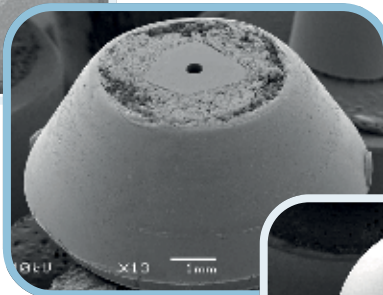
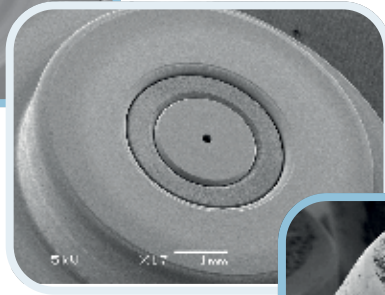
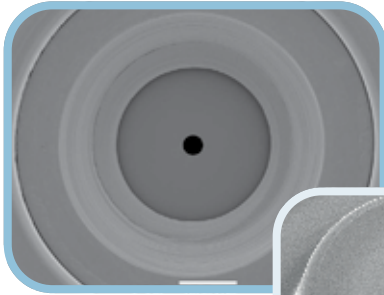


WATERJET ORIFICES: JUST THE FACTS



The waterjet orifice is the single most overlooked component in a waterjet cutting machine, and yet without it, the entire system would fail to function. This guide provides the facts that every individual in the waterjet industry should know about orifices—their material make up, failure modes and retaining methods.

The Waterjet Orifice **GUIDE**

Ruby & Sapphire Material

All Corundum is Created Equal



RUBY



SAPPHIRE

The most commonly used orifice material is synthetic corundum, ordinarily known in the waterjet industry as ruby and sapphire. It is often unknown by end users that these jewels are made of the same material, the only two differences being a small amount of the element chromium used in rubies to create red pigment and manufactured internal geometries.

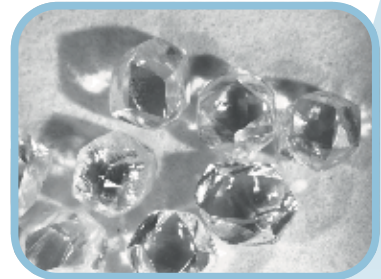
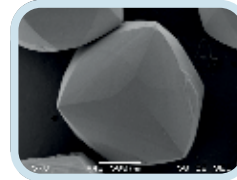
Corundum has been used abundantly in many applications due to its ease of reproduction and inherent use benefits, such as its extreme hardness. Pure corundum is a 9.0 on the Mohs hardness scale and the second hardest material next to diamond.

Diamond Material

The Hardest Material Known on Earth

With the highest score on the Mohs hardness scale, diamond is the hardest known material on earth. It is also interesting to note, that a rating of 10.0 is not simply one point higher than ruby, but exponentially higher due to the fact that the Mohs scale is not linear.

Diamond is made up of tetrahedrally bonded carbon atoms crystallized into the diamond lattice. Its exceptional physical characteristics promote its utilization in a vast number of applications. These exceptional attributes encompass optical, thermal, chemical, electrical, and mechanical properties.



Orifice Design

SAPPHIRE

Sapphires utilize what is known as sharp edge technology. These produce a long coherent stream, but are vulnerable to minor impacts of debris in the high pressure system which quickly can destroy their integrity.

RUBY

Rubies are designed to incorporate a robust inlet edge radius which is typically about .001", depending on the orifice diameter. This larger radius can withstand a higher amount of abuse before failing, but causes a shorter coherent jet stream than sapphire. Typically, rubies also produce a higher vacuum than sapphire.

DIAMOND

Diamonds utilize a combination of these designs which only they can do because of their inherent strengths. This allows for maximized jet stream lengths while still maintaining robust material integrity. In addition, these design elements allow versatility for effective use in a large array of cutting applications.

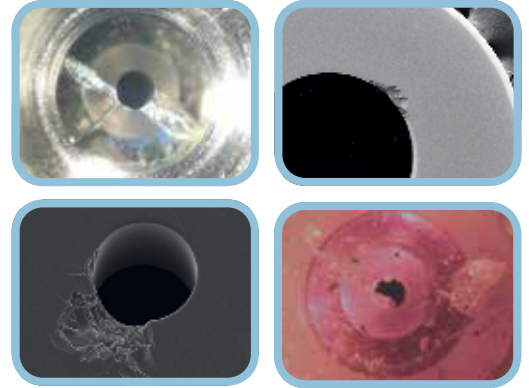


Orifice Failure Modes

The # 1 Failure Mode, encompassing 99% of all synthetic corundum orifice failure, is attributed to PARTICLE IMPACT.

