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ELECTRICAL STABILITY PROBE WITH TEMPERATURE SENSOR

Abstract

A fluid electrical probe includes a body portion housing a cleaner, a head portion forming a gap, an electrode disposed in the gap, and a temperature sensor disposed in the gap. The cleaner is extendable into the gap to clean the electrode and the temperature sensor. The body portion comprises a handle configured to be gripped by an operator.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application claims priority to and the benefit of U.S. Provisional Application Ser. No. 63/371,953, entitled "Electrical Stability Probe with Temperature Sensor" and filed Aug. 19, 2022, the disclosure of which is incorporated herein by reference in its entirety for all purposes.

FIELD

[0002] This patent application addresses electrical probes. Specifically, electrical stability probes having incorporated temperature sensors and/or cleaners are described herein.

BACKGROUND

[0003] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0004] To perform an electrical stability test on a fluid, an electrical stability probe is used to detect an electrical property of the fluid. The electrical stability probe generally applies a sinusoidal voltage across a gap containing the fluid. Magnitude of the sinusoidal voltage is ramped upward and any current flowing across the gap is monitored. The electrical stability probe reports a peak voltage when a current that corresponds to a target or threshold value (e.g., 61 microamperes (μA)) is detected.

[0005] The American Petroleum Institute (API) 13B-2 standard for an electrical stability test requires averaging two discrete measurements taken at a fluid temperature of 50° C. ±2° C. (120° F. ±5° F.) using an electrical stability probe having electrodes with specific dimensions separated by a specific gap along with specific voltage reading circuitry. Typically, to perform the electrical stability test in compliance with the API 13B-2 standard, an operator uses a thermometer to verify that the fluid temperature of a fluid sample falls within specifications of API 13B-2, then performs a first measurement followed by a probe cleaning operation before proceeding to a second measurement. To achieve compliance with the API 13B-2 standard, the first and second measurements must be within 5 percent of each other. However, measuring the fluid temperature and completing the probe cleaning operation are time consuming, and use of multiple different implements (e.g., the thermometer, the electrical stability probe, and/or a cleaner that are physically separate implements) increases likelihood of inaccurate measurements. There is a need for a way to measure electrical stability of a fluid with more relatable temperature measurement and more expeditious probe cleaning.

SUMMARY

[0006] A summary of certain embodiments disclosed herein is set forth below. It should be understood that these aspects are presented merely to provide the reader with a summary of these certain embodiments and that these aspects are not intended to limit the scope of this disclosure. Indeed, this disclosure may encompass a variety of aspects that may not be set forth below.

[0007] In certain embodiments, a fluid electrical probe includes a body portion housing a cleaner, a head portion forming a gap, an electrode disposed in the gap, and a temperature sensor disposed in the gap. The cleaner is extendable into the gap to clean the electrode and the temperature sensor.

[0008] In certain embodiments, a monitoring system includes a fluid electrical probe comprising a housing. The housing includes a handle with a conduit that slidingly supports a cleaner and a head

structure with opposed surfaces that define a gap and support an electrode at the gap. The cleaner is adjustable between a retracted position in which the cleaner is withdrawn from the gap and an extended position in which the cleaner extends into the gap to clean the electrode.
[0009] In certain embodiments, a method of measuring an electrical property of a fluid includes obtaining a probe with a body portion housing a cleaner, a head portion forming a gap, an electrode disposed in the gap, and a temperature sensor disposed in the gap, wherein the cleaner is extendable into the gap. The method also includes using the temperature sensor to measure a temperature of the fluid. The method further includes extending the cleaner to clean the electrode and the temperature sensor. The method further includes using the electrode to measure the electrical property of the fluid.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0010] Various features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying figures in which like characters represent like parts throughout the figures, wherein:
[0011] FIG. **1** is an isometric view of an electrical stability probe, according to an embodiment;
[0012] FIG. **2** is a detail view of a head portion of the electrical stability probe of FIG. **1**, according to an embodiment;
[0013] FIG. **3** is a detail view of the head portion of the electrical stability probe of FIG. **1**, wherein a cleaner is in an extended position, according to an embodiment;
[0014] FIG. **4** is a detail view of the head portion of the electrical stability probe of FIG. **1**, wherein a temperature sensor, according to an embodiment;
[0015] FIG. **5** is schematic diagram of an electrical stability monitoring system with the electrical stability probe of FIG. **1**, according to an embodiment; and
[0016] FIG. **6** is a flow diagram of a method of using the electrical stability monitoring system of FIG. **5**, according to an embodiment.
DETAILED DESCRIPTION
[0017] One or more specific embodiments of the present disclosure will be described below. The described embodiments are only exemplary of the present disclosure. Additionally, to provide a concise description of these exemplary embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.
[0018] An electrical stability probe described herein incorporates (e.g., integrates; built-in) a temperature sensor and/or a cleaner to enable efficient measurement of electrical stability in a material (e.g., a fluid). For example, the electrical stability probe described herein may incorporate both the temperature sensor and the cleaner to provide a single implement (e.g., tool) for temperature measurement and probe cleaning to enable efficient measurement of the electrical stability in the material. Use of the single implement, as described herein, may reduce time and/or distance between the temperature measurement and the electrical stability measurement (e.g., as compared to use of separate implements for the temperature measurement and the electrical stability measurement), which reduces a chance that the electrical stability measurement is taken at a temperature outside a standard range (e.g., a target range; set by API 13B-2).

