps concludes: "Accordingly, in 2005 a person of ordinary skill in the art would have understood that the addition of the polymeric drag reducing agents of Eaton would serve to suppress the growth of turbulent eddies, and thus reduce the frictional pressure loss associated with the turbulent flow of crude oil through a pipeline." Ex. 1005 at ¶ 45. Therefore, Eaton expressly discloses the first element of claim 1.

> **Claim 1, element 2:** ***into a liquid hydrocarbon having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon***

Eaton discloses the introduction of a drag reducing polymer into a liquid hydrocarbon having the specific asphaltene content and API gravity recited in claim 1. In particular, in Example 1, Eaton discloses the introduction of drag reducing polymers into Bow River crude oil: "Each of the four DRA compositions (A)-(D) was measured for Percent Flow Increase, using three 'test hydrocarbons,' namely, Alaska North Slope crude oil (ANS), Bow River crude oil (BOW RIVER), and hexane. The BOW RIVER test hydrocarbon was a highly viscous crude oil

from the IPL Pipeline in Canada." Ex. 1002 at 14:33-38. Eaton reports that DRAs "A" and "B" successfully treated the Bow River crude oil:

> As reflected in Tables I and II, the Percent Flow Increase for invention compositions 'A' and 'B' was substantially higher than the Percent Flow Increase for comparative compositions 'C' and 'D.' For example, when placed in hexane, invention compositions 'A' showed 48% improvement in Percent Flow Increase over that of Composition 'D.' *Even more surprising, and also indicative of the superior drag reducing capabilities of the present invention in an actual commercial setting, Compositions 'A' and 'B' both increased the flow rate of BOW RIVER crude oil*, while neither compositions 'C' nor 'D' were able to increase the flow of the BOW RIVER crude oil."

Id. at 14:55-59 (emphasis added).

Furthermore, the 118 patent expressly states that Bow River crude oil meets the asphaltene content and API gravity limitations of claim 1. Specifically, Table 1 of the 118 patent states that Bow River crude oil has an asphaltene content of 11.4 (Test 1) or 10.3 (Test 2)—i.e., "at least 3 weight percent"—and an API gravity of 21.8°—i.e., "less than about 26°":

TABLE 1

Asphaltene Content, API Gravity, and Elasticity Response

Crude Oil Sample	Type	ASPHALTENE CONTENT Test 1	Test 2	API Gravity	ELASTICITY RESPONSE (AFFINITY) LP 100	LP 300	Polymer A	Polymer B
Merey	Heavy	16.8	15.5	16.0°	None	None	High	High
Petrozuata	Heavy	18.8	18.1	9.1°	None	None	High	High
Corocoro	Heavy	6.0	6.7	25.1°	None	None	High	High
Albian	Heavy	11.0	10.6	22.4°	None	None	High	High
Bow River	Heavy	11.4	10.3	21.8°	None	None	High	High
Maya	Heavy	14.6	15.4	21.9°	None	None	High	High
Western Canadian Select	Heavy	11.5	11.9	20.9°	None	None	High	High
San Joaquin Valley	Heavy	8.9	8.9	13.0°	None	None	High	High
Marlim Blend	Heavy	6.7	6.6	22.2°	High	High	High	High
West Texas Sour	Intermediate	2.8	2.8	31.6°	High	High	Moderate	Moderate
West Texas Intermediate	Light	0.5	—	41.6°	High	High	Moderate	Moderate
Basrah	Light	4.8	—	31.0°	High	High	Moderate	Moderate

Id. at 14:51-15:18 (emphasis added). *See also* Ex. 1005 at ¶ 48 ("Bow River crude oil meets the limitations of the liquid hydrocarbon recited in the claims of the 118 patent"). Thus, Eaton expressly discloses element 2 of claim 1.

Claim 1, element 3: ***wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;***

Eaton does not expressly disclose the viscosity of the Bow River crude oil before and after treatment with the drag reducing polymer. But Prof. Epps, based on a detailed analysis of Eaton's disclosure, concludes that a person of ordinary

skill in the art in 2005 would have understood that the introduction of compositions A and B to Bow River crude oil, as described in Example 1 of Eaton, would not measurably reduce the viscosity of the heavy crude oil. Ex. 1005 at ¶¶ 50-55.

As an initial matter, Prof. Epps explains that because the drag reducing polymers in Eaton's DRA compositions A and B are ultra-high molecular weight molecules and they are added to Bow River crude oil in such a small quantity in Example 1 (4.6 ppm), "a person of ordinary skill in the art in 2005 would have understood that the drag reducing polymers themselves . . . would have no appreciable effect on the viscosity of the heavy crude oil when added at concentrations of parts per million to the crude oil." Ex. 1005 at ¶ 50.[3]

Next, Prof. Epps calculates the amount of carrier solvent present in Eaton's DRA compositions A and B and concludes that "a person of ordinary skill in the art in 2005 would have recognized that the amount of solvent introduced into the Bow River crude oil from DRA compositions A and B would be small enough to have no appreciable effect on the viscosity of the crude oil." Ex. 1005 at ¶ 51.

[3] In addition, Patent Owner's 30(b)(6) witness testified in concurrent litigation involving the 118 patent that a drag reducing polymer itself, when dissolved in a hydrocarbon, would never decrease the viscosity of the hydrocarbon. Instead, it would only increase the viscosity of the hydrocarbon. *See* Ex. 1032.

More specifically, based on Eaton's description of the preparation of compositions A and B, (*see* Ex. 1002 at 13:57-14:32), Prof. Epps calculates that in Example 1 of Eaton, the concentration of solvent added to Bow River crude oil was 30.5 ppm in composition "A" and 52.9 ppm in composition "B". Ex. 1005 at ¶¶ 52-53.

Eaton identifies the carrier solvent in compositions A and B as KOCH Sure-Sol-150, (Ex. 1002 at 14:7-31), which is composed primarily of "Heavy Aromatic Solvent Naphtha." Ex. 1005 at ¶ 54 (citing Ex. 1010). As Prof. Epps explains:

> At least in part because naphtha is also a component of crude oil, a person of ordinary skill in the art would have understood that the addition of up to 53 ppmw of KOCH Sure-Sol-150 solvent would not have an appreciable effect on the viscosity of the Bow River crude oil. A person of ordinary skill in the art could have confirmed his or her understanding by applying mixing rules, such as the Arrhenius mixing rule, which is applicable at extremely low concentrations of solvent, such as 53 ppm or less.