1. FAILURE DUE TO IMPACTS FROM...

- Debris from the material being cut, which has been sucked through the orifice in the vacuum created when turning the jet off.
- Metal or plastic particles from high pressure tubing and filters.
- Garnet particles pulled back through the jewel's orifice via the vacuum created when the stream is cycled off.
- High pressure seal particles.
- Other line-borne contaminants.



2. FAILURE DUE TO OVAL SHAPED THROUGH HOLES

Faulty manufacturing of orifices may lead to oval shaped or out-of-round through holes within the orifice, if proper quality control processes are not followed. This type of manufacturing error will then negatively affect jet stream coherency and render it unusable. If this type of failure mode has occurred, typically you will see a fluctuating jet stream that frequently alternates from coherent to turbulent. You may also hear spitting and sputtering sounds while this occurs.



3. FAILURE TO SEAL

When a manufacturer machines an orifice mount, it is very important that it is machined in a way that leaves concentric machine lines. If inconcentric machine lines result, the jewel is unable to seat properly in the mount and therefore will not seal. If unable to seal, water as well as foreign debris is able to pass around the jewel and cause immediate orifice failure. With this type of failure mode, it is typical to see a jet stream that fluctuates frequently from coherent to turbulent.

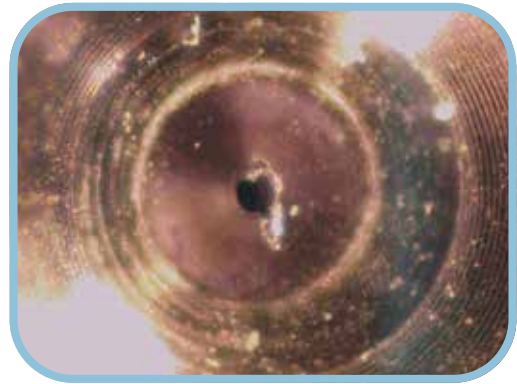


4. FAILURE DUE TO POOR WATER QUALITY

Water contaminants can be classified into two groups, dissolved solids and suspended solids. Particles suspended in water can impact the edge of the orifice and in extreme cases, chip it, causing orifice failure. This results in poor jet quality, poor cutting capability and lowered mixing tube life. In some applications, especially those that operate under extreme heat, solids that are dissolved can collect onto the entrance of the orifice. Over time, a ring of precipitate can build up around the orifice. Eventually, a portion of this ring may break, damage the orifice and disrupt jet quality, causing orifice failure.

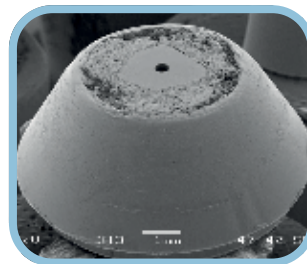
5. FAILURE DUE TO ORIFICE PLUGGING

The particles that will cause failure to synthetic jewels are typically the same particles that are capable of plugging orifices. While both corundum and diamond may become plugged, the difference lies in the fact that most often diamond and not corundum will maintain its integrity once the plugged particle has been removed. Typically, corundum will have sustained damage sufficient enough to render the orifice useless.



6. ORIFICE RETAINER FAILURE

The key objective of the orifice retainer is to hold the jewel in place without affecting the coherency of the jet stream. If the optimal retaining method and materials are not used for each varying application, this can cause improper jewel retention, leading to blown out orifices, angled jet streams and fractured jewels. When the orifice retainer fails to keep the jewel in place, most typically with high amounts of on/off cycles, the jewel may become dislodged. At this moment, the orifice is susceptible to particles that may become wedged between the orifice and the seat, which will permanently dislodge the jewel and cause failure.



7. FAILURE DUE TO OVER TORQUEING

When an orifice assembly is over torqued, deforming, marring, gouging of the mount and in extreme cases, fracturing of the jewel can occur, all of which cause or lead to premature orifice failure or inefficient jet stream quality. Oftentimes, manufacturers will provide torqueing specifications which can be very helpful in preventing this type of failure mode. In general, if you have water leakage from the weep hole, this may indicate that the assembly has been over torqued. If reasonable torque has already been applied and leakage continues, it is essential that the mating surfaces be examined for damage.