[0019] FIG. **1** is an isometric view of an electrical stability probe **100**, according to an embodiment. As described herein, the electrical stability probe **100** may be utilized to measure electrical properties (e.g., electrical stability) in a material (e.g., a fluid, which is typically a liquid; drilling fluid for drilling operations to access natural resources; oil-based drilling fluid; synthetic-based drilling fluid). For example, the electrical stability probe **100** may be handled by an operator (e.g., human operator) and inserted into a sample of the material to measure the electrical properties in the material. To facilitate discussion, the electrical stability probe **100** and its components may be described with reference to an axial axis or direction **2**, a lateral axis or direction **4**, and/or a circumferential axis or direction **6**.

[0020] As shown in FIG. **1**, the electrical stability probe **100** has a head portion **102** and a body portion **104** connected to the head portion **102**. The head portion **102** includes a head structure **103** (e.g., frame; paddle; electrode holder), and the body portion **104** includes a handle **105** (e.g., rod) configured to be gripped by the operator. It should be appreciated that the head structure **103** and the handle **105** may be two separate components that are coupled to one another (e.g., via fasteners, such as bolts or welds) or may be a one-piece structure (e.g., integrally formed, such as via molding or printing). Together, the head structure **103** and the handle **105** may be considered to form or be part of a housing of the electrical stability probe **100**.

[0021] FIG. **2** is a detail view of the head portion **102** of the electrical stability probe **100** of FIG. **1**, according to an embodiment. The head portion **102** has the head structure **103** that defines a gap **106** to accommodate the material for analysis. Electrodes **108** are positioned at the gap **106** to create an electric field within the gap **106** to analyze the electrical properties of the material in the gap **106**. In particular, the gap **106** is defined by a first surface **110** (e.g., axially-extending; laterally-facing) and a second surface **112** (e.g., axially-extending; laterally-facing) of the head structure **103**. The first surface **110** and the second surface **112** generally face each other (e.g., positioned as opposed surfaces), and the electrodes **108** are generally arranged at the first surface **110** and the second surface **112**. In certain embodiments, the first surface **110** and the second surface **112** are flat surfaces that face each other and that are parallel (e.g., parallel or substantially parallel, accounting for manufacturing variations and/or within manufacturing tolerances) to one another, as this may simplify analysis of the electrical properties of the material in the gap **106**.

[0022] As shown, the head structure **103** includes or is formed by two prongs **114** (e.g., arms) that extend from the body portion **104** (e.g., from the handle **105**) to the gap **106**. In this case, the two prongs **114** extend and/or diverge from an end **116** (e.g., distal end; end portion) of the body portion **104** that defines a transition from the body portion **104** to the head portion **102**. In particular, the two prongs **114** extend from and/or diverge from the end **116** of the body portion **104**, and the two prongs **114** also extend (e.g., bend or curve) away from each other to form an opening **117** (e.g., through hole). The opening **117** is located between the two prongs **114** along the lateral axis **4**, and also between the end **116** of the body portion **104** and the gap **106** along the axial axis **2**. As shown, the head structure **103** with the two prongs **114** may define a planar structure with a c-shape (e.g., rounded portions, such as the two prongs **114**, that curve to form the first surface **110** and the second surface **112** to define the gap **106**). It should be noted that any of a variety of geometries and configurations are envisioned. For example, the head structure **103** may not include the prongs **114**, the head structure **103** may extend from another location other than the end **116** of the body portion **104**, and/or the head structure **103** and/or the prongs **114** may have another geometry and/or configuration.

[0023] FIG. **3** is a detailed view of the head portion **102** of the electrical stability probe **100** of FIG. **1**, according to an embodiment. As shown, a cleaner **118** is disposed in and/or supported by the body portion **104** (e.g., by the handle **105**). The cleaner **118** is extendable from the body portion **104** and retractable to the body portion **104** (e.g., transitions or moves between an extended position in which the cleaner **118** extends from the body portion **104** and into the gap **106** and a retracted position in which the cleaner **118** is retracted within the body portion **104** and withdrawn from the gap **106**).

[0024] In particular, the cleaner **118** is extendable from the body portion **104** to the gap **106**, such that a cleaning tip **120** (e.g., cleaning end portion; distal end portion) of the cleaner **118** extends into the gap **106**. With reference to FIG. **3**, the cleaning tip **120** extends into the gap **106** while the cleaner **118** is in the extended position. Further, the cleaner **118** is retractable to the body portion **104**, such that the cleaning tip **120** is withdrawn from the gap **106**. With reference to FIG. **2**, the cleaning tip **120** is withdrawn from the gap **106** while the cleaner **118** is in the retracted position. As shown in FIG. **2**, the cleaning tip **120** may also be withdrawn from the opening **117** while the cleaner **118** is in the retracted position, such as to be flush with an inner surface of the head structure **103** that defines the opening **117**. In this case, the gap **106** is generally parallel to the body portion **104** (e.g., the gap **106** and the body portion **104** extend in the axial direction **2**; the cleaner **118** moves in the axial direction **2**; a central axis of the gap **106** is generally aligned with a central axis of the body portion **104** to provide a path for the cleaner **118** to extend into the gap **106** from the body portion **104**).

