Reliability of Next Generation UHPLC Connections

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Introduction

In this paper, fluidic connection experts from IDEX Health & Science explore the connection challenges facing modern UHPLC users. A practical review of the new MarvelX™ and MarvelXACT™ connection technologies is presented to show how advances in high pressure fluidic connections enable users to achieve reliable, repeatable and consistent performance to 19,000 psi with over 100 repeat uses, thereby reducing the complexity and cost of their UHPLC systems.

Performance

One of the biggest advances of next generation connections is that some products, like IDEX Health & Science's MarvelX and MarvelXACT, seal at the bottom of the connection port. This reduces and redefines the sealing area needed to make a connection capable of UHPLC pressures and significantly reduces the amount of force needed to properly install a connection. This reduction in force improves longevity of the fitting and reduces wear on the receiving port while maintaining high performance with a finger tight connection.

We can show (Figure 1) that, when a connection seals at the bottom of a port, installation force has been limited to approximately 2 in-lbs of torque while still maintaining an ultimate constant safe pressure rating of 19,000 psi. The average UHPLC user is able to install this connection to 2 in-lbs without the use of tools. In the case of MarvelX the fitting has been designed with a form that makes over-tightening by hand very difficult for a wide range of product users. In the case of MarvelXACT the fitting has been designed with a torque limiting mechanism that ensures proper installation force is achieved each time a connection is made (Figure 2). Both fitting styles rely on the same tubing and seal to maintain consistent liquid handling performance while allowing users to make a fitting choice that best meets their needs. This combination of convenience and performance is not achievable with conventional fittings and sets this new style of connection apart.

