

ACTUATING A DOWNHOLE DEVICE WITH A REACTIVE METAL

CROSS-REFERENCE TO RELATED APPLICATIONS

This International Patent Application claims priority to and benefit of U.S. Non-
5 Provisional Patent Application No. 16/683,098, filed November 13, 2019, the disclosure of
which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

The present disclosure relates to actuating a downhole device, and more particularly,
10 to actuating a downhole device via pneumatic pressure provided by a gas produced from the
reaction of a reactive metal and a reaction-inducing fluid.

BACKGROUND

The actuation of downhole devices (e.g., opening, closing, shifting, setting, etc.) is an
15 important part of wellbore operations such as setting packers, opening/closing in-flow control
devices, gravel pack bypasses, shifting or setting production sleeves, releasing an anchor, etc.
Typically, wellbore personnel may intervene to actuate the downhole device. Intervention can
extend operation time and increase overall operation expenses. Intervention-less methods of
actuating downhole devices may be used to decrease operation expenses and increase
20 productivity. Some intervention-less methods of actuating downhole devices may utilize
hydraulic pressure actuation. Hydraulic pressure actuation requires a downhole fluid to
achieve a fluid pressure exceeding the threshold pressure necessary for actuation. Hydraulic
pressure actuation also requires a downhole fluid to be directed to a desired location. In some
wellbore operations, fluid properties such as composition and pressure may not be known
25 which may create uncertainty with regards to utilizing hydraulic pressure actuation.

The present disclosure provides improved apparatus and methods for actuating a
downhole device in a wellbore.

BRIEF DESCRIPTION OF THE DRAWINGS

30 Illustrative examples of the present disclosure are described in detail below with
reference to the attached drawing figures, which are incorporated by reference herein, and
wherein:

FIG. 1 is a cross-section view of an example downhole device in accordance with the
examples disclosed herein;

FIG. 2 is a cross-section view of the example downhole device of FIG. 1 after actuation in accordance with the examples disclosed herein;

FIG. 3 is a cross-section view of another example downhole device in accordance with the examples disclosed herein;

5 FIG. 4 is a cross-section view of the example downhole device of FIG. 3 after actuation in accordance with the examples disclosed herein;

FIG. 5 is a cross-section view of another example downhole device in accordance with the examples disclosed herein;

10 FIG. 6 is a cross-section view of the example downhole device of FIG. 5 after actuation in accordance with the examples disclosed herein;

FIG. 7 is a cross-section view of another example downhole device in accordance with the examples disclosed herein; and

FIG. 8 is a cross-section view of the example downhole device of FIG. 7 after actuation in accordance with the examples disclosed herein.

15 The illustrated figures are only exemplary and are not intended to assert or imply any limitation with regard to the environment, architecture, design, or process in which different examples may be implemented.

DETAILED DESCRIPTION

20 The present disclosure relates to actuating a downhole device, and more particularly, to actuating a downhole device via pneumatic pressure provided by a gas produced from the reaction of a reactive metal and a reaction-inducing fluid.

In the following detailed description of several illustrative examples, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration examples that may be practiced. These examples are described in sufficient detail to enable those skilled in the art to practice them, and it is to be understood that other examples may be utilized, and that logical structural, mechanical, electrical, and chemical changes may be made without departing from the spirit or scope of the disclosed examples. To avoid detail not necessary to enable those skilled in the art to practice the examples described herein, the description may omit certain information known to those skilled in the art. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the illustrative examples is defined only by the appended claims.

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Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, reaction conditions, and so forth used in the present

specification and associated claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the examples of the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claim, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. It should be noted that when “about” is at the beginning of a numerical list, “about” modifies each number of the numerical list. Further, in some numerical listings of ranges some lower limits listed may be greater than some upper limits listed. One skilled in the art will recognize that the selected subset will require the selection of an upper limit in excess of the selected lower limit.

Unless otherwise specified, any use of any form of the terms “connect,” “engage,” “couple,” “attach,” or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the elements and may also include indirect interaction between the elements described. Further, any use of any form of the terms “connect,” “engage,” “couple,” “attach,” or any other term describing an interaction between elements includes items integrally formed together without the aid of extraneous fasteners or joining devices. In the following discussion and in the claims, the terms “including” and “comprising” are used in an open-ended fashion, and thus should be interpreted to mean “including, but not limited to.” Unless otherwise indicated, as used throughout this document, “or” does not require mutual exclusivity.