[0025] A slide member **122** is attached to the cleaner **118** at a location that is within the body portion **104** (e.g., the handle **105**). The electrical stability probe **100** has a conduit **124** (e.g., passageway) that extends along the axial axis **2**, and the cleaner **118** is slidably disposed in the conduit **124**. The slide member **122** extends through a cleaner opening **126** (also shown in FIG. **1**) to connect to the cleaner **118** in the conduit **124** (e.g., with a fixed connection, such as via a fastener) and to be accessible at an exterior side location of the body portion **104**. Thus, the slide member **122** can be operated (e.g., manually by the operator; contacted by the operator; to slide along the body portion **104**) to extend the cleaner **118** out of the conduit **124** so the cleaning tip **120** can enter the gap **106** and contact the first surface **110** and the second surface **112** of the head structure **103**, as shown in FIG. **3**. Moving the slide member **122** along the body portion **104** toward the head portion **102** extends the cleaner **118** and the cleaning tip **120** from the conduit **124** across the opening **117** to insert the cleaning tip **120** into the gap **106**. Moving the slide member **122** along the body portion **104** away from the head portion **102** retracts the cleaner **118** and the cleaning tip **120** from the gap **106** into the conduit **124** through an end opening **128** of the conduit **124**. It should be appreciated that any suitable mechanical member may be utilized to move the cleaner **118** within the conduit **124**. For example, in lieu of the slide member **122** that slides axially along the body portion **104**, a mechanical member may include a rotatable member (e.g., rotatable knob that can be gripped and rotated relative to the body portion **104** by the operator). In such cases, rotation of the rotatable member may move the cleaner **118** within the conduit **124** as described herein (e.g., via a series of linkages and/or gears, such as worm drive).

[0026] The cleaner **118** may include a rod **121** that supports the cleaning tip **120**. The rod **121** may be formed from a material (e.g., metal; plastic) that is sufficiently rigid and/or supportive to support the cleaning tip **120**. The cleaning tip **120** may be formed from a material that provides gentle contact and movement along the first surface **110** and the second surface **112** to remove substantially all material from the gap **106**, the first surface **110**, and the second surface **112**. For example, the cleaning tip **120** may be a compressible material (e.g., textile, such as felt; foam; plastic; rubber; elastomer polytetrafluoroethylene [PTFE]) and/or may have a textured surface (e.g., integrally formed and/or coupled thereto; soft bristles).

[0027] The cleaner **118** has dimensions suitable for slidable motion within the conduit **124**. In this case, the cleaner **118** has a rectangular shape, and the conduit **124** also has a rectangular shape. The cleaner **118** has dimensions less than dimensions of the conduit **124**, so the cleaner **118** can move within the conduit **124**. It should be noted that the cleaner **118** can have any suitable shape for moving within the conduit **124**, which can also have any suitable shape. In certain embodiments, the cleaning tip **120** has dimensions selected to provide a tight fit within the conduit **124** at the end opening **128** thereof. As noted herein, the cleaning tip **120** may retract into the conduit **124**, such as by moving the slide member **122** along the body portion **104** away from the head portion **102**. The cleaning tip **120** may have dimensions larger than a remainder of the cleaner **118** (e.g., along the lateral axis **4**), but small enough to retract into the end opening **128** of the conduit **124** (e.g., upon or with compression of the cleaning tip **120**). The cleaning tip **120** can have dimensions, such that when the cleaning tip **120** retracts into the conduit **124**, the tight fit of the cleaning tip **120** within the end opening **128** provides a scouring and/or squeezing pressure to the material of the cleaning tip **120** to remove the material from the cleaning tip **120**. In this way, the material removed from the gap **106**, the first surface **110**, and the second surface **112** by the cleaning tip **120** (and subsequently carried on the cleaning tip **120**) is removed from the cleaning tip **120** automatically by retracting the cleaning tip **120** into the end opening **128** of the conduit **124**.

[0028] In certain embodiments, a resilient member **130** (e.g., biasing member, coil spring, rubber band) is disposed within the conduit **124** to provide retracting force for the cleaner **118**. Shown in FIG. **3** in phantom, the resilient member **130** is a coil spring in this case and is disposed around the cleaner **118** between the end opening **128** of the conduit **124** and the slide member **122** along the axial axis **2**. A retention feature **132** is positioned at or proximate to the end opening **128** of the conduit **124** to retain the resilient member **130** between the retention feature **132** and the slide member **122** along the axial axis **2**. The retention feature **132** may be a ledge (e.g., annular ledge, shelf, protrusion, tab, bump) that extends radially inward from an interior wall of the conduit **124**. As the slide member **122** is operated to drive the cleaner **118** through the end opening **128** to extend the cleaning tip **120** into the gap **106**, the slide member **122** and the retention feature **132** cooperate to compress the resilient member **130**, which develops a retracting force under compression. When the slide member **122** is released (e.g., by the operator), the retracting force of the resilient member **130** retracts the cleaner **118** into the conduit **124**, bringing the cleaning tip **120** into the end opening **128** of the conduit **124** to provide cleaning contact between the cleaning tip **120** and the end opening **128** of the conduit **124** (e.g., driving the cleaning tip **120** into the end opening **128** of the conduit **124** to scrape the material from the cleaning tip **120** and/or to compress the cleaning tip **120** to squeeze the material from the cleaning tip **120**).

