UNIVERSAL® LASER SYSTEMS

Laser Processing of Aearo Technologies LLC – ISOLOSS™ LS Polyurethane Foam

Key Material Outcomes – Process Improvements

- Consistent and repeatable processing with a high degree of dimensional accuracy
- Optimized kiss-cutting with adhesive transfer tapes and double coated tapes providing a very high-quality product
- Smooth laser-processed edges and minimal heat-affected zones for multiple densities and thicknesses
- No post-processing clean-up required due to gas (air) assist configuration
- No degradation to the physical properties of the materials
- Elimination of material deformation that was previously an issue with laser processing

Primary Laser Processes

- Cutting (through)
- Kiss-Cutting (to liner)
- Marking (surface modification)
- Engraving
- Vector Scribing/Scoring

Laser Processing Results

The images above represent top and bottom views of the laser processed ISOLOSS™ LS Polyurethane Foam LS-1506 and 3M™ Adhesive Transfer Tape 467MP with 3M™ Acrylic Adhesive 200MP stack-up. The sample piece demonstrates CO_2 laser cutting (outer edge), kiss-cutting (inner rectangles with top one partially pulled up), engraving (top and bottom text), as well as fiber laser surface marking (logos and DataMatrix code).

The images above represent top and bottom views of the laser processed ISOLOSS™LS Foam LS-1025. The sample piece demonstrates CO_2 laser cutting (outer edge), scribing (inner square with radius corners), engraving (top and bottom copy), and fiber laser surface marking (logo and DataMatrix code).

Material Overview

ISOLOSS™ LS Polyurethane Foams are microcellular open-cell polyurethane foams with a low compression set to maintain the components original fit, form, and function throughout the product's lifecycle. The highly shock absorbent, and flame and chemical resistant foams provide strength and longevity in extreme environments with a wide temperature range. Whether the application is for gasketing, cushioning, sealing, vibration management, or acoustics control - ISOLOSS™ LS Foams provide an all-purpose solution across many industries.

ISOLOSS™ LS Foams are available in several thicknesses and densities. Thickness ranges from 0.03” (1/32) to 0.25” (1/4). Densities (lb/ft^3) include 10lb (LS-10xxLM), 15lb (LS-15xx), 20lb (LS-20xx), and 25lb (LS-25xx). The foam comes in soft and very soft (LS-10xxLM). The foam is black and has a removeable Polycoated Kraft (PCK) 0.0065” easy release liner on the bottom.

Materials and Lasers	**Optics**
ISOLOSS™ LS Foam LS-1506 (foam only)	13X/52X
ISOLOSS™ LS Foam LS-1025LM (foam only)	4X/52X
ISOLOSS™ LS Foam LS-1006LM Foam with 3M™ 200MP 467MP and PCK Liner	13X/52X
ISOLOSS™ LS Foam LS-1506 with 3M tape 467MP and a PCK Liner	13X/52X
ISOLOSS™LS Foam LS-1525 with 3M tape 467MP and a PCK Liner	4X/52X
ISOLOSS™ LS Foam LS-2506 with 3M tape 8532 and a PCK Liner	1X*/52X
ISOLOSS™ LS Foam LS-1025LM with 3M tape 8532 and a PCK Liner	4X/52X
A 50 watt 9.3µm CO_2 laser produced the best results for material removal processes including laser cutting, kiss-cutting, engraving and vector scribing. A 50 watt 1.06µm fiber laser produced the best results for surface marking. *13X can be used for high detail engraving.	

Laser Cutting

Laser cutting of available durometers of the ISOLOSS™ LS Polyurethane Foams at thicknesses of 0.06” and 0.25” was found to be successful. Tests were performed using a range of laser power ratings from 10 watts to 150 watts at both the 9.3µm and 10.6µm CO_2 laser wavelengths. Material modification tests were also performed with this material using the 50watt 1.06µm fiber laser. From these tests it was determined that a CO_2 laser, specifically the 9.3µm wavelength, provided the best results for this process.

The 50 watt fiber laser with 1.06µm wavelength interacts only with the carbon black pigment within the polyurethane cells. This thermal interaction with the pigment causes the polyurethane to melt, resulting in the gross collapse of the microcellular structure of the polymer. Testing of this material with this process showed a result with significant thermal expansion and flowing liquid (viscous) phase urethane by-products that predominantly resealed the two cut edges. The 1.06µm wavelength is not recommended for this process.