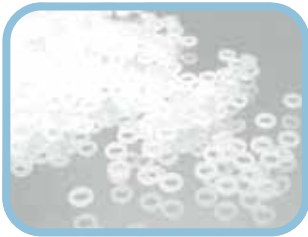
The Effects of Cutting with a Defective Orifice

- Damaged work piece material
- Wet products
- Premature failure of mixing tube
- Slower cut speeds
- Poor edge cut quality
- Decreased direct drive pressures
- Over stroking
- Shortened intensifier component life
- Increased flow rate
- Inefficiently focused garnet

Orifice Retainers

The sole purpose of the orifice retainer is holding the jewel in place without affecting jet stream coherency

Retaining Materials



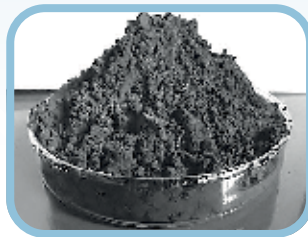
Acetal Plastic: Retainers that appear white are made from acetal plastic and have been in use with ruby and sapphire orifices for many years. This material has low water absorption; it is cost effective and performs efficiently when used with synthetic jewels.



Aluminum Bronze: Retainers that appear gold are typically made out of aluminum bronze or aluminum nickel bronze and are commonly incorporated with ruby or sapphire orifices.



Titanium: Silver retainers are typically made with aerospace grade titanium for use with diamond. This combination of jewel and retainer create an extremely robust orifice preferred for the most rigorous of applications, for example abrasive applications with frequent on/off cycling.



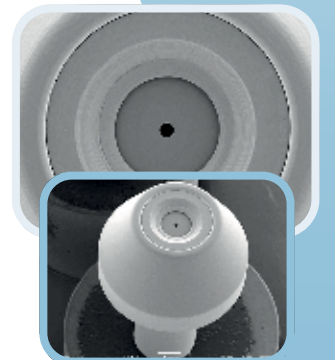
Nickel Powder Base: This is a nickel, powder based alloy often times used with oddly shaped natural or synthetic diamonds. As an alternative to aerospace grade titanium, this material tends not to maintain its material integrity as well as titanium in abrasive and water only applications. Due to better alternatives, this material is quickly becoming an obsolete retaining material.

Retaining Methods

O-Ring Method: This method utilizes acetal, aluminum bronze or titanium retaining materials shaped in an O-ring for press fitting around the outside diameter of the jewel. This retaining method has been in use for many years and has proven to hold up very well with the lifetime of synthetic jewels.



Retainer Method: This method typically utilizes titanium and aluminum bronze retaining materials and retains around the jewel with a positive downward pressure. For added protection, this method also incorporates a small lip over the top of the jewel. Today, this method is becoming the most commonly used, as it is significantly more reliable and may enhance jet stream coherency.



Adhesive Method: This method is less common today and simply uses an adhesive to secure the jewel to the mount. Typically ruby and sapphire orifices can be retained with this method and in general, the glue maintains effectiveness for the lifetime of the jewel.



Sintering Method: This method envelopes the jewel with sintered, nickel powder based alloy. This is a very old technique which is now becoming an obsolete process used only by manufacturers with oddly shaped jewels. This method should not be used with pressures exceeding 55K, and it is the most susceptible to orifice failure due to disintegration of the retainer. This retaining method will not hold up in the higher pressures of today and is also more vulnerable to failure due to over torquing.



DIAMOND TECHNOLOGY INNOVATIONS

dti is a specialized manufacturer of precision aligned diamond orifices and nozzles for OEMs and distributors only.
For more information, please ask your waterjet parts supplier or go to our diamond orifice information page at:

www.dticore.com or www.waterjetdiamonds.com

Email: info@dticore.com

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30 years of expert engineering design and development has made the dti CORE™ diamond the most efficient and effective diamond orifice in the waterjet cutting industry.

When put to the test in high pressure hostile environments, unlike any other diamond product, the dti CORE™ diamond maintains its material integrity, yielding longer life, better cut quality and the least down time.



THE DIAMOND INSIDE

For engineered diamond
excellence,

DEMAND dti CORE™

PREFERRED BY NASA

dti is the sole diamond orifice supplier of NASA JPL research.