[0029] It should be appreciated that one or more seal elements (e.g., annular seal elements; elastomer seal elements; O-rings) may be provided to form a seal (e.g., annular seal) about the cleaner **118** to block the material from passing into the conduit **124**. The one or more seal elements may be located on the cleaner **118** and/or within the conduit **124** (e.g., the retention feature **132** may operate as one of the one or more seal elements).

[0030] FIG. **4** is a detailed view of the head portion **102** of the electrical stability probe **100** of FIG. **1**, according to an embodiment. As shown in FIG. **4**, one electrode **108** is disposed at the first surface **110**. Further, as shown in FIG. **2**, another electrode **108** is disposed at the second surface **112**. The electrodes **108** are aligned with one another (e.g., along the axial axis **2**) and face each other (e.g., along the lateral axis **4**; across the gap **106**) to form an electric field in the gap **106** when power is supplied to the electrodes **108**.

[0031] As shown, the electrical stability probe **100** may also include a temperature sensor **134**. The temperature sensor **134** may be located on the head structure **103**, such as at the first surface **110**. In certain embodiments, to facilitate measuring a temperature of the material in the gap **106**, the temperature sensor **134** may be positioned in the gap **106** (e.g., at the first surface **110**) and is spaced apart from the electrodes **108** (e.g., along the axial axis **2**). In this way, the electrical stability probe **100** may facilitate measuring the electrical properties of the material in the gap **106** with the temperature in the standard range (e.g., the target range; set by API 13B-2). It should be appreciated that the temperature sensor **134** may be located at the second surface **112** or any other suitable surface of the head structure **103**. Further, it should be appreciated that one or more additional temperature sensors may be provided on the head structure **103**.

[0032] In certain embodiments, the electrodes **108** are positioned at a portion (e.g., proximal portion) of the gap **106** that is near (e.g., proximate) the body portion **104**. Locating the electrodes **108** close to the body portion **104** in this manner provides ready access for the cleaning tip **120** to reach between the electrodes **108** and to contact both of the electrodes **108** with cleaning force. In certain embodiments, the temperature sensor **134** is spaced apart from the electrodes **108** (e.g., along the axial axis **2**) to provide access for the cleaning tip **120** to reach the temperature sensor **134** and to capture the temperature measurements of the material in a vicinity of the electrodes **108**, but also to block any effect of the temperature sensor **134** on the electric field formed between the electrodes **108**. For example, in FIG. **4**, the temperature sensor **134** is located near a middle location of the gap **106** (e.g., approximately midway between the electrodes **108** and a distal end of the gap **106** and/or the head structure **103** along the axial axis **2**). Further, such placement of the temperature sensor **134** (e.g., in the middle location of the gap **106**; away from the distal end of the gap **106** and/or the head structure **103**) may also separate the temperature sensor **134** from a bottom surface of a container that holds the material, which may result in the temperature sensor **134** capturing more accurate temperature measurements for the material in the vicinity of the electrodes **108** (e.g., away from a heater under the container that holds the material, as compared to placement of the temperature sensor **134** at or near the distal end of the gap **106** and/or the head structure **103**, which may contact the bottom surface of the container that holds the material). In this case, the temperature sensor **134** is spaced apart from one of the electrodes **108** on the first surface **110** by at least a full dimension of the electrode **108**. The temperature sensor **134** and the electrodes **108** are both depicted as circular, disk-like members, but the temperature sensor **134** and the electrodes **108** can have any suitable and/or convenient shape.

[0033] Further, the electrodes **108** are generally made of any suitable conductive material, for example gold, copper, or gold plating over a suitable metal material. The temperature sensor **134** may be a thermocouple or a resistive temperature device, which can be made of a suitable material, such as stainless steel or platinum. The temperature sensor **134** and/or the electrodes **108** may be supported within respective recesses (e.g., grooves) defined in the head structure **103** (e.g., the first surface **110** and the second surface **112**) so as to be protected within the head structure **103** and/or so as to be flush with the head structure **103** (e.g., the first surface **110** and the second surface **112**), which may maintain the gap **106** and/or facilitate cleaning with the cleaner **118**. It should be appreciated that one or more additional temperature sensors may be disposed on the electrical stability probe **100**. Further, the temperature sensors **134** and/or the one or more additional temperature sensors may be disposed at any suitable position location of the electrical stability probe **100**, such as at the first surface **110**, the second surface **112**, and/or along other surface(s) of the head structure **103**, for example. With reference to FIG. **1** and FIG. **4**, it should also be appreciated that conductors (e.g., electrical conductors or wires that transmit power and/or signals) may connect to the temperature sensor **134** and the electrodes **108**, extend through the head structure **103** of the head portion **102**, through the handle **105** of the body portion **104**, and into a cable **136**.

