CLAIMS

1. A valve assembly for a fire suppression system, the valve assembly comprising:

a valve armature having a top portion and a bottom portion spaced from the top portion along a longitudinal axis, the bottom portion including an armature cavity, the armature cavity including a cavity inlet for receiving fluid and a cavity outlet proximate a bottom portion of the cavity for delivering fluid,

a plunger slidable along the longitudinal axis within the armature cavity, the plunger slidable between a closed state and an open state, wherein: in the closed state the plunger is at a predetermined bottom position in the armature cavity that is proximate the cavity outlet for fluidly sealing the cavity outlet; and in the open state the plunger is in a predetermined top position in the cavity that is distal the cavity outlet, and

a monitoring system operatively connected to the valve armature, the monitoring system acoustically sensing whether the plunger is longitudinally misaligned when the plunger is in the closed state and the open state;

wherein:

the top portion of the valve armature fluidly isolates the monitoring system from the bottom portion of the valve armature, and

the monitoring system includes an ultrasonic transducer operatively connected to the top portion of the valve armature, and a pulse-transmitting and echo-receiving circuit operatively connected to the ultrasonic transducer;

wherein:

the monitoring system transmits an ultrasonic pulse into the valve armature and receives a plurality of ultrasonic echoes including:

a first ultrasonic echo from the ultrasonic pulse traveling through the top portion of the valve armature,

a second ultrasonic echo from the ultrasonic pulse traveling through the fluid, and

a third ultrasonic echo from the ultrasonic pulse traveling through the plunger; and

wherein the monitoring system includes:

a processing unit operatively connected to the pulse-transmitting and echo-receiving circuit for measuring a plurality of acoustic travel periods including:

a first acoustic travel period between transmission of the ultrasonic pulse and reception of the first ultrasonic echo,

a second acoustic travel period between transmission of the ultrasonic pulse and reception of the second ultrasonic echo, and

a third acoustic travel period between transmission of the ultrasonic pulse and reception of the third ultrasonic echo, and

determining from the plurality of the travel periods whether the plunger is longitudinally misaligned.

2. The assembly of claim 1 wherein the monitoring system includes an electronic control unit for controlling the monitoring system to monitor whether the plunger is longitudinally misaligned when the plunger is in the closed state and the open state.

3. The assembly of claim 2 wherein when the plunger is in the open state, the monitoring system determines the plunger is longitudinally aligned by:

determining that the plurality of acoustic travel periods are within a first predetermined tolerance indicative of the plunger being at the predetermined top position.

4. The assembly of claim 3 wherein when the plunger is in the open state, the monitoring system determines the plunger is longitudinally misaligned by:

determining that the second acoustic travel period is longer than the first predetermined tolerance and indicative of the plunger being below the predetermined top position.

5. The assembly of claim 2 wherein when the plunger is in the closed state, the monitoring system determines the plunger is longitudinally aligned by:

determining that the plurality of acoustic travel periods are within a second predetermined tolerance indicative of the plunger being at the predetermined bottom position.

6. The assembly of claim 5 wherein when the plunger is in the closed state, the monitoring system determines the plunger is longitudinally misaligned by:

determining that the second acoustic travel period is shorter than the second predetermined tolerance and indicative of the plunger being above the predetermined bottom position.

7. The assembly of claim 2 wherein the ultrasonic transducer is fixedly mounted at the top portion of the valve armature.

8. The assembly of claim 7 further comprising:

a solenoid disposed within the cavity, the solenoid being operatively connected to the plunger for sliding the plunger between the closed state and the open state, and a solenoid controller electronically connected to the solenoid for controlling operation of the solenoid.

9. The assembly of claim 8 further comprising:

an armature housing having a top surface and a bottom surface spaced along the longitudinal axis,

a channel disposed in the armature housing, the channel having: a top opening 158 at the top surface of the housing; and a bottom opening at the bottom surface of the housing,

wherein the valve armature is fixedly disposed within the channel, the top portion of the valve armature is proximate the top surface of the armature housing, and the bottom portion of the valve armature is proximate the bottom surface of the armature housing.

10. The assembly of claim 9 wherein the armature housing includes: a fluid inlet for communicating fluid from a supply conduit 164 that supplies fluid to the valve armature.

11. The assembly of claim 10 including a fluid exhaust housing fixedly connected to the bottom surface of the housing and fluidly connected to the cavity outlet in the valve armature, the fluid exhaust housing includes at least one passage for directing fluid away from the cavity outlet.

12. A method of testing longitudinal alignment of a plunger in a valve assembly for a fire suppression system, the method comprising:

transmitting an ultrasonic pulse into a valve armature and sequentially receiving a plurality of ultrasonic echoes including:

a first ultrasonic echo from interaction between the ultrasonic pulse and a top portion of the valve armature,

a second ultrasonic echo from interaction between the ultrasonic pulse and fluid within a bottom portion of the valve armature, and

a third ultrasonic echo from interaction between the ultrasonic pulse and a plunger within the bottom portion of the valve armature, and

measuring a plurality of acoustic travel periods including:

a first acoustic travel period between transmission of the ultrasonic pulse and reception of the first ultrasonic echo,

a second acoustic travel period between transmission of the ultrasonic pulse and reception of the second ultrasonic echo, and

a third acoustic travel period between transmission of the ultrasonic pulse and reception of the third ultrasonic echo, and

determining from the plurality of the travel periods whether the plunger is longitudinally misaligned.

13. The method of claim 12 wherein when the plunger is in the open state, the method comprises determining the plunger is longitudinally aligned by:

determining that the plurality of acoustic travel periods are within a first predetermined tolerance indicative of the plunger being at the predetermined top position.

14. The method of claim 13 wherein when the plunger is in the open state, the method comprises determining the plunger is longitudinally misaligned by:

determining that the second acoustic travel period is longer than the first predetermined tolerance and indicative of the plunger being below the predetermined top position.

15. The method of claim 13 wherein when the plunger is in the closed state, the method includes determining the plunger is longitudinally aligned by:

determining that the plurality of acoustic travel periods are within a second predetermined tolerance indicative of the plunger being at the predetermined bottom position.

16. The method of claim 15 wherein when the plunger is in the closed state, the method includes determining the plunger is longitudinally misaligned by:

determining that the second acoustic travel period is shorter than the second predetermined tolerance and indicative of the plunger being above the predetermined top position.