Testing of the material with numerous CO_2 lasers showed that a 50watt laser source produced the least amount of negative thermal effects, narrowest kerf, and the most uniform cut face.

The material interaction was tested using different optical configurations, specifically using the 4X (0.005” spot size) and the 13X (0.001” spot size) power density optics. It was found that processing the thinner ISOLOSS™ LS Foam LS-1506 (0.06” thick) with the 13X configuration reduced the overall kerf width of the cut path. However, when processing the thicker ISOLOSS™ LS Foam LS-1025LM (10lb/ft^3, 0.25” thick) foam with the 13X optical configuration, the kerf created was more angular in nature (“V” shaped) with increased melt along the top surface. It was found that using the 4X optical configuration for the ISOLOSS™ LS Foam LS-1025LM foam created a uniform and parallel edge along the cut path. This behavior is due to the differences in the overall beam profile and focal tolerance of the two optical configurations.

The effect of gas assist configuration during material modification tests was investigated to determine the effect each would have on the substrate. Processing both ISOLOSS™ LS Foams LS-1506 and LS-1025LM in the coaxial gas assist configuration resulted in the ejection of liquid phase by-products to the surface of the foam along the cut path. This was observed to a greater degree when processing the thicker ISOLOSS™ LS Foam LS-1025LM. Laser cutting both material thicknesses with the lateral gas assist configuration was found to remove both the gas and liquid phase by-products.

Post process cleaning of the material is not necessary. However, some surface tackiness was observed along the cut path for both thicknesses of the material. This resolved itself within a couple of hours.

Laser Kiss-Cutting

The “kiss-cutting” process of ISOLOSS™ LS Foams is possible, provided a stack-up or laminate is created by the addition of an adhesive and release liner to the foam.

For testing purposes, two types of adhesives were applied to various foams for process development. In one configuration, the 3M™ Adhesive Transfer Tape 467MP with 3M™ Acrylic Adhesive 200MP, was applied to sheets of ISOLOSS™ LS Foams LS-1506 and LS-1025LM. The 3M tape 467MP consists of a 0.002” thick acrylate adhesive layer and a 0.0042” thick PCK (PolyCoated Kraft paper) liner. In a second configuration, the 3M™ Double Coated Tape 9832 with 3M™ Acrylic Adhesive 300MP was applied to sheets of ISOLOSS™ LS Foams LS-1025LM (10lb/ft^3, 0.25”) and LS2506 (25lb/ft^3, 0.06”). The 3M tape 9832 with 3M adhesive 300MP is a laminate composed of two 0.0023” thick layers of 3M adhesive 300MP on a 0.0005” PET carrier (core) and PCK liner.

The kiss-cutting process using the 3M tape 467MP with ISOLOSS™ LS Foams LS-1506 and LS-1025LM was found to be successful**.** Both the foam and adhesive layers were completely cut, providing complete separation from the liner when manually pulled apart. During process development it was determined that use of the lateral gas assist configuration provided a more uniformly cut channel through both the foam and adhesive layers. This configuration additionally reduced much of the piercing observed through the PCK liner as well as surface deposition.

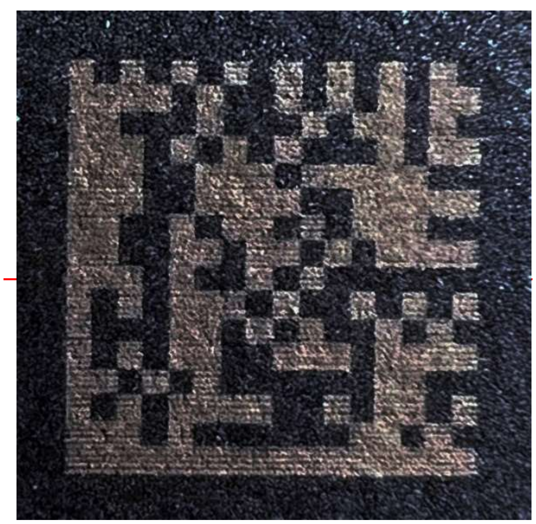
Process development of the ISOLOSS™ LS Foam LS-1506 with the 3M tape 467MP showed that 13X was the best optical configuration, producing an average kerf width of approximately 155µm (0.006”). The 4X optical configuration was found to be the best configuration for processing the ISOLOSS™ LS Foam LS-1025LM, producing an average kerf width of approximately 341µm (0.013”).