[0034] FIG. **5** is schematic diagram of an electrical stability monitoring system **150** with the electrical stability probe of FIG. **1**, according to an embodiment. As shown, the electrical stability monitoring system **150** includes a monitor **152** (e.g., electrical stability monitor; computing system; computing device; controller) with a processor **154**, a memory device **156**, an output device **158**, an input device **160**, and/or a power source **162** (e.g., battery). The electrical stability probe **100** is coupled to the monitor **152**, such as via the cable **136**. However, while a wired connection between the electrical stability probe **100** and the monitor **152** is shown in FIG. **5**, it should be appreciated that the electrical stability probe **100** and the monitor **152** may include communication components (e.g., wireless transceivers) that provide a wireless connection between the electrical stability probe **100** and the monitor **152** (e.g., to communicate via radiofrequency waves).

[0035] At certain times (e.g., periodically during drilling operations), the operator may use the electrical stability monitoring system **150** to measure the electrical properties of the material. For example, the operator may place a sample of the material in a container **170**. Then, the operator may grip the handle **105** of the body portion **104** of the electrical stability probe **100** and insert the head structure **103** of the head portion **102** of the electrical stability probe **100** into the sample of the material in the container **170**. In some cases, the operator may move the electrical stability probe **100** to mix (e.g., swirl) the sample of the material in the container **170**. It should be appreciated that a geometry of the head structure **103** (e.g., expanded diameter; the opening **117**) may facilitate mixing of the sample of the material in the container **170**.

[0036] The operator may also provide an input via the input device **160** to initiate and/or to carry out an electrical stability test for the material. For example, the operator may actuate a key (e.g., physical or virtual button) on the monitor **152** to initiate the electrical stability test for the material. Then, the monitor **152** may instruct a heater **178** to adjust (e.g., increase) a temperature of the sample of the material, and the monitor **152** may also receive and/or request temperature data (e.g., signals) from the temperature sensor **134** of the electrical stability probe **100**. In this way, the monitor **152** may determine and/or monitor the temperature of the sample of the material.

[0037] The monitor **152** may compare the temperature of the sample of the material to a standard range (e.g., target range; set by API 13B-2). In response to determining that the temperature of the sample of the material is within the standard range and/or while the temperature of the sample of the material is within the standard range, the monitor **152** obtain a first electrical reading from the electrodes **108** (e.g., the monitor **152** may instruct an increase in a voltage and monitor a current between the electrodes **108**, and then the monitor **152** may identify and record a peak voltage when the current between the electrodes **108** corresponds to a target or threshold value, such as 61 μA).

[0038] In some embodiments, in response to obtaining the first electrical reading from the electrodes **108**, the monitor **152** may provide an output via the output device **158**. For example, the monitor **152** may provide a visual notification (e.g., the peak voltage; a text message) via a display and/or an audible notification (e.g., an alarm) via a speaker to notify the operator that the first electrical reading is complete and that the operator should complete a cleaning operation with the cleaner **118**.

[0039] Then, the operator may apply a force to the slide member **122** to move the slide member **122** toward the head portion **102** until the cleaning tip **120** enters the gap **106** (e.g., brushes past the electrodes **108** and the temperature sensor **134**). Then, the operator may apply another force to the slide member **122** to move the slide member **122** away from the head portion **102** and/or the operator may release the slide member **122** to cause the resilient member **130** to retract the cleaner **118**, to thereby withdraw the cleaning tip **120** from the gap **106** and into the conduit **124** of the electrical stability probe **100**. As described herein, the electrical stability monitoring system **150** may be configured to carry out the cleaning process in the automated manner (e.g., without human manipulation of input devices and/or the electrical stability probe **100** and components thereof). For example, in response to obtaining the first electrical reading from the electrodes **108**, the monitor **152** may provide control signals to an actuator of the electrical stability probe **100** to adjust a position of the cleaner **118** (e.g., between the extended position and the retracted position) to carry out the cleaning process in the automated manner. In some such cases, the electrical stability probe **100** may include various structural features, such as a solenoid that is configured to receive the control signals from the monitor **152** and actuate to adjust the position of the cleaner **118**, a piston that is configured to receive fluid (e.g., hydraulic fluid) and actuate to adjust the position of the cleaner **118**, and/or any other suitable structure capable of moving the cleaner **118** based on the control signals. Further, the electrical stability probe **100** may include one or more sensors (e.g., proximity sensors) to detect movement of the cleaner **118**. The one or more sensors may provide signals to the monitor **152** to enable the monitor **152** to determine and/or to confirm appropriate movement of the cleaner **118** for the cleaning process.