The terms uphole and downhole may be used to refer to the location of various components relative to the bottom or end of a well. For example, a first component described as uphole from a second component may be further away from the end of the well than the second component. Similarly, a first component described as being downhole from a second component may be located closer to the end of the well than the second component.

Examples of the methods and systems described herein relate to the use of reactive metals to provide a pneumatic pressure sufficient for actuating a downhole device. The reactive metals chemically react with a specific reaction-inducing fluid to produce hydrogen gas and a metal hydroxide. The pneumatic pressure of the hydrogen gas increases as the reaction proceeds. When the pneumatic pressure exceeds a desired threshold, the downhole device may be actuated. Advantageously, the reactive metal may be used in a variety of wellbore applications where intervention-less actuation is desired. Yet a further advantage is

that the reactive metal generates a volume of gas sufficient to provide the pneumatic pressure necessary for actuating the downhole device. An additional advantage is that the methods may be used for a variety of downhole devices including sleeves, gravel pack bypasses, packer setting tools, inflow control devices, anchor releases, etc. Another advantage is that the gas-producing reaction does not require oxygen. One other advantage is that the reaction-inducing fluid may be a brine either present in the subterranean formation or introduced at the surface in the downhole device.

The reactive metal undergoes a chemical reaction in the presence of a reaction-inducing fluid (e.g., a brine) to form a reaction product (e.g., hydrogen gas and metal hydroxide). Magnesium may be used to illustrate the reaction in equation 1 below:



The hydrogen gas generated from the reaction may continue to be produced so long as the reactive metal is in contact with the reaction-inducing fluid. The reactive metal may comprise any metal or metal alloy that undergoes a chemical reaction to form a reaction product of a gas.

Examples of suitable metals for the reactive metal include, but are not limited to, magnesium, calcium, aluminum, zinc, iron, potassium, sodium, or any combination of reactive metals. Preferred metals include magnesium, calcium, and aluminum.

Examples of suitable metal alloys for the reactive metal include, but are not limited to, alloys of magnesium, calcium, aluminum, zinc, iron, potassium, sodium, or any combination of reactive metals and/or alloys. Preferred metal alloys include alloys of magnesium-zinc, magnesium-aluminum, or calcium-magnesium. In some examples, the metal alloys may comprise alloyed elements that are not metallic. Examples of these non-metallic elements include, but are not limited to, graphite, carbon, silicon, boron nitride, and the like. In some examples, the metal is alloyed to increase or decrease reactivity and/or to control the formation of oxides and hydroxides. In other examples, the metal is heat treated to control the size and shape of the oxides and hydroxides including precipitation hardening, quenching, and tempering.

In some examples, the metal alloy is also alloyed with a dopant metal that promotes corrosion or inhibits passivation and thus increases the rate of the gas and hydroxide formation. Examples of dopant metals include, but are not limited to, nickel, iron, copper, carbon, titanium, gallium, mercury, cobalt, iridium, gold, palladium, or any combination thereof. In another example, particles of the metal are coated with the dopant, and the coated metal powder is pressed and extruded to create the metal alloy.

The reactive metal may be provided in any shape sufficient for its purpose. The reactive metal may be formed in a solid solution process, a powder metallurgy process, or through any other method as would be apparent to one of ordinary skill in the art.

5 In some optional examples, the reactive metal may include a removable barrier coating. The removable barrier coating may be used to cover the exterior surfaces of the reactive metal and isolate the reactive metal to prevent contact with the reaction-inducing fluid. The removable barrier coating may be removed when the reaction is to occur. The removable barrier coating may be used to delay the reaction and/or prevent a premature reaction. Examples of the removable barrier coating include, but are not limited to, any
10 species of plastic shell, elastomeric shell, organic shell, metallic shell, anodized shell, paint, dissolvable coatings (e.g., solid magnesium compounds), eutectic materials, or any combination thereof. When desired, the removable barrier coating may be removed from the reactive metal with any sufficient method. For example, the removable barrier coating may be removed through dissolution, a phase change induced by changing temperature, corrosion,
15 hydrolysis, the degradation of the support of the barrier coating, or the removable barrier coating may be time-delayed and degrade after a desired time under specific wellbore conditions.