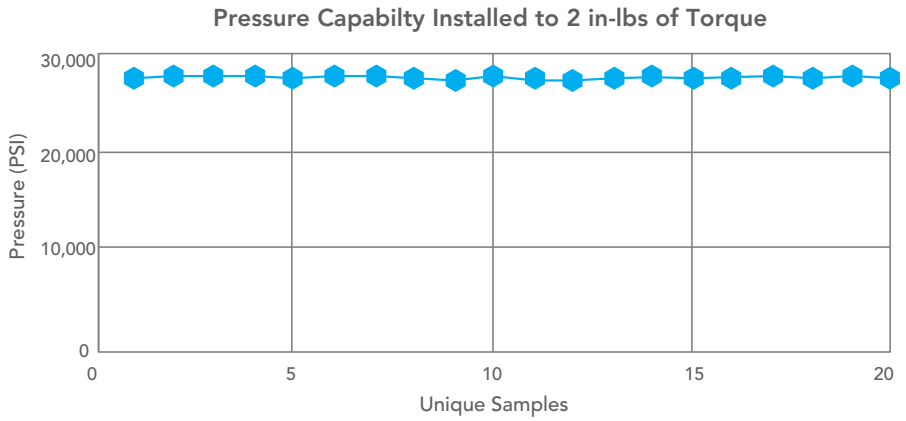

Figure 1. *MarvelX SS 100µm ID x 350mm Long*

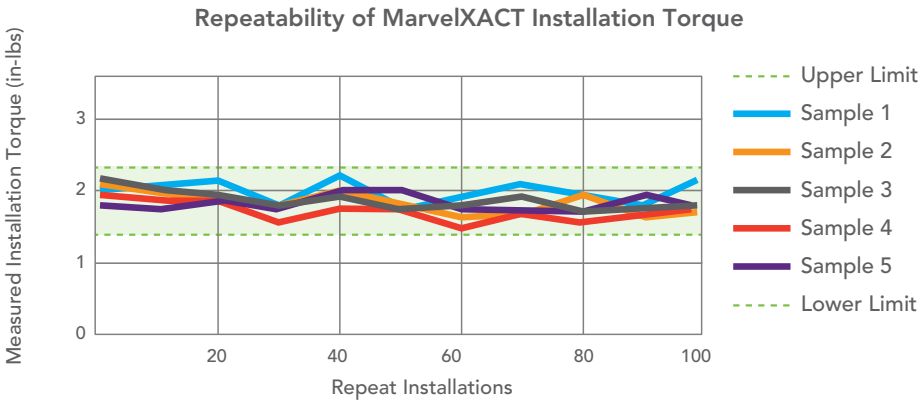

Figure 2. *MarvelXACT SS Torque Repeatability*

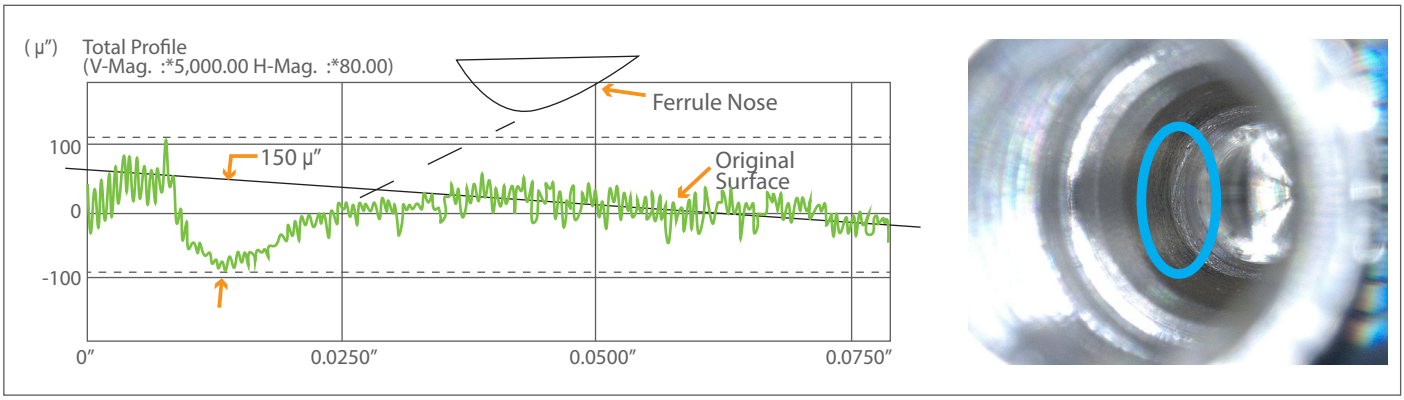

Figure 3. *Common Coned Fitting Wear*

The new sealing mechanism is also beneficial to mating components or receiving ports. When less force is needed to make a connection, there is less chance of damage to components, which can be witnessed in many common stainless steel mating parts as physical deformation or, in extreme cases, galling. It has been shown that a metal coned ferrule can indent a metal receiving port mating surface as much as 150 µ-inches (Figure 3) during a routine high force installation, typical of these conventional style connections. When damage is done to the sealing surface of a receiving port the potential for leaking connections increases with each subsequent installation and may result in the need to replace system components.

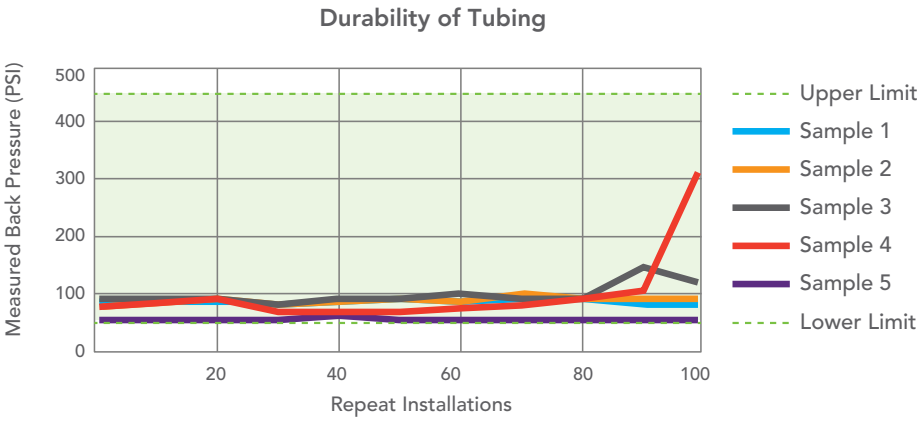

Figure 4. *MarvelX SS 100µm ID x 150 mm Long, Back Pressure*

Back Pressure Performance was measured based on repeatability against a calculated tubing standard after every 10 repeat installations up to 100 cycles.

