

# APPENDIX B: MATERIAL SETTINGS

Fusion Galvo Suggested Material Settings (F163 Lens)			
Material	30 watt pulsed	30 watt MOPA	60 watt MOPA
<b>Aluminum (Anodized)</b>			
<b>Etching/Marking</b>	Angle: 0 / 90 Speed: 100% Power: 75% Frequency: 1% / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 60% Frequency: 1% Waveform: 10 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 35% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.0015 Cycles: 1
<p>The contrast / brightness of marks achievable on the fiber laser are excellent and can often be much brighter than marks from a CO2 laser. Taking the fiber laser out of focus by +.03" - .09" broadens the beam and produces a very bright mark on anodized coating. Lower frequency and higher power settings help offset the change in focal point. Different grades of anodized &amp; core aluminum alloy will affect how the final marks look.</p>			
<b>Aluminum (Bare)</b>			
<b>Polishing</b>	Angle: 45 / 90 Speed: 70% / 100% Power: 85% / 60% Frequency: 15% / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 50% / 40% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 45 Speed: 70% Power: 50% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.002 Cycles: 1
<p>Engraving aluminum will result in various shades of gray, not black. Fine tuning the settings can provide a bit more contrast but the range of applicable marks is very narrow. If the application calls for a black etch, consider using an oxidizer after engraving. Oxidizers are used most commonly if the aluminum has a protective coating (urethane, clear coat, clear anodized) covering the area that is not engraved. Deep metal engraving on aluminum can be done using multiple passes. Consider deep engraving and using a black epoxy/color fill. Although the marks on aluminum are not black like they are on steel, we have no difficulty getting 2D, UID barcodes to scan and verify.</p>			
<b>Laserable Plastic</b>			
<b>Black Plastic</b>	Angle: 90 / 45 / 0 Speed: 100% Power: 20% Frequency: 1% Focus: 0 Spacing: 0.0025 Cycles: 1	Angle: 90 Speed: 100% Power: 45% Frequency: 1% Waveform: 5 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 Speed: 100% Power: 40% Frequency: 1% Waveform: 5 Focus: 0 Spacing: 0.002 Cycles: 1
<b>White Plastic (Polystyrene)</b>	Angle: 90 Speed: 100% Power: 65% Frequency: 45% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 0 Speed: 100% Power: 50% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.003 Cycles: 1	Angle: 45 Speed: 100% Power: 45% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.003 Cycles: 1

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<b>Black Acrylic (White mark)</b>	n/a	Angle: 45 / 90 Speed: 100% Power: 65% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.0025 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 50% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.0025 Cycles: 1
<b>Stainless Steel</b>			
<b>Annealing</b>	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Focus: 0.175 Spacing: 0.0002 Cycles: 1	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Waveform: 15 Focus: 0.15 Spacing: 0.00015 Cycles: 1	Angle: 90 Speed: 35% Power: 100% Frequency: 1% Waveform: 6 Focus: 0.15 Spacing: 0.0001 Cycles: 1
<p><b>Etching:</b> Like our CO2 counterparts, the slower the speed setting, the deeper the etching. However, many metal applications can be processed at higher speed settings. Again, consider the marking requirements.</p> <p><b>Annealing:</b> To achieve an annealed mark, the focal point should be significantly away from zero. The unfocused, broader beam provides the heat to change the surface color without actually penetrating the metal. The focal point can be either closer to or away from zero. Focusing away from the material should be in the range of .060" to .090". Focusing closer to the material is generally in the range of -.070" to -.110". Both focusing methods will result in annealing of the metal. Focusing up typically results in a slight indentation of the metal. Multiple passes can darken the mark even more (no data to confirm whether multiple passes offer more permanency).</p> <p><b>Polishing:</b> Some steel alloys are easier to polish than others. For best results, clean off the surface with alcohol prior to processing. Any leftover grease, oils or residue can affect how well the polished mark turns out. Polishing the metal where the final marks result in a bright white engraving requires finer tuning of settings, more so than the etched or annealed marks. Determine a base speed and frequency setting and adjust the power in small increments/decrements. If you are unable to get a white bright mark, increase the frequency setting and try again by adjusting only the power.</p>			
<b>Titanium</b>			
<b>Annealing</b>	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Focus: 0.175 Spacing: 0.0002 Cycles: 1	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Waveform: 15 Focus: 0.15 Spacing: 0.00015 Cycles: 1	Angle: 90 Speed: 35% Power: 100% Frequency: 1% Waveform: 6 Focus: 0.15 Spacing: 0.0001 Cycles: 1

