Whitepaper

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Syringe filling

When we think of syringes, we think of injections. Long, sharp needles that doctors and nurses poke into our arms and elsewhere. This may be the most common application but it is far from the only one.

Syringes allow very precise control of dosing by markings on the barrel. They also allow precise control of the dispensing rate. This is important both when injecting into a person to prevent pain and laying down a bead of adhesive. Needles or other dispensing tips may be used. Common non pharmaceutical applications include glue dispensers, two part epoxy dispensers, caulking and grease dispensers. This paper will refer to all as syringes for simplicity.

Some syringes are supplied empty and filled at time of use. Many are supplied pre-filled for convenience. This paper will focus on pre-filled syringes and the filling and stoppering process.

Syringes may be made of plastic or glass. Plastic syringes may be supplied in bulk for feeding to the filler using a centrifugal or vibratory orienter or other feeder. Glass syringes are commonly provided in tubs or “nests” sealed with a plastic film. These consist of a plastic tub with a tray resting on a lip. The tray holds approximately 100 to 160 syringes depending on syringe diameter. The tray separates and protects the syringes during handling. Tray and syringes can be lifted out of the tub for filling and plugging. Plastic syringes may be provided in tubs as well.

The typical syringe consists of 2 main components, the syringe itself, called the barrel or body and the plug. The barrel is open at both ends. One end to full barrel diameter. The other end has a smaller opening called a luer where the needle or other tip is fitted. The

below picture shows a plain tapered luer. They may also have lugs or threads. Most syringes have a flange around the open end. This allows the syringe to be conveniently gripped with two fingers when dispensing. The plug, sometimes mis-called the plunger, is a product compatible elastomeric and seals tightly to the barrel walls, preventing leakage. Ribs are commonly used to enhance sealing.

Syringes also have a plunger or rod, threaded or snapped into the plug. In use this pushes the plug down dispensing product through the luer. This is often inserted after filling and plugging are finished. In some cases it is not assembled to the plug but shipped with the syringe for assembly at point of use. This means one less operation for manufacturing to worry about.

Some syringes such as this lidocaine syringe are designed to be used with a separate dispenser and have no flange.

Filling the syringe is not particularly difficult compared to other packages. The tricky part is inserting the plug, with no head space and not forcing any product out the luer end during insertion.

Bottom filling – Typically filling introduces the product from the top of the container. Bottom filling fills through the luer. Syringes are delivered to the filler with the plug pre-inserted all the way to the bottom of the syringe barrel. Bottom filling can be done with the luer end up or down depending on the filling machine design. It can be done on fully automated machines or on manual or semi-automated machines for low volumes such as a laboratory.

The syringe is introduced to the filling station, the luer is fitted to the filling system and the fill cycle started. As product enters the syringe, it forces the plug up. Some systems rely on fill pressure alone to push the plug up. This may not always be sufficient and vacuum may be applied to the open end of the syringe to help draw the plug up.

When the luer opening is too small, when the needle is pre-mounted or when the product is too viscous, it may not be possible to achieve the desired flow rate through the luer. Then filling must be done through the open end.

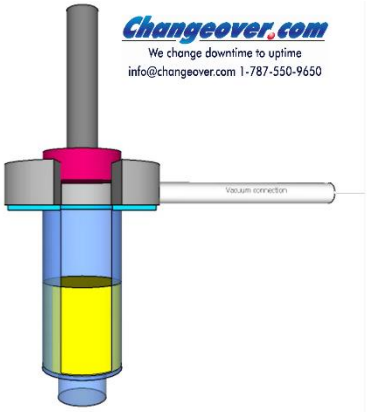
Filling is relatively straightforward. Most volumetric filling architectures, piston, gear pump or time-pressure may be used. When precise volume is not an issue, cosmetic or level filling technologies may be employed.

One filled, the challenge is to inser the plug without leaving a head space not forcing product out the luer. There are 2 basic methods for doing this.

Vacuum plugging

Vacuum plugging relies on the absence of air in the barrel prior to inserting the plug. A vacuum collar is used to achieve this. The bottom end of the vacuum collar is sealed tightly against the top of the syringe. A plug is inserted in the top of the vacuum collar and held in place by friction with the collar walls. Air is evacuated from the syringe and collar via a vacuum port on the side of the collar.

After air has been evacuated, the push rod pushes the plug through the vacuum collar, into the syringe until it reaches the surface of the product. Rod and vacuum collar are withdrawn and the system is ready for the next syringe.



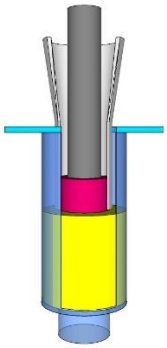
A variation on applying vacuum individually with collars is to place a tray or “nest” of filled syringe into a vacuum chamber with a matching tray of plugs positioned above. The chamber is closed and the air evacuated. An array of push rods push the plugs into the barrel to the surface of the product.

Relatively simple manual machines to do one syringe at a time are available for laboratory or other small production requirements. Other fully automatic machines are available to run up to 600 syringes per minute.

Volatile products may not be compatible with vacuum plugging. Under vacuum, product may evaporate or even boil. This can cause loss of product or foaming.

In these cases, compression plugging must be used.

Compression Plugging – Compression plugging uses a two part mechanical system to insert the plug into the syringe. The system consists of a tube with a plunger inside. The upper end of the tube is tapered and sized so that the plug can be easily staged in the upper end of the tube. Below this section, the balance of the tube is sized to a smaller outside diameter than the barrel inside diameter allowing space between tube and barrel for air to escape.



In preparation for the next plugging cycle, the plug is placed in the upper end of the tube. A rod pushes the plug through the insertion tube. The plug is pushed through the tapered section, squeezing its diameter, until it is at the end of the insertion tube. As the tube with plug is lowered into the barrel. Air vents through the concentric space between tube and barrel wall. Once the plug has been lowered to the liquid surface, the tube, but not the plunger, is withdrawn. This leaves the plug in contact with the product and allows it to expand, sealing to the barrel walls. Once the tube has completely discharged the plug, the pusher rod is withdrawn as well.

Syringe handling

A common means of syringe handling it to leave them in the tray. Sometimes they are left in the tray other systems lift the tray with syringes out of the tub and place it in the

filler. In the filling station, and array of filling needles fills 10 syringes at a time (in a 10X10, 100 syringe tray) with the tray indexing to the next row after each fill. The tray then moves to the plug insertion station where 10 plugs are inserted at a time. If the tray has been removed from the tub, it is replaced in the tub after plug insertion.

Other formats

A variation on the standard syringe discussed above is the dual chamber syringe. This packages 2 products in the same syringe, keeping them separate until used. One example would be a lyophilized (freeze dried) active ingredient packaged with water for dissolution at time of use. There are several designs but most fill, place a plug as describes above, fill above the plug and apply a second plug.

Some products, such as caulking tubes, may not seem like syringes, and they are not by any normal definition. They do share the same problem of needing to insert a plug for dispensing, leaving no head space and discharging no product during insertion. The plugging process, vacuum or compression, is similar in both cases.

Other formats include the univial with 2 chambers. This fills one product in the lower chamber, inserts the center plug, fills the upper chamber and applies a top closure. The top closure is designed to compress the upper chamber at time of use, displacing the center plug and allowing mixing of the two parts.

Pre-filled syringes are an excellent package for many products. Proper plug insertion does seem, to the uninitiated, to provide a challenge. As this paper shows, it should not. It is a well known and well developed technology, reliable and easy to use once understood.