Generally, the reaction-inducing fluid induces a reaction in the reactive metal to form hydrogen gas. Examples of the reaction-inducing fluid include, but are not limited to,
20 saltwater (e.g., water containing one or more salts dissolved therein), brine (e.g., saturated saltwater, which may be produced from subterranean formations), seawater, freshwater, or any combination thereof. Generally, the reaction-inducing fluid may be from any source provided that the fluid does not contain an excess of compounds that may undesirably affect other components in the downhole device. In the case of saltwater, brines, and seawater, the
25 reaction-inducing fluid may comprise a monovalent salt or a divalent salt. Suitable monovalent salts may include, for example, sodium chloride salt, sodium bromide salt, potassium chloride salt, potassium bromide salt, and the like. Suitable divalent salt can include, for example, magnesium chloride salt, calcium chloride salt, calcium bromide salt, and the like. In some examples, the salinity of the reaction-inducing fluid may exceed 10%.
30 In some examples, the density of the reaction-inducing fluid may exceed 8.5 pounds per gallon. Advantageously, the reactive metal of the present disclosure may not be impacted by contact with high-salinity fluids. One of ordinary skill in the art, with the benefit of this disclosure, should be readily able to select a reaction-inducing fluid for inducing a reaction with the reactive metal.

In some optional examples, the reaction-inducing fluid may comprise an acid. The acid may be mixed with the general aqueous fluids described above, such as a brine. The acid may help maintain the reactive metal reactant in solution and may help accelerate the reaction. Examples of acids generally include any organic or inorganic acid. Specific
5 examples of acids may include, but are not limited to, citric acid, hydrochloric acid, succinic acid, sulfamic acid, adipic acid, lactic acid, or any combination of acid. One of ordinary skill in the art, with the benefit of this disclosure, should be readily able to select an optional acid for use with the reaction-inducing fluid.

The reactive metal and the downhole device may be used in high-temperature
10 formations, for example, in formations with zones having temperatures equal to or exceeding 350° F. Advantageously, the use of the reactive metal of the present disclosure may not be impacted in high-temperature formations. In some examples, the reactive metal may be used in both high-temperature formations and with high-salinity fluids. In a specific example, the reactive metal may react with a brine having a salinity of 10% or greater while also being
15 disposed in a wellbore zone having a temperature equal to or exceeding 350° F. Additionally, oxygen is not necessary for the reaction to take place.

The downhole device may be any device that can be actuated by the pressurized gas produced from the reaction of the reactive metal and the reaction-inducing fluid. Examples of the downhole device include, but are not limited to, setting tools, inflow control devices,
20 gravel pack bypasses, packers, annular casing packer, frac plug, bridge plug, production sleeves, injection sleeves, anchor releases such as anchor slips, etc. The downhole device may be any device comprising a mechanism that may be actuated by pneumatic pressure.

In some examples, the downhole device comprises an isolation barrier. The isolation barrier isolates the reactive metal from the reaction-inducing fluid until it is desired for the
25 chemical reaction to commence. An example of the isolation barrier is the removable barrier coating described above. Another example of the isolation barrier is a rupture disk which may be ruptured at a specific applied pressure. Other examples of isolation barriers may be degradable materials which may degrade from chemical reactions or wellbore conditions at desired times. Another example of an isolation barrier is an impermeable gate or other type of
30 openable barrier which may be opened electronically either remotely or at a designated time. Other examples of isolation barriers may be any species of valves including valve pins. Any type of barrier sufficient for isolating the reactive metal from the reaction-inducing fluid may be used provided the barrier is able to be removed when desired.

FIG. 1 is a cross-section view of an example downhole device, generally 5. Downhole device 5 comprises a reactive metal 10 isolated from a reaction-inducing fluid 15. The reactive metal 10 is isolated from the reaction-inducing fluid 15 with isolation barrier 20. In this illustrated example, the isolation barrier 20 is a rupture disc. It is to be understood that the illustrated rupture disc may be substituted for any other species of isolation barrier as would be readily apparent to one of ordinary skill in the art. The reaction-inducing fluid 15 is present in the downhole device 5 as it is brought downhole. In some alternative examples, the reaction-inducing fluid 15 may be a wellbore fluid which may enter the downhole device 5 when the downhole device 5 is downhole. A piston 25 may apply hydraulic pressure to the isolation barrier 20 via compression of the reaction-inducing fluid 15. Piston 25 may be moved to compress the reaction-inducing fluid 15 via pressure applied from a fluid to the right of the piston 25. The fluid may apply hydraulic pressure to the piston 25 after passing through check valve 30. The amount of pressure applied may be determined by the operator. For example, if isolation barrier 20 is rated for 5000 psi and the hydrostatic pressure of the reaction-inducing fluid 15 is 4000 psi, the operator may apply 1000 psi to piston 25 to rupture the isolation barrier 20. The fluid pressure applied to piston 25 may be activated by pumping a fluid from the surface or by inflow of a specific volume of a downhole fluid sufficient to apply the desired pressure. In some alternative examples, the isolation barrier 20 may be ruptured solely when the hydrostatic pressure of the reaction-inducing fluid 15 reaches a desired threshold. In said examples, a fluid or other mechanism may not be needed to apply pressure to the right of piston 25.

