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DESIGN GUIDELINES
LASER WELDING

Key Design Considerations for Laser Welding

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What is Laser Welding? How Does it Work?

"Laser" stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. Simply put, laser welding uses a laser's energy to generate heat in a focused beam. The beam is focused on a designated area, and energy is then pulsed through the beam and directed at that area. The beam causes the metal or metals to heat and melt at the point of the target, or "weld". In their liquid state, the two metals combine so that when they are cooled, they are bonded together. The laser beam has a high-power density (typically 1 MW/CM2) which produces a very small, **heat-affected zone**, or "HAZ." This HAZ is typically only fractions of a millimeter to a few millimeters in diameter, which means that it heats and cools very rapidly.

What are the Benefits of Laser Welding?

Laser welding provides a very precise weld as it has a very small HAZ. This makes laser welding ideal for products with intricate weld patterns, or where the area to be welded is difficult to reach. Because the laser beam can be focused so precisely, there is less likelihood of damaging or deforming the surrounding surfaces, or any components that may have been previously installed. Because the laser welding operation is simply the fusing of metals, **there is no need for filler materials**, and there are no additional environmental risks. This oftentimes makes laser welding the most cost-effective and eco-friendly option.

Other benefits of laser welding include:

- **Material Thickness Range:** Laser welding is suitable for jobs ranging from as thin as .005 inches up to about .25 inches (in the case of steel). This makes laser welding well suited for jobs where the metal is so thin that conventional welding would destroy it.
- **Precision:** The power output, size of weld, depth of weld, speed of weld, and the track of the laser beam on the metal surface are all highly controllable. The result is a very precise weld.
- **Automation:** Another benefit of a highly controlled process is that laser welding is highly programmable and robotic. Since it's easier to automate compared to metal inert gas (MIG)* or tungsten inert gas (TIG)* welding methods, greater repeatability and faster throughput can be achieved.
  *Accumet does not currently offer MIG or TIG welding services.
- **Contamination:** With laser welding, the only materials involved are the metals to be welded. For best results, the metals should be cleaned of any oil and dirt prior to welding. The welding itself introduces no filler or slag that could contaminate application environments, such as an operating room, in the case of surgical instruments.

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- **Environmental Impact:** A cleaner process also means there's much less impact on the environment.

- **Corrosion:** With some metals such as steel, aluminum, and titanium alloys, **brittleness can result from conventional welding**. This can occur when the electrode used for welding contains trace amounts of moisture. The heat of the welding causes the water to decompose quickly, and in doing so, it releases hydrogen that enters the metal causing it to become fragile. Because laser welding does not rely on an electrode to conduct heat, there is no risk of corrosion.

DID YOU KNOW?

Accumet serves over 400 customers annually and ships millions of parts with 95% on time delivery and fewer than 2% defects.

What Types of Material Can be Welded?

Lasers can weld many different types of materials together. Stainless steel, titanium, nickel, aluminum, molybdenum, and Inconel are just a few of the metals that are well-suited to laser welding. What is important to note, however, is that **not all metal combinations are weldable**.

Aluminum, for example, can be laser welded. However, **only dissimilar grades of aluminum can be welded together due to a high probability of cracking**. This is one area where laser welding differs from conventional welding. In conventional welding, the metals don't bond directly with one another, but rather with the filler material being used. This can be a major factor in determining whether or not a particular application lends itself to laser welding.

Please see the chart on the next page for further information about common metals and their compatibility with laser welding.

Material	Comments
Aluminum 1100	Welds well, but needs to be welded with dissimilar aluminum
Aluminum 2219	Welds well, but needs to be welded with dissimilar aluminum
Aluminum 2024/5052/6061	Requires filler material
Cu-Zn Brasses	Out-gassing of Zn prevents good welds
Beryllium Copper	Low reflectivity so welds well
Copper	High reflectivity creates uneven welds
Hastelloy-X	Welds well, with specific pulse rates
Molybdenum	Brittle weld but weld may be acceptable for low strength weld requirements
Inconel 625	Welds well, but some tendency for porosity in deep welds
Monel	Good weld, good penetration
Nickel	Good weld, but must be cleaned
Steel, Carbon	Good welds with carbon content under 0.25%
Steel, Galvanized	Porous, brittle weld
Steel, 300 Stainless	Welds well, except 3030 and 303SE which crack
Steel, 17-4 PH Stainless	Welds well with post weld
Tantalum	Welds well but oxidation likely
Titanium	Welds well but oxidation likely
Tungsten	Weld can be brittle

Is Laser Welding Right for My Product?

