## CLAIMS

What is claimed is:

1. A test cartridge for insertion into an analysis instrument having a linear actuation mechanism, a rotational actuation mechanism, a heater, a pump actuation mechanism, a second linear actuation mechanism, and a cartridge receiver, the test cartridge comprising:

a test cartridge housing having a form factor to be received by the cartridge receiver of the analysis instrument;

a plurality of first linear translation sensors, each first linear translation sensor having first detector and a corresponding first movable element linearly translatable along a first axis, wherein at least a first portion of each of the plurality of first linear translation sensors is positioned within the test cartridge housing such that the corresponding first movable element thereof is to engage with the linear actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the linear actuation mechanism of the analysis instrument is actuated, and wherein each first detector of each of the plurality of first linear translation sensors is to detect a first distance moved by the corresponding first movable element along the first axis relative to the test cartridge housing responsive to a linear input provided by the linear actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the linear actuation mechanism of the analysis instrument is actuated;

a second linear translation sensor having a second detector and a second movable element linearly translatable along a second axis, wherein at least a second portion of the second linear translation sensor is positioned within the test cartridge housing such that the second movable element is to engage with the pump actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated, and wherein the second detector is to detect a second distance moved by the second movable element along the second axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated;

an angular rotation sensor having a third detector and a rotatable element rotatable about a third axis, wherein the angular rotation sensor is positioned within the test cartridge housing such that the rotatable element is to engage with the rotational actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated, and wherein the third detector is to detect an angle moved by

the rotatable element about the third axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated;

a temperature sensor having a receptacle in the test cartridge housing and a temperature detector positioned within the receptacle, wherein the temperature sensor is positioned within the test cartridge housing such that the receptacle is to engage with the heater of the analysis instrument when the test cartridge is inserted into the analysis instrument, and wherein the temperature detector is to detect a temperature inside the receptacle when the test cartridge is inserted into the analysis instrument; and

a plurality of load cells, each of the plurality of load cells is positioned within the test cartridge housing such that each load cell is to engage with a the second linear actuation mechanism when the test cartridge is inserted into the analysis instrument and the second linear actuation mechanism of the analysis instrument is actuated, and wherein each of the plurality of load cells is to detect a force applied to the respective load cell when the test cartridge is inserted into the analysis instrument and the second linear actuation mechanism of the analysis instrument is actuated.

2. The test cartridge of claim 1, further comprising a controller having one or more processors and one or more memory devices, wherein:

the controller is communicatively connected with each first detector each of the plurality of first linear translation sensors, the second detector of the second linear translation sensor, the third detector of the angular rotation sensor, the temperature detector of the temperature sensor, and each of the plurality of load cells, and

the controller is to receive and store data generated by each first detector, the second detector, the third detector, the temperature sensor, and each of the plurality of load cells.

3. The test cartridge of claim 2, wherein:

the controller is to cause the transmission of updated movement data to the analysis instrument, and

the updated movement data is based, at least in part, on one or more of data generated by one or more of the first detectors, the second detector, the third detector, the temperature sensor, and each of the plurality of load cells.

4. The test cartridge of claim 2, wherein:

the controller is to cause the transmission of the data generated by the first detectors, the second detector, the third detector, the temperature sensor, and each of the plurality of load cells to the analysis instrument, and

the analysis instrument is to issue a notification based, at least in part, on the data generated by the first detectors, the second detector, the third detector, the temperature sensor, and each of the plurality of load cells.

5. The test cartridge of any one of claims 1–4, further comprising a communications interface to transmit data generated by each of the plurality of first linear translation sensors, the second linear translation sensor, the angular rotation sensor, the temperature sensor, and the plurality of load cells to an external device.

6. The test cartridge of claim 5, wherein the external device is the analysis instrument.

7. The test cartridge of any one of claims 1–4, wherein:

each of the plurality of first linear translation sensors further includes a first resistive element to apply a first resistive force against the first movable element along the first axis, and

the angular rotation sensor further includes a second resistive element to apply a second resistive force against the rotatable element.