FIG. 2 is a cross-section view of the example downhole device 5 of FIG. 1 after the isolation barrier 20 is ruptured. The rupture of the isolation barrier 20 removes the isolation of the reactive metal 10 from the reaction-inducing fluid 15. As the reaction-inducing fluid 15 contacts the reactive metal 10, hydrogen gas 35 is evolved. As the reaction proceeds, the volume of hydrogen gas 35 increases and increasing pneumatic pressure is applied to the actuating mechanism 40. In this specific example, the actuating mechanism 40 is illustrated as comprising an actuating piston and an actuating rod. It is to be understood that the illustrated actuating rod and actuating piston may be substituted for any other species of actuating mechanism as would be readily apparent to one of ordinary skill in the art. The actuating mechanism 40 may perform any number of actuating operations to actuate the downhole device 5. For example, the actuating mechanism 40 may set a packer, set or release anchor slips, open or close an inflow control device, slide a sleeve, trigger expansion of a sealing element, set plug slips, and the like. Upon application of sufficient pneumatic

pressure the actuating mechanism 40 is moved to the left as illustrated. After the downhole device 5 is actuated, the hydrogen gas 35 may be released through shearing shear pins of the check valve 30, pressurized opening of a port, or through any other release mechanism. In an optional example, the check valve 30 is a barrier such as a screen that is permeable to the reaction-inducing fluid 15. In this optional example, the reactive metal 10 may produce fines upon reaction with the reaction-inducing fluid 15 and the fines may plug the screen thereby isolating the hydrogen gas 35 and allowing it to actuate the downhole device 5.

FIG. 3 is a cross-section view of an example downhole device, generally 100. In the illustrated example, downhole device 100 is a sliding sleeve disposed within a conduit 105. Downhole device 100 comprises a reactive metal 10 isolated from a reaction-inducing fluid 15. The reactive metal 10 is isolated from the reaction-inducing fluid 15 with isolation barrier 110. In this illustrated example, the isolation barrier 110 is an electronically controlled gate that rotates or has a portion that rotates, such as the illustrated portion. It is to be understood that the illustrated electronically controlled gate may be substituted for any other species of isolation barrier as would be readily apparent to one of ordinary skill in the art. The reaction-inducing fluid 15 is present in the downhole device 100 as it is brought downhole. In some alternative examples, the reaction-inducing fluid 15 may be a wellbore fluid which may enter the downhole device 100 when the downhole device 100 is downhole. Additional fluid may be introduced through check valve 30 if necessary. The additional fluid may be introduced by pumping a fluid from the surface or by inflow of a specific volume of a downhole fluid. When ready for use, the isolation barrier 110 may be triggered to rotate to an open orientation either from a control signal from the surface or a preprogrammed signal set to a desired time.

FIG. 4 is a cross-section view of the example downhole device 100 of FIG. 3 after the isolation barrier 110 has been triggered to rotate to an open position. The rotation of the isolation barrier 110 removes the isolation of the reactive metal 10 from the reaction-inducing fluid 15. As the reaction-inducing fluid 15 contacts the reactive metal 10, hydrogen gas 35 is evolved. As the reaction proceeds, the volume of hydrogen gas 35 increases and increasing pneumatic pressure is applied to the actuating mechanism 115. In this specific example, the actuating mechanism 115 is illustrated as a hydraulic line used to build pressure for a downstream actuation indicated by the associated arrow illustrating pressure transfer to the hydraulic line. After the downhole device 100 is actuated, the hydrogen gas 35 may be released through shearing shear pins of the check valve 30, pressurized opening of a port, or through any other release mechanism.

