ACCELERON® INC.

Specialists in Electron Beam and Laser Technology

Electron Beam Welding

Electron Beam Drilling

Laser Welding, Drilling & Cutting

TECHNICAL DATA SUMMARY

Acceleron has been in operation for more than 30 years as the largest privately owned Electron Beam and Laser production facility in North America. Acceleron's experienced staff takes great pride in providing a wide variety of cutting-edge technologies to meet their customers' most demanding applications and scheduling requirements.

Our areas of expertise span the following technologies

- **Electron beam welding**
- **Electron beam drilling**
- **Laser welding drilling and cutting**

Acceleron's R&D department continually works to enhance processes with new technologies and applications to offer our customers the most innovative technology in the industry today!

This reference material was created to help our customers better understand some of the technologies that we utilize. We hope that you find this comprehensive information to be helpful and informative. Please feel free to call or e-mail us with any questions you may have. Once again, thank you for your interest in Acceleron, Inc.

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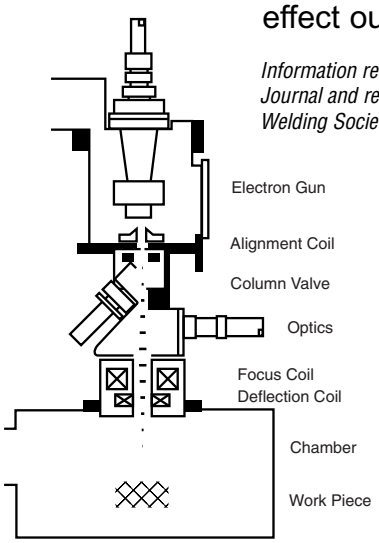
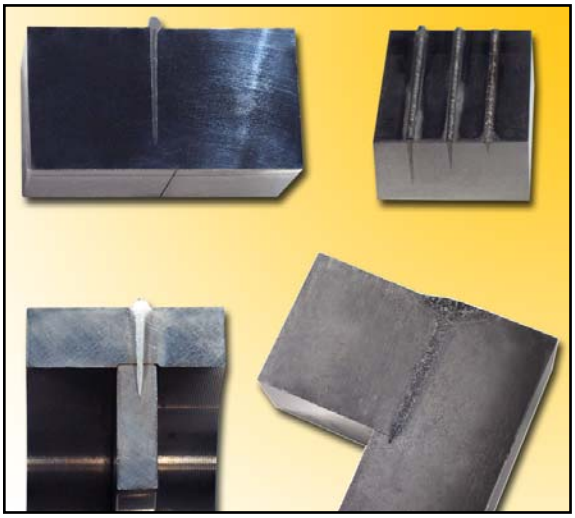
Electron Beam Welding

What Is Electron Beam Welding?

In simple terms, electron beam welding is accomplished by heating a tungsten filament which then releases a stream of electrons through an electromagnetic field, focusing them into a precise beam of energy less than .010" (0.254 mm) in diameter. As the beam penetrates the surface of the work piece, using no filler and with a heat concentration of up to 500 times that of conventional welding methods, electrons transform metal beneath the beam through a molten state to a gas, allowing the beam to travel deeper and deeper. As the beam penetrates the material, the small gas hole produced closes rapidly, and the surrounding molten metal then fuses, causing minimal distortion and heat effect outside the weld zone.

Information referenced from the American Welding Journal and reproduced with permission of the American Welding Society (dated 7/02).





***PARTS, clockwise from top left:** 1" penetration in a stainless steel stepped butt weld; Side view of a typical weld profile of stainless steel; 1.125" Titanium stepped butt weld, welded at a speed of 40 IPM; Cylindrical lap weld.*

High-power 25 Kw electron beam welding machine, capable of 3" penetration. Large chamber (60" x 72" x 108"), updated with new 2006 CNC multi-axis control to simplify complex applications.