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<p>Titanium and Ti alloys are highly amenable to marking at this wavelength. Similar to aluminum, a black mark from the etching process is difficult to achieve. Various shades of gray can be made, from very dark gray to light gray. Annealed marks can also be made on titanium materials using the same processing parameter described for stainless steel. Depending on the Ti alloy, marks of various colors can be achieved by changing the frequency values for 1% up to 100%. It is common to see red, blue, green, orange, yellows and purple marks, depending on the frequency selected.</p>			
<b>Metals</b>			
<b>Etching/Marking</b>	Angle: 0 / 45 / 90 / 315 Speed: 25% Power: 100% Frequency: 1% Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 0 / 45 / 90 / 315 Speed: 100% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1+	Angle: 0 / 45 / 90 / 315 Speed: 50% Power: 100% Frequency: 1 Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1+
<b>Polish</b>	Angle: 45 / 90 Speed: 70% / 100% Power: 85% / 60% Frequency: 15% / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 70% Power: 85% / 70% Frequency: 15 Waveform: 15 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 0 Speed: 70% Power: 50% Frequency: 40 Waveform: 15 Focus: 0 Spacing: 0.002 Cycles: 1
<p>Metals are often plated to assist with conductivity, to provide a protective coating against rust and elements and for aesthetic purposes. Plating thickness will depend on application and purpose. Most of the plated metals processed through the applications lab are electronic components (to enhance conductivity) and various fittings (protection against environment &amp; rust). The typical plating thickness varies from .001" up to .005". Our recommended settings for general metal engraving works well for ablating through the plating; exposing the base metal. Ablating the plating will also provide high contrast. Using an oxidizer will enhance the look.</p> <p>Our recommended settings for polishing of metals are a good starting point where ablating through the plating isn't an option. This is likely the most common plated metal application as exposing the raw metal underneath will break continuity and / or expose the bare metal to rust and other elements. Note that the contrast of polishing of plated metals won't be as consistent or contrasting as a direct ablation. Multiple passes will help and end results will vary based on the metal used for plating, thickness of plating &amp; size of mark. Our recommended settings for annealing will often work for plated metals where the plating has a thicker wall and material used has high levels of carbon or metal oxides.</p>			

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Powder Coating			
<b>Etching/Marking</b>	Angle: 90 / 45 / 315 Speed: 50% / 50% / 100% Power: 100% / 100% / 50% Frequency: 1% / 1% / 25% Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 45 / 90 / 315 Speed: 50% / 100% Power: 100% / 100% / 50% Frequency: 1% Waveform: 15 / 12 / 10 Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 45 / 90 Speed: 50% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1
Two to three passes are suggested (one pass to ablate the powder coating, 2nd or 3rd pass to polish up the metal underneath). A little less power, higher frequency and less focus adjustment will be required for the 2nd or 3rd pass, depending on the base metal. The idea is to ablate then polish. An alternative to running two or more passes is to run one pass and then use a common cleaner such as Simple Green or a citric-based cleaner with short, stiff bristle brush to scrub out the residual material remaining in the mark area. If using this technique, it may be necessary to raise or lower the marking table from around 0.07" to 0.10".			
Painted Metal			
<b>Polish</b>	n/a	Angle: 0 / 45 Speed: 100% Power: 50% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 0 / 45 Speed: 100% Power: 45% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.002 Cycles: 1
Deep Metal Engraving			
	Angle: 0 / 45 / 90 / 315 Speed: 20% Power: 100% Frequency: 1% Focus: 0 Spacing: 0.0015 Cycles: 4+	Angle: 0 / 45 / 90 / 315 Speed: 50% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 4+	Angle: 0 / 45 / 90 / 315 Speed: 50% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 4+
Multiple passes. Slower speeds tend to erupt material rather than ablate. You may also enhance the edges by running 2-5 passes of the outline of the artwork at 50% Speed / 100% Power / 1% Frequency & 15 Waveform.			

- **These are only guidelines:** Brightness or darkness of a mark is a matter of personal preference and can be very dependent of the type of material being marked. As such, there is no “correct” setting. Working with the four different fiber settings becomes fairly intuitive in a very short period of time for most users. If you have a material that is not listed, try to compare it to similar materials listed and use those settings as your starting point.
- **Speed Settings:** The speed setting scale of 1% to 100% is not linear – i.e. 100% speed will not be twice as fast as 50% speed. This non-linear scale is very useful in compensating for the different factors that affect engraving time.
- **Power Settings:** The power settings are linear – i.e. 50% power is half as much as 100% power.
- **General Metal Engraving / Base Settings:** In the world of metals the grade, type, hardness and chemical composition are endless. Metal alloys are engineered for specific applications and have their own strengths and weaknesses. Metals can be engraved at just about any settings. Of course, there are many variables to consider for metal engraving. The lasers wattage, hardness of metal, desired mark (etch, polish, anneal) and the required time/contrast/depth will have to be considered when deciding on the final settings.

