Evaluation of the force to extrude washing-up liquid from a syringe

BACKGROUND:

Syringes are one of the primary methods for introducing a drug into the body or other system. As an important medical tool, it is necessary to test its performance in order to ensure that the force required to draw or eject fluid into or from the barrel is not too high or too low. The required force should also be consistent from one syringe to another of the same make. The design of the syringe (material make up, size, shape, and thickness) and the fluid viscosity will however determine the force required to draw or eject a fluid. These factors can either hinder or ease user comfort, administration force, and ability to express a full dose. The plunger rod for instance, must be stiff enough thus providing a sense of stability and a linear motion of the plunger rod during expression by the user. The size and shape of the syringe barrel will also influence user comfort making it either easy or difficult to grasp and stabilise the syringe. For instance, a large barrel diameter will reduce a user's grip strength while a small barrel diameter will cause a high pinch grip.

The CT3 compression test can measure the force required to initiate the plunger movement as well as maintain movement during fluid ejection. For fluid suction, a tension test can be performed to measure the force required to draw a fluid into the syringe barrel. These tests can accommodate syringes of variable sizes and diameters.

METHOD

Equipment:

4.5 Kg CT3 Instrument
Syringe Fixture (TA-STJ)
Fixture Base Table (TA-BT-KIT)
Catchment drawer (or other container)

Test Settings:

Test Type:	Compression
Pre-Test Speed	1.0 mm/s
Test Speed:	2.0 mm/s
Post Test Speed:	Return at Test Speed
Distance:	35 mm
Trigger Load:	10 g

PROCEDURE:

1. Attach the syringe plunger connector to the probe shaft of the instrument

2. Place the fixture base table on the base of the instrument and loosely tighten the thumb nuts to enable some degree of mobility

3. Fasten the syringe fixture onto the fixture base table using the thumb screws of the base table

4. Fill the syringe with the liquid sample

5. Place the syringe (nozzle facing downwards) into the aperture of the syringe fixture and slide the syringe inserts in order to engage the inserts with the wings of the barrel. Loosely tighten the small thumb screws of the syringe fixture to secure the syringe into position

6. Lower the instrument arm so that the plunger of the syringe is located a few millimetres from the plunger connector.

7. Centrally align the plunger of the syringe to the plunger connector that is attached to the probe shaft of the instrument. To achieve this, the fixture base table and the syringe may need to be re-positioned.

8. Once in position, tighten the small thumb screws of the syringe fixture and the thumbscrews of the fixture base table to prevent any further movement.

9. Commence the test

Note:
Once a starting position for the syringe plunger connector has been chosen above the sample surface, the plunger connector will automatically return to this starting position at the end of the test. The starting position may only need to be reset if the instrument overloads or an error occurs during the test.

This method can be extended to other syringes and solutions. For larger capacity syringes, a larger test distance may be necessary. For syringes requiring higher extrusion forces, a higher capacity load cell may be required.

To optimise test settings, the hardest sample should be tested first in order to anticipate the maximum testing range for subsequent samples