Ex. 1005 at ¶ 54. Thus, Prof. Epps concludes that "a person of ordinary skill in the art would have understood that the introduction of Compositions A and B to Bow River crude oil, as described in Example 1 of Eaton, would not measurably reduce the viscosity of the heavy crude oil." *Id.* at ¶ 55.

Moreover, Eaton also discloses that the drag reducing polymers disclosed therein may be used in the absence of solvent:

> In another specific embodiment, the process is carried out in the absence of a hydrocarbon solvent until all available alpha olefin monomers have been exhausted, i.e., polymerized. Due to the absence of solvent, after the alpha olefin monomers have been polymerized, a polyalphaolefin block is formed. "Polyalphaolefin block" is herein defined as polyalphaolefin having a sufficiently high viscosity such that the polyalphaolefin is gel-like and may even retain its three-dimensional shape, e.g., a cylindrical block, at room temperature. The polyalphaolefin block is preferably a ductile or malleable mass which is resilient and tacky. The polyalphaolefins which form the polyalphaolefin block should be amorphous and substantially non-crystalline having an ultra-high molecular weight.
>
> The polyalphaolefin block may then be used to reduce drag in a conduit by adding the polyalphaolefin block, or pieces of the polyalphaolefin block, to a conduit containing hydrocarbons. The polyalphaolefin block may also be further processed by any method known to those skilled in the art to be utilized to reduce drag in a conduit. For example, the polymer block may be frozen using liquid nitrogen and ground into smaller pieces which may then be directly combined with hydrocarbon in a conduit to reduce drag, or dissolved in an emulsifier or dispersant and then combined with hydrocarbon in a conduit to reduce drag.

Ex. 1001 at 11:43-67. Prof. Epps explains that a person of ordinary skill in the art in 2005 would have understood that adding a drag reducing polymer as a "polyaphaolefin block" to a heavy crude oil, such as Bow River crude oil, would

not cause a decrease in the viscosity of the oil. Ex. 1005 at ¶ 56. Accordingly, Eaton expressly discloses element 3 of claim 1.

Claim 1, element 4: ***wherein the drag reducing polymer has a solubility parameter within 4 MPa$^{1/2}$ of the solubility parameter of the liquid hydrocarbon***

As Prof. Epps explains, solubility parameters are used to assess the solubility of one material in another. Ex. 1005 at ¶ 32. In this case, although Eaton does not specifically disclose the solubility parameters of drag reducing polymers A and B, Eaton's disclosure of those polymers is a disclosure of all of the properties of those polymers, whether or not the properties are expressly recited. *See In re Papesch*, 315 F. 2d 381, 391 (C.C.P.A. 1963) ("From the standpoint of patent law, a compound and all of its properties are inseparable; they are one and the same thing."); *In re Spada*, 911 F.2d 705, 708 (Fed. Cir. 1990) (citing *Papesch*). Indeed, from Eaton's descriptions of drag reducing polymers A and B, Prof. Epps calculates the solubility parameters of those polymers and determines that they are each within 4 MPa$^{1/2}$ of the solubility parameter of Bow River crude oil.

Specifically, using the same method that a person of ordinary skill in the art in 2005 would have used, Prof. Epps determines that the solubility parameter of Eaton's drag reducing polymer A is 16.31 MPa$^{1/2}$ and the solubility parameter of Eaton's drag reducing polymer B is 16.11 MPa$^{1/2}$. Ex. 1005 at ¶¶ 66-67.

Furthermore, Prof. Epps explains that a person of ordinary skill in the art in 2005 would have recognized that the solubility parameters of Eaton's polymers A and B are within 3.5 $MPa^{1/2}$ of the solubility parameter of Bow River crude oil. *Id.* at ¶¶ 68-74. Accordingly, the drag reducing polymers A and B of Eaton must have solubility parameters that are within 4 $MPa^{1/2}$ of the solubility parameter of Bow River crude oil, as recited in claim 1 of the 118 patent. *Id.* at ¶ 75. Thus, Eaton discloses element 4 of claim 1.

Claim 1, element 5: ***and the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.***

According to Eaton, "flow improvement can result when the drag reducing agent's polymer is added to the hydrocarbon at a concentration of as low as 1 part per million (ppm) by weight." Ex. 1002 at 2:6-9. More particularly, Eaton states: "The polyalphaolefin DRA mixture should be introduced in an amount sufficient to increase the flow of the flowing hydrocarbons, preferably at a concentration of from about 1 to 250 ppm by weight, and more preferably from about 25 to 150 ppm by weight." *Id.* at 2:35-40. Further, as explained above, in Eaton's Example 1 the drag reducing polymers were added to Bow River crude oil at a concentration of 4.6 ppm, which is within the "0.1 to about 500 ppmw" range recited in claim 1 of the 118 patent. *Id.* at 15:1-12 (Table I). Thus, Eaton expressly discloses element 5 of claim 1.

Claim Chart for Claim 1:

Element	Claim 1	Prior Art Disclosure
1	A method comprising: introducing a drag reducing polymer, into a pipeline, such that such that the friction loss associated with the turbulent flow through the pipeline is reduced by suppressing the growth of turbulent eddies,	"The present invention is directed to methods of improving the flow of hydrocarbons through conduits, particularly viscous crude oil flowing through pipelines. Surprisingly, it has been discovered that a drag reducing agent (DRA) made in accordance with the methods of this invention can produce as much as about thirty percent (30%) or greater flow improvement when added to a hydrocarbon flowing through a conduit." Ex. 1002 at 1:66-2:6. "A preferred aspect of the present invention is directed to 'flow increase' or 'drag reduction.' As discussed below, drag reducing agents reduce drag and increase the flow rate of hydrocarbons passing through conduits, particularly crude oil or refined hydrocarbons passing through pipelines. In at least one aspect, the DRA can be introduced into the conduit to improve flow conditions by reducing frictional pressure losses, or frictionally generated energy bursts, associated with movement of fluid within the conduit. These frictionally generated energy bursts typically emanate from throughout the turbulent core of the flowing hydrocarbons and include lateral turbulent microbursts generated from or near the conduit walls. More simply stated, the DRAs tend to reduce the impact of turbulence through direct interaction and absorption of some or most of these energy bursts thus improving flow characteristics in the conduit." *Id.* at 5:8-23.
2	into a liquid hydrocarbon having an	"Each of the four DRA compositions (A)-(D) was measured for Percent Flow Increase, using three 'test hydrocarbons,' namely, Alaska North Slope

