

The Wrench

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Plunger Seals

Nearly all contemporary HPLC pumps use either a single or dual plunger set-up to pump mobile phase through the system. The pump head is where ‘the rubber meets the road’ as far as using the mechanical motion of reciprocating sapphire plunger rods to produce an even flow of liquid. Figure 1 shows a simplified diagram of a generic pump head.

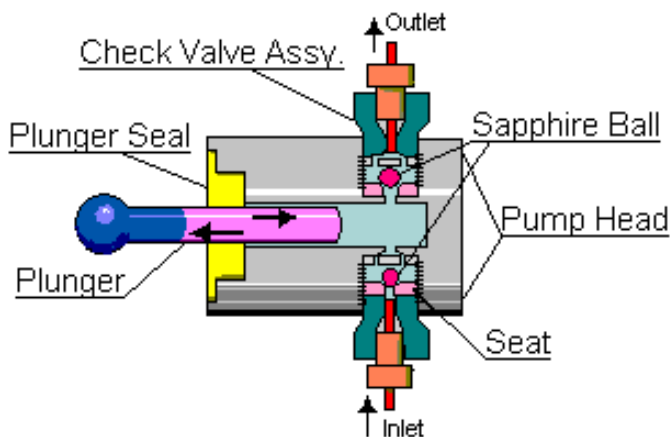


Figure 1

The basic concept within the pump head is that the plungers are driven in and out by a motor. At the inlet and outlet ends of the pump head are a set of check valves. These valves only allow liquid to flow in one direction, from the mobile phase reservoir to the autosampler, column, and detector. One critical area within the set-up is at the plunger seals, they play a crucial role in the overall system performance.

There are four requirements for a good plunger seal. It should prevent any mobile phase from leaking from around the sapphire plunger. A leak can cause fluctuations in retention time. Incorrect flow rates may cause system shut-down if enough solvent is present, and if you are using a high pressure mixing gradient system the mobile phase ratios may be incorrect. Secondly, and somewhat in contradiction to the first requirement, the seal needs to be supple and flexible enough to allow for the movement of the sapphire plunger across its surface. Next, a seal should be resistant to a wide range of mobile phase solvents and modifiers. Finally, the seal should be rugged so that the frequency of replacement is minimized.

One way to think of plunger seals is like the windshield wiper blades on your vehicle. They must be flexible enough to move easily across the surface glass, yet to be effective they need to be strong enough

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to wipe the water from the surface. They must be able to withstand changes in temperature, as well as soot, road salt and other possible contaminants. Plus as drivers we want the blades to last as long as possible.

Of course just like your windshield blades wear out and need to be replaced, plunger seals need routine replacement.

As a seal manufacturer, the goal is to optimize the four disparate requirements of flexibility, strength, chemical resistance, and durability into the best possible solution. Two of the most widely used materials are UHMW-PE and graphite filled Teflon®.



Figure 2

UHMW-PE materials generally are a clear to golden color (figure 2). UHMW-PE has excellent resistance to abrasion and wear and may last longer than graphitized Teflon®. UHMW-PE is also compatible with most aqueous based mobile phases, and holds up in the presence of buffer salts. UHMW-PE's shortcoming is that it is not compatible with some types of solvents, especially those used in many normal phase mobile phases. Graphitized-Teflon® is generally gray to nearly black in coloration (figure 3). Graphitized-Teflon® is suitable for a wider range of solvents, including most normal phase solvents. However, it is less wear resistant and may exhibit shorter lifetime than the UHMW-PE. Interestingly, though, because of its flexibility minor scratches and abrasions are easily sealed. The seals do not generally leak as soon as the UHMW-PE seals, instead the issue tends to be particles that are thrown off and clog the HPLC system farther downstream causing elevated back-pressure in the system.

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Figure 3

CTS has both types of material available sized for a variety of different manufacturers, including Agilent® and Waters®. Your choice should be based on the recommendations of the OEM or the needs of your analysis. We have undertaken a program of verifying both the physical characteristics as well as the performance for our products, including our plunger seals.

As a component that wears, it is advisable that seal replacement be a part of any routine maintenance program. Generally the seals should be replaced a minimum of every 6 months. Each manufacturer has specific instructions for seal replacement in the maintenance section of their manuals. For the best practice, follow the specific instructions from your manufacturer. The basic procedure involves removing the pump head from the pump. Care must be taken when removing pumps heads from the pump to avoid cracking the sapphire plunger. Once the head is removed the old seal can be pulled from the head. This can be done with the aid of a plunger removal tool supplied by the manufacturer or other vender. Alternatively, if you are careful a pair of tweezers can be used to lift out the old seal. No matter what tool is used you must ensure that the pump head surface is not scratched. Marring the metal surface can lead to leaks around the pump head. Once the old seal is out, the new seal should be wetted with either isopropanol or methanol and then inserted into place. Again the best way to do this is with a seal insertion tool. With the seal in place the pump head is ready to be re-assembled and the system should be up and ready to go.

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