DIAMOND™ Seal Technology:
Next Generation Valve and
One-Piece Waterway
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Delta Faucet Company has introduced a patented new water delivery system—
DIAMOND Seal Technology—that provides guaranteed protection from leaks and 
drips. This system reduces the number of potential leak points, simplifies installation, 
and provides long lasting performance. DIAMOND Seal Technology also satisfies 
California statute AB 1953 mandating that by January 1, 2010, the weighted average 
lead content in pipes, fittings and fixtures used to convey drinking water cannot 
exceed 0.25% on wetted surfaces. Once inside the faucet, water is not in contact 
with potential metal contaminants.

DIAMOND Seal Technology consists of two components:

1) DIAMOND™ Valve
2) InnoFlex™ waterways

DIAMOND Valve
The DIAMOND Valve is an integrated ceramic valve cartridge featuring one ceramic 
disc and one diamond-embedded ceramic disc (see Figure 1). Performance tested 
to failure, the DIAMOND Valve will last up to 5 million cycles—10 times longer than 
the industry standard* (see Figure 2).

*Industry standard based on ASME A112.18.1 of 500,000 cycles.

![DIAMOND Valve Diagram]

Water stays below the upper ceramic disc, so there is no potential for leaking 
under the handle and no water in contact with metal components.

Figure 1: DIAMOND Valve

Diamonds—the hardest substance on earth—provide an extremely durable finish. 
As the two discs in the DIAMOND Valve move against each other, the diamond-
embedded ceramic disc constantly polishes the uncoated ceramic disc, preventing 
build up of calcium and mineral deposits and ensuring smooth, consistent operation 
over the life of the faucet.
Performance tested to failure, the DIAMOND™ Valve will last up to 5 million cycles—10 times longer than the industry standard. *

![Diagram](image)

**Figure 2:** Valve Life Cycle Comparison

**Coefficient of Friction Comparison**

Coefficient of friction is a measure of the “stickiness” between two materials as they attempt to slide against one another. A high coefficient of friction between two materials indicates that it takes more force to make them slide, whereas a low coefficient of friction means they will move against each other more easily. For example, a shoe on ice would have a low coefficient of friction, but a shoe on a dry sidewalk would have a high coefficient of friction.

Due to a high coefficient of friction (see Figure 3), ceramic-on-ceramic valves require lubricant, which is applied during the manufacturing process. With use, the factory-applied lubricants wash away—causing the two ceramic discs to “stick” together (known as “stiction”)—making it increasingly difficult to operate the faucet. In areas with hard water, calcium deposits also build up on the ceramic discs further impeding performance. Calcium is the binder for alumina, which is the material that makes up ceramic discs. While calcium will physically bond to ceramic discs, it does not have an affinity for diamond, meaning it will not adhere to the diamond-embedded ceramic disc.

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient of Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic on Ceramic</td>
<td>.40</td>
</tr>
<tr>
<td>Diamond on Ceramic</td>
<td>.04</td>
</tr>
</tbody>
</table>

**Figure 3:** Coefficient of Friction Comparison

The pairing of diamond-embedded and ceramic discs in the DIAMOND Valve yields a low coefficient of friction, making it easy to operate the valve without lubrication and ensuring consistent performance over the life of the faucet. The diamond-embedded disc prevents calcium deposits from building up on the ceramic disc.

**DIAMOND Valve – Other Materials and Features**

The DIAMOND Valve is a “closed” system, meaning there are no dynamic seals to wear out. Water does not enter the top half of the cartridge (see Figure 1), eliminating

*Industry standard based on ASME A112.18.1 of 500,000 cycles.
the possibility for leaks under the handle. The metal parts of the valve—which are located in the top half of the cartridge—are not exposed to water, which also eliminates any metal leachate issues within the valve.

The DIAMOND™ Valve system also features:

- **Static silicone seals:** Stationary silicone seals remain pliable without drying out and provide greater chemical resistance. They also have a low propensity for compression set (less than 2% versus 10-15% for conventional rubber seals), meaning that when compression is released they return to their original state.
- **Stainless steel handle stem:** Stronger than plastic (which is commonly used in other faucets), the stainless steel stem adds durability to DIAMOND Seal Technology faucets.
- **A two-function handle limit stop:** Easily accessible by removing the faucet handle, the handle limit stop allows the user to choose between a full range of handle motion (which is pre-set at the factory) or to restrict handle motion to a 50/50 mix of hot and cold water. The handle limit stop should not be considered an anti-scald device.

