CLAIMS:

1. A system (60) for visually indicating an engagement status of a submerged subsea connector (45, 47), the system (60) being characterized by:

a measurement device (61, 63) positioned to provide a signal indicating positive engagement of a locking mechanism for a submerged subsea connector (45, 47); and

a visual engagement status indicator assembly (71, 81) including a visual engagement status indicator (97) positioned to provide a visual indication corresponding to an engagement status of the locking mechanism provided by the measurement device (61, 63), and a power supply assembly (101, 111, 121, 131) configured to interface with portions of an adjacent cathodic protection system (91) to provide supply power or voltage multiplication to the visual engagement status indicator (97).

2. A system (60) as defined in claim 1,

wherein the measurement device (61, 63) is a first measurement device (61) comprising a first piezoelectric strain gauge or position sensor (61) connected to one or more of the following: an outer surface of a cam ring (42) for engaging a recess (46) in an upper subsea connector (45), the one or more connector dogs (41) each positioned to engage a recess (46) in a lower subsea connector (47) , the one or more connector dogs (41) operably coupled with the cam ring (42),, and portions of an upper connector body assembly (49) operably coupled with the cam ring (42) to measure position of or stress on the cam ring (42),

the system (60) further being characterized by a second measurement device (63) comprising a second piezoelectric strain gauge or position sensor (63) located on one of the following: an outer surface of a lock ring (53) for engaging an engagement surface (57) of each of the one or more connector dogs (41), a piston (51) operably coupled with the lock ring (53), and a component located between the lock ring (53) and the piston (51) to measure position of or stress on the lock ring (53).

3. A system (60) as defined in either of claims 1 or 2, wherein the measurement device (61, 63) comprises a piezoelectric device (61, 63), and wherein the piezoelectric device (61, 63) is positioned to measure strain resulting from engagement of an engagement surface (44) of a locking member (41) with a corresponding locking recess (46) extending into an outer surface of a subsea connector (47) for a lower portion of an emergency disconnect package (30), a threshold level of the strain indicating engagement of the engagement surface (44) of the locking member (41) with the locking recess portion (46) of the subsea connector (47) as a result of engagement of the locking member (41) by a connecting ring (42) operably coupled to one or more hydraulic cylinders (43) connected to an upper connector body assembly (49) of the emergency disconnect package (30).

4. A system (60) as defined in any of claims 1 to 3, wherein the measurement device (61, 63) comprises a piezoelectric strain gauge or position sensor device (61, 63) positioned on an outer surface of one or more of the following: a cam ring (42) for engaging one or more connector dogs (41) positioned to engage a recess (46) in a lower subsea connector (47), the one or more connector dogs (41) operably coupled with the cam ring (42), and a portion of an upper connector body assembly (49) operably coupled with the cam ring (42) to measure position of or stress on the cam ring (42), and a lock ring (53) for engaging an engagement surface of the one or more connector dogs (41), a piston (51) operably coupled with the lock ring (53), and a component between the lock ring (53) and the piston (51) to measure position of or stress on the lock ring (53).

5. A system (60) as defined in any of claims 1 to 4,

wherein the power supply assembly (101, 111, 121, 131) comprises: a switching circuit (103) configured to complete a circuit between a first element (93) of the cathodic protection system (91) defining an anode (93) and the visual engagement status indicator (97) when the measurement device (61, 63) provides a signal voltage having an amplitude exceeding a threshold voltage level; a first conductor (77, 87) extending between the measurement device (61, 63) and a first

terminal of the switching circuit (103); and a second conductor (105, 106) extending between the first element (93) of the cathodic protection system (91) and a second terminal of the switching circuit (103); and

wherein the visual engagement status indicator (97) is electrically coupled to a second element (95) of the cathodic protection system (91) defining a cathode (95) to emit a sufficient light level to be visually detected via a remotely operated vehicle ("ROV") when the measurement device (61, 63) encounters a threshold level of strain or other movement.