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- **General Annealing Settings:** Producing an annealed mark is very dependent on the material being out of focus. Run the laser at slow speed and full power then adjust the focus while the machine is running until you achieve the annealed mark you need.
- **Test your material:** If you do not achieve the results you are looking for with the recommended settings, try resending the job and start by changing only one variable at a time. Changing only one variable at a time will help to determine the correct setting for your material.
- Laser settings can sometimes be confusing because many materials can be marked over such a broad range of settings. If you have difficulty in finding the correct setting you can send a sample to the Epilog Laser Applications lab. We will determine if the material can be marked and provide appropriate setting for your laser.



- To print a copy of these settings to keep next to your laser, go to [www.epiloglaser.com/material-settings](http://www.epiloglaser.com/material-settings).

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Fusion Galvo Suggested Material Settings (F254 Lens)			
Material	30 watt pulsed	30 watt MOPA	60 watt MOPA
<b>Aluminum (Anodized)</b>			
<b>Etching/Marking</b>	Angle: 0 / 90 Speed: 100% Power: 75% Frequency: 1% / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 60% Frequency: 1% Waveform: 10 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 50% Frequency: 1% Waveform: 10 Focus: 0 Spacing: 0.002 Cycles: 1
The contrast / brightness of marks achievable on the fiber laser are excellent and can often be much brighter than marks from a CO2 laser. Taking the fiber laser out of focus by +.03" - .09" broadens the beam and produces a very bright mark on anodized coating. Lower frequency and higher power settings help offset the change in focal point. Different grades of anodized & core aluminum alloy will affect how the final marks look.			
<b>Aluminum (Bare)</b>			
<b>Polishing</b>	Angle: 45 / 90 Speed: 70% / 100% Power: 85% / 60% Frequency: 15 / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 70% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 0 / 90 Speed: 100% Power: 50% / 35% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.0015 Cycles: 1
Engraving aluminum will result in various shades of gray, not black. Fine tuning the settings can provide a bit more contrast but the range of applicable marks is very narrow. If the application calls for a black etch, consider using an oxidizer after engraving. Oxidizers are used most commonly if the aluminum has a protective coating (urethane, clear coat, clear anodized) covering the area that is not engraved. Deep metal engraving on aluminum can be done using multiple passes. Consider deep engraving and using a black epoxy/color fill. Although the marks on aluminum are not black like they are on steel, we have no difficulty getting 2D, UID barcodes to scan and verify.			
<b>Laserable Plastic</b>			
<b>Black Plastic</b>	Angle: 90 / 45 / 0 Speed: 100% Power: 20% Frequency: 1% Focus: 0 Spacing: 0.0025 Cycles: 1	Angle: 45 Speed: 100% Power: 45% Frequency: 1% Waveform: 5 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 Speed: 100% Power: 30% Frequency: 1% Waveform: 5 Focus: 0 Spacing: 0.0025 Cycles: 1
<b>White Plastic (Polystyrene)</b>	Angle: 90 Speed: 100% Power: 60% Frequency: 45% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 Speed: 100% Power: 55% Frequency: 1% Waveform: 6 Focus: 0 Spacing: 0.003 Cycles: 1	Angle: 45 Speed: 100% Power: 50% Frequency: 25% Waveform: 4 Focus: 0 Spacing: 0.003 Cycles: 1

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Material	30 watt pulsed	30 watt MOPA	60 watt MOPA
<b>Black Acrylic (White mark)</b>	n/a	Angle: 45 / 90 Speed: 100% Power: 55% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.0025 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 40% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.003 Cycles: 1
<b>Stainless Steel</b>			
<b>Annealing</b>	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Focus: 0.25 Spacing: 0.0002 Cycles: 1	Angle: 90 Speed: 35% Power: 75% Frequency: 1% Waveform: 10 Focus: 0.2 Spacing: 0.0001 Cycles: 1	Angle: 90 Speed: 35% Power: 75% Frequency: 1% Waveform: 10 Focus: 0.2 Spacing: 0.0001 Cycles: 1
<p><b>Etching:</b> Like our CO2 counterparts, the slower the speed setting, the deeper the etching. However, many metal applications can be processed at higher speed settings. Again, consider the marking requirements.</p> <p><b>Annealing:</b> To achieve an annealed mark, the focal point should be significantly away from zero. The unfocused, broader beam provides the heat to change the surface color without actually penetrating the metal. The focal point can be either closer to or away from zero. Focusing away from the material should be in the range of .060" to .090". Focusing closer to the material is generally in the range of -.070" to -.110". Both focusing methods will result in annealing of the metal. Focusing up typically results in a slight indentation of the metal. Multiple passes can darken the mark even more (no data to confirm whether multiple passes offer more permanency).</p> <p><b>Polishing:</b> Some steel alloys are easier to polish than others. For best results, clean off the surface with alcohol prior to processing. Any leftover grease, oils or residue can affect how well the polished mark turns out. Polishing the metal where the final marks result in a bright white engraving requires finer tuning of settings, more so than the etched or annealed marks. Determine a base speed and frequency setting and adjust the power in small increments/decrements. If you are unable to get a white bright mark, increase the frequency setting and try again by adjusting only the power.</p>			
<b>Titanium</b>			
<b>Annealing</b>	Angle: 90 Speed: 20% Power: 100% Frequency: 1% Focus: 0.25 Spacing: 0.0002 Cycles: 1	Angle: 90 Speed: 35% Power: 75% Frequency: 1% Waveform: 10 Focus: 0.2 Spacing: 0.0001 Cycles: 1	Angle: 90 Speed: 35% Power: 75% Frequency: 1% Waveform: 10 Focus: 0.2 Spacing: 0.0001 Cycles: 1