[0040] Then, immediately or after some amount of time (e.g., set by API 13B-2), the monitor **152** may instruct the heater **178** to operate to adjust (e.g., increase) the temperature of the sample of the material and/or the monitor **152** may receive and/or request the temperature data from the temperature sensor **134** of the electrical stability probe **100**. Again, the monitor **152** may compare the temperature of the sample of the material to the standard range. In response to determining that the temperature of the sample of the material is within the standard range and/or while the temperature of the sample of the material is within the standard range, the monitor **152** obtain a second electrical reading from the electrodes **108** (e.g., the monitor **152** may identify and record another peak voltage when the current between the electrodes **108** corresponds to the target or threshold value).

[0041] In some embodiments, in response to obtaining the second electrical reading from the electrodes **108**, the monitor **152** may provide another output via the output device **158** to notify the operator that the second electrical reading is complete and that the operator should complete another cleaning operation with the cleaner **118**. It should be appreciated that the electrical stability probe **100** may be withdrawn or removed from the sample of the material for the cleaning operation(s). Further, between the first electrical reading and the second electrical reading, the electrical stability probe **100** may be held outside of the sample of the material in order for the temperature sensor **134** to equilibrate (e.g., at least until readings from the temperature sensor **134** are stable), and then the electrical stability probe **100** may be handled to insert the head structure **103** of the head portion **102** of the electrical stability probe **100** back into the sample of the material to obtain the second electrical reading.

[0042] The monitor **152** may process the first electrical reading and the second electrical reading to yield a final analysis (e.g., average the first electrical reading and the second electrical reading to yield a result). Further, the monitor **152** may output the final analysis via the output device **158** (e.g., via presentation of the result on the display) and/or may communicate the final analysis to a separate computing system or device (e.g., to a mobile device of the operator; to a remote desktop computer or server; to a storage device for recordation in a database, such as in a data repository or log for a wellsite and/or a cloud system). While two electrical readings are described (e.g., for compliance with API 13B-2), it should be appreciated that the electrical stability monitoring system **150** may be configured to obtain any number of electrical readings (e.g., 1, 2, 3, 4, or more) and then evaluate the electrical readings to yield the final analysis (e.g., average the electrical readings to yield the result).

[0043] The processor **154** may be processing circuitry that includes one or more processors configured to execute software, such as software for processing signals (e.g., from the temperature sensor **134** and the electrodes **108**) and/or controlling components of the electrical stability monitoring system **150** (e.g., the output device **158**). The memory device **156** may include one or more memory devices (e.g., a volatile memory, such as random access memory [RAM], and/or a nonvolatile memory, such as read-only memory [ROM]) that may store a variety of information and may be used for various purposes. For example, the memory device **156** may store processor-executable instructions (e.g., firmware or software) for the processor **154** to execute, such as instructions for processing signals (e.g., from the temperature sensor **134** and the electrodes **108**) and/or controlling components of the electrical stability monitoring system **150** (e.g., the output device **158**). It should be appreciated that the monitor **152** may include various other components, such as a communication device (e.g., wireless transceiver) that is capable of communicating data and/or other information to various other devices (e.g., a remote desktop computer or server, the Internet, a cloud system).

[0044] It should be appreciated that the monitor **152** may be a dedicated and/or contained controller with processing circuitry that carries out the various techniques disclosed herein. However, the monitor **152** may be part of and/or include a distributed controller (e.g., remote computing system and/or cloud computing system) with processing circuitry that carries out the various techniques disclosed herein. Thus, while certain operations are described as being performed by the monitor **152** to facilitate discussion, it should be appreciated that the various techniques disclosed herein may be performed by any suitable device and/or distributed between any suitable combination of devices (e.g., the processor **154** of the monitor **152**, on-board processing circuitry of the electrical stability probe **100**, processing circuitry of the remote computing system, and/or processing circuitry of the cloud computing system).

[0045] Additionally, the monitor **152** may include the output device **158**, such as a display that is configured to display the probe readings and/or other result (e.g., the average probe readings). For example, the monitor **152** may be configured to instruct the display to present one, two, or more temperature readings; an indication of whether each temperature reading complies with the standards; a prompt to an operator when a temperature reading complies with the standards; one, two, or more related electrode readings; whether two electrode readings comply with the standards (e.g., by being no more than some percentage, such as 5%, apart); an average of the electrode readings; and/or a message indicating whether any measurement is compliant or non-compliant based on comparison (e.g., by the monitor) of the temperature readings with the range required by the standards and/or based on comparison (e.g., by the monitor) of two electrode readings with some percentage required by the standard (e.g., whether the two electrode readings are within 5% of each other). Further, the output device **158** may operate as the input device **160** (or an additional input device) of the monitor **152**. For example, the output device **158** may include a touch screen display that presents virtual keys or buttons that may be selected by the operator to provide inputs.

[0046] FIG. **6** is a flow diagram of a method **180** of using the electrical stability monitoring system **150** of FIG. **1**, according to an embodiment. It should be appreciated that steps of the method **180** may be performed by processing circuitry (e.g., the monitor **152**). It should be appreciated that steps may be omitted, steps may be added, and/or steps may be carried out in any suitable order.