- *Target Test Pressure: 19,000 PSI*
- *Test Flow Rate: 1.0 mL/min*
- *Test Fluid: Water, Room Temperature*
- *Installation Torque: Approximately 2 in-lbs*
- *Calculated Max Back Pressure Allowed: 430 PSI*
- *Calculated Target Back Pressure: 134 PSI*

By changing the sealing mechanism and drastically decreasing required installation force, we remove the potential to damage critical system components. When a properly manufactured UHPLC receiving port is used, MarvelX and MarvelXACT connections can be made and remade 100 times while maintaining consistent pressure holding and installation torque performance. To demonstrate this, flow data was measured (Figure 4) for 5 unique samples over 100 repeat installation cycles. The samples tested showed that target pressure is maintained and the flow path is not adversely degraded, no ID restriction or out of range increase in flow resistance, over the lifetime of the connection.

Ease-of-Use

In addition to achieving reliable performance in demanding UHPLC applications, we can evaluate connections for their ease of use, including features such as simplicity of installation and the ability to route through an instrument.

The tubing supplied with MarvelX and MarvelXACT has been designed to auto-adjust to various port depths (Figure 5). This accommodates a range of receiving ports that include different valves and column manufacturers and models. This design makes this a universal connection for industry standard 10-32 coned receiving ports, so no special consideration is needed when connecting to a mating port. Our test data demonstrates that a single fitting can be re-used many times in different ports with varying depth and still make a high-performing, reliable UHPLC seal. With most conventional fittings, a new port e.g. due to moving to a different column would require replacing the fitting with a new one as well.

Conventional UHPLC tubing is typically rigid stainless steel and can be difficult to bend and route to connection points. MarvelX is supplied with 1/32" flexible tubing. This flexible tubing allows considerable leeway to route throughout an instrument, which is further eased by removable fittings. The separation of tubing from fittings also allows the tubing to be replaced independently of the fittings at a lower cost than competitive products. Ease of routing, coupled with ease of fitting installation without tools, will significantly reduce the time required to make each connection.