8. The test cartridge of any one of claims 1–4, wherein:

the angular rotation sensor further includes a friction element to contact and apply a frictional resistance force against the rotatable element,

the angular rotation sensor further includes a resistive element positioned such that the friction element is interposed between the resistive element and the rotatable element, and

the resistive element is to apply a force to the friction element along the third axis and in a direction towards the rotatable element.

9. The test cartridge of any one of claims 1–4, further comprising a second angular rotation sensor having a second angular detector and a second rotatable element rotatable about a second rotation axis, wherein the second angular rotation sensor is positioned such that the second rotatable element is to engage with the rotational actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated, and wherein the second angular detector is to detect a second angle moved by the second rotatable element about the second rotation axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated.

10. A test cartridge for insertion into an analysis instrument having a linear actuation mechanism and a cartridge receiver, the test cartridge comprising:

a test cartridge housing having a form factor to be received by the cartridge receiver of the analysis instrument; and

a plurality of linear translation sensors, each of the linear translation sensors having a first detector and a corresponding first movable element linearly translatable along a first axis, wherein at least a portion of each of the linear translation sensors is positioned within the test cartridge housing of the test cartridge such that the corresponding first movable element thereof is to engage with the linear actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the linear actuation mechanism of the analysis instrument is actuated, and each detector is to detect a distance moved by the corresponding first movable element along the corresponding first axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the linear actuation mechanism of the analysis instrument is actuated.

11. The test cartridge of claim 10, wherein each linear translation sensor further includes a resistive element to apply a resistive force against the first movable element along the first axis in a first direction.

12. The test cartridge of claim 11, wherein the resistive element is a compression spring.

13. The test cartridge of claim 10, wherein each linear translation sensor further includes a contact portion to be contacted by an engagement pin of the linear actuation mechanism.

14. The test cartridge of claim 10, wherein:

each movable element includes an encoder strip, and

each detector is an optical sensor to detect a movement of the encoder strip included in the corresponding movable element.

15. The test cartridge of any one of claims 10–14, further comprising a controller having one or more processors and one or more memory devices, wherein:

the controller is communicatively connected with each first detector of each of the linear translation sensors, and

the controller is to receive and store data generated by each first detector of each of the linear translation sensors.

16. The test cartridge of claim 15, further comprising a communications interface to transmit data generated by each of the one or more first linear translation sensors.

17. The test cartridge of claim 16, wherein:

the communications interface is to transmit data generated by each of the one or more first linear translation sensors to the analysis instrument,

the controller is to cause the transmission of calibration data to the analysis instrument, and

the calibration data is based, at least in part, data generated by one or more first linear translation sensors of the analysis instrument.

18. A test cartridge for insertion into an analysis instrument having a pump actuation mechanism and a cartridge receiver, the test cartridge comprising:

a test cartridge housing having a form factor to be received by the cartridge receiver of the analysis instrument, a first hole and a second hole opposite the first hole, the second hole to receive a portion of the pump actuation mechanism of the analysis instrument; and

a linear translation sensor having a detector and a movable element linearly translatable along a first axis, wherein at least a portion of the movable element is positioned within the test cartridge housing of the test cartridge, the movable element is positioned in between the first hole and the second hole, the movable element is to engage with and is movable by the portion of the pump actuation mechanism inserted through the second hole when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated and, while being moved by the pump actuation mechanism when the test cartridge is inserted into the analysis instrument and the pump actuation mechanism of the analysis instrument is actuated, the movable element is movable through the first hole, and the detector is to detect a distance moved by the movable element along the first axis relative to the test cartridge housing.

19. The test cartridge of claim 18, further comprising a controller having one or more processors and one or more memory devices, wherein:

the controller is communicatively connected with the detector of the linear translation sensor, and

the controller is to receive and store data generated by the detector of the linear translation sensor.

