INSTRON®

The difference is measurable™

Residual Seal Force Measurement of Parenteral Vials

Parenteral products contained in vial package systems require a robust seal at the interface between the glass vial and the elastomeric closure to prevent contamination and product leakage. The seal is established in the manufacturing process, but must withstand a variety of handling, processing, and storage conditions.

The vial seal is comprised of three major parts - the glass vial, a rubber stopper, and an aluminum cap that secures the rubber stopper in the vial. The aluminum cap must be crimped onto the stopped vial with a compressive force that will ensure sufficient mating of the glass and rubber surfaces. Closure variables of major importance include dimensional characteristics and tolerances, along with the mechanical properties of the three components, including modulus, hardness, and compression set.

The initial force with which the closure compresses the vial is a function of the vertical and horizontal crimping forces applied during the aluminum cap application. However, due to the viscoelastic relaxation behavior of rubber, the force of the closure pressing against the vials decays as a function of time, elastomer composition, and as a result of various processing procedures. It is required that manufacturers of parenteral vials have a quantitative method for measuring the force a closure exerts against the vial after the initial seal is made and throughout the shelf life of the product. This force is defined as the residual seal force.

A method for performing such a test with an Instron® electromechanical test frame was described by Morton and Lordi in a research article titled, “Residual Seal Force Measurement of Parenteral Vials, I. Methodology” from the Journal of Parenteral Science and Technology (Jan/Feb, 1988). The article explains that force required to overcome the residual seal force will be the point at which the lower lip of the aluminum cap “breaks away” and begins to move in the direction of compressive load.

Figure 1:
Vial specimen positioned between platens before start of test.

Figure 2: Vial specimen being tested on a 5965 with a 100 N load cell.

Test Configuration

Frame: 5965
Load Cell: 100 N load cell
Fixtures: Customized spherically seated parenteral vial platens
Software: Bluehill® with cursor select points used to mark residual seal force on curve
Test speed: 0.02 in/min

The specimen is placed at the center of the lower platen and the fine adjustment jog key on the control panel is used to lower the upper platen to a point just above the top of the vial. The anvil height is recorded prior to the start of the test.

It should be noted that this paper calls for a special crosshead platen that allows for contact along the outer diameter of the vial.

Discussion

The compression curve shown in Figure 3 can be explained as a combination of metal seal and elastomeric closure stress- deformation responses. Initially, as a compressive load is applied, the metal seal is distorted and reflected by the linear response shown from points A to B on the curve. This is followed by a pattern, from points B to C, which is a combination of viscous and elastic responses to stress that involve both closure and seal deformation. It was theorized by Morton and Lordi that the stress measured from points C to D correspond with the force at which the lower portion of the aluminum seal finally breaks away from the lower lip of the vial and the residual seal force is exceeded. The residual seal force measurement is taken at point C.

It can be concluded from these results that the Instron system is capable of performing residual seal force measurements. As discussed in the test configuration, an appropriate upper fixture is recommended. The residual force measurements would be expected to increase with a decrease in the effective cross-sectional area of the fixture.

Results

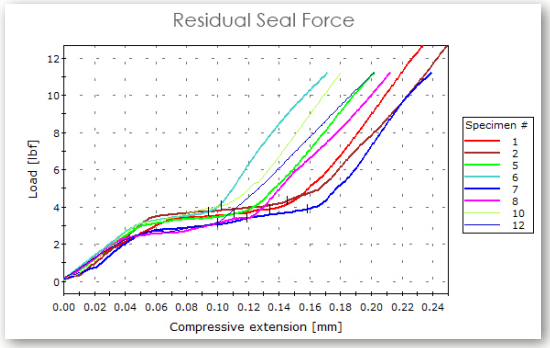

Figure 3:
Compressive load vs. displacement results for residual force tests on 12 specimens. The vertical tick mark on the graph corresponds with the measured residual seal force.

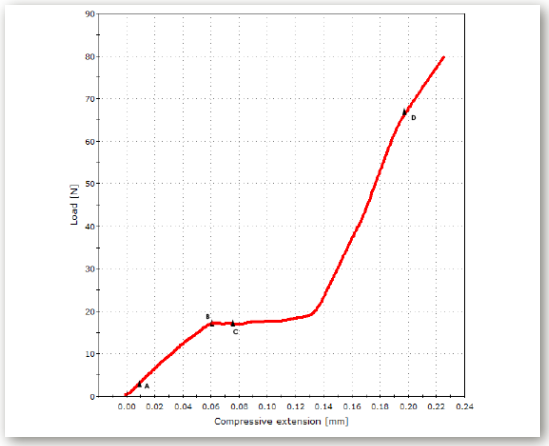

Figure 4:
Compressive load vs. displacement results for one residual seal force test.

Load at Residual Seal

Specimen 1	3.9 lbf
Specimen 2	4.3 lbf
Specimen 3	3.6 lbf
Specimen 4	3.7 lbf
Specimen 5	3.9 lbf
Specimen 6	3.4 lbf
Specifmen 7	4.1 lbf
Specimen 8	3.2 lbf
Mean	3.7 lbf
Standard Deviation	0.37 lbf

INSTRON®

Worldwide Headquarters
825 University Ave, Norwood, MA 02062-2643, USA
Tel: +1 800 564 8378 or +1 781 575 5000

European Headquarters
Coronation Road, High Wycombe, Bucks HP12 3SY, UK
Tel: +44 1494 464646