Advantages of Electron Beam Welding

- Total energy input is approximately 1/25 of conventional welding energy
- Low heat input results in minimal distortion
- Able to hold close tolerances
- Weld deep penetrations with extremely limited heat-affected zones
- Repeatability of weld parameters job to job, lot to lot
- High-strength weld integrity (clean, strong and consistent)
- No fluxes or shielding gases to affect the properties of the weld
- Penetration control to within 10% welding in vac. 1x10-TORR, producing contamination-free welds
- Joins similar and dissimilar metals
- Cost-effective joining meets difficult design requirements and restraint
- Little or no cleanup after welding – ready for N.D.T.
- Weld in areas that are not possible to reach with other processes
- Magnified optical viewing for additional weld accuracy (20-40x typical)

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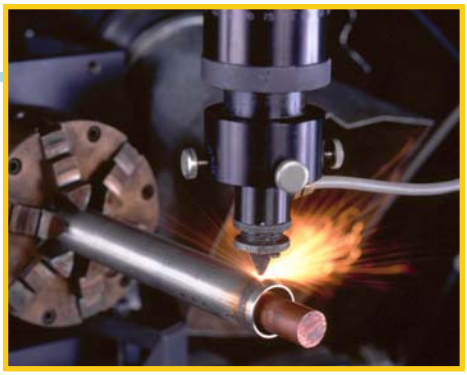
Laser Welding & Cutting



Nd: YAG laser beam welding allows for extremely narrow welds with minimal shrinkage and distortion.

What Is Laser Technology?

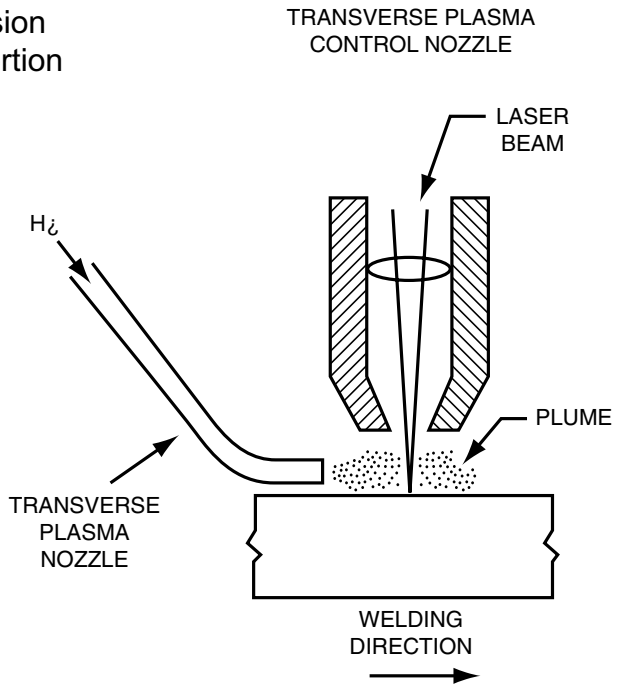
LASER is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation, a process by which the laser generates a coherent optical beam that has an essentially constant wavelength. This wavelength varies depending on the type of laser. There are many types of lasers for different processes, with varying power output capabilities. The most popular laser machines in the industry are CO_2 and Nd: Yag.

The carbon dioxide (CO_2) laser is the most powerful type of industrial laser presently available. It is in general use for contour cutting and deep penetration welding. The long wavelength of CO_2 light, 10.6um, is absorbed by most solids. This allows CO_2 lasers to process a wide variety of materials.

The most common solid-state laser in industrial application is the **N**eodymium-**D**oped **Y**ttrium-**A**luminum-**G**arnet laser, commonly referred to as the **Nd: YAG** laser. The **Nd: YAG** is used as the host crystal because it has relatively high thermal conductivity, high mechanical strength, good optical quality, and it can be grown in large sizes. Because the 1.06 um light from the **Nd: YAG** is transmitted easily through flexible quartz fibers, system design can be considerably simpler than with CO_2 Lasers. In addition, the **Nd: YAG** wavelength is absorbed more readily by metals than CO_2 laser radiation, further improving process efficiency.

