tubular body in which is embedded a wear sensor which emits an alert signal when the inner surface of the seal has been worn away by a preset amount, wherein the wear sensor comprises an inductive proximity sensor which has a probe comprising an inductive coil which is embedded in the seal.

The alert signal is preferably discernible by an operator on a drilling rig.

The alert signal may be an electrical signal.

The alert signal may comprise a change in electrical current or voltage.

The wear sensor may include an electrical power supply which has a first pole which is electrically connected to the seal and a second pole which is adapted to be connected to a tubular extending through the seal. In this case, the first pole of the power supply may be electrically connected to an electrically conductive probe embedded in the seal.

The seal assembly may further comprise an electrical output circuit including a switching device.

The switching device may be configured to move from an open position, in which it prevents flow of current around the output circuit, to a closed position to permit flow of electrical current around the output circuit, when the seal has worn by the preset amount. Alternatively, the switching device may be configured to move from a closed position in which it allows flow of electrical current around the output circuit, to an open position, in which it prevents flow of current around the output circuit, when the seal has worn by the preset amount. By virtue of this arrangement, when the seal has worn by the present amount, the current and voltage in the output circuit will change - either falling to zero or increasing from zero, depending on the arrangement of switching device used. Thus, by monitoring the current and/or voltage in the output circuit an operator is made aware when the seal has worn by the preset amount.

Claims

1. A seal assembly for use in a pressure containment device for containing fluid pressure in an annular space around a drill string whilst allowing the drill string to rotate in the pressure containment device, the seal assembly comprising a seal with a tubular body in which is embedded a wear sensor which emits an alert signal when the inner surface of the seal has been worn away by a preset amount, wherein the wear sensor comprises an inductive proximity sensor which has a probe comprising an inductive coil which is embedded in the seal.

2. A seal assembly according to claim 1 wherein the alert signal is discernible by an operator on a drilling rig.

3. A seal assembly according to claim 1 or 2 wherein the alert signal is an electrical signal.

4. A seal assembly according to claim 3 wherein the alert signal comprises a change in electrical current or voltage.

5. A seal assembly according to claim 4 wherein the wear sensor includes an electrical power supply which has a first pole which is electrically connected to the seal and a second pole which is adapted to be connected to a tubular extending through the seal.

6. A seal assembly according to claim 4 wherein the wear sensor includes an electrical power supply which has a first pole which is electrically connected to an electrically conductive probe embedded in the seal and a second pole which is adapted to be connected to a tubular extending through the seal.

7. A seal assembly according to any preceding claim wherein the seal assembly further comprises an electrical output circuit including a switching device.

8. A seal assembly according to claim 7 wherein the switching device is configured to move from an open position, in which it prevents flow of current around the output circuit, to a closed position to permit flow of electrical current around the output circuit, when the seal has worn by the preset amount.

9. A seal assembly according to claim 7 wherein the switching device is configured to move from a closed position in which it allows flow of electrical current around the output circuit, to an open position, in which it prevents flow of current around the output circuit, when the seal has worn by the preset amount.

10. A seal assembly according to claim 7, 8 or 9 wherein the assembly further comprises a meter for measuring the electrical current passing around the output circuit or the voltage across a part of the output circuit.

11. A seal assembly according to any preceding claim wherein the seal assembly further comprises an electrical power supply.

12. A seal assembly according to claim 7 wherein the inductive proximity sensor is connected to the electrical output circuit.

13. A seal assembly according to any preceding claim wherein the alert signal changes as further wear of the seal occurs.

14. A seal assembly according to claim 13 wherein where dependant on claim 5 the probe is tapered, the cross-sectional area of the probe increasing from a first end to a second end.

15. A seal assembly according to claim 13 wherein the first end of the probe is closest to the inner surface of the seal, whilst the second end of the probe is closest to the outer surface of the seal.

16. A seal assembly according to claim 13 wherein the probe comprises a plurality of inductive coils which each produce a different size of magnetic field.

17. A seal assembly according to any preceding claim, the assembly further comprising a control display which monitors for an alert signal from the seal, and is configured to provide a visual indication, such as lighting a light, that such an alert signal has been emitted.

18. A seal assembly according to claim 17 wherein the control display is configured to alternatively or additional emit an audible warning signal if it detects that an alert signal has been emitted.

19. A seal assembly according to any preceding claim, wherein, where the alert signal comprises a change in voltage or electrical current, the control display may be provided with an analogue or digital display which provides a visual indication of the magnitude of the measured electrical current and/or voltage.

20. A seal assembly according to any preceding claim wherein where the alert signal changes with the degree of wear of the seal, the control display is configured to provide a first visual indication, such as lighting a first light, that an alert signal has been emitted, and to provide a second visual indication when the alert signal has changed in such a way that indicates that the seal has worn by a second preset amount.

21. A seal assembly according to any preceding claim wherein the wear sensor comprises a plurality of probes embedded in the seal.

22. A seal assembly according to claim 21 wherein the probes are spaced in a longitudinal array extending generally parallel to the passage enclosed by the tubular seal.

23. A seal assembly according to claim 21 or 22 wherein, alternatively or additionally, the probes are spaced around the circumference of the tubular seal.

24. A seal assembly according to any one of claim 21, 22 or 23 wherein the system is configured to emit an alert signal when one of the sensors detects that the seal has worn by the preset amount.

25. A seal assembly according to any preceding claim wherein the seal has a non-elastomeric part, and an elastomeric part, the non-elastomeric part forming the inner surface of the seal and being surrounded by the elastomeric part so that the elastomeric part forms the outer surface of the seal.

26. A seal assembly according to claim 25 wherein the or each sensor is located at the boundary between the non-elastomeric part and the elastomeric part.

27. A pressure containment device having a seal assembly according any one of claims 1 to 26.

28. A pressure containment device according to claim 27 further including a housing with a main passage, and an actuator which is operable to urge the seal into sealing engagement with a drill string extending through the pressure containment device.

29. A pressure containment device according to claim 28 wherein the actuator comprises a piston which is movable generally parallel to the longitudinal axis of the main passage in the housing.

30. A pressure containment device according to claims 28 or 29 wherein the pressure containment device further includes an annular packer which has a central aperture in which the seal is mounted, the actuator being operable to act on the packer so that the packer pushes the seal into engagement with a drill string extending along the main passage of the housing.

31. A drilling system including a drill string and a pressure containment device according any one of claims 27 to 30.