Element	Claim 1	Prior Art Disclosure
	asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon	crude oil (ANS), Bow River crude oil (BOW RIVER), and hexane. The BOW RIVER test hydrocarbon was a highly viscous crude oil from the IPL Pipeline in Canada." Ex. 1002 at 14:33-38. "As reflected in Tables I and II, the Percent Flow Increase for invention compositions 'A' and 'B' was substantially higher than the Percent Flow Increase for comparative compositions 'C' and 'D.' For example, when placed in hexane, invention compositions 'A' showed 48% improvement in Percent Flow Increase over that of Composition 'D.' Even more surprising, and also indicative of the superior drag reducing capabilities of the present invention in an actual commercial setting, Compositions 'A' and 'B' both increased the flow rate of BOW RIVER crude oil, while neither compositions 'C' nor 'D' were able to increase the flow of the BOW RIVER crude oil." *Id.* at 14:55-59. TABLE I PERCENT FLOW INCREASE DRA | ANS @3 ppm | BOW RIVER @4.6 ppm | HEXANE @1 ppm A | 15.0 | 3.0 | 40.1 B | 12.0 | 5.5 | 37.5 C[1] | 10.8 | −0.5 | 31.1 D[2] | — | 0.0 | 27.1 [1]LIQUID POWER ™ commercial DRA from Conoco Inc. [2]FLO-1005 ™ commercial DRA from Baker-Hughes, Inc. *Id.* at 15:1-12.

<table>
<tr><th>Element</th><th>Claim 1</th><th>Prior Art Disclosure</th></tr>
<tr><td></td><td></td><td>TABLE 1
Asphaltene Content, API Gravity, and Elasticity Response
<table><tr><th></th><th></th><th colspan="2">ASPHALTENE CONTENT</th><th></th><th colspan="4">ELASTICITY RESPONSE (AFFINITY)</th></tr><tr><th>Crude Oil Sample</th><th>Type</th><th>Test 1</th><th>Test 2</th><th>API Gravity</th><th>LP 100</th><th>LP 300</th><th>Polymer A</th><th>Polymer B</th></tr><tr><td>Mercy</td><td>Heavy</td><td>16.8</td><td>15.5</td><td>16.0°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Petrozuata</td><td>Heavy</td><td>18.8</td><td>18.1</td><td>9.1°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Corocoro</td><td>Heavy</td><td>6.0</td><td>6.7</td><td>25.1°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Albian</td><td>Heavy</td><td>11.0</td><td>10.6</td><td>22.4°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Bow River</td><td>Heavy</td><td>11.4</td><td>10.3</td><td>21.8°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Maya</td><td>Heavy</td><td>14.6</td><td>15.4</td><td>21.9°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Western Canadian Select</td><td>Heavy</td><td>11.5</td><td>11.9</td><td>20.9°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>San Joaquin Valley</td><td>Heavy</td><td>8.9</td><td>8.9</td><td>13.0°</td><td>None</td><td>None</td><td>High</td><td>High</td></tr><tr><td>Marlim Blend</td><td>Heavy</td><td>6.7</td><td>6.6</td><td>22.2°</td><td>High</td><td>High</td><td>High</td><td>High</td></tr><tr><td>West Texas Sour</td><td>Intermediate</td><td>2.8</td><td>2.8</td><td>31.6°</td><td>High</td><td>High</td><td>Moderate</td><td>Moderate</td></tr><tr><td>West Texas Intermediate</td><td>Light</td><td>0.5</td><td>—</td><td>41.6°</td><td>High</td><td>High</td><td>Moderate</td><td>Moderate</td></tr><tr><td>Basrah</td><td>Light</td><td>4.8</td><td>—</td><td>31.0°</td><td>High</td><td>High</td><td>Moderate</td><td>Moderate</td></tr></table>
Ex. 1001 at 14:51-15:18.</td></tr>
<tr><td>3</td><td>wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;</td><td>Eaton Composition A contains 30.5 ppmw of KOCH Sure-Sol-150 solvent. Ex. 1005 at ¶ 52. Eaton Composition B contains 52.9 ppmw of KOCH Sure-Sol-150 solvent. Id. at ¶ 53.

“[T]he addition of between 30 ppmw and 53 ppmw of KOCH Sure-Sol-150 solvent with a drag reducing polymer to Bow River heavy crude oil would not appreciably decrease the viscosity of the crude oil. Accordingly, . . . the introduction of Compositions A and B to Bow River crude oil, as described in Example 1 of Eaton, would not measurably reduce the viscosity of the heavy crude oil.” Id. at 55.

“In another specific embodiment, the process is carried out in the absence of a hydrocarbon solvent until all available alpha olefin monomers have been exhausted, i.e., polymerized. Due to the absence of solvent, after the alpha olefin monomers have been</td></tr>
</table>

Element	Claim 1	Prior Art Disclosure
		polymerized, a polyalphaolefin block is formed. 'Polyalphaolefin block' is herein defined as polyalphaolefin having a sufficiently high viscosity such that the polyalphaolefin is gel-like and may even retain its three-dimensional shape, e.g., a cylindrical block, at room temperature. . . . The polyalphaolefin block may then be used to reduce drag in a conduit by adding the polyalphaolefin block, or pieces of the polyalphaolefin block, to a conduit containing hydrocarbons." Ex. 1002 at 11:43-60. Introducing the drag reducing polymer as a polyalphaolefin block into the crude oil, i.e., "without a carrier solvent . . . would not reduce the viscosity of the crude oil." Ex. 1005 at ¶ 56.
4	wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon	The solubility parameter of Eaton DRA A is ~16.31 $MPa^{1/2}$. Ex. 1005 at ¶ 66. The solubility parameter of Eaton DRA B is 16.11 $MPa^{1/2}$. *Id.* at ¶ 67. The solubility parameters of Eaton DRAs A and B are within about 3.5 $MPa^{1/2}$ of the solubility parameter of Bow River crude oil. *Id.* at ¶¶ 68-75.
5	and the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.	"The polyalphaolefin DRA mixture should be introduced in an amount sufficient to increase the flow of the flowing hydrocarbons, preferably at a concentration of from about 1 to 250 ppm by weight, and more preferably from about 25 to 150 ppm by weight." Ex. 1002 at 2:35-40. *See also id.* at 15:1-10 (Table I) (stating that the DRA was added to Bow River crude oil at a concentration of "4.6 ppm").