6. A system (60) as defined in any of claims 1 to 5, wherein the visual engagement status indicator (97) comprises one or more light emitting diodes (97).

7. A system (60) as defined in any of claims 1 to 6, wherein the visual engagement status indicator (97) comprises one or more light emitting diodes (97) positioned on an outward facing outer surface (73) of an upper frame element (75) of an upper portion (31) of an emergency disconnect package (30) or an outward facing outer surface (83) of the lower frame element (85) of a lower portion (33) of the emergency disconnect package (30).

8. A system (60) as defined in any of claims 1 to 7, wherein the visual engagement status indicator (97) is a first visual engagement status indicator (97) including one or more light emitting diodes (97) located on an outward facing outer surface (73) of a first frame element (75) of an emergency disconnect package (30), the system (60) further being characterized by a second visual engagement status indicator (97) including one or more light emitting diodes (97) located on an outward facing outer surface (83) of a second frame element (85) of the emergency disconnect package (30).

9. A system (60) as defined in any of claims 1 to 8, wherein the visual engagement status indicator (97) is electrically connected in series with a plurality of separate segments (93, 93', 95, 95') of the cathodic protection system (91).

10. A system (60) as defined in any of claims 1 to 9, wherein the visual engagement status indicator (97) is electrically connected in parallel with a plurality of separate segments (93, 93', 95, 95') of the cathodic protection system (91).

11. A system (60) for visually indicating an engagement status of a submerged subsea connector (45, 47), the system (60) being characterized by:

a piezoelectric device (61, 63) positioned to provide at least a threshold level of voltage indicative of engagement of a connection mechanism (45, 47, 50, 51, 53, 55) for a submerged subsea connector (45, 47); and

a visual engagement status indicator assembly (71, 81) including a light emitting visual engagement status indicator (97) positioned to provide a visual indication corresponding to an engagement status of the connection mechanism (45, 47, 50, 51, 53, 55) provided by the piezoelectric device (61, 63), and a power supply assembly (101, 111, 121, 131) configured to interface with portions of an adjacent cathodic protection system (91) to provide supply power or voltage multiplication to the visual engagement status indicator (97).

12. A system (60) as defined in claim 11, wherein the piezoelectric device (61, 63) measures strain resulting from engagement of a connecting ring (42) operably coupled to one or more hydraulic cylinders (43) connected to an upper connector body assembly (49) of an emergency disconnect package (30) with one or more engagement surfaces of one or more actuators (41) configured to engage one or more recesses (46) extending into an outer surface of a subsea connector (47) for a lower portion (31) of the emergency disconnect package (30), a threshold level of the strain indicating engagement of the one or more engagement surfaces (44) of the one or more actuators (41) with the one or more engagement recesses (46) of the subsea connector (47).

13. A system (60) as defined in either of claims 11 or 12, wherein the piezoelectric device (61, 63) measures strain resulting from engagement of a lock ring (53) with an engagement surface of each of one or more connector actuators (41), operably coupled to a piston (51) to measure strain on the locking ring (53), a threshold level of

the strain indicating locking engagement of the lock ring (53) with the one or more connector actuators (41).

14. A system (60) as defined in any of claims 11 to 13,

wherein the visual engagement status indicator (97) comprises one or more light emitting diodes (97);

wherein the power supply assembly (101, 111, 121, 131) comprises: a switching circuit (103) configured to complete a circuit between a first element (93) of the cathodic protection system (91) defining an anode (93) and the visual engagement status indicator (97) when the piezoelectric device (61, 63) provides a signal voltage having an amplitude exceeding a threshold voltage level; a first conductor (77, 87) extending from the piezoelectric device (61, 63) and connected to a first terminal of the switching circuit (103); and a second conductor (105, 106) extending from the first element (93) of the cathodic protection system (91); and

wherein the visual engagement status indicator (97) is electrically coupled to a second element (95) of the cathodic protection system (91) defining a cathode (95) to emit a sufficient light level to be visually detected via a remotely operated vehicle when the piezoelectric device (61, 63) encounters a threshold level of strain or other movement.