Now that we are equipped with this information, it's time to determine whether laser welding is the right choice for your specific design. To do this, there are two basic questions to ask:

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Accumet provides a wide range of custom restoration services for the auto industry. We have helped restore exotic antique automobiles, like vintage Ferraris. We can also help with restoration needs including laser etching, marking emblems, markings, logos, and more.

1. **Are the materials weldable?**
   This is critical, as both materials must be compatible to bonding.

2. **How much of a gap exists between the two surfaces that are to be welded?**
   As stated above, laser welding does not introduce a filler material. Therefore, **a gap larger than .003 inches cannot exist at the weld point**. There is simply not enough material to bond to successfully make a connection.

As always, Accumet's team of manufacturing consultants are available to answer any questions regarding specific material compatibility. Please contact our sales department to verify requirements.

Can Laser Welding Produce a Hermetically-tight Seal?

Absolutely. A **hermetic seal** is any type of sealing that renders a given object airtight. There are many types of hermetic seals and packaging materials a designer can choose from. Laser-welded hermetic seals have become the leading solution for applications that require complex, mixed material, and/or precise, fast sealing.

Though welding can be performed by various methods, laser fusion welding typically provides the most reliable seal, as well as a variety of other benefits, including tighter tolerances, three different joint-type options, and flexibility that can enable new geometries and material use.

There are several points to consider when designing your package, with regards to laser welding:

1. **You must evaluate your package design.**
   As laser welding is typically an **autogenous welding process**, meaning only the materials of the lid and enclosure are part of the weld. This means that **the exact material matchup of the lid/enclosure materials is critical**, along with any inter-metallics, cooling rate matchups, reflectivity and plating.

2. **Laser welding also has a small heat affected zone (HAZ) and imparts minimal heat to the material, so cooling tends to happen very quickly.**
   Depending on the metals being used, this could impact weld quality and yields. So, gaining a basic understanding of various material properties and their interaction with laser energy is an important first step in ensuring quality seals.

3. **While most metals, and even mixed metals can be laser welded, some alloys and metal combinations are not compatible with laser welding without filler materials.**
   Some combinations and alloys cannot be laser welded reliably for hermetic seals. The exact geometries, materials, and weld type determine the exact amount of laser energy and exposure necessary to produce reliable welds.

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"Our commitment to offering our customers top quality product, consistently, on time is at the heart of everything we do."

Greg Sexton,
CEO of Accumet

Is Hermetic Seal Testing Provided?

Accumet can provide hermetic seal testing to those customers who require it. Hermetic seal validation is critical to packages that require protection from environmental elements. This level of complete and absolute protection is especially important in maintaining reliability over the required lifetime of critical electronics. Laser welding hermetic seals is the method most certified by many military and aerospace quality and reliability standards (MIL-STDs)*. Devices designed to, or near to these standards, include those found in the space, aerospace, military, high-power, high-frequency, science, R&D, and medical device markets.

Depending on the product, Accumet offers a number of tests which can be used independently or in concert with one another to verify the quality of the seal. These include **helium leak testing, water leak testing, and thermal shock/temperature cycling testing**.

- **Helium leak testing** is used to find small leaks or larger leaks in bigger volumes. Helium is well suited to leak testing applications due to its small molecular size and the fact that it is inert. It is also relatively safe to use (in comparison to hydrogen, for example) and, in most instances, non-reactive with the materials within the tested part. In leak testing, the helium is used as a tracer gas, its concentration is measured before the test, and observed throughout. Accumet's equipment can test to well below 10^{-9} Torr.
- **Water leak testing** is even more straightforward. The part being tested is attached to a fixture and submerged in water. If bubbles are detected, the weld is deemed faulty, the lid is removed, the is device re-inspected, and the process of resealing begins.
- **Thermal shock/temperature cycling** exposes the product to alternating low and high air temperatures to accelerate failures caused by repeated temperature variations during normal use conditions. The transition between temperature extremes occurs very rapidly, greater than 15 °C per minute. This conforms with MIL-STD-883J method 1010.9.

*Accumet is both ISO 9001:2015 and AS9100:2016 certified.

What are the Benefits of Partnering with Accumet?

Accumet has been an industry leader for the past 50 years. In addition to half a century's worth of experience, our facilities boast state-of-the-art technology. We currently have 26 lasers operating on our production floor, with multiple laser systems specifically dedicated to our laser welding operations. Pulsed yttrium, aluminum, and garnet (YAG) welders and fiber laser welders all line our production floor.

"Everyone in the industry has come in contact with something Accumet's processed."

Greg Sexton,
CEO of Accumet

Why does this matter?

Put simply, different lasers offer an array of benefits. These include, but are not limited to, **optical alignment, rotary welding, different power outputs**, and the capability to be fixtured to accommodate a multitude shaped parts of various sizes.