RESULTS

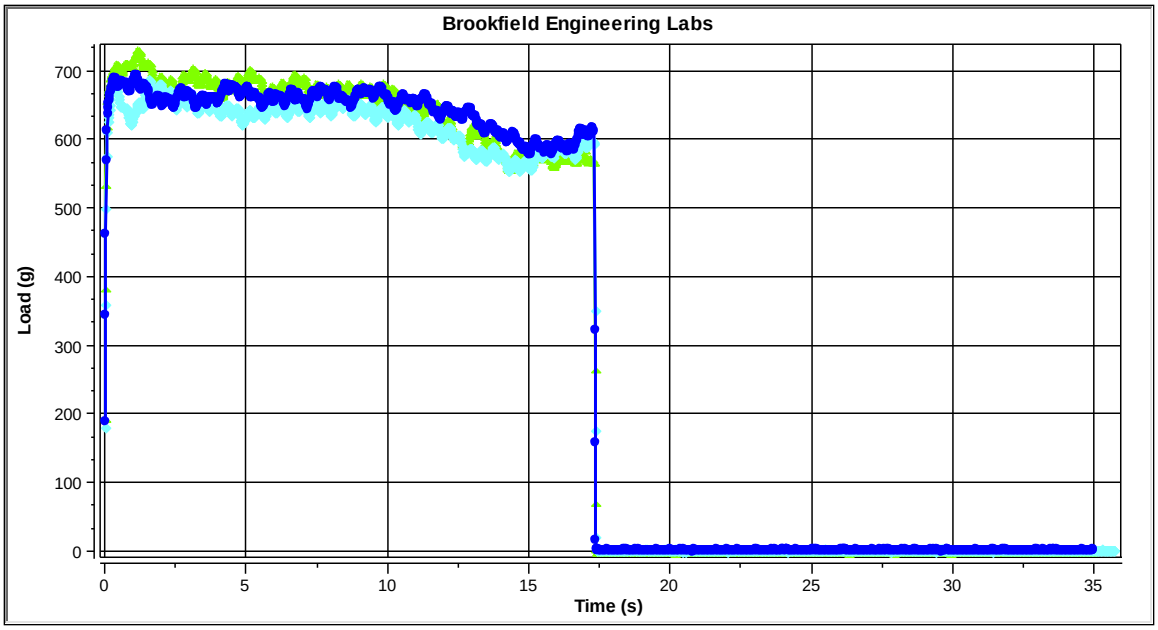

Figure 1
The load/time graph showing the maximum force required to expel washing-up liquid from a syringe, and the force required to continue extrusion

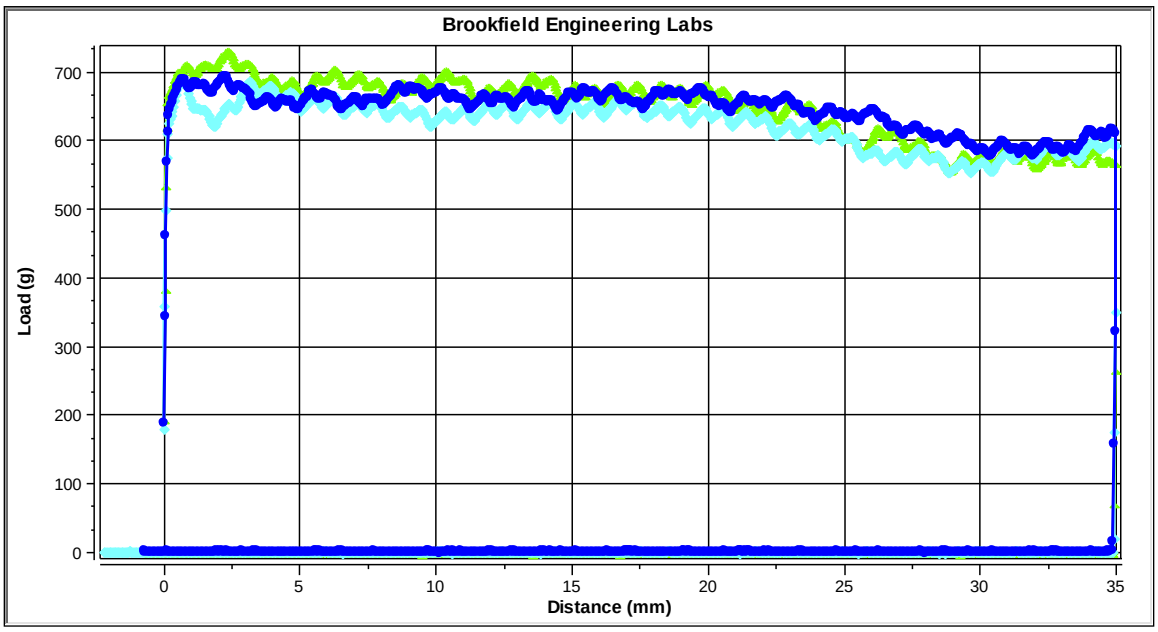

Figure 2

speed of 2 mm/s. Once the plunger connector is in full contact with the plunger surface and a trigger load of 10 g has been detected, the test begins. The plunger connector exerts a compressive force on the syringe plunger at a test speed of 2mm/s over a distance of 35 mm. During this time, the force increases rapidly before reaching a plateau. The maximum force value is a measure of the force required to initiate moving the syringe plunger and to begin expelling the contents of the syringe. The higher the maximum force value, the harder it is to initiate expelling the contents in the syringe.

The maximum force value is followed by a plateau as the force required to expel the contents reaches steady flow. This steady state indicates that there is a linear motion of the plunger rod during expression. Large fluctuations in force during extrusion would indicate irregular flow of the syringe contents that can be due to the syringe design.

The mean load expended during extrusion can be calculated from the load/time graph. This is the average load expended over a specified time period. Here the calculations have been based over the time period of 1-17 seconds.

The work done to expel the fluid over the distance of 35 mm is measured as the area under the load/distance graph. This is the energy required to expel the contents in the syringe.

When the target distance has been attained, the plunger connector withdraws from the syringe plunger and returns to its starting position. This is indicated by the sudden drop in load values to zero as the plunger returns to its starting position.

The table below shows the average results taken from three tests:

Sample	Peak Load (g)	Mean Load (g)	Work (mJ)
Syringe with washing-up liquid	704 ± 23.9	639 ± 13.8	218.20 ± 4.7

A 4.5 kg CT3 instrument was used for this test. For syringes requiring higher extrusion forces, a higher capacity load cell may be required.