FIG. 5 is a cross-section view of an example downhole device, generally 200. Downhole device 200 is an anchor setting device for a conduit 205. Downhole device 200 comprises a reactive metal 10 isolated from a reaction-inducing fluid 15. The reactive metal 10 is isolated from the reaction-inducing fluid 15 with isolation barrier 20. In this illustrated example, the isolation barrier 20 is a rupture disc. It is to be understood that the illustrated rupture disc may be substituted for any other species of isolation barrier as would be readily apparent to one of ordinary skill in the art. The reaction-inducing fluid 15 is present in the downhole device 200 as it is brought downhole. In some alternative examples, the reaction-inducing fluid 15 may be a wellbore fluid which may enter the downhole device 200 when the downhole device 200 is downhole. A piston 25 may apply hydraulic pressure to the isolation barrier 20 via compression of the reaction-inducing fluid 15. Piston 25 may be moved to compress the reaction-inducing fluid 15 via pressure applied from a fluid to the left of the piston 25. The fluid may apply hydraulic pressure to the piston 25 after passing through check valve 30. The amount of pressure applied may be determined by the operator. The fluid pressure applied to piston 25 may be activated by pumping a fluid from the surface or by inflow of a specific volume of a downhole fluid sufficient to apply the desired pressure. In some alternative examples, the isolation barrier 20 may be ruptured solely when the hydrostatic pressure of the reaction-inducing fluid reaches a desired threshold. In said examples, a fluid or other mechanism may not be needed to apply pressure to the right of piston 25. Downhole device 200 further comprises anchor slips 210 which anchor the downhole device 200 to a surface 215. Anchor slips 210 are forced outward to contact surface 215 via force applied from setting mechanism 220. When setting mechanism 220 is actuated, the anchor slips 210, which may be biased inward towards the axis of the downhole device 200, are forced outward to anchor the downhole device 200 to surface 215. The downhole device 200 remains anchored until the setting mechanism 220 is released.

FIG. 6 is a cross-section view of the example downhole device 200 of FIG. 5 after the isolation barrier 20 is ruptured. The rupture of the isolation barrier 20 removes the isolation of the reactive metal 10 from the reaction-inducing fluid 15. As the reaction-inducing fluid 15 contacts the reactive metal 10, hydrogen gas 35 is evolved. As the reaction proceeds, the volume of hydrogen gas 35 increases and increasing pneumatic pressure is applied to the actuating mechanism 40. In this specific example, the actuating mechanism 40 is illustrated as an actuating piston. It is to be understood that the illustrated actuating piston may be substituted for any other species of actuating mechanism as would be readily apparent to one of ordinary skill in the art. The actuating mechanism 40 may perform any number of

actuating operations to actuate the downhole device 200. As actuating piston 40 moves to the left due to the increasing pneumatic pressure, the actuating piston 40 may slide the setting mechanism 220 towards the anchor slips 210. Upon application of sufficient pneumatic pressure the setting mechanism 200 is moved to the right as illustrated. Movement of the setting mechanism 220 to the right applies force to the anchor slips 210. The anchor slips 210 are then forced outward to anchor the downhole device 200 to the surface 215. After the downhole device 200 is actuated, the hydrogen gas 35 may be released through shearing shear pins of the check valve 30, pressurized opening of a port, or through any other release mechanism.

FIG. 7 is a cross-section view of an example downhole device, generally 300. Downhole device 300 is a generic setting tool which may be used to set a packer, a sealing element, plug slips, etc. Downhole device 300 comprises a reactive metal 10 isolated from a reaction-inducing fluid 15. The reaction-inducing fluid 15 is a wellbore fluid disposed in an annulus 305 existing between the downhole device 300 and a conduit or wellbore surface. The reactive metal 10 is isolated from the reaction-inducing fluid 15 with isolation barrier 310. In this illustrated example, the isolation barrier 310 is a valve. It is to be understood that the illustrated valve may be substituted for any other species of isolation barrier as would be readily apparent to one of ordinary skill in the art. The reaction-inducing fluid 15 is not present in the downhole device 300 as it is brought downhole. In some alternative examples, the reaction-inducing fluid 15 may be present in a chamber isolated from the reactive metal 10 as the downhole device 300 is brought downhole. Ports 315 provide fluid pathways for the reaction-inducing fluid 15 to enter the downhole device 300 when the isolation barrier 310 is opened.