[0047] In block **182**, the method **180** may begin with controlling a heater to heat a sample of material (e.g., a fluid in a container). In block **184**, the method **180** may include monitoring a temperature of the sample of the material with a temperature sensor of an electrical stability probe. As described herein, the temperature sensor may be integrated into the electrical stability probe (e.g., within a housing and/or along a surface of the housing of the electrical stability probe).

[0048] In block **186**, if the temperature does not correspond to a range (e.g., a standard range; set by API 13B-2), then the method **180** may return to block **182**. However, if the temperature corresponds to the range, then the method **180** may proceed to block **188**. In block **188**, the method **180** may include providing (e.g., increasing) a voltage to electrodes of the electrical stability probe. As described herein, the electrodes may be integrated into the electrical stability probe (e.g., within the housing and/or along the surface of the housing of the electrical stability probe; proximate to the temperature sensor).

[0049] In block **190**, the method **180** may include monitoring a current between the electrodes of the electrical stability probe. In block **192**, if the current does not correspond to a threshold value (e.g., set by API 13B-2; 61 μA), then the method **180** may return to block **188**. However, if the current corresponds to the threshold value (e.g., meets or exceeds the threshold value), then the method **180** may proceed to block **194**.

[0050] In block **194**, the method **180** may include recording a peak voltage when the current corresponds to the threshold value. In block **196**, the method **180** may include providing a notification to complete a cleaning process (e.g., a cleaning operation) with a cleaner of the electrical stability probe. As described herein, the cleaner may be integrated into the electrical stability probe (e.g., within the housing of the electrical stability probe). The notification may prompt the operator to withdraw the electrical stability probe from the sample of the material, apply a force to a slide member to extend the cleaner from a conduit formed in the housing of the electrical stability probe and into a gap defined by the housing to clean the temperature sensor and/or the electrodes positioned at the gap (e.g., exposed to and/or facing the gap). Upon completion of the cleaning process, the operator may apply another force to the slide member to withdraw the cleaner from the gap and to retract the cleaner into the conduit formed in the housing of the electric stability probe. Additionally or alternatively, the operator may release the slide member to enable a resilient member to drive the cleaner into the conduit formed in the housing of the electric stability probe. The notification may include a visual output (e.g., a text message; the peak voltage) and/or an audible output (e.g., an alarm).

[0051] In block **198**, if a desired number of acceptable electrical stability readings have not been obtained (e.g., less than two readings obtained while the temperature is within the range, as set by API 13B-2), then the method **180** may return to block **182**. However, if the desired number of acceptable electrical stability readings have been obtained (e.g., two readings obtained while the temperature is within the range and the two readings are within 5% of one another, as set by API 13B-2), then the method **180** may proceed to block **200**. In block **200**, the method **180** may include calculating and/or outputting a final result (e.g., an average of the electrical stability readings). For example, the method **180** may include presenting the final result on a display, storing the final result (e.g., in a database), and/or communicating the final result to another computing system (e.g., for display at a remote computing station; for automated control for modification to the material, such as additions and/or dilutions for drilling fluid, based on the final result). In block **202**, the method **180** may include providing another notification to complete another cleaning process (e.g., another cleaning operation) with the cleaner of the electrical stability probe. It should be appreciated that outputting the final result in block **200** may operate as the another notification that is intended to prompt the operator to complete the another cleaning process.

[0052] Importantly, as set forth in the method **180** of FIG. **6**, the temperature sensor, the electrodes, and the cleaner are part of the electrical stability probe. Accordingly, the method **180** may be carried out in an efficient manner (e.g., with a single instrument) and in an accurate manner (e.g., with accurate temperature readings obtained near the electrodes).

[0053] It should be appreciated that the electrical stability monitoring system **150** may support any of a variety of levels of automation. For example, the electrical stability monitoring system **150** may carry out any of the blocks **182-202** in an automated manner (e.g., without human manipulation of input devices and/or the electrical stability probe and components thereof). In some embodiments, the electrical stability monitoring system **150** may be configured to carry out any of the blocks **182-202** in the automated manner, including accessing the range, the threshold value, the desired number, and/or other standards (e.g., according to the API 13B-2) and also carrying out the controlling, monitoring, comparing, analysis, notifying, calculating, outputting, and so forth. In some embodiments, the electrical stability monitoring system **150** may be configured to carry out the cleaning process in the automated manner. In some such cases, the electrical stability probe may include various structural features, such as a solenoid that is configured to receive control signals and actuate to adjust a position of the cleaner (e.g., between the extended position and the retracted position), a piston that is configured to receive fluid (e.g., hydraulic fluid) and actuate to adjust the position of the cleaner, and/or any other suitable structure capable of moving the cleaner based on the control signals.

[0054] Accordingly, as described herein, an electrical stability monitoring system may include a monitor and an electrical stability probe. The monitor may be configured to control various aspects of probe operation, as well as to collect and/or interpret signals from the electrical stability probe. In particular, the electrical stability probe may be configured to receive signals from one or more temperature sensors and from electrodes, relate signals from the electrodes to signals from the temperature sensor (e.g., using a time horizon), analyze probe readings (e.g., average probe readings according to API standards), and/or determine whether the probe readings comply with standards (e.g., the API standards) by comparing temperature readings with a temperature range set forth in the standards.