15. A method of visually indicating an engagement status of a submerged subsea connector (45, 47), the method being characterized by the steps of:

positioning a measurement device (61, 63) to provide a signal indicating positive engagement of a locking mechanism for a submerged subsea connector (45, 47);

positioning a visual engagement status indicator (97) to provide a visual indication corresponding to an engagement status of the locking mechanism provided by the measurement device (61, 63); and

interfacing components of a power supply assembly (101, 111, 121, 131) with portions of a cathodic protection system (91) adjacent the visual engagement status indicator (97) to provide supply power or voltage multiplication to the visual engagement status indicator (97).

16. A method as defined in claim 15, wherein the measurement device (61, 63) comprises a piezoelectric strain gauge or position sensor device (61, 63), and wherein the step of positioning the measurement device (61, 63) comprises positioning the piezoelectric strain gauge or position sensor device (61, 63) on an outer surface of one or more of the following: a cam ring (42) for engaging one or more connector actuators positioned to engage a recess (46) in a lower subsea connector (47), one or more connector dogs (41) operably coupled with the cam ring (42), and an upper connector body assembly (49) operably coupled with the cam ring (42), to measure position of or stress on the cam ring (42), and on a lock ring (53) for engaging an interface (55) in a lower subsea connector (47), a piston (51) operably coupled with the lock ring (53), and a component between the lock ring (53) and the piston (51), to measure position of or stress on the lock ring (53).

17. A method as defined in either of claims 15 or 16,

wherein the measurement device (61, 63) is a first measurement device (61) comprising a first piezoelectric strain gauge or position sensor (61);

wherein the step of positioning the first measurement device (61) comprises connecting the first measurement device (61) to an outer surface of one or more of the following: a cam ring (42) for engaging one or more connector dogs each positioned to engage a recess (46) in a lower subsea connector (47), the one or more connector dogs of a set of connector dogs (41) operably coupled with the cam ring (42), and a portion of an upper connector body assembly (49) operably coupled with the cam ring (42) to measure position of or stress on the cam ring (42); and

wherein the method further comprises the step of connecting a second measurement device (63) comprising a second piezoelectric strain gauge or position sensor (63) to an outer surface of one or more of the following: a lock ring (53) for

engaging an engagement surface of the one or more connector dogs (41), a piston (51) operably coupled with the lock ring (53), and a component between the lock ring (53) and the piston (51) to measure position of or stress on the lock ring (53).

18. A method as defined in any of claims 15 to 17, wherein the measurement device (61, 63) comprises a piezoelectric strain gauge device (61, 63), and wherein the method further comprises the step of:

measuring strain resulting from engagement of an engagement surface (44) of a locking member (41) with a corresponding locking recess (46) extending into an outer surface of a subsea connector (47) for a lower portion (31) of an emergency disconnect package (30), a threshold level of the strain indicating engagement of the engagement surface (44) of the locking member (41) with the locking recess portion (46) of the subsea connector (47) as a result of engagement of the locking member (41) by a connecting ring (42) operably coupled to one or more hydraulic cylinders (43) connected to an upper connector body assembly (49) of the emergency disconnect package (30).

19. A method as defined in any of claims 15 to 18,

wherein the measurement device (61, 63) comprises a piezoelectric strain gauge or position sensor device (61, 63);

wherein the step of interfacing components of a power supply assembly (101, 111, 121, 131) with portions of a cathodic protection system (91) includes:

configuring a switching circuit (103) to complete a circuit between a first element (93) of the cathodic protection system (91) defining an anode (93) and the visual engagement status indicator (97) when the measurement device (61, 63) provides a signal voltage having an amplitude exceeding a threshold voltage level,

connecting a first conductor (77, 87) between the piezoelectric device (61, 63) and a first terminal of the switching circuit (103), and

connecting a second conductor (105, 106) between the first element (93) of the cathodic protection system (91) and a second terminal of the switching circuit (103); and

wherein the step of positioning a visual engagement status indicator (97) includes electrically coupling the visual engagement status indicator (97) to a second element (95) of the cathodic protection system (91) defining a cathode (95) to emit a sufficient light level to be visually detected via a remotely operated vehicle ("ROV") when the measurement device (61, 63) encounters a threshold level of strain or other movement.