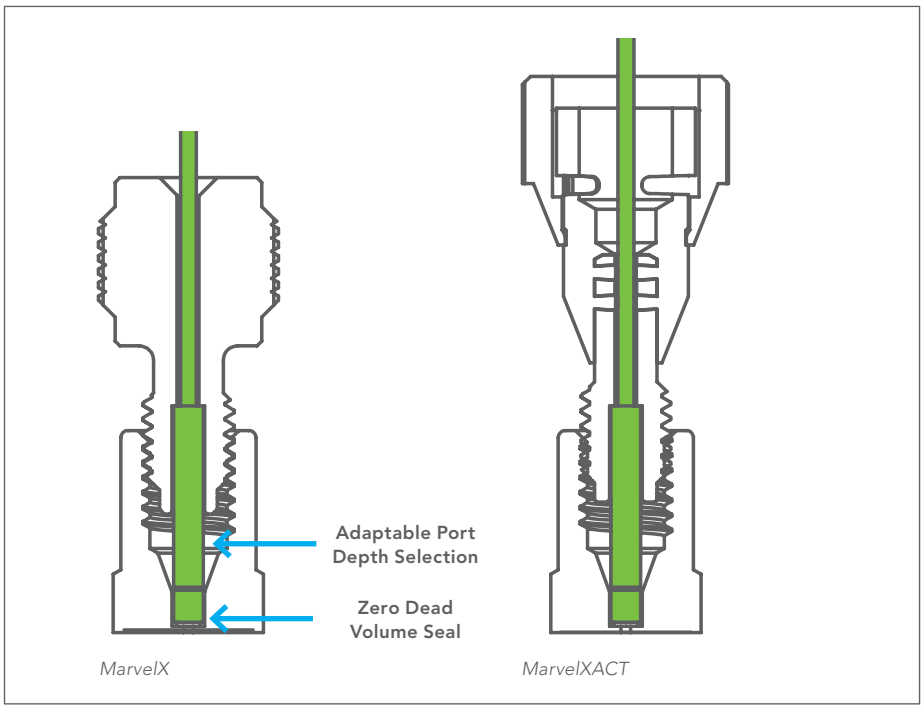

Figure 5. *Component Diagram*

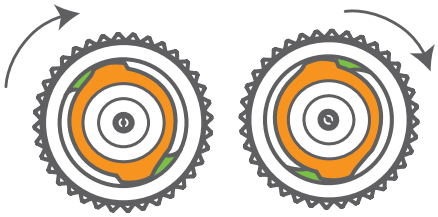

Figure 6. *MarvelXACT Torque Limiting Mechanism On the left the ramp engages, on the right the ramp releases and fitting can no longer be tightened*

MarvelXACT is supplied with fittings attached to the same 1/32" flexible tubing as MarvelX. Although the fittings are not removable, MarvelXACT incorporates a patented torque limiting mechanism to enable consistent installation and eliminate guesswork. MarvelXACT has a PEEK polymer fitting head over stainless steel threads with a built in ramp mechanism (Figure 6) to limit the force applied by a user when tightening the fitting. As the fitting is tightened to the optimal level the head will give haptic "click" feedback to the user and further tightening will be impossible. Through the use a proprietary manufacturing process, this torque mechanism is tightly controlled to ensure consistent performance through many repeat installations.

When we consider high performance connections with high reuse factors and the ability to use a connection in multiple different ports we begin to see real economic value to make a change to new fitting technology.

Economic Value

Let us examine a common application case for UHPLC connections and understand how performance and ease of use can improve economic value of fluidic connections. This application case uses a common fitting system and 100µm ID, 350mm long stainless steel tubing in comparison to a stainless steel MarvelX or MarvelXACT connection with the same ID and length. This is connected to a column that will be changed once every four days.

	Common Connection System	MarvelX MarvelXACT
Number of Instruments	3	3
Number of Connections per Instrument	1	1
Number of Connects/Disconnects per Day	0.25	0.25
Time to Install Each Connection (min)	3	1
List Prices for Each Connection	$24	$135
Cost of Labor to Install Connection ($/Hr)	$60	$60
Number of Connections/Disconnects Before Replacement	1	100
Total Annual Connection Cost	**$4,860**	**$450**
Cost of Materials	$4,320	$270
Cost of Labor	$540	$180

Data above is based on
- *240 Working days per year*
- *List prices in the USA at the time of publication*
- *Properly installed connections used in industry standard applications*
- *The common connection system is replaced each time a column is changed to prevent dead volume*

Conclusion

Reliable and high performing fluidic connections are critical to maximize overall system value of UHPLC instruments.

MarvelX family products (including the newly introduced MarvelXACT) have been designed with reliability and ease-of-use in mind. The fittings can be finger tightened to simplify and speed installation without sacrificing high performance. Furthermore, any user can make a perfect connection using MarvelX/MarvelXACT without any training or experience required. The connection auto-adjusts port depth and face seals at the port bottom every time it is connected, minimizing additional internal volume in the system. The connection can be re-used over 100 times in different ports so there is no need to replace connections when mating hardware is changed.

The level of robustness and ease of installation provide potentially thousands of dollars in savings to UHPLC labs even within a year time frame.

Find out how MarvelXACT adds real value to UHPLC applications at www.idex-hs.com/MarvelXACT.

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