Advantages of Laser Beam Welding

- The laser beam welding process produces narrow fusion and heat-affected zones, minimal shrinkage and distortion
- Weld repeatability from part to part
- By using magnifying optics for alignments, accurate placement is possible
- It is a noncontact process – the beam needs only a line-of-sight to the weld joint
- Sections as thin as .025 mm (.001") can be successfully welded
- Welds are usually made directly in atmosphere usinga shielding gas
- The laser beam is unaffected by magnetism
- No x-rays are generated by this process
- The laser beam can be time-shared among a number of workstations



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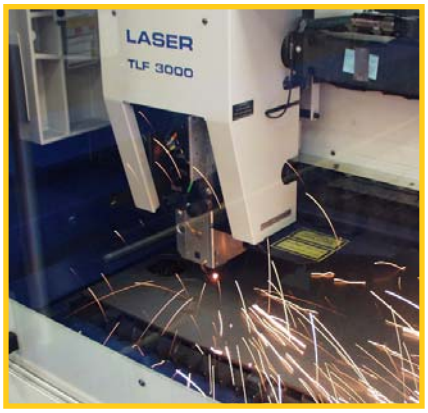
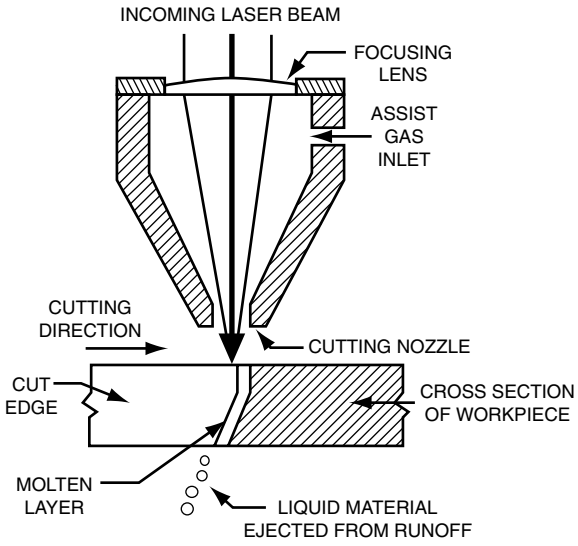


3000 Watt Turbo Laser with 4 x 8 cutting tables and dual pallet auto change for high efficiency.

Advantages of Laser Beam Cutting



- Low heat input to the work piece, hence low distortion or warping of the cut components
- Very thin (as thin as 0.025mm / .001") and flexible materials can be cut without distortion
- Cut edges are relatively smooth and approximately perpendicular to the surface and frequently need no further shaping or cleaning prior to further fabrication
- Because of narrow kerf width and heat-affected zones, patterns can be closely nested, resulting in material savings
- The process is easily automated and can be interfaced other automatic equipment
- Limited fixturing is required for many cutting jobs
- There is no tool wear as in cutting with a saw milling tool or punch press operation
- Tool changes are "soft" software changes rather then hardware changes as in the use of punches and dies, for example
- "Blind" or partial cuts can be made in some materials, particularly those with volatilized such as wood and acrylic, resulting in decoration patterns
- Difficult-to-cut materials, including very soft material, such as foam rubber, and very hard material, such as ceramics, can be cut
- Composites can be cut without tearing of edges
- There is considerably less noise than in water jet or plasma cutting

Electron Beam Drilling

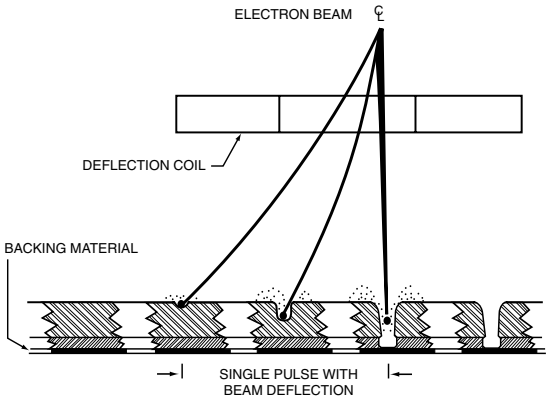
What Is Electron Beam Drilling?

