DIAMOND™ Seal Technology:
Next Generation Valve and
One-Piece Waterway
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Delta Faucet Company's proprietary water delivery system—DIAMOND Seal Technology—provides enhanced protection from leaks. This system reduces the number of potential leak points, simplifies installation, and provides long-lasting performance. DIAMOND Seal Technology faucets also satisfy the federal “Reduction of Lead in Drinking Water” Act (S.3874), California Health and Safety Code 116875 (AB 1953) and other state laws, which mandate that 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.

The DIAMOND Seal Technology system consists of two primary 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). The DIAMOND Valve will last up to 5 million cycles—10 times longer than the industry standard* (see Figure 2).

Diamods—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, reducing build up of calcium and mineral deposits and helping to ensure smooth, consistent operation over the life of the faucet.

*Industry standard based on ASME A112.18.1/CSA B125.1 of 500,000 cycles.
The DIAMOND™ Valve will last up to 5 million cycles—10 times longer than the industry standard.*

**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 typically require lubricant, which is applied during the manufacturing process. With use, the factory-applied lubricants may wash away—causing the two ceramic discs to “stick” together—making it increasingly difficult to operate the faucet. In areas with hard water, calcium deposits may 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 is far less likely to 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 lower 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 also helps prevent 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), reducing

*Industry standard based on ASME A112.18.1/CSA B125.1 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 seal(s):** Stationary silicone seals remain pliable without drying out and provide greater chemical resistance than traditionally used rubber seal materials. They also have a low propensity for compression set (less than 5% versus 10-20% for conventional rubber seals), meaning that when compression is released they return to their original state.

- **Metal handle stems:** DIAMOND Valves include either a stainless steel stem (single-handle models) or brass stem (two-handle models). The metal stems add durability to DIAMOND Seal Technology faucets.

- **A two-function handle limit stop (single-handle models only):** 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.

- **Quarter-turn handle operation for two-handle models:** The DIAMOND Valve used in two-handle faucets enables handles to be turned 90° maximum (¼ turn).

**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, such as 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](image)
The carbon molecules form a rigid, triangulated structure—like a web of pyramids—creating a hard, durable and smooth diamond surface. The diamond-embedded surface material is known as an sp³ tetrahedral hydrogen-free amorphous carbon film.

**About Conventional Hard Coatings**
Most conventional hard 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 conventional hard coatings may degrade over time.

**InnoFlex® Waterways**
InnoFlex waterways are made using a proprietary blend of materials that are then cross-linked to create 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 cross-linking method. The cross-linking 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 cross-linking</td>
</tr>
</tbody>
</table>

**Figure 6: PEX Cross-Linking 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 (see Figure 7). The puck and waterways are also cross-linked to improve resistance to chlorinated water and allow for use in hot water applications.

Figure 7: Over-Molding Produces a One-Piece Waterway System
Puck shown is representative of single-handle faucets with DIAMOND Seal Technology. For two-handle faucets with DIAMOND Seal Technology, the puck assembly includes two InnoFlex PEX tubes for each valve.

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 resist over-tightening. Adapters for ½” fittings are readily available at plumbing suppliers.

The resulting supply lines and fittings constitute a one-piece assembly with fewer leak points in the waterway.

Figure 8: InnoFlex Waterway Anchor Fittings
Fittings shown are for single-handle (left) and two-handle (right) faucets with DIAMOND Seal Technology.

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 distribution, radiant heating, and snow and ice melt applications. With only a few exceptions, PEX is also code-approved for in-wall plumbing applications.
A highly stable material, the PEX-C material will not impart any taste, odor or other impurities that may contaminate the water stream.

Although numbers vary by region, approximately 55% of the U.S. single-family new construction market is currently using PEX for in-wall plumbing applications (see Figure 9).

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, with few exceptions.

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

**Figure 9:** U.S. PEX Usage for Water Distribution Pipes in Single-Family Detached New Construction Housing  
Source Data: National Association of Home Builders Research Center  
See Appendix A for regional PEX usage.

**Advantages of PEX**
PEX is a flexible material that’s easy to install and service. It is highly resistant to kinks, oxidation, corrosion and impact. If kinks do occur, heating the tubing slowly with a hair dryer will usually 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, the PEX-C material will not impart any taste, odor or other impurities that may contaminate the water stream.

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

Figure 10: Example Installation Showing Adjustment for Shorter Runs

The supplies can also be cut to length and connected using a plastic ferrule connection (included with each DIAMOND™ Seal Technology faucet), although the Delta Faucet Company warranty does not apply to ferrule connections. See the DIAMOND Seal Technology model-specific Maintenance and Installation Sheets available at deltafaucet.com for installation details.

InnoFlex copper and vinyl supply line covers may be used to conceal exposed InnoFlex waterways.

Comparing InnoFlex Waterways and Traditional Waterways

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

Over-molding the water supplies and valve base together in the InnoFlex waterways all but eliminates leak points at the connection between the two pieces (see Figure 11). In most cases, 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: Over-molding All but Eliminates Potential Leak Points

Tested to Perform Beyond Expectations

InnoFlex waterways have been burst tested to the national product standard (ASME A112.18.1/CSA B125.1 of 500 PSI at room temperature) and were found to outperform the standard (see Figure 12).
InnoFlex® waterways outperform the national product standard (ASME A112.18.1/CSA B125.1 of 500 PSI at room temperature).