**DIAMOND Valve Coating Process**

The diamond-embedded disc is created by layering three materials: ceramic, a proprietary bonding material and diamond. The bonding layer is a highly corrosion-resistant metal used in a variety of applications such as jet engine components and medical implants, like artificial joints. The bonding layer adheres to the ceramic disc, and serves as a primer coat for the diamond surface. The top diamond layer is applied using **Physical Vapor Deposition (PVD)**—a coating process in which there’s an atom-by-atom transfer of material from the solid phase to a plasma phase (a cloud of charged particles) and back again to the solid phase.

In the PVD process, a graphite source is electrically “shocked” causing it to release charged carbon atoms. A high-powered magnet is used to sort the carbon atoms. The charged carbon atoms are aimed at the ceramic discs, striking the surface of the discs and gradually forming a diamond-embedded surface (see Figure 4).

**Figure 4: PVD Process**

The resulting bond is molecular, not chemical (diamond-like coatings are chemical). The carbon molecules form a rigid, triangulated structure—like a web of pyramids—creating a hard, durable and smooth diamond surface. The diamond-embedded
Cross-linking changes the molecular structure of the polyethylene, creating a thermoset polymer that’s a strong, durable, heat resistant material.

Surface material is known as an sp³ tetrahedral hydrogen-free amorphous carbon film.

**About Diamond-Like Coatings**

Diamond-like coatings (used by other manufacturers) are applied using high temperatures and methane gas. This coating process results in a surface material containing some diamond (only 30-50%) and other compounds, including hydrocarbons. Hydrocarbons are subject to degradation by water, so diamond-like coatings will degrade over time.

**InnoFlex™ Waterways**

InnoFlex waterways are made using a proprietary blend of PEX-C (cross-linked polyethylene)—a highly-engineered, durable polymer material.

To create PEX, single strands of polyethylene are transformed into a dense interwoven network of high-density polyethylene through cross-linking. Cross-linking changes the molecular structure of the polyethylene, creating a thermoset polymer that’s a strong, durable, heat resistant material (see Figure 5).

![Cross-Linked Polyethylene](image)

**Figure 5: Cross-Linking Polyethylene Creates Stronger Material**

The three most common ways to cross-link polyethylene are noted in Figure 6. InnoFlex waterways are created using the electron beam irradiation method. The irradiation process used to manufacture PEX-C is the same process used to sterilize some medical equipment.

<table>
<thead>
<tr>
<th>PEX Type</th>
<th>Cross-Link Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEX-A</td>
<td>A combination of peroxide and heat</td>
</tr>
<tr>
<td>PEX-B</td>
<td>A combination of vinylsilane, heat and humidity</td>
</tr>
<tr>
<td>PEX-C</td>
<td>Electron beam irradiation</td>
</tr>
</tbody>
</table>

**Figure 6: PEX Cross-Link Methods**
Manufacturing InnoFlex™ Waterways

PEX-C was selected by Delta Faucet Company for use in InnoFlex waterways because of its unique over-molding capabilities, which allow the manufacture of an integrated, one-piece water delivery system.

The puck (see Figure 7)—which becomes the base for the DIAMOND™ Valve—is over-molded onto the extruded InnoFlex waterway supply lines. During the over-molding process, the waterways and puck are physically fused together. The connection is strengthened at the molecular level by cross-linking the two materials together via electron beam irradiation (see Figure 7), which also sterilizes the product.

**Figure 7: Over-Molding Produces a One-Piece Waterway System**

InnoFlex waterway anchor fittings are also over-molded and then cross-linked (see Figure 8), eliminating the need for crimped fittings. The water supply connections are engineered for 3/8" compression shut-off valves and are designed to prevent overtightening. Adapters are readily available for 1/2" fittings.

The resulting supply lines and fittings constitute a one-piece assembly with no leak points.

**Figure 8: InnoFlex Waterway Anchor Fittings**

**About PEX**

PEX has been used in plumbing applications in Europe for more than 30 years, and was introduced in the United States in the 1980s. With its ability to withstand temperature ranges from below freezing to up to 180°F, PEX is code approved for use in water filtration, radiant heating, and snow and ice melt applications. With only a few exceptions, PEX is also code approved for in-wall plumbing applications.
Traditional copper piping is being replaced by PEX and other alternative materials—including PEX-AL-PEX (made with a layer of aluminum between two layers of PEX, also known as KiTec), PVC and CPVC—across the U.S. (see Figure 9). Although numbers vary by region, approximately 42% of the U.S. market is currently using PEX for in-wall plumbing applications.

PEX-C is used as the waterway in a DIAMOND™ Seal Technology faucet. Even in areas of the U.S. where PEX is not approved for in-wall plumbing applications, usage in faucets (as is the case with DIAMOND Seal Technology) is allowed.