FIG. 8 is a cross-section view of the example downhole device 300 of FIG. 7 after the isolation barrier 310 is opened. The valve isolation barrier 310 may be opened remotely or electronically programmed to open at a desired time. The opening of the isolation barrier 310 removes the isolation of the reactive metal 10 from the reaction-inducing fluid 15. As the reaction-inducing fluid 15 contacts the reactive metal 10, hydrogen gas 35 is evolved. As the reaction proceeds, the volume of hydrogen gas 35 increases and increasing pneumatic pressure is applied to the actuating mechanism 320. In this specific example, the actuating mechanism 320 comprises a setting piston 325, hydraulic fluid 330, and a setting chamber 335. It is to be understood that the illustrated actuating mechanism 320 may be substituted for any other species of actuating mechanism as would be readily apparent to one of ordinary skill in the art. Upon application of sufficient pneumatic pressure, the setting piston 325 is

moved to the left as illustrated. Movement of the setting piston 325 to the left forces the hydraulic fluid 330 in to the setting chamber 335. The hydraulic fluid 330 may then act to set a packer, set or release anchor slips, open or close an inflow control device, slide a sleeve, trigger expansion of a sealing element, set plug slips, and the like. After the downhole device 5 300 is actuated, the hydrogen gas 35 may be released through any release mechanism. The isolation barrier 310 may also be configured to close at a predetermined time. For example, the isolation barrier 310 may close after a certain volume of fluid is allowed through ports 315. The isolation barrier 310 may be preprogrammed to close at a specific time or after a specific volume of fluid has flowed through, or the isolation barrier 310 may be triggered to 10 close via a signal sent from the surface or a downhole controller apparatus.

It should be clearly understood that the examples illustrated by FIGs. 1-8 are merely general applications of the principles of this disclosure in practice, and a wide variety of other examples are possible. Therefore, the scope of this disclosure is not limited in any manner to the details of any of the FIGURES described herein.

15 The downhole devices may flow control devices configured to control flow into and out of a conduit. In some examples, a multiple of downhole devices may be used to control flow into and out of a conduit. In some examples, the multiple downhole devices may be actuated simultaneously. In other examples, the actuation of the multiple downhole devices may be staggered. Different types of downhole devices may be used in the wellbore. For 20 example, a sliding sleeve downhole device and a packer setting tool device may be used in the same wellbore.

It is also to be recognized that the downhole devices may also directly or indirectly affect the various downhole equipment and tools that may come into contact with the downhole devices during operation. Such equipment and tools may include, but are not 25 limited to, wellbore casing, wellbore liner, completion string, insert strings, drill string, coiled tubing, slickline, wireline, drill pipe, drill collars, mud motors, downhole motors and/or pumps, surface-mounted motors and/or pumps, centralizers, turbolizers, scratchers, floats (e.g., shoes, collars, valves, etc.), logging tools and related telemetry equipment, actuators (e.g., electromechanical devices, hydromechanical devices, etc.), sliding sleeves, production 30 sleeves, plugs, screens, filters, flow control devices (e.g., inflow control devices, autonomous inflow control devices, outflow control devices, etc.), couplings (e.g., electro-hydraulic wet connect, dry connect, inductive coupler, etc.), control lines (e.g., electrical, fiber optic, hydraulic, etc.), surveillance lines, drill bits and reamers, sensors or distributed sensors, downhole heat exchangers, valves and corresponding actuation devices, tool seals, packers,

cement plugs, bridge plugs, and other wellbore isolation devices, or components, and the like. Any of these components may be included in the systems generally described above and depicted in any of the FIGURES.

5 Provided are methods for actuating a downhole device in a wellbore in accordance with the disclosure and the illustrated FIGURES. An example method comprises positioning a downhole device in a wellbore, the downhole device comprising a reactive metal and a reaction-inducing fluid; wherein the reaction-inducing fluid is isolated from the reactive metal. The method further comprises removing the isolation of the reactive metal such that it reacts with the reaction-inducing fluid to generate a hydrogen gas, and actuating the
10 downhole device with the hydrogen gas.