20. The test cartridge of claims 18 or 19, further comprising a communications interface to transmit data generated by the linear translation sensor.

21. A test cartridge for insertion into an analysis instrument having a rotational actuation mechanism, a heater, and a cartridge receiver, the test cartridge comprising:

a test cartridge housing having a form factor to be received by the cartridge receiver of the analysis instrument and a port to receive the heater of the analysis instrument;

a first angular rotation sensor having a first detector and a first rotatable element rotatable about a first rotation axis, the first angular rotation sensor is positioned within the test cartridge housing such that the first rotatable element is to engage with the

rotational actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated, and wherein the first detector is to detect a first angle moved by the first rotatable element about the first rotation axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated; and

a temperature sensor having a receptacle in the test cartridge housing and a temperature detector positioned within the receptacle, wherein the temperature sensor is positioned within the test cartridge housing such that the receptacle is to engage with the heater of the analysis instrument when the test cartridge is inserted into the analysis instrument, wherein the receptacle is to be heated by the heater of the analysis instrument, and wherein the temperature detector is to detect a temperature inside the receptacle.

22. The test cartridge of claim 21, further comprising a second angular rotation sensor having a second detector and a second rotatable element rotatable about a second rotation axis, wherein the second angular rotation sensor is positioned within the test cartridge housing such that the second rotatable element is to engage with the rotational actuation mechanism of the analysis instrument when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated, and wherein the second detector is to detect a second angle moved by the second rotatable element about the second rotation axis relative to the test cartridge housing when the test cartridge is inserted into the analysis instrument and the rotational actuation mechanism of the analysis instrument is actuated.

23. The test cartridge of claim 22, wherein the first rotation axis and second rotation axis are parallel to each other.

24. The test cartridge of claim 21, wherein the rotatable element includes a shaft and features to engage with the rotational actuation mechanism of the analysis instrument.

25. The test cartridge of claim 21, wherein:

the first angular rotation sensor further includes an encoder disk having a disk center axis that is collinear with a center axis of the rotatable element and the first axis, and

the first detector is an optical sensor to detect a movement of encoder disk.

26. The test cartridge of claim 21, wherein the first angular rotation sensor further includes a resistive element to apply a resistive force against the rotatable element.

27. The test cartridge of any one of claims 21–26, wherein the first angular rotation sensor further includes a friction element to contact and apply a frictional resistance force against the rotatable element.

28. The test cartridge of claim 27, wherein:

the first angular rotation sensor further includes a resistive element positioned such that the friction element is interposed between the resistive element and the first rotatable element, and

the resistive element is to apply a force to the friction element along the rotation axis in a direction towards the rotatable element.

29. The test cartridge of any one of claims 21–26, wherein the receptacle is comprised of a metal.

30. The test cartridge of any one of claims 21–26, wherein the receptacle is to be contacted by the heater inserted through the port.

31. The test cartridge of claim 30, wherein:

the receptacle further includes a heating collar around the receptacle, and

the heating collar is to be contacted by the heater inserted through the port.

32. The test cartridge of any one of claims 21–26, further comprising a torque sensor to measure a torque applied to the rotatable element.

33. The test cartridge of any one of claims 21–26, further comprising a controller having one or more processors and one or more memory devices, wherein:

the controller is communicatively connected with the first detector and the temperature detector, and

the controller is to receive and store data generated by the first detector and the temperature detector.

34. The test cartridge of claim 33, further comprising a communications interface to transmit data generated by the first angular rotation sensor and the temperature sensor.

35. The test cartridge of claim 34, wherein:

the communications interface to transmit data generated by the first angular rotation sensor and the temperature sensor,

the controller is to cause the transmission of data generated by the first angular rotation sensor and the temperature sensor to the analysis instrument, and

the analysis instrument is to issue a notification based, at least in part, on data generated by one or more of the first angular rotation sensor and the temperature sensor.