B. Claim 3

Claim 3 recites: "The method of claim 1, wherein the drag reducing polymer comprises at least about 25,000 repeating units."

Eaton discloses drag reducing polymers comprising at least about 25,000 repeating units. For example, each of Eaton's drag reducing polymers "A" and "B" comprises more than 25,000 repeating units. *See* Ex. 1005 at ¶ 62. As Prof. Epps explains, the number of repeating units in DRAs "A" and "B" can be calculated from Eaton's identification of the monomers used for synthesizing the DRAs, the molecular weights and relative proportions of the monomers, and the molecular weights of the DRA polymers. *Id.*

More specifically, Eaton states that DRA "A" was synthesized from C_6 and C_{12} alpha olefin monomers that were "allowed to polymerize to form ultra-high molecular weight polyalphaolefins." Ex. 1002 at 14:13-19. Similarly, Eaton states that DRA "B" was synthesized from C_8 and C_{14} alpha olefin monomers that were "allowed to polymerize to form ultra-high molecular weight polyalphaolefins." *Id.* at 14:26-31. Eaton defines "ultra-high molecular weight" as "a molecular weight corresponding to an inherent viscosity of at least about 10 dL/g," which "corresponds roughly to a molecular weight of at least about 10 or 15 million." *Id.* at 6:15-32. Therefore, if DRAs "A" and "B" have, for example, a molecular weight of 10 million (the minimum under Eaton's definition), Prof. Epps calculates

that DRA "A" comprises 89,116 repeating units and DRA "B" comprises 70,016 repeating units. Ex. 1005 at ¶¶ 62-63. Thus, DRAs "A" and "B" comprise far in excess of the recited "at least about 25,000 repeating units." Therefore, Eaton discloses the method according to claim 3.

C. Claim 4

Claim 4 recites: "The method of claim 1, wherein the drag reducing polymer has a weight average molecular weight of at least 1 x 10^6."

As explained above, with regard to claim 3, Eaton states that DRAs "A" and "B" were "allowed to polymerize to form ultra-high molecular weight polyalphaolefins." As also explained above, Eaton defines "ultra-high molecular weight" as "a molecular weight corresponding to an inherent viscosity of at least about 10 dL/g," which "corresponds roughly to a molecular weight of at least about 10 or 15 million." Moreover, Eaton states that "[t]he polyalphaolefins formed should also have a narrow molecular weight distribution." Ex. 1002 at 6:34-36. Based on this disclosure, Prof. Epps concludes that "the drag reducing polymers disclosed by Eaton have weight average molecular weights that are well above the 1 million (1 x 10^6) g/mol lower boundary claimed by the 118 patent." Ex. 1005 at ¶ 58. Accordingly, Eaton discloses the method of claim 4.

D. Claim 6

Claim 6 recites: "The method of claim 1, wherein the solubility parameter of the liquid hydrocarbon is determined by the following equation:

$$\delta_2=[(\Delta Hv-RT)/V]^{1/2}$$

where ΔHv is the energy of vaporization, R is the universal gas constant, T is the temperature in Kelvin, V is the molar volume and δ_2 is the solubility parameter." Prof. Epps explains that this equation was well known in 2005, Ex. 1005 at ¶ 34, and that a person of ordinary skill in the art would have used this equation to determine the solubility parameter of Bow River crude oil. *See id.* at ¶¶ 68-69. Therefore, Eaton anticipates the method according to claim 6. *See In re Graves*, 69 F.3d 1147, 1152 (Fed. Cir. 1995) (a reference anticipates if "it discloses the claimed invention such that a skilled artisan could take its teachings in combination with his own knowledge of the particular art and be in possession of the invention.").

E. Claim 7

Claim 7 recites: "The method of claim 1, wherein the solubility parameter of the drag reducing polymer is determined by the following equation:

$$\delta=(\delta_d^2+\delta_p^2+\delta_h^2)^{1/2}$$

where δ is the solubility parameter, $\delta_d=\Sigma F_{di}/V$, $\delta_h=(\Sigma F_{hi}/V)^{1/2}$, $\delta_p=(\Sigma F^2_{pi})^{1/2}/V$." Prof. Epps explains that this equation was well-known to those of ordinary skill in

2005, Ex. 1005 at ¶ 35, and that he used it to determine the solubility parameters of Eaton's DRA compositions A and B. *See* Ex. 1005 at ¶¶ 66-67. Therefore, Eaton anticipates the method according to claim 7. *See Graves*, 69 F.3d at 1152.

F. Claim 11

Claim 11 is an independent claim that is identical to claim 1 except that, in addition, it specifies an equation (identical to the equation of claim 6) by which the solubility parameter of the liquid hydrocarbon is determined and an equation (identical to the equation of claim 7) by which the solubility parameter of the drag reducing polymer is determined. In other words, claim 11 is essentially a modified version of claim 1 incorporating the equations of claims 6 and 7 for determining the solubility parameters of the liquid hydrocarbon and drag reducing polymer, respectively. As explained above, Eaton discloses each and every element of claims 1, 6, and 7. Therefore, Eaton likewise discloses each and every element of claim 11.

VIII. CLAIMS 1-7 AND 11 ARE OBVIOUS OVER EATON IN VIEW OF STRAUSZ

As explained above, Eaton expressly discloses each and every element of claims 1, 3, 4, 6, 7, and 11 except the solubility parameter limitation of claim 1 ("wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon"). As also explained above,

Prof. Epps calculated the solubility parameters of Eaton's drag reducing polymers "A" and "B" and determined that they are within 4 $MPa^{1/2}$ of the solubility parameter of Bow River crude oil. *See* discussion of "Claim 1, element 4" at pp. 30-31, *supra*. Therefore, Eaton's disclosure of the compositions of DRA Compositions "A" and "B" and the introduction of Compositions A and B into Bow River crude oil is a disclosure of this limitation.

Strausz (Ex. 1003) describes the use of solubility parameters in the context of heavy crude oil. *See* pp. 19-20, *supra*. Therefore, as explained below, the combination of Eaton and Strausz would have led a person of ordinary skill in the art to prepare a drag reducing polymer that meets the solubility parameter limitation of claim 1, as well as the additional solubility parameter limitations of claims 2 and 5. Thus, even without calculating the solubility parameters of Eaton's drag reducing polymers, claims 1-7 and 11 of the 118 patent would have been, at a minimum, obvious to a person of ordinary skill in the art.