20. A method as defined in any of claims 15 to 19, wherein the visual engagement status indicator (97) comprises one or more light emitting diodes (97), and wherein the step of positioning the visual engagement status indicator (97) includes:

positioning the visual engagement status indicator (97) on one or more of the following surfaces: an outward facing outer surface (73) of an upper frame element (75) of an upper portion (31) of an emergency disconnect package (30), and an outward facing outer surface (83) of the lower frame element (85) of a lower portion (33) of the emergency disconnect package (30).

CLAIMS

1. A system for visually indicating an engagement status of a submerged subsea connector of a subsea apparatus including one or more components prone to corrosion, the system comprising:

a measurement device positioned to provide a signal indicating positive engagement of a locking mechanism for the submerged subsea connector; and

a visual engagement status indicator assembly including a visual engagement status indicator positioned to provide a visual indication corresponding to an engagement status of the locking mechanism provided by the measurement device, and a power supply assembly configured to interface with portions of an adjacent cathodic protection system providing cathodic protection to the subsea apparatus to provide supply power or voltage multiplication to the visual engagement status indicator, the cathodic protection system including a first element comprising a sacrificial material functioning as an anode and a second element comprising at least a portion of one or more components prone to corrosion functioning as a cathode, whereby the first and second elements generate an electrical potential when submerged in seawater.

2. A system as defined in claim 1,

wherein the measurement device is a first measurement device comprising a first piezoelectric strain gauge or position sensor connected to one or more of the following: an outer surface of a cam ring for engaging one or more connector dogs each positioned to engage a recess in a lower subsea connector, the one or more connector dogs operably coupled with the cam ring, and portions of an upper connector body assembly operably coupled with the cam ring to measure position of or stress on the cam ring,

the system further comprising a second measurement device comprising a second piezoelectric strain gauge or position sensor located on one of the following: an outer surface of a lock ring for engaging an engagement surface of each of the one or more connector dogs, a piston operably coupled with the lock ring, and a component located between the lock ring and the piston to measure position of or stress on the lock ring.

3. A system as defined in claim 1, wherein the measurement device comprises a piezoelectric device, and wherein the piezoelectric device is positioned to measure strain resulting from engagement of an engagement surface of a locking member with a corresponding locking recess extending into an outer surface of a subsea connector for a lower portion of an emergency disconnect package, a threshold level of the strain indicating engagement of the engagement surface of the locking member with the locking recess portion of the subsea connector as a result of engagement of the locking member by a connecting ring operably coupled to one or more hydraulic cylinders connected to an upper connector body assembly of the emergency disconnect package.

4. A system as defined in claim 1, wherein the measurement device comprises a piezoelectric strain gauge or position sensor device positioned on an outer surface of one or more of the following: a cam ring for engaging one or more connector dogs positioned to engage a recess in a lower subsea connector, the one or more connector dogs operably coupled with the cam ring, and a portion of an upper connector body assembly operably coupled with the cam ring to measure position of or stress on the cam ring, and a lock ring for engaging an engagement surface of the one or more connector dogs, a piston operably coupled with the lock ring, and a component between the lock ring and the piston to measure position of or stress on the lock ring.