Electron Beam Drilling is an innovative machining process, which drills many small holes in resistant material. This process is the best solution in specific cases. The perforation technique is simple: The highly concentrated energized electron beam instantly vaporizes the material at the point of impact. In just a few thousandths of a second, the beam forms a fine channel through the work piece.

As a machining process, Electron Beam Machining (EBM) is often mentioned along with Laser Beam Machining (LBM), Electrical Discharge Machining (EDM) and Electro Chemical Machining (ECM). These nontraditional techniques are used when the requirements exceed mechanical machining and drilling capabilities or when they have overriding cost advantages. Compared to other hole drilling techniques, the electron beam process has unique features that give it special capabilities for hole drilling over a wide range of applications. With drill speeds up to 2000 holes per second, this technology is far ahead of its competitors. In response to recent industry demands for smaller hole diameters, Acceleron continues to develop NEW processes and tools. We currently drill holes as small as 0.002” - 0.004” in small tubes down to 1/2” diameter.

Drilling .125” thick stainless steel at a rate of 120 holes per second to produce a .008” dia. hole. Spot inspection of drilled components is a critical function in maintaining accurate hole diameter criteria.

2,600,000 holes drilled in a .060” thick 316 stainless steel basket. Hole size is .004”.



Advantages of Electron Beam Drilling

- Process is a noncontact thermal “tool”
- High power density is focused into a small spot
- Critical beam parameters can be adjusted electronically at high speed
- Can produce inclined holes at various angles to the surface
- Drills on a continuously moving target to maximize drill speed
- Provides a drilling rate up to 2,000 holes per second in thin sheet metal
- Can drill material thicknesses from 0.002” to 0.200”
- Drills holes from 0.002” to 0.040” in diameter
- Is capable of an aspect ratio (depth to diameter) of 25 to 1
- Hole profiles can be taper, cylinder or bell

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FACILITIES LIST

ELECTRON BEAM WELDING MACHINES

A total of fifteen (15) electron beam machines with available power up to 25 kw.

- (4) Large chambers up to 60" x 72" x 108" with full IKE and CNC capabilities
- (8) Medium chambers 56" x 36" x 36" with circle generator and pulse beam control, 4 with full CNC capabilities
- (3) Small chambers 23" x 24" x 52" and larger, with quick pumping package and intricate hand control

** All measurements are W x H x L*

ELECTRON BEAM DRILLING MACHINES

- (2) Steigerwald multi-axis CNC controlled high-speed electron beam perforators

LASERS

- (1) CO_2 3000 watt flat sheet cutter
- (1) 1000 watt CW YAG on CNC bridge station
- (1) CO_2 1700 watt laser on CNC bridge station
- (4) Nd:YAG 400 watt lasers on multi-station indexing tables, standard and fiber optics
- (1) Nd:YAG 240 watt laser on multi-station indexing tables, standard and fiber optics
- (1) Nd:Glass laser for small components drilling and welding
- (1) 50 watt laser marker
- (1) Mechanical engraver

WELDING MISCELLANEOUS

- (5) TIG & ARC welding machines
- (6) Variable power resistance tack welding machines
- (1) Fast cycle TIG welding system
- (1) Plasma cutting system
- (1) Fully automated integrated CNC TIG welding machine and lathe

MODEL SHOP

- (3) CNC vertical milling machines
- (3) Lathes — (1) CNC
- (2) Surface grinders — (1) CNC
- (1) Hydraulic press
- (2) Band saws

CALIBRATION AND INSPECTION EQUIPMENT

- (1) Karl Storz Borescope, Techno-pack 2 12" monitor with various attachments
- (17) Stereo Zoom lens microscopes for preassembly and inspection control
- (1) Unitron 500X power microscope with photographic capabilities
- (1) Mitutoyo non-contact image measuring system to within ±.0002"
- (2) Nikon optical comparators (SPC) integrated
- (3) Helium mass spectrometers
- (10) Inspection surface plates
- Miscellaneous calipers, micrometers, height indicators, etc.