A. Claims 1, 3, 4, 6, 7, and 11

As Prof. Epps explains, and as Strausz discloses, solubility parameters are properties that are commonly used to assess the solubility of one material in another. Ex. 1005 at ¶ 32. The closer the solubility parameters of the two materials are to one another, the more miscible the two materials. *Id.* Accordingly, by claiming that the drag reducing polymer has a solubility parameter

that is similar to the solubility parameter of the liquid hydrocarbon, the 118 patent simply teaches one of ordinary skill in the art that the drag reducing polymer was predicted to be soluble in the liquid hydrocarbon. *Id.*

As Prof. Epps also explains, it was well understood that the more soluble a drag reducing polymer is in the fluid being treated, the greater its effectiveness. *Id.* at ¶ 41. Accordingly, a person of ordinary skill in the art in 2005 would have understood that, to maximize the effectiveness of the drag reducing polymers of Eaton in Bow River crude oil, the drag reducing polymers should have a solubility parameter that is as close as possible to the solubility parameter of the Bow River crude oil. *Id.* at ¶¶ 81-82.

Specifically, based on the combination of Eaton and Strausz, a person of ordinary skill in the art would have been able to determine that the solubility parameter of the Bow River crude oil lies between about 17.1 $MPa^{1/2}$ and about 19.6 $MPa^{1/2}$. Ex. 1005 at ¶ 83. Accordingly, as explained by Prof. Epps, a person of ordinary skill in the art would have been motivated to prepare a drag reducing polymer having a solubility parameter within the range of about 17.1 $MPa^{1/2}$ to about 19.6 $MPa^{1/2}$ because such a polymer would be particularly effective in Bow River crude oil. *Id.* at ¶ 84.

Moreover, using the disclosure of Eaton, a person of ordinary skill in the art would have been able to identify and prepare a drag reducing polymer having a

solubility parameter between 17.1 $MPa^{1/2}$ and 19.6 $MPa^{1/2}$ as a matter of routine. Specifically, a person of ordinary skill in the art would have needed only to (a) identify, such as from published solubility parameter information, a desirable polymer within the disclosure of Eaton that has a solubility parameter within the target range and then (b) perform the polymerization reaction of Eaton under conditions suitable to obtain the desired polymer. Ex. 1005 at ¶¶ 85-92.

For instance, Prof. Epps explains how, using materials and information available in 2005, he was able to calculate the solubility parameter of polystyrene, a homopolymer disclosed by Eaton, to be 17.98 $MPa^{1/2}$. Ex. 1005 at ¶¶ 85-92. Similarly, Prof. Epps determines that a poly(ethylene/styrene) copolymer, a copolymer disclosed by Eaton, containing at least 45 wt.% styrene would have a solubility parameter of at least 17.1 $MPa^{1/2}$, and that the inclusion of a higher percentage of styrene would result in a polymer having a solubility parameter between 17.1 $MPa^{1/2}$ and 17.98 $MPa^{1/2}$. *Id.* Moreover, Prof. Epps explains that a person of ordinary skill in the art could easily have prepared these polymers simply by following the disclosure of Eaton. *Id.*

Furthermore, a person of ordinary skill in the art would have understood that a polymer having a solubility parameter within the range of 17.1 to 17.98 $MPa^{1/2}$ would be within 4 $MPa^{1/2}$ of the solubility parameter of the Bow River crude oil into which the drag reducing polymer would be introduced. Ex. 1005 at ¶ 93.

Accordingly, claim 1 would have been obvious over the combination of Eaton and Strausz.

B. Claim 2

Claim 2 recites: "The method of claim 1, wherein the solubility parameter of the drag reducing polymer is at least about 17 $MPa^{1/2}$."

For the reasons discussed above, it would have been obvious to a person of ordinary skill in the art desiring to incorporate a drag reducing polymer into heavy crude oil of the kind described by Eaton to use a drag reducing polymer having a solubility parameter between 17.1 and 19.6 $MPa^{1/2}$ in order to obtain improved drag reduction. Ex. 1005 at ¶¶ 81-84. Accordingly, a person of ordinary skill in the art seeking to provide a drag reducing polymer for Bow River crude oil would have been motivated to prepare, and using the disclosure of Eaton could easily have prepared, a polystyrene homopolymer, which would have a solubility parameter of about 17.98 $MPa^{1/2}$, and/or a poly(ethylene/styrene) copolymer having a solubility parameter between 17.1 and 17.98 $MPa^{1/2}$, both of which are at least about 17.1 $MPa^{1/2}$. Ex. 1005 at ¶¶ 85-92.

C. Claim 5

Claim 5 recites: "The method of claim 1, wherein the drag reducing polymer has a solubility parameter within 2.5 $MPa^{1/2}$ of the liquid hydrocarbon."

For the reasons discussed above, it would have been obvious to a person of ordinary skill in the art desiring to incorporate a drag reducing polymer into heavy crude oil of the kind described by Eaton to use a drag reducing polymer having a solubility parameter between 17.1 and 19.6 $MPa^{1/2}$ in order to obtain improved drag reduction. Ex. 1005 at ¶¶ 81-84. Accordingly, a person of ordinary skill in the art seeking to provide a drag reducing polymer for Bow River crude oil would have been motivated to prepare, and using the disclosure of Eaton could easily have prepared, a polystyrene homopolymer, which would have a solubility parameter of about 17.98 $MPa^{1/2}$, and/or a poly(ethylene/styrene) copolymer having a solubility parameter between 17.1 and 17.98 $MPa^{1/2}$. Ex. 1005 at ¶¶ 85-92.

A person of ordinary skill in the art would have understood that a polymer having a solubility parameter within the range of 17.1 to 17.98 $MPa^{1/2}$ would be within 2.5 $MPa^{1/2}$ of the solubility parameter of the Bow River crude oil into which the drag reducing polymer would be introduced. Ex. 1005 at ¶ 93.

D. A Person of Ordinary Skill in the Art Would Have Been Motivated to Combine Eaton with Strausz, and Would Have Had a Reasonable Expectation of Success

One of ordinary skill in the art in 2005 seeking to provide a drag reducing polymer that is effective for reducing frictional pressure losses in Bow River crude oil—the problem identified by Eaton—would, having the teachings of Eaton at

hand, have been motivated to improve upon those teachings by taking advantage of the information and data in Strausz. Specifically, a person of ordinary skill in the art in 2005 would have been motivated by Eaton's disclosure of successfully using drag reducing polymers in heavy, high-asphaltene Bow River crude oil to prepare a drag reducing polymer having a solubility parameter within the range of about 17.1 to about 19.6 $MPa^{1/2}$, the range at which a polymer would have maximum effectiveness as determined using the teachings of Eaton and Strausz. Ex. 1005 at ¶ 84.