5. A system as defined in claim 1,

wherein the power supply assembly comprises: a switching circuit configured to complete a circuit between the first element of the cathodic protection system and the visual engagement status indicator when the measurement device provides a signal voltage having an amplitude exceeding a threshold voltage level; a first conductor extending between the measurement device and a first terminal of the switching circuit; and a second conductor extending between the first element of the cathodic protection system and a second terminal of the switching circuit; and

wherein the visual engagement status indicator is electrically coupled to the second element of the cathodic protection system defining the cathode to emit a sufficient light level to be visually detected via a remotely operated vehicle (“ROV”) when the measurement device encounters a threshold level of strain or other movement.

6. A system as defined in claim 1, wherein the visual engagement status indicator comprises one or more light emitting diodes.

7. A system as defined in claim 1, wherein the visual engagement status indicator comprises one or more light emitting diodes positioned on an outward facing outer surface of an upper frame element of an upper portion of an emergency disconnect package or an outward facing outer surface of the lower frame element of a lower portion of the emergency disconnect package.

8. A system as defined in claim 1, wherein the visual engagement status indicator is a first visual engagement status indicator including one or more light emitting diodes located on an outward facing outer surface of a first frame element of an emergency disconnect package, the system further comprising a second visual engagement status indicator including one or more light emitting diodes located on an outward facing outer surface of a second frame element of the emergency disconnect package.

9. A system as defined in claim 1, wherein the visual engagement status indicator is electrically connected in series with a plurality of separate segments of the cathodic protection system.

10. A system as defined in claim 1, wherein the visual engagement status indicator is electrically connected in parallel with a plurality of separate segments of the cathodic protection system.

11. A system for visually indicating an engagement status of a submerged subsea connector of a subsea apparatus including one or more components prone to corrosion, the system comprising:

a piezoelectric device positioned to provide at least a threshold level of voltage indicative of engagement of a connection mechanism for the submerged subsea connector; and

a visual engagement status indicator assembly including a light emitting visual engagement status indicator positioned to provide a visual indication corresponding to an engagement status of the connection mechanism provided by the piezoelectric device, and a power supply assembly configured to interface with portions of an

adjacent cathodic protection system providing cathodic protection to the subsea apparatus to provide supply power or voltage multiplication to the visual engagement status indicator, the cathodic protection system including a first element comprising a sacrificial material functioning as an anode and a second element comprising at least a portion of one or more components prone to corrosion functioning as a cathode, whereby the first and second elements generate an electrical potential when submerged in seawater.

12. A system as defined in claim 11, wherein the piezoelectric device measures strain resulting from engagement of a connecting ring operably coupled to one or more hydraulic cylinders connected to an upper connector body assembly of an emergency disconnect package with one or more engagement surfaces of one or more actuators configured to engage one or more recesses extending into an outer surface of a subsea connector for lower portion of the emergency disconnect package, a threshold level of the strain indicating engagement of the one or more engagement surfaces of the one or more actuators with the one or more recesses of the subsea connector.

13. A system as defined in claim 11, wherein the piezoelectric device measures strain resulting from engagement of a lock ring with an engagement surface of each of one or more connector actuators, operably coupled to a piston to measure strain on the locking ring, a threshold level of the strain indicating locking engagement of the lock ring with the one or more connector actuators.

14. A system as defined in claim 11,

wherein the visual engagement status indicator comprises one or more light emitting diodes;

wherein the power supply assembly comprises: a switching circuit configured to complete a circuit between the first element of the cathodic protection system and the visual engagement status indicator when the piezoelectric device provides a signal voltage having an amplitude exceeding a threshold voltage level; a first conductor extending from the piezoelectric device and connected to a first terminal of the switching circuit; and a second conductor extending from the first element of the cathodic protection system; and

wherein the visual engagement status indicator is electrically coupled to a second element of the cathodic protection system to emit a sufficient light level to be visually detected via a remotely operated vehicle when the piezoelectric device encounters a threshold level of strain or other movement.