Additionally or alternatively, the method may include one or more of the following features individually or in combination. The downhole device may be a setting tool, an inflow control device, a gravel pack bypass, a sliding sleeve, a packer, an annular casing packer, a frac plug, a bridge plug, or a tubing anchor. The removal of the isolation of the reactive metal
15 may comprise rupturing a rupture disc, opening a gate, opening a valve, degrading a coating on the reactive metal, or any combination thereof. The actuation of the downhole device may comprise applying pneumatic pressure to a surface. The surface may be a surface of a piston. The reactive metal may comprise a metal selected from the group consisting of magnesium, calcium, aluminum, zinc, iron, potassium, sodium, and any combination thereof. The reactive
20 metal may comprise a metal alloy selected from the group consisting of magnesium-zinc, magnesium-aluminum, or calcium-magnesium and any combination thereof. The reaction-inducing fluid may comprise an aqueous fluid. The aqueous fluid may further comprise an acid. The acid may be selected from the group consisting of citric acid, hydrochloric acid, succinic acid, sulfamic acid, adipic acid, lactic acid, and any combination thereof.

25 Provided are downhole devices for a wellbore in accordance with the disclosure and the illustrated FIGURES. An example downhole device comprises a reactive metal, a reaction-inducing fluid, and a check valve.

Additionally or alternatively, the downhole device may include one or more of the following features individually or in combination. The downhole device may be a setting
30 tool, an inflow control device, a gravel pack bypass, a sliding sleeve, a packer, an annular casing packer, a frac plug, a bridge plug, or a tubing anchor. The downhole device may further comprise an isolation barrier comprising a rupture disc, a gate, a valve, a coating on the reactive metal, or any combination thereof. The reactive metal may comprise a metal selected from the group consisting of magnesium, calcium, aluminum, zinc, iron, potassium,

sodium, and any combination thereof. The reactive metal may comprise a metal alloy selected from the group consisting of magnesium-zinc, magnesium-aluminum, or calcium-magnesium and any combination thereof. The reaction-inducing fluid may comprise an aqueous fluid. The aqueous fluid may further comprise an acid. The acid may be selected
5 from the group consisting of citric acid, hydrochloric acid, succinic acid, sulfamic acid, adipic acid, lactic acid, and any combination thereof.

Provided are systems for actuating a downhole device in a wellbore in accordance with the disclosure and the illustrated FIGURES. An example system comprises a reactive metal, a reaction-inducing fluid, and an isolation barrier isolating the reactive metal from the
10 reaction-inducing fluid. The system further comprises a conduit disposed in the wellbore; wherein the downhole device is configured to control flow into and out of the conduit.

Additionally or alternatively, the system may include one or more of the following features individually or in combination. The downhole device may be a setting tool, an inflow control device, a gravel pack bypass, a sliding sleeve, a packer, an annular casing packer, a
15 frac plug, a bridge plug, or a tubing anchor. The downhole device may further comprise an isolation barrier comprising a rupture disc, a gate, a valve, a coating on the reactive metal, or any combination thereof. The reactive metal may comprise a metal selected from the group consisting of magnesium, calcium, aluminum, zinc, iron, potassium, sodium, and any combination thereof. The reactive metal may comprise a metal alloy selected from the group
20 consisting of magnesium-zinc, magnesium-aluminum, or calcium-magnesium and any combination thereof. The reaction-inducing fluid may comprise an aqueous fluid. The aqueous fluid may further comprise an acid. The acid may be selected from the group consisting of citric acid, hydrochloric acid, succinic acid, sulfamic acid, adipic acid, lactic acid, and any combination thereof.

The preceding description provides various examples of the apparatus, systems, and
25 methods of use disclosed herein which may contain different method steps and alternative combinations of components. It should be understood that, although individual examples may be discussed herein, the present disclosure covers all combinations of the disclosed examples, including, without limitation, the different component combinations, method step
30 combinations, and properties of the system. It should be understood that the compositions and methods are described in terms of “comprising,” “containing,” or “including” various components or steps. The systems and methods can also “consist essentially of” or “consist of” the various components and steps.” Moreover, the indefinite articles “a” or “an,” as used in the claims, are defined herein to mean one or more than one of the element that it introduces.

For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as ranges from any lower limit may be combined with any other lower limit to recite a range not explicitly recited. In the same way, ranges from any upper
5 limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range are specifically disclosed. In particular, every range of values (of the form, “from about a to about b,” or, equivalently, “from approximately a to b,” or, equivalently, “from approximately a-b”) disclosed herein is
10 to be understood to set forth every number and range encompassed within the broader range of values even if not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

One or more illustrative examples incorporating the examples disclosed herein are
15 presented. Not all features of a physical implementation are described or shown in this application for the sake of clarity. Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned, as well as those that are inherent therein. The particular examples disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners
20 apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown other than as described in the claims below. It is therefore evident that the particular illustrative examples disclosed above may be altered, combined, or modified, and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively
25 disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein.