Moreover, the process of calculating solubility parameters of polymers from within those disclosed by Eaton and then preparing a polymer having a solubility parameter within the range of about 17.1 to about 19.6 $MPa^{1/2}$ by following the teachings of Eaton would have been a matter of routine for a person of ordinary skill in the art. Ex. 1005 at ¶ 85, ¶ 92. Thus, a person of ordinary skill in the art would have had a reasonable expectation that, by combining the teachings of Eaton and Strausz, one could have successfully prepared a drag reducing polymer having particularly desirable properties, including the claimed solubility parameter relationship, for reducing frictional pressure losses in Bow River heavy crude oil. *Id.* at ¶ 94.

Accordingly, a person of ordinary skill in the art seeking to provide a drag reducing polymer for heavy crude oil would have had a motivation to consult the

teachings of both Eaton and Strausz, and would have had a reasonable expectation that, by combining these teachings and using one's ordinary skill, one would have prepared a drag reducing polymer that was effective for reducing frictional pressure losses in heavy crude oil having a high asphaltene content and low API gravity, such as Bow River crude oil. Ex. 1005 at ¶ 94. Thus, the methods of claims 1-7 and 11 would have been obvious over the combination of Eaton and Strausz.

IX. CLAIMS 8-10 ARE OBVIOUS OVER EATON IN VIEW OF STRAUSZ AND NAIMAN

Claims 8-10 recite a method of introducing a drag reducing polymer into a heavy crude oil, as in claim 1, but "wherein a plurality of the repeating units [in the drag reducing polymer] comprise a heteroatom." Thus, claims 8-10 differ from claim 1 in defining the chemical structure of the drag reducing agent.

Like Eaton, Naiman discloses drag reducing polymers that are effective in crude oil. In contrast to the polymers disclosed by Eaton, however, the polymers of Naiman contain a plurality of repeating units that include an oxygen heteroatom. Specifically, the polymers disclosed by Naiman are made up of (1) styrene and alkyl acrylate units or (2) styrene, alkyl acrylate, and carboxylic acid units that are then reacted with a polyamine. Ex. 1004 at Abstract, 4:50-5:8. Notably, each of the alkyl acrylate units has an oxygen heteroatom.

As shown below, a person of ordinary skill in the art would have been led to replace the polymers of Eaton with the polymers of Naiman, which have a plurality of repeat units containing an oxygen heteroatom. Doing so would have satisfied each and every limitation of claims 8-10. Thus, claims 8-10 would have been obvious to a person of ordinary skill in the art over the combination of Eaton, Strausz, and Naiman.

A. Claim 8

As described above, based on the teaching of Eaton and Strausz, a person of ordinary skill in the art would have recognized that, to be most effective in the Bow River crude oil disclosed by Eaton, a drag reducing polymer should have a solubility parameter between 17.1 $MPa^{1/2}$ and 19.6 $MPa^{1/2}$. Ex. 1005 at ¶ 107. Although a person of ordinary skill in the art would have understood that it would be possible to prepare such a drag reducing polymer by following the disclosure of Eaton (as explained in Section VIII, *supra*), such a person would have recognized that the drag reducing polymers of Eaton are prepared using a Ziegler-Natta polymerization process and would have known that such a process requires the use of an expensive catalyst system and limits the range of useful monomers. Ex. 1005 at ¶ 108. Accordingly, a person of ordinary skill in the art would have been led to look for other drag reducing polymers that (1) would also be effective in heavy crude oil, but that (2) might be prepared using a more commercially desirable

process. *Id.* A person of ordinary skill in the art would thus have been led to Naiman.

First, a person of ordinary skill in the art would have recognized that the drag reducing polymers of Naiman would be effective in the Bow River crude oil disclosed by Eaton. Specifically, using methods that were conventional at the time, a person of ordinary skill in the art would have been able to identify the polymers of Naiman as having solubility parameters within the target range of 17.1 $MPa^{1/2}$ to 19.6 $MPa^{1/2}$. Ex. 1005 at ¶ 109, see also *id.* at ¶¶ 113-114. Accordingly, a person of ordinary skill in the art would have recognized that the drag reducing polymers of Naiman would be soluble, and thus effective, in the Bow River heavy crude oil disclosed by Eaton. *Id.* at ¶ 109.

Second, a person of ordinary skill in the art would have understood that the polymers of Naiman could be prepared using a more commercially desirable polymerization process than that employed by Eaton. Specifically, the polymers of Naiman are described as being prepared by an emulsion polymerization process, which was well understood by persons of ordinary skill in the art as being both less limited in terms of the types of monomers that could be used and less expensive to perform than the Ziegler-Natta polymerization process of Eaton. Ex. 1005 at ¶ 110.

Because the drag reducing polymers of Naiman would have been understood to be both (1) effective in the Bow River crude oil disclosed by Eaton and (2) prepared by a more commercially desirable process than the drag reducing polymers of Eaton, a person of ordinary skill in the art would have considered the drag reducing polymers of Naiman to be an advantageous replacement for the drag reducing polymers of Eaton for use in Bow River heavy crude oil. Ex. 1005 at ¶ 110. A person of ordinary skill in the art seeking to provide a drag reducing polymer for incorporation into Bow River crude oil would therefore have been led to replace the drag reducing polymer of Eaton with one of the drag reducing polymers of Naiman. *Id.* at ¶ 111.

Moreover, following the disclosure of Naiman, a person of ordinary skill in the art would have been led to prepare, and could easily have prepared, a drag reducing polymer meeting each and every limitation of claims 1 and 8 of the 118 patent. Specifically, according to Prof. Epps, it would have been well within the ability of a person of ordinary skill to (a) identify polymers of Naiman having a solubility parameter within the target range of 17.1 $MPa^{1/2}$ to 19.6 $MPa^{1/2}$, and then (b) perform the polymerization process of Naiman to obtain the desired polymer. Ex. 1005 at ¶ 112.