METALLURGICAL LAB EQUIPMENT CAPABILITIES

- (1) Buehler hot mounting press
- (4) Buehler polishing stations
- (2) Abrasive cut-off wheels
- (1) Low speed cut-off saw
- Full acid etching capabilities
- Nikon stereo scope with image analysis
- Rockwell hardness tester
- 50X - 1000X Olympus inverted stage metallograph capable of re-cast layer analysis, qualitative phase analysis, digital image capturing, automatic microstructural analysis

SUPPORT EQUIPMENT

- (3) Abrasive cut-off wheels
- (2) Ovens for stress relief
- (4) Ultrasonic cleaning units
- (2) Class 100 laminar flow benches
- (1) Monitored 24-hour security system
- Software: – Cad/Cam
  – Autocad 2006
  – Cimcad/Cimcam

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CUSTOMER / QA CERTIFICATIONS

PARTIAL LISTING OF CUSTOMERS REQUIRING CERTIFIED ELECTRON BEAM AND LASER PROCESSES

Anderson Greenwood Crosby (Crosby Valve,Inc.)	Class 1 Nuclear
Brush Wellman, Inc.	AlBeWeld TM Process, EMPS 02-02
CarletonTechnologies	CPS-751
BAE (Allied Bendix Corp)	
EGG Sealol, Inc. (Perkin Elmer)	
E. I. Dupont Company	
General Electric Company	P8TF3, P8TF5, P8FT8, P8FT10, S312, S422
Goodrich Aerospace (Chandler Evans)	
Government Cage Code	8V938
Hamilton Sundstrand	HS-1448, HS-1442 (HSMI & HSM2)
Hamilton Sundstrand International Space Systems	SVHS 13663, SVHS 13747, SVHS 9106
Honeywell	WBS 52, WBS 53 (Laser Weld for Space Station)
Kamatics Corporation	KCS-27
Lawrence Livermore Laboratories	
Lockheed Martin Corp.	
Lucas Aerospace	
Marotta Scientific Controls	
Moog, Inc.	
Pfizer Corporation	
Pratt & Whitney Aircraft (E.Hartford)	PWA-119, (PWA-16-2, 22, 222, 3, 33, 333, 39, 4, 6, 66, 666, 7)
(LCS certified)	Vendor Code S-38640
PWA (Canada)	(CPW24-33, 333, 66) (426-2) (CPW 24-2 TIG)
Rolls-Royce	
Smith Aerospace	
Twin Manufacturing	FAA Satellite Facility VP50283N
TYCO/U.S. Surgical	
United Technologies Research Center	
Windsor Manufacturing	
Wood Group Fuel Systems	

APPROVED MIL SPECIFICATIONS & REFERENCE LIST*

AMS-2680	Welding
AMS-2681B	Welding
ANSI/NCSL Z540-1-1994	Calibration
ARP-1317	Welding
FAR-145	FAA Manual (Acceleron/Twin Manufacturing partner in FAA repair. Twin Manufacturing is primary holder.)
MIL-STD-1595A, AWS D17.1:2000	Operator Qualification
MIL-W-8604A	Welding

** Note: Listed specifications are applicable to customers above.*

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CUSTOMER / QA CERTIFICATIONS - *continued*

NADCAP QUALIFICATIONS

Scope of Compliance – Aerospace Quality Systems

- C7004 Rev. C. – Nadcap Criteria for Inspection and Test Quality System

Scope of Accreditation – Welding

- AC7110/3 Rev. C. – Nadcap Criteria for Electron Beam Welding
- AC7110/5 Rev. C. – Nadcap Audit Criteria for Fusion Welding
- Gas Tungsten Arc Welding
- AC7110/6 Rev. C. – Nadcap Audit Criteria for Laser Welding
- AC7110 Rev. C. – Nadcap Audit Criteria for Welding / Brazing

Scope of Accreditation – Non Conventional Machining and Surface Enhancement

- AC7116 – Nadcap Audit Criteria for Nonconventional Machining (ECM, ECG, EDM, LBM)
- AC7116/4 – Nadcap Audit Criteria for Laser Beam Machining (LBM) – cutting & drilling