Kiss-cutting using the ISOLOSS™ LS Foam LS-1025LM and 3M tape 9832 laminate was found to be more successful using the 4X optical configuration. The wider kerf width produced in this optical configuration helped to reduce the amount of adhesive resealing as well as perforations to the liner. The kerf width was found to be approximately 178µm (0.007”). Kiss-cutting development using the ISOLOSS™ LS Foam LS-2506 and 3M tape 9832 laminate was found to be more successful when using the 1X optical configuration. The wider kerf width produced in this optical configuration, with the addition of raising the “C” axis (final focus lens) up by 0.015” from focus with the material, helped to further increase the kerf width, reducing the amount of resealing as well as perforations to the liner. The kerf width was found to be approximately 485µm (0.019”).

Feedback from a converter promoted that the ability to control kerf and to provide a wider kerf is a great advantage. A wider kerf is less likely to reseal (join back together) post-processing especially during shipping where temperature control in hot climates is not possible or practical.

Laser Marking (surface modification)

Surface modification of the ISOLOSS™ LS Foams can be performed by either a selective ablation process for the removal of a surface layer or a surface marking process. For this material, a surface marking process involves the bleaching of the carbon black pigment within the polyurethane cells at the surface of the foam. This process produces a high contrast mark without a change to the topography.



Quality Parameter	Result (Raw)	Grade
Overall Grade [custom grade]	4.00	A
Pixels Per Module	11.43	
Symbol Contrast	29.40	A
Axial Non-uniformity	0.01	A
Print Growth	0.24	A
Unused Error Correction	66.00	A
Signal to Noise Ratio	3.40	A
Horizontal Mark Growth	54.16	A
Vertical Mark Growth	49.89	A
Data Matrix Cell Width	11.34	A
Data Matrix Cell Height	11.52	A
Horizontal Mark Misplacement	948.21	A
Vertical Mark Misplacement	781.35	A
Cell Defects	31.25	A
Finder Pattern Defects	32.10	A

The image is a micrograph taken of a DataMatrix code produced using the fiber laser surface modification process. The chart to the right shows the passing results of Cognex Code Verification.

To prevent melting of the surface, the process is performed at a high rate of speed (100% raster speed on the X6000) and with a wide waveform (waveform 3 at 176kHz). The simmer power was set to 80% for this process. Marking was performed with a 50 watt 1.06µm fiber laser.

For fiber lasers, all optical configurations produce 52X because the shorter wavelength produces a very small spot size with high power density, and the beam path is fixed for fiber lasers. The fiber laser beam essentially bypasses the special optics and beam path used to modify the CO_2 (9.3µm and 10.6µm) power densities.

Laser Engraving

Laser engraving of all durometers of ISOLOSS™ LS Polyurethane Foams was found to be successful. Tests were performed using a range of laser power ratings from 10 watts to 150 watts at both the 9.3µm and 10.6µm wavelengths. Tests were also performed using the 50 watt 1.06µm fiber laser with this material. From these tests it was determined that a CO_2 laser, specifically the 50 watt 9.3µm wavelength laser provided the best results for this process. The engraving process is essentially the selective ablation of the uniformly smooth top layer of the foam to expose the underlying open cells.

Laser Vector Scribing

Laser scribing is a derivative of the vector cutting process. For the scribing process, the beam follows the vector path while selectively removing only a top layer of the substrate, exposing the underlying urethane cellular matrix. The vector scribing process was tested and found to be compatible with all ISOLOSS™ LS Foams. Tests showed that the 9.3µm CO_2 laser wavelength provided the cleanest results with reduced surface deposition and a narrow kerf.

ISOLOSS™ LS Polyurethane Foam Materials Processing Considerations

- The ISOLOSS™ LS Foams were found to absorb the 9.3µm CO_2 energy more efficiently than the common 10.6µm wavelength, producing minimal negative thermal effects.
- Marking (surface modification) without creating depth requires a 1.06µm fiber laser. If this type of marking is not required, then a fiber laser is not required.
- Power and kerf control especially for kiss-cutting is critical so laser stability, focus, and selection of appropriate power densities for focusing optics is required.
- It was observed that gas (air) assist that blows across the material instead of into it removes contamination and eliminates the need for post-process cleaning.
- Materials tend to have some curl; they typically do not lie perfectly flat.
- Materials are soft and vary in density so typical mechanical focus methods that apply pressure to the material are not suitable. Because focus is critical with these materials ultrasonic based focus is typically not suitable because of sound absorption and accuracy issues.
- Materials may come in large sizes and cutting it down to small sheets is not always practical.
- Materials are flammable so safe processing is a consideration.