[0055] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the present disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow. Further, any features shown in FIGS. **1-6** or described with reference to FIGS. **1-6** may be combined in any suitable manner

[0056] The techniques presented and claimed herein are referenced and applied to material objects and concrete examples of a practical nature that demonstrably improve the present technical field and, as such, are not abstract, intangible or purely theoretical. Further, if any claims appended to the end of this specification contain one or more elements designated as “means for (perform) ing (a function) . . . ” or “step for (perform) ing (a function) . . . ”, it is intended that such elements are to be interpreted under 35 U.S.C. 112 (f). However, for any claims containing elements designated in any other manner, it is intended that such elements are not to be interpreted under 35 U.S.C. 112 (f).

Claims

1. A fluid electrical probe, comprising: a body portion housing a cleaner; a head portion forming a gap; an electrode disposed in the gap; and a temperature sensor disposed in the gap, wherein the cleaner is extendable into the gap to clean the electrode and the temperature sensor.
2. The fluid electrical probe of claim 1, wherein the body portion comprises a handle configured to be gripped by an operator.
3. The fluid electrical probe of claim 1, wherein the head portion comprises a c-shaped structure that extends from the body portion and defines the gap.
4. The fluid electrical probe of claim 1, wherein the head portion comprises two curved prongs that define an opening between the two curved prongs along a lateral axis and between the body portion and the gap along an axial axis.
5. The fluid electrical probe of claim 1, wherein the head portion comprises two opposed surfaces that define the gap, and the electrode and the temperature sensor are positioned on one of the opposed surfaces.
6. The fluid electrical probe of claim 5, wherein the electrode is positioned between the temperature sensor and the body portion relative to an axial axis.
7. The fluid electrical probe of claim 1, wherein the cleaner comprises a rod that supports a cleaning tip, wherein a respective dimension of the rod along a lateral axis is less than a respective dimension of the cleaning tip along the lateral axis.
8. The fluid electrical probe of claim 7, comprising a conduit within the body portion, wherein a respective dimension of an end portion of the conduit is configured to cause the end portion of the conduit to contact the cleaning tip as the cleaner is retracted into the conduit.
9. The fluid electrical probe of claim 8, wherein the respective dimension of the end portion of the conduit is configured to cause the end portion of the conduit to compress the cleaning tip as the cleaner is retracted into the conduit.
10. The fluid electrical probe of claim 1, wherein a cleaning tip of the cleaner comprises a compressible material.
11. The fluid electrical probe of claim 1, comprising a mechanical member accessible to an operator along the body portion and coupled to the cleaner to enable the operator to apply a force to the mechanical member to extend the cleaner into the gap to clean the electrode and the temperature sensor.
12. The fluid electrical probe of claim 11, wherein the mechanical member comprises a slide member, and the fluid electrical probe comprises a resilient member configured to retract the cleaner from the gap and into the body portion upon release of the slide member by the operator.
13. A monitoring system, comprising: a fluid electrical probe comprising a housing, wherein the housing comprises: a handle comprising a conduit that slidingly supports a cleaner; and a head structure comprising opposed surfaces that define a gap and support an electrode at the gap; wherein the cleaner is adjustable between a retracted position in which the cleaner is withdrawn from the gap and an extended position in which the cleaner extends into the gap to clean the electrode.
14. The monitoring system of claim 13, wherein the housing comprises a temperature sensor.

15. The monitoring system of claim 14, comprising processing circuitry configured to: receive a temperature signal from the temperature sensor; provide voltage to the electrode in response to determining that the temperature signal indicates a temperature corresponds to a target range; receive a current signal from the electrode; record a peak voltage in response to determining that the current signal indicates a current corresponds to a threshold value; and after recording the peak voltage, provide a notification to adjust the cleaner from the retracted position to the extended position.
16. The monitoring system of claim 15, wherein the notification comprises a visual notification, an audible notification, or both.
17. The monitoring system of claim 13, wherein the cleaner comprises a rod that supports a cleaning tip, and the cleaning tip comprises a compressible material.
18. The monitoring system of claim 13, wherein the head structure comprises two curved prongs that define an opening and form the opposed surfaces, wherein the conduit is separated from the gap by the opening along an axial axis.
19. A method of measuring an electrical property of a fluid, comprising: obtaining a probe that comprises: a body portion housing a cleaner; a head portion forming a gap; an electrode disposed in the gap; and a temperature sensor disposed in the gap, wherein the cleaner is extendable into the gap; using the temperature sensor to measure a temperature of the fluid; extending the cleaner to clean the electrode and the temperature sensor; and using the electrode to measure the electrical property of the fluid.
20. The method of claim 19, comprising extending the cleaner from a retracted position in which the cleaner is positioned within a conduit that extends through the body portion and is withdrawn from the gap to an extended position in which the cleaner extends from the conduit and is positioned within the gap to clean the electrode and the temperature sensor.