CLAIMS

1. An insulated pipe comprising: an elongated tube comprising a first end, a second end, and a sidewall extending therebetween, the sidewall comprising an inner surface and an outer surface; an insulating member at least partially covering a portion of the outer surface of the sidewall of the elongated tube, the insulating member comprising at least one channel extending through at least a portion of the insulating member; and at least one coaxial moisture sensor positioned within at least a portion of the channel configured to sense moisture in the channel, the at least one coaxial moisture sensor comprising: a dielectric member comprising a sleeve defining a center hole formed from an absorbent dielectric polymer material; an outer electrode electrically connected with an outer surface of the dielectric member, the outer electrode comprising a moisture permeable sleeve which permits moisture to pass to the dielectric member; and an inner electrode comprising a wire extending through the center hole of and electrically connected with an inner surface of the dielectric member, wherein the dielectric member is in electrical contact with the inner electrode and the outer electrode and maintains the inner electrode and the outer electrode spaced from one another.

2. The insulated pipe of claim 1, further comprising sensor electronics operatively connected to the electrodes of the moisture sensor to measure an electrical property of the moisture sensor to determine an amount of moisture absorbed by the dielectric member, wherein the sensor electronics comprise: a power source for applying alternating electrical current to at least one of the inner electrode electrode and the outer electrode; and an electrical measurement device configured to measure a complex impedance (ohms) of the dielectric member.

3. The insulated pipe of claim 2, wherein the sensor electronics further comprise a controller operatively connected to the power source and to the electrical measurement device, and wherein the controller is configured to cause the power source to periodically apply the alternating current to at least one of the electrodes.

4. The insulated pipe of claim 3, wherein the controller is further configured to determine an amount of moisture within the channel based on the measured complex impedance.

5. The insulated pipe of claim 1, wherein the coaxial moisture sensor is wrapped around at least a portion of the outer surface of the elongated tube within the at least one channel in a helical arrangement.

6. The insulated pipe of claim 1, wherein the coaxial moisture sensor extends axially along at least a portion of the outer surface of the elongated tube within the at least one channel in a straight line.

7. The insulated pipe of claim 1, wherein the insulating member comprises one or more of open cell foam insulation, closed cell foam insulation, fiber glass insulation, cellulose insulation, cotton batts, and wool batts.

8. The insulated pipe of claim 1, wherein the dielectric polymer material comprises one or more of nylon 4-6, nylon 6, nylon 6-6, nylon 6-12, nylon 11, polyamide-imide, polybenzimidazole, polyethersulfone, or polysulfone.

9. The insulated pipe of claim 1, wherein the electrodes comprise one or more of ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, copper, tin, nickel, chromium, or aluminum, or mixtures, alloys, or combinations thereof.

10. The insulated pipe of claim 1, wherein a maximum outer diameter of a cross-section of the sensor along a longitudinal axis of the sensor is 0.060 inch or less.

11. A container enclosing a cavity configured to enclose objects in a low moisture environment, the container comprising: a top portion, a bottom portion, and sides extending between the top portion and the bottom portion thereof, each of the top portion, the bottom portion, and the sides comprising an inner surface and an outer surface; and at least one coaxial moisture sensor mounted to and extending over at least a portion of at least one of the inner surface or the outer surface of at least one of the top portion, the bottom portion, or the sides, the coaxial moisture sensor comprising: a dielectric member comprising a sleeve defining a center hole formed from an absorbent dielectric polymer material; an outer electrode electrically connected with an outer surface of the dielectric member, comprising a porous sleeve for permitting moisture to pass through the sleeve; and an inner electrode comprising a wire extending through the center hole of and electrically connected with an inner surface of the dielectric member, wherein the dielectric member is in electrical contact with the inner electrode and the outer electrode and maintains the inner electrode and the outer electrode spaced from one another.

12. The container of claim 11, further comprising sensor electronics operatively connected to the electrodes of the moisture sensor to measure an electrical property of the moisture sensor to determine an amount of moisture absorbed by the dielectric member, wherein the sensor electronics comprise: a power source for applying alternating electrical current to at least one of the inner electrode and the outer electrode; and an electrical measurement device configured to measure a complex impedance (ohms) of the dielectric member.

13. The container of claim 12, wherein the sensor electronics further comprises a controller electronically connected to the power source and to the electric measurement device, and wherein the controller is configured to: cause the power source to periodically apply the alternating current to at least one of the electrodes; receive a complex impedance measurement from the electrical measurement device in response to the applied alternating current; and detect a presence of moisture in the cavity of the container based on the measured complex impedance.

14. The container of claim 12, wherein the container is a housing of a portable electronic device, and further comprising electronic circuitry of the electronic device positioned in the cavity of the container and in electrical communication with the sensor electronics of the moisture sensor, wherein the electronic circuitry of the portable electronic device is configured to one or more of automatically power down, automatically save data to computer memory of the electronic circuitry, or transmit data to a remote source when the measured complex impedance exceeds a predetermined value.

15. The container of claim 11, wherein the container comprises a liquid storage tank, and wherein the at least one moisture sensor is positioned to detect at least one of leaks from the storage tank and/or moisture ingress into the storage tank.

16. The container of claim 11, wherein the container comprises a liquid storage tank, and further comprising a controller in electrical communication with the moisture sensor configured to: receive the measured complex impedance from the moisture sensor; and determine a concentration of polar and non-polar liquids in the storage tank based on the measured complex impedance.

17. The container of claim 11, wherein the container comprises a liquid storage tank and a plurality of equidistantly spaced coaxial moisture sensors on an inner surface of a side of the container, and further comprising a controller configured to: receive the measured complex impedance from the plurality of moisture sensors; and determine a volume of liquid in the storage tank based on the measured complex impedance of the plurality of moisture sensors.

18. The container of claim 11, wherein the at least one moisture sensor has a maximum outer

diameter of 0.060 inch or less.

19. A method for detecting moisture in insulation surrounding a pipe, the method comprising: applying an alternating electrical current to a coaxial moisture sensor positioned within a channel extending through insulation at least partially covering an outer surface of the pipe, the moisture sensor comprising: a dielectric member comprising a sleeve defining a center hole formed from an absorbent dielectric polymer material, a first electrode surrounding at least a portion of the dielectric member, and a second electrode extending through a portion of the center hole of the dielectric member; continually or periodically measuring a complex impedance of the dielectric member with sensor electronics connected to the first and/or the second electrodes; and determining an amount of moisture within the insulation based on the measured complex impedance.