Naiman discloses drag reducing polymers that contain styrene, alkyl acrylates of from about four to about twelve carbon atoms (and preferably from

about six to about ten carbon atoms), and, in some cases, a small amount of acrylic or methacrylic acid. Ex. 1004 at 2:56-3:17. Prof. Epps explains how, using materials and information available in 2005, he was able to calculate the solubility parameters for a number of these polymers. First, Prof. Epps calculated the solubility parameters of polystyrene, poly(hexyl acrylate), poly(octyl acrylate), and poly(dodecyl acrylate). Ex. 1005 at ¶ 113. Next, Prof. Epps determined that, depending on the relative amounts of styrene and alkyl acrylate present in the polymers, the solubility parameter of a polymer made up of styrene and hexyl (C_6) acrylate would have a solubility parameter between about 17.36 $MPa^{1/2}$ and 17.98 $MPa^{1/2}$; the solubility parameter of a polymer made up of styrene and octyl (C_8) acrylate would have a solubility parameter between about 17.52 $MPa^{1/2}$ and 17.98 $MPa^{1/2}$; and the solubility parameter of a polymer made up of styrene and dodecyl (C_{12}) acrylate would have a solubility parameter between about 17.95 $MPa^{1/2}$ and 17.98 $MPa^{1/2}$. *Id.* at ¶ 114. Using these simple calculations, one of ordinary skill would have understood that the solubility parameters of these polymers range from 17.36 $MPa^{1/2}$ up to 17.98 $MPa^{1/2}$. Moreover, a person of ordinary skill in the art could easily have prepared these polymers simply by following the disclosure of Naiman. *Id.* at ¶ 115.

As explained in detail below, by replacing the drag reducing polymer of Eaton with one of the drag reducing polymers disclosed by Naiman, each and every element of claim 1 (from which claim 8 depends) and claim 8 is met.

> **Claim 1, element 1:** ***A method comprising: introducing a drag reducing polymer, into a pipeline, such that such that the friction loss associated with the turbulent flow through the pipeline is reduced by suppressing the growth of turbulent eddies,***

Eaton discloses the first element of claim 1. *See* pp. 23-24, *supra*. A person of ordinary skill in the art would also have understood that, when introduced into the Bow River crude oil disclosed by Eaton, the drag reducing polymer of Naiman would cause a reduction in frictional pressure loss associated with turbulent flow by suppressing the growth of turbulent eddies. Ex. 1005 at ¶ 121.

> **Claim 1, element 2:** ***into a liquid hydrocarbon having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon***

Eaton discloses the second element of claim 1. *See* pp. 24-26, *supra*.

> **Claim 1, element 3:** ***wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;***

It would have been obvious for a person of ordinary skill in the art to incorporate the drag reducing polymer of Naiman into Bow River crude oil in a

manner that would not measurably decrease the viscosity of the crude oil. Ex. 1005 at ¶ 122. According to Prof. Epps, for example, a person of ordinary skill in the art would have recognized from Naiman that the drag reducing polymer could be dried and dissolved in an organic solvent, such as xylene, and then added to Bow River crude oil in the preferred amounts disclosed by Naiman without having any appreciable effect on the viscosity of a Bow River crude oil. *Id.* at ¶ 123. Alternatively, one could have simply incorporated the drag reducing polymer as a solid, such as is taught by Eaton (e.g., by adding the dried polymer disclosed in Example 2 of Naiman directly to the Bow River crude oil), which a person of ordinary skill would have understood to have no appreciable effect on the viscosity of the crude oil. *Id.* at ¶ 124.

Claim 1, element 4: ***wherein the drag reducing polymer has a solubility parameter within 4 MPa$^{1/2}$ of the solubility parameter of the liquid hydrocarbon***

A person of ordinary skill in the art would have understood that polymers having solubility parameters between 17.36 MPa$^{1/2}$ and 17.98 MPa$^{1/2}$, such as those prepared following the disclosure of Naiman, as described above, would have solubility parameters within 4 MPa$^{1/2}$ of the solubility parameter of the Bow River crude oil (which has solubility parameter between 17.1 MPa$^{1/2}$ and 19.6 MPa$^{1/2}$, *see* Ex. 1005 at ¶ 83).

Claim 1, element 5: ***and the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.***

It would have been obvious for a person of ordinary skill in the art to add the drag reducing polymer of Naiman to Bow River heavy crude oil in an amount between about 3 and about 35 ppmw by weight, which is the range that is described by Naiman as providing superior drag reduction results. Ex. 1005 at ¶ 120. This range also coincides with the range described by Eaton, which teaches the addition of drag reducing polymer to highly viscous crude oil in amounts between 1 and 250 ppmw, and preferably between 25 and 150 ppmw. *Id.* Both disclosed ranges fall within the claimed range of 0.1 to about 500 ppmw.

Claim 8: ***The method of claim 1, wherein a plurality of the repeating units comprise a heteroatom***

Because the polymers of Naiman contain alkyl acrylate repeating units, which each contain an oxygen heteroatom, any polymer prepared following the disclosure of Naiman would have been one in which a plurality of the repeating units comprise a heteroatom.

B. Claim 9

Claim 9 recites: "The method of claim 8, wherein the heteroatom is selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and/or a phosphorus atom." Because the polymers of Naiman contain alkyl acrylate

repeating units, which each contain an oxygen heteroatom, any polymer prepared following the disclosure of Naiman would have been one in which a plurality of the repeating units comprise a heteroatom.

C. Claim 10

As explained above with respect to claim 8, a person of ordinary skill in the art would have been led to replace the polymers of Eaton with the polymers of Naiman, which have a plurality of repeat units containing an oxygen heteroatom. Further, as explained in detail below, by replacing the drag reducing polymer of Eaton with one of the drag reducing polymers disclosed by Naiman, each and every element of claim 10 is met.

> **Claim 10, element 1:** ***A method comprising: introducing a drag reducing polymer having a solubility parameter of at least about 17 MPa$^{1/2}$ into a pipeline, such that such that the friction loss associated with the turbulent flow through the pipeline is reduced by suppressing the growth of turbulent eddies,***

Eaton discloses the first element of claim 10, (*see* pp. 23-24, *supra*), with the exception that Eaton does not explicitly disclose that his drag reducing polymers have solubility parameters of at least about 17 MPa$^{1/2}$. A person of ordinary skill in the art would have understood that, when introduced into the Bow River crude oil disclosed by Eaton, the drag reducing polymer of Naiman would cause a reduction in frictional pressure loss associated with turbulent flow by suppressing

the growth of turbulent eddies. Ex. 1005 at ¶ 121. Moreover, polymers prepared following the disclosure of Naiman, as described above, have solubility parameters between about 17.36 $MPa^{1/2}$ and 17.98 $MPa^{1/2}$, the entire range of which meets the claim recitation of at least about 17 $MPa^{1/2}$.