15. A method of visually indicating an engagement status of a submerged subsea connector of a subsea apparatus including one or more components prone to corrosion, the method comprising steps of:

positioning a measurement device to provide a signal indicating positive engagement of a locking mechanism for a submerged subsea connector;

positioning a visual engagement status indicator to provide a visual indication corresponding to an engagement status of the locking mechanism provided by the measurement device; and

interfacing components of a power supply assembly with portions of a cathodic protection system adjacent the visual engagement status indicator to provide supply power or voltage multiplication to the visual engagement status indicator, the cathodic protection system functioning to provide cathodic protection to the one or more components of the subsea apparatus and including a first element comprising a sacrificial material functioning as an anode and a second element comprising at least a portion of one or more components prone to corrosion functioning as a cathode, whereby the first and second elements generate an electrical potential when submerged in seawater.

16. A method as defined in claim 15, wherein the measurement device comprises a piezoelectric strain gauge or position sensor device, and wherein the step of positioning the measurement device comprises positioning the piezoelectric strain gauge or position sensor device on an outer surface of one or more of the following: a cam ring for engaging one or more connector actuators positioned to engage a recess in a lower subsea connector, one or more connector dogs operably coupled with the cam ring, and an upper connector body assembly operably coupled with the cam ring, to measure position of or stress on the cam ring, and on a lock ring for engaging an interface in a lower subsea connector, a piston operably coupled with the lock ring, and a component between the lock ring and the piston to measure position of or stress on the lock ring.

17. A method as defined in claim 15,

wherein the measurement device is a first measurement device comprising a first piezoelectric strain gauge or position sensor;

wherein the step of positioning the first measurement device comprises connecting the first measurement device to an outer surface of one or more of the following: a cam ring for engaging one or more connector dogs each positioned to engage a recess in a lower subsea connector, the one or more connector dogs of a set of connector dogs operably coupled with the cam ring, and a portion of an upper connector body assembly operably coupled with the cam ring to measure position of or stress on the cam ring; and

wherein the method further comprises the step of connecting a second measurement device comprising a second piezoelectric strain gauge or position sensor to an outer surface of one or more of the following: a lock ring for engaging an engagement surface of the one or more connector dogs, a piston operably coupled with the lock ring, and a component between the lock ring and the piston to measure position of or stress on the lock ring.

18. A method as defined in claim 15, wherein the measurement device comprises a piezoelectric strain gauge device, and wherein the method further comprises the step of:

measuring strain resulting from engagement of an engagement surface of a locking member with a corresponding locking recess extending into an outer surface of a subsea connector for a lower portion of an emergency disconnect package, a threshold level of the strain indicating engagement of the engagement surface of the locking member with the locking recess portion of the subsea connector as a result of engagement of the locking member by a connecting ring operably coupled to one or more hydraulic cylinders connected to an upper connector body assembly of the emergency disconnect package.

19. A method as defined in claim 15,

wherein the measurement device comprises a piezoelectric strain gauge or position sensor device;

wherein the step of interfacing components of a power supply assembly with portions of a cathodic protection system includes:

configuring a switching circuit to complete a circuit between the first element of the cathodic protection system and the visual engagement status indicator when the measurement device provides a signal voltage having an amplitude exceeding a threshold voltage level,

connecting a first conductor between the piezoelectric device and a first terminal of the switching circuit, and

connecting a second conductor between the first element of the cathodic protection system and a second terminal of the switching circuit; and

wherein the step of positioning a visual engagement status indicator includes electrically coupling the visual engagement status indicator to the second element of the cathodic protection system to emit a sufficient light level to be visually detected via a remotely operated vehicle (“ROV”) when the measurement device encounters a threshold level of strain or other movement.

20. A method as defined in claim 15, wherein the visual engagement status indicator comprises one or more light emitting diodes, and wherein the step of positioning the visual engagement status indicator includes:

positioning the visual engagement status indicator on one or more of the following surfaces: an outward facing outer surface of an upper frame element of an upper portion of an emergency disconnect package, and an outward facing outer surface of the lower frame element of a lower portion of the emergency disconnect package.