Optimal Laser System Configuration

- ULTRA X6000 configured with the following:
- Patented MultiWave Hybrid™ Technology (MWH)
- 50 watt 9.3µm CO_2 Laser
- 50 watt 1.06µm Fiber Laser with 52X Power Density
- 13X Controllable Power Density Optics
- 1X Controllable Power Density Optics
- 4X Controllable Power Density Optics (standard with ULTRAs)
- Lateral Gas Assist Attachment (compressed air source is required)

- Multi-Function Table (included) and available Vacuum Booster
- Precision Material-Independent Autofocus (standard with ULTRAs)
- Class 4 Conversion Module enabling Pass-Through
- Fire Suppression

Laser System Configuration Details and Advantages:

- ULTRA X6000 – This platform provides highest accuracy beam positioning plus compatibility with other required features and accessories exclusive to ULTRAs.

- Patented MultiWave Hybrid™ Technology (MWH) – This allows multiple lasers of different wavelengths to be utilized without mechanically changing lasers or changing focus height. This keeps multiple laser processes in precise mechanical alignment and saves time.

- 9.3µm CO_2 laser – This is optimal for ISOLOSS™ LS Foams along with most polymers and elastomers and minimizes edge roughness and heat affected zone. The ISOLOSS™ LS Foams were found to absorb the 9.3µm CO_2 energy more efficiently than the 10.6µm wavelength, producing minimal negative thermal effects.

- 1.06µm Fiber Laser - This is required for surface marking without damaging the ISOLOSS™ LS Foam base material.

- 13X Controllable Power Density Optics – This provides the smallest laser spot size providing the thinnest kerf (cutting width) to allow for production of smaller parts and features especially with thin ISOLOSS™ LS Foams.

- 1X Controllable Power Density Optics – This provides the largest spot size and widest kerf (cutting width) and is especially useful for kiss-cutting ISOLOSS™ LS Foams to separate the material enough to eliminate edges from sticking together after processing and during shipment to customers. The 13X and 1X Controllable Power Density Optics are combined into one module.

- 4X Controllable Power Density Optics – These are the standard optics shipped with ULTRA systems. They are used when 13X or 1X are not required.

- Lateral Gas Assist Attachment – With ISOLOSS™ LS Foams the lateral gas assist attachment provides much cleaner results than the standard coaxial (cone) attachment. The coaxial gas assist configuration resulted in the ejection of liquid phase by-products to the surface of the foam along the cut path. This was observed to a greater degree when processing thicker material. Laser cutting with the lateral gas assist configuration was found to remove both the gas and liquid phase by-products from the material.

- Multi-Function Table and Vacuum Booster - ISOLOSS™ LS Foams tend to curl and do not lie perfectly flat. The Multi-Function Table with the negative pressure created by the Vacuum Booster keeps the material flat. Keeping the material flat during processing is critical for consistent and repeatable focusing that is critical for consistent processing results.

- Precision Material-Independent Autofocus – This utilizes a precision touch sensor that accurately measures material thickness. The light touch sensor is not affected by material transparency, reflectivity or color and functions with hard and soft materials.

- Class 4 Conversion Module enabling Pass-Through – Pass-Through operation may be a consideration. The patented Class 4 Conversion Module allows the user to, quickly and easily, convert a laser system between fully enclosed Class 1 operation and open Class 4 operation, allowing the user to place oversized objects in the laser system for laser material processing or pass continuous objects such as rolls of material or conveyor systems through the laser system. This feature, in conjunction with the Automation Interface, allows a laser system to be safely integrated into a high productivity manufacturing environment.

- Fire Suppression – This is included in the configuration because ISOLOSS™ LS Foams, adhesives, and liners are flammable. The first line of defense against the potential of sustained combustion during laser processing is an attentive operator who is always monitoring laser processing. However, as a backup, a fire suppression system can reduce or eliminate damage to expensive assets and surrounding property, thereby reducing risk and improving overall safety.

Conclusion

With the recent advances in laser technology, ISOLOSS™ LS Polyurethane Foams are very well suited for laser processing and were extensively tested to determine the optimal laser system configuration. The ULTRA X6000 with its inherent accuracy and its configurability to support the appropriate laser powers and wavelengths, optics, focusing method, gas assist, vacuum booster and other available features is ideal for laser processing these materials.

Contact us to discuss these results with ISOLOSS™ LS Foams and your specific material processing requirements.

Information on this page includes products from Aearo Technologies LLC, a 3M company.

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