Although the present disclosure and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the disclosure as defined by the following
30 claims.

WHAT IS CLAIMED IS:

1. A method for actuating a downhole device, the method comprising:

positioning a downhole device in a wellbore comprising a wellbore fluid, the downhole device comprising a reactive metal and a reaction-inducing fluid; wherein the reactive metal is alloyed with a dopant metal selected from the group consisting of nickel, iron, carbon, titanium, gallium, mercury, cobalt, iridium, gold, palladium, or any combination thereof; wherein the reaction-inducing fluid is isolated from the reactive metal by an isolation barrier; wherein the reaction-inducing fluid is present in the downhole device as the downhole device is brought downhole; wherein the reaction-inducing fluid is isolated from the wellbore fluid; wherein the downhole device is a setting tool, an inflow control device, a gravel pack bypass, a sliding sleeve, a packer, an annular casing packer, a frac plug, a bridge plug, or a tubing anchor;

removing the isolation barrier such that the reactive metal reacts with the reaction-inducing fluid to generate a hydrogen gas, and

actuating the downhole device with the hydrogen gas.

2. The method of claim 1, wherein the removing the isolation barrier comprises rupturing a rupture disc, opening a gate, opening a valve, degrading a coating on the reactive metal, or any combination thereof.
3. The method of any of claims 1 to 2, wherein the actuating the downhole device comprises applying pneumatic pressure to a surface of an actuating mechanism, wherein the surface is a surface of a piston.
4. The method of any of claims 1 to 3, wherein the reactive metal comprises a metal selected from the group consisting of magnesium, calcium, aluminum, zinc, iron, potassium, sodium, and any combination thereof.

5. The method of any of claims 1 to 4, wherein the reactive metal comprises a metal alloy selected from the group consisting of magnesium-zinc, magnesium-aluminum, or calcium-magnesium and any combination thereof.
6. The method of any of claims 1 to 5, wherein the reaction-inducing fluid comprises an aqueous fluid.
7. The method of claim 6, wherein the aqueous fluid further comprises an acid selected from the group consisting of citric acid, hydrochloric acid, succinic acid, sulfamic acid, adipic acid, lactic acid, and any combination thereof.
8. A downhole device for a wellbore, the downhole device comprising:
- a reactive metal, wherein the reactive metal is alloyed with a dopant metal selected from the group consisting of nickel, iron, carbon, titanium, gallium, mercury, cobalt, iridium, gold, palladium, or any combination thereof;
 - a reaction-inducing fluid stored in a chamber of the downhole device;
 - wherein the reaction-inducing fluid is isolated from the reactive metal by an isolation barrier, wherein the reaction-inducing fluid is isolated from a wellbore fluid after the downhole device is introduced into the wellbore;
 - an actuating mechanism comprising a setting piston, hydraulic fluid, and a setting chamber; wherein the reaction of the reaction-inducing fluid and the reactive metal releases hydrogen gas which translates the setting piston thereby forcing the hydraulic fluid into the setting chamber; and
 - a check valve;
 - wherein after actuation, the hydrogen gas is released through shearing shear pins of the check valve or the pressurized opening of a port in the chamber; and
 - wherein the downhole device is a setting tool, an inflow control device, a gravel pack bypass, a sliding sleeve, a packer, an annular casing packer, a frac plug, a bridge plug, or a tubing anchor.

9. The downhole device of claim 8, wherein the downhole device further comprises an isolation barrier comprising a rupture disc, a gate, a valve, a coating on the reactive metal, or any combination thereof.
10. The downhole device of claim 8 or 9, wherein the reactive metal comprises a metal selected from the group consisting of magnesium, calcium, aluminum, zinc, iron, potassium, sodium, and any combination thereof.
11. The downhole device of any of claims 8 to 10, wherein the reactive metal comprises a metal alloy selected from the group consisting of magnesium-zinc, magnesium-aluminum, or calcium-magnesium and any combination thereof.
12. The downhole device of any of claims 8 to 11, wherein the reaction-inducing fluid comprises an aqueous fluid, an acid, or a combination thereof.
13. A system for isolating flow in a wellbore using the downhole device of any of claims 8 to 12, the system comprising:
- the downhole device; and
 - a conduit disposed in the wellbore;
- wherein the downhole device is configured to control flow into and out of the conduit.