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<b>Metals</b>			
<b>Etching/Marking</b>	Angle: 0 / 45 / 90 / 315 Speed: 20% Power: 100% Frequency: 1% Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 0 / 45 / 90 / 315 Speed: 20% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1+	Angle: 0 / 45 / 90 Speed: 75% Power: 100% Frequency: 1 Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1+
<b>Polish</b>	Angle: 45 / 90 Speed: 70% / 100% Power: 85% / 60% Frequency: 15% / 25% Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 70% Power: 100% Frequency: 15 Waveform: 1 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 Speed: 70% Power: 50% Frequency: 15 Waveform: 15 Focus: 0 Spacing: 0.002 Cycles: 1
<p>Metals are often plated to assist with conductivity, to provide a protective coating against rust and elements and for aesthetic purposes. Plating thickness will depend on application and purpose. Most of the plated metals processed through the applications lab are electronic components (to enhance conductivity) and various fittings (protection against environment &amp; rust). The typical plating thickness varies from .001" up to .005". Our recommended settings for general metal engraving works well for ablating through the plating; exposing the base metal. Ablating the plating will also provide high contrast. Using an oxidizer will enhance the look.</p> <p>Our recommended settings for polishing of metals are a good starting point where ablating through the plating isn't an option. This is likely the most common plated metal application as exposing the raw metal underneath will break continuity and / or expose the bare metal to rust and other elements. Note that the contrast of polishing of plated metals won't be as consistent or contrasting as a direct ablation. Multiple passes will help and end results will vary based on the metal used for plating, thickness of plating &amp; size of mark. Our recommended settings for annealing will often work for plated metals where the plating has a thicker wall and material used has high levels of carbon or metal oxides.</p>			

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<b>Etching/Marking</b>	Angle: 90 / 45 / 315 Speed: 50% / 50% / 100% Power: 100% / 100% / 60% Frequency: 1% / 1% / 10% Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 45 / 90 Speed: 50% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 1	Angle: 90 / 45 / 315 Speed: 100 % Power: 100% / 45% Frequency: 1% Waveform: 15 / 7 Focus: 0 Spacing: 0.0015 Cycles: 1
Two to three passes are suggested (one pass to ablate the powder coating, 2nd or 3rd pass to polish up the metal underneath). A little less power, higher frequency and less focus adjustment will be required for the 2nd or 3rd pass, depending on the base metal. The idea is to ablate then polish. An alternative to running two or more passes is to run one pass and then use a common cleaner such as Simple Green or a citric-based cleaner with short, stiff bristle brush to scrub out the residual material remaining in the mark area. If using this technique, it may be necessary to raise or lower the marking table from around 0.07" to 0.10".			
Painted Metal			
<b>Polish</b>	n/a	Angle: 0 / 45 Speed: 100% Power: 50% Frequency: 1% Waveform: 4 Focus: 0 Spacing: 0.002 Cycles: 1	Angle: 45 / 90 Speed: 100% Power: 50% / 45% Frequency: 1% Waveform: 8 Focus: 0 Spacing: 0.002 Cycles: 1
Deep Metal Engraving			
	Angle: 0 / 45 / 90 / 315 Speed: 20% Power: 100% Frequency: 1% Focus: 0 Spacing: 0.0015 Cycles: 4+	Angle: 0 / 45 / 90 / 315 Speed: 20% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 4+	Angle: 0 / 45 / 90 / 315 Speed: 50% Power: 100% Frequency: 1% Waveform: 15 Focus: 0 Spacing: 0.0015 Cycles: 4+
Multiple passes. Slower speeds tend to erupt material rather than ablate. You may also enhance the edges by running 2-5 passes of the outline of the artwork at 50% Speed / 100% Power / 1% Frequency & 15 Waveform.			

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