<table>
<thead>
<tr>
<th>Number of Turns Past Finger Tight</th>
<th>Number of Turns Past Wrench Tight</th>
<th>Ultimate Burst Pressure (PSI)</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Anchor Fitting</td>
<td>Sample Ferrule Connection</td>
<td>Ambient Temperature</td>
<td>180° F</td>
</tr>
<tr>
<td>½ turn</td>
<td>1 turn</td>
<td>1250</td>
<td>500</td>
</tr>
<tr>
<td>1 turn</td>
<td>1 turn</td>
<td>1250</td>
<td>500</td>
</tr>
<tr>
<td>2 turns</td>
<td>1 turn</td>
<td>1250</td>
<td>500</td>
</tr>
<tr>
<td>3 turns</td>
<td>1 turn</td>
<td>1250</td>
<td>500</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 one turn past wrench tight. In all cases, 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 with a wrench until the nut feels tight, and then the nut should be tightened one more revolution.

**John Guest® Fittings**

In widespread lavatory and kitchen faucets with DIAMOND Seal Technology, a John Guest push-connect fitting securely joins the InnoFlex waterways that come from the DIAMOND™ Valves in the handles to the spout inlet tube (see Figure 13). The fitting is sealed with two o-rings and can be released and reconnected. For custom installations, the valve outlet and spout inlet tubes can be trimmed and reconnected with the John Guest fitting.

John Guest fittings are capable of withstanding forces that are more extreme than those applied in a typical usage situation. See Figure 14 for John Guest fitting performance test results (per ASME A112.18.1/CSA B125.1 of 500 PSI for high-pressure test and an internal test for pull-off force).

John Guest is a registered trademark of John Guest International Limited.
Figure 13: John Guest Fittings
John Guest “Y” (left) and “W” (center) fittings are used in widespread kitchen and lavatory models, respectively. The image at right illustrates an installed “W” fitting.

<table>
<thead>
<tr>
<th>Test</th>
<th>Maximum Force</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure test</td>
<td>500 PSI</td>
<td>No failure</td>
</tr>
<tr>
<td>Pull-off force</td>
<td>40 pounds</td>
<td>PEX tube deformation</td>
</tr>
</tbody>
</table>

Figure 14: John Guest Fitting Performance Test Results

Flexible Installation
Widespread lavatory and kitchen faucets with DIAMOND Seal Technology feature flexible mounting—from 4 to 16 inches on center for lavatory models and 6 to 16 inches on center for kitchen faucets. They also include self-centering mounting bushings to simplify installation. Lavatory and kitchen models are capable of mounting on decks up to 2¼ and 2½ inches thick, respectively.

Added Durability Below the Deck
Select DIAMOND Seal Technology models feature the DURAMOUNT® mounting system, which provides a durable, quick and corrosion-resistant installation. The mounting shanks are made of Celstran®, a fiberglass-reinforced polymer commonly used in a variety of applications, including automotive structural components. The mounting nuts, made of a fiberglass-reinforced polymer with a 30-year track record in this application, are designed to be hand-tightened for tool-free installation. All DURAMOUNT shanks and nuts incorporate quick tightening double-lead threads, so the nut moves twice as far with each turn, making installation quicker. Models with the DURAMOUNT® system are capable of thick-deck installations of up to 2½ inches.

The DURAMOUNT system has been tested and is capable of withstanding extreme forces that would not be applied in a typical usage situation. See Figure 15 for test results.

Celstran is a registered trademark of CNA Holdings LLC.
Component | Test* | Maximum Force
---|---|---
Faucet | Side load force | 950 pounds
Mounting shanks | Axial pull | 1,400 pounds
Mounting nuts | Torque | 200 inch-pounds
Spout | Top loading | 400 pounds

**Figure 15:** DURAMOUNT System Performance Test Results

Unlike brass shanks that may corrode over time, the DURAMOUNT connections will not corrode, making it easier to remove the faucet for future renovations.

All DIAMOND Seal Technology products undergo rigorous quality testing during manufacture to help ensure leak-free performance.

DIAMOND Seal Technology products meet the following statutes and standards:

- Reduction of Lead in Drinking Water Act (S.3874)
- California Health and Safety Code 116875 (AB 1953, low lead)
- Vermont Law No. 193 (S152, low lead)
- NSF 61 (lead and other health effects of drinking water)
- ASME A112.18.1/CSA B125.1 (faucets)
- ASME 112.18.6 (flexible water connections)

DIAMOND Seal Technology products also satisfy other state statutes mandating that the weighted average lead content in pipes, fittings and fixtures used to convey drinking water cannot exceed 0.25% on wetted surfaces.

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

*The side load force, axial pull and torque tests were conducted to provide information about the robustness of the DURAMOUNT system. The top loading test was performed per ASME A112.18.1/CSA B125.1 of 14 pounds. Tests were conducted on the Delta® 520 Classic single-handle lavatory. Due to high-arc, tubular spouts, kitchen models featuring the DURAMOUNT system may not be able to withstand similar loads.
Appendix A
U.S. PEX Usage in 2010 for Water Distribution Pipes in Single-Family Detached New Construction Housing

Source Data: National Association of Home Builders Research Center