Note: PEX is approved for plumbing applications only up to 180°F.

A highly stable material, PEX will not impart any taste, odor or other impurities to contaminate the water stream.

Advantages of PEX
PEX is a flexible material that’s easy to install and service. It is highly resistant to kinks, corrosion and impact. If kinks do occur, heating the tubing slowly with a hair dryer will return it to its original form, undamaged. Unlike metal pipes, PEX will not corrode or accumulate mineral buildup inside the tubing. It is also resistant to freeze damage, expanding under freezing conditions due to its flexibility. PEX does not include any metals that could possibly leach into the water stream. A highly stable material, PEX will not impart any taste, odor or other impurities to contaminate the water stream.

Integrated Supply Lines
The InnoFlex™ waterways integrated supply lines measure 38” from the valve base to the fittings, with a minimum of 32” below the deck. The waterways can be connected directly to the hot and cold water shut-off valves. No intermediate riser connections are needed. The flexible supply lines can be coiled (no smaller than 8” in diameter) to adjust them to the right length as necessary (see Figure 10).
The InnoFlex™ waterways integrated supply lines measure 38” from the valve base to the fittings, with a minimum of 32” below the deck. The waterways can be connected directly to the hot and cold water shut-off valves. No intermediate riser connections are needed.

Figure 10: Example Installation Showing Adjustment for Shorter Runs

The supplies can also be cut to length using a plastic ferrule connection (included with each DIAMOND™ Seal Technology faucet), although the Delta Faucet Company warranty does not apply to ferrule connections. Ferrule connections—if not tightened correctly (two turns past finger tight)—can leak or blow off. See the DIAMOND Seal Technology model-specific Maintenance and Installation Sheets available at deltafaucet.com for installation details.

Comparing InnoFlex Waterways and Traditional Waterways

Traditional waterways consisting of brass body valves with copper supplies result in three potential leak points—one at each of the braze joints. Two additional leak points are introduced when intermediate riser connections are used to connect the brass supplies to the hot/cold water shut-off valves.

Because the water supplies and valve base are over-molded together in the InnoFlex waterways, there are no leak points at the connection between the two (see Figure 11). The water supplies can be connected directly to the hot/cold water shut-off valves, eliminating the need for intermediate riser connections—and two potential leak points (see Figure 10).

Figure 11: InnoFlex Waterways Eliminate Potential Leak Points

Tested to Perform Beyond Expectations

InnoFlex waterways have been burst tested at ambient temperature and at 180° F, and were found to outperform the national product standard (ASME A112.18.1/CSAB125.1) of 125 PSI by ten and four times respectively (see Figure 12).
InnoFlex™ waterways outperform the national product standard (ASME A112.18.1/CSAB125.1).

<table>
<thead>
<tr>
<th>Number of Turns Past Finger Tight</th>
<th>Ultimate Burst Pressure (PSI)</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Anchor Fitting</td>
<td>Sample Ferrule Connection</td>
<td>Ambient Temperature</td>
</tr>
<tr>
<td>½ turn</td>
<td>2 turns</td>
<td>1250</td>
</tr>
<tr>
<td>1 turn</td>
<td>2 turns</td>
<td>1250</td>
</tr>
<tr>
<td>2 turns</td>
<td>2 turns</td>
<td>1250</td>
</tr>
<tr>
<td>3 turns</td>
<td>2 turns</td>
<td>1250</td>
</tr>
</tbody>
</table>

Figure 12: Supply and Fittings Burst Pressure Test Results

Each test included one standard DIAMOND™ Seal Technology anchor fitting that was tightened one-half to three turns past finger tight and one plastic ferrule connection that was tightened two turns past finger tight. In all cases, the failure mode occurred in the PEX tubing material. The molded anchor connections (standard) and ferrule connections remained secure. The anchor connection is very robust, providing secure performance at a variety of tightness levels.

Delta Faucet Company recommends tightening the anchor fitting one turn past finger tight. Ferrule connections should be tightened two turns past finger tight.

All DIAMOND Seal Technology products undergo pressure decay testing during manufacture to ensure leak-free performance.

DIAMOND Seal Technology meets the following statutes and standards:

- California AB 1953 (no lead)
- NSF 61 (lead and other health effects of drinking water)
- ASME A112.18.1/CSAB125.1 (faucets)
- ASME 112.18.6 (flexible water connections)

For more information about DIAMOND Seal Technology, contact your local Delta Faucet Company sales representative, call (800) 345-DELTA or visit diamondsealtechnology.com.