Claim 10, element 2: ***into a liquid hydrocarbon having an asphaltene content of at least 3 weight percent and an API gravity of less than about 26° to thereby produce a treated liquid hydrocarbon***

Eaton discloses the second element of claim 10. *See* pp. 24-26, *supra*.

Claim 10, element 3: ***wherein the viscosity of the treated liquid hydrocarbon is not less than the viscosity of the liquid hydrocarbon prior to treatment with the drag reducing polymer;***

It would have been obvious to a person of ordinary skill in the art to incorporate the drag reducing polymer of Naiman into Bow River crude oil in a manner that would not measurably decrease the viscosity of the crude oil. *See* pp. 51-52, *supra*.

Claim 10, element 4: ***wherein the drag reducing polymer has a solubility parameter within 4 $MPa^{1/2}$ of the solubility parameter of the liquid hydrocarbon***

A person of ordinary skill in the art would have understood that polymers prepared following the disclosure of Naiman would be within 4 $MPa^{1/2}$ of the solubility parameter of the Bow River crude oil. *See* p. 52, *supra*.

Claim 10, element 5: ***and the drag reducing polymer comprises at least about 25,000 repeating units,***

A person of ordinary skill in the art would easily recognize that many of the polymers disclosed by Naiman have greater than 25,000 repeating units. Ex. 1005 at 100-103. It would have been obvious for a person of ordinary skill in the art to have selected a polymer having greater than 25,000 repeating units from among those disclosed by Naiman for incorporation into Bow River crude oil, especially since it is well understood that increased molecular weight—such as would be present in polymers having a greater number of repeating units—is a desirable property of a drag reducing polymer. *Id.* at ¶ 116.

Claim 10, element 6: ***and wherein a plurality of the repeating units comprise a heteroatom, wherein the heteroatom is selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and/or a phosphorous atom***

Because the polymers of Naiman contain alkyl acrylate repeating units, which each contain an oxygen heteroatom, any polymer prepared following the disclosure of Naiman would have been one in which a plurality of the repeating units comprise a heteroatom.

Claim 10, element 7: ***and wherein the drag reducing polymer has a weight average molecular weight of at least 1 x 10^6 g/mol***

The drag reducing polymers of Naiman are described as having a molecular weight of about 3 million g/mol to about 5 million g/mol (prior to any polyamine salt formation, which raises the effective molecular weight even higher). Ex. 1004 at 2:45-51. Thus, the polymers of Naiman have molecular weights greater than the claimed 1 x 10^6, i.e., 1 million, g/mol.

Claim 10, element 8: ***and the drag reducing polymer is added to the liquid hydrocarbon in the range from about 0.1 to about 500 ppmw.***

It would have been obvious to a person of ordinary skill in the art to add the drag reducing polymer of Naiman to Bow River heavy crude oil in an amount within the claimed 0.1 to about 500 ppmw. *See* p. 52, *supra*.

D. A Person of Ordinary Skill in the Art Would Have Been Motivated to Combine Eaton with Strausz and Naiman, and Would Have Had a Reasonable Expectation of Success

One of ordinary skill in the art in 2005 seeking to provide a drag reducing polymer that is effective for reducing frictional pressure losses in Bow River crude oil would, having the teachings of Eaton at hand, have been motivated to improve upon those teachings by taking advantage of the information in Strausz and Naiman. Specifically, a person of ordinary skill in the art in 2005 would have been motivated to prepare a drag reducing polymer having a solubility parameter within the range of about 17.1 to about 19.6 $MPa^{1/2}$, the range at which a polymer would

have maximum effectiveness as determined using the teachings of Eaton and Strausz, for introduction into the Bow River crude oil. Ex. 1005 at ¶ 84.

Further, because the drag reducing polymers of Naiman (1) have solubility parameters within this target range and (2) are prepared by a more commercially desirable process than the drag reducing polymers of Eaton, a person of ordinary skill in the art would have considered the drag reducing polymers of Naiman to be an advantageous replacement for the drag reducing polymers of Eaton for use in Bow River heavy crude oil. Ex. 1005 at ¶¶ 109-11. For these same reasons, a person of ordinary skill in the art would have been motivated to incorporate the drag reducing polymers taught by Naiman into the Bow River heavy crude oil disclosed by Eaton. Ex. 1005 at ¶ 119.

Moreover, as stated by Prof. Epps, a person of ordinary skill in the art would have had a reasonable expectation that, by combining the teachings of Eaton, Strausz, and Naiman, one would have successfully prepared a drag reducing polymer in which a plurality of the repeat units comprise an oxygen heteroatom and which has the properties recited in the claims of the 118 patent, including a solubility parameter that is within 4 $MPa^{1/2}$ of the solubility parameter of the Bow River crude oil disclosed by Eaton. Ex. 1005 at ¶ 117. A person of ordinary skill in the art would also have understood that, when incorporated into the Bow River crude oil, the drag reducing polymer of Naiman would cause a reduction in

frictional pressure loss associated with turbulent flow by suppressing the growth of turbulent eddies. *Id.* at ¶ 121.

Thus, a person of ordinary skill in the art seeking to provide a drag reducing polymer for heavy crude oil would have had a motivation to consult the teachings of Eaton, Strausz, and Naiman, and would have had a reasonable expectation that, by combining these teachings, one could have prepared a drag reducing polymer that was particularly effective for reducing frictional pressure losses in heavy crude oil having a high asphaltene content and low API gravity, such as Bow River heavy crude oil. Ex. 1005 at ¶ 118. Accordingly, the methods of claims 8-10 would have been obvious over the combination of Eaton, Strausz, and Naiman.

X. CONCLUSION

Petitioner has established a reasonable likelihood of prevailing as to each of claims 1-11 of the 118 patent, and therefore respectfully requests that the Board institute *inter partes* review of those claims.

Respectfully submitted,

McANDREWS, HELD & MALLOY, LTD.

Dated: April 1, 2016

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e)(4) and 42.105, the undersigned certifies on this date, a true and correct copy of this Petition for *Inter Partes* Review and all supporting exhibits were served by Priority Mail Express to the Patent Owner at the following correspondence address of record for U.S. Patent No. 8,022,118:

Phillips 66 Company
Intellectual Property – Legal
PO Box 4428
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Dated: April 1, 2016

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