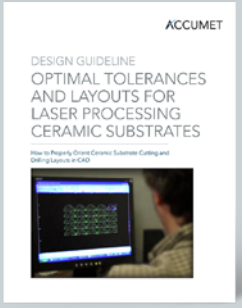
- Optical alignment offers many benefits, including the ability to line up to an existing weld and repair it, for example.
- Rotary welding allows for welding both inside and outside tubes, and even allows us to weld a tube within a tube.
- Different power outputs allow for the welding of varying types and thicknesses of materials, which also allows for spot welds and continuous welds, dictated by the materials being welded, as well as the size of the weld.

Varying machines allow us to achieve any combinations of power, focus diameter of a beam, pulsed energy, pulse duration, and pulse frequency, amongst other parameters, as specified by your project's unique requirements.

We also offer a one-stop experience for all of your production needs, including direct engineering support for new applications, as well as cost-effective, repeatable solutions.

Additional Materials Processing Capabilities:

We have the equipment and materials to be your trusted resource. We can do so much more than lapping and polishing. See our additional capabilities and download our other resources for more information.



Laser Machining Ceramics
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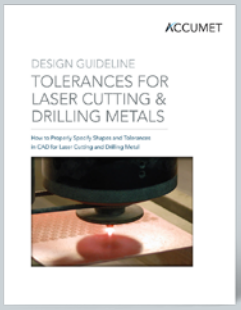

Laser Machining Metals
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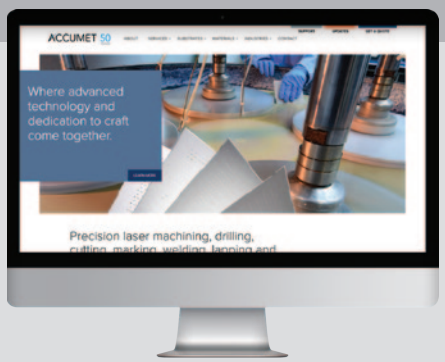
NEXT STEPS



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Equipment:

Accumet owns and operates over 15 lapping machines (including double-sided lappers), 9 polishing machines, an edge grinder, dicer, and 25 laser systems including CO2, Yag and Fiber lasers. We have micro-positioning tables, multiple beam systems, and statistical process controls to get your parts done perfectly. And with up to 2200 watts of CO2 energy, 2000 watts of fiber energy and 400 watts of Yag energy, you can rest assured we have the power and adaptability to get the job done right.

Materials:

Accumet offers the service of procuring and maintaining inventory on a wide variety of materials. We are also happy to receive, store and machine customer-supplied materials for individual or blanket orders.

Quality:

"Our commitment to offering our customers top quality product, consistently, on time is at the heart of everything we do." said Greg Sexton, CEO of Accumet. "Maintaining our ISO9001:2015 and AS9100 certifications is always very important to us and our customers because it confirms we adhere to the strictest quality standards put in place by the aerospace industry in order to satisfy FAA, NASA and the DOD," added Sexton. You may view and download Accumet's ISO9001:2015 AS9100:2016 certifications here.

Let's get started.

Please submit all requests for quotation to sales@accumet.com. Please include DXF (preferred file format) or pdf, tolerances, include the type of material, whether or not you will be supplying material or if you would like Accumet to supply it (and therefore include material in pricing), quantities and any specific finishes.

About Accumet

Founded in 1970, Accumet is an ISO 9001 industry pioneer and AS9100 certified advanced materials processing powerhouse. Accumet offers expert engineering support and proven manufacturing techniques for laser drilling, laser cutting, laser marking, laser ablation, laser welding, lapping, polishing, and diamond sawing. Fifty years after its founding, Accumet manufactures millions of top quality products and parts for over 400+ customers annually, with 95% on-time delivery and less than 2% defects. Because of these results, Accumet is widely recognized as a trusted "go-to" manufacturing partner with quality, speed, and reliability at its core.

Accumet can quickly fulfill small minimum orders or large production runs from their vast inventory, or process customer-supplied materials. Either way, Accumet utilizes advanced technologies, quality materials, and skilled expertise to help customers innovate products better, faster, and more efficiently with higher yields. Materials and parts can be expertly custom made to nearly any size or shape with a wide variety of surface finishes. Accumet has the flexibility to efficiently manage the smallest custom projects to the largest complex jobs—and the engineering expertise to add value at every step. Accumet supplies medical and bioscience, RF/microwave and microelectronics, aerospace and defense manufacturers and many other industries throughout the United States from two facilities just north of Boston, Massachusetts.

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