Cutting Know-how

for

Amada Lasers

PRODUCTION
laser
Systems

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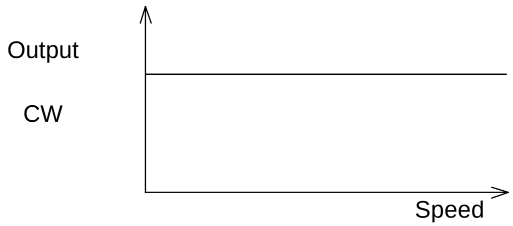
Cutting Condition Parameters and their effects on Cutting

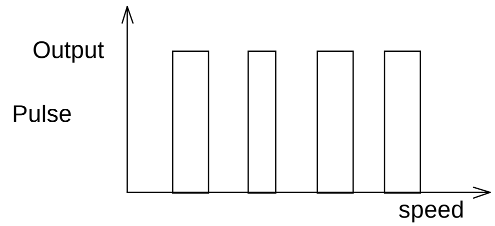
Speed

Cutting speed should be selected according to the output of the machine, that is, cutting speed will differ depending on what kind of cutting the machine is performing. For example, if you are cutting a straight line it will be high speed. On the other hand, if your are cutting small holes and performing a detail cutting, the speed will be low. (It also depends on the cutting material and thickness)

Output

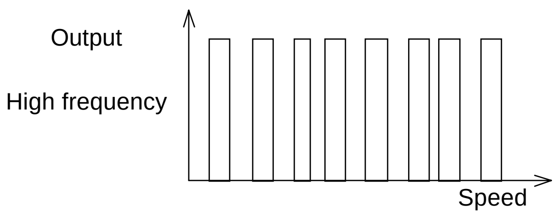
When the output is too high for the selected speed it will result in burning. If the output is too low for the selected speed it will result in gouging. It is very important that you choose the appropriate output for the selected speed. You also need to choose either CW cutting (Continuous Wave) or Pulse cutting (alternating ON/OFF) depending on the types, thickness and the shapes of materials.

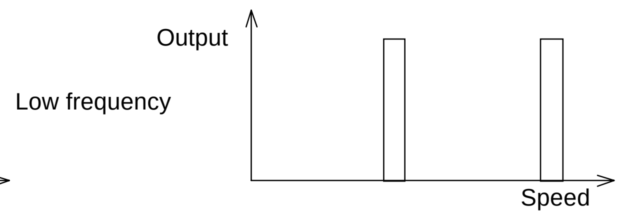




Frequency

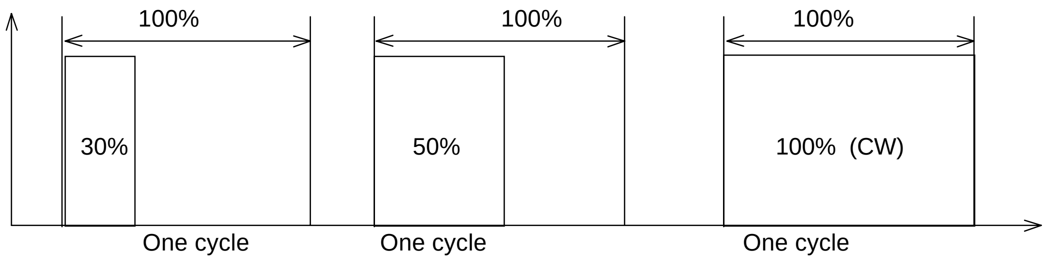
The higher frequency gives more pulses (more frequent ON/OFF alternation) to the laser beam, and thereby, gives more output energy to the cutting material. Generally, high frequency is being used for the high-speed cutting and low frequency is being used for the low speed cutting. When you have small hole cutting or detail cutting, you should use low frequency so that it won't give too much output energy to the cutting material.





Duty

Duty indicates the ON/OFF ratio of the laser beam. A higher duty number means higher ratio of ON compared to OFF, and therefore, it gives more output energy. Duty 100 means continuous ON, which is, CW (Continuous Wave) cutting.



Gas

Cutting Condition Parameters — Laser cutting generally uses oxygen, nitrogen, or air.

Oxygen Cut — Use oxygen for the assist gas. It is mainly used to cut soft materials. It utilizes oxidization to cut thick materials. It can be used to cut stainless, but it leaves oxidization film on the cutting surface.

Clean Cut — Use nitrogen for the assist gas. It is mainly used to cut stainless by non-oxidization.
High pressure (7 to 8 kgf) is generally used.

Air Cut — Use air for the assist gas. It is mainly used to cut aluminum, stainless, non-metal materials. High pressure (7 to 8 kgf) is generally used. Although it gives more oxidization film on the cutting surface, the operation cost will be much cheaper compared to clean cut (in stainless cutting)

Easy cut — Extracts the necessary components from the air for laser cutting in the environment and uses it for the assist gas.
(The operating cost is relatively low as it uses the pressured air for the Amada option assist gas)

Gas Pressure

The pressure of the assist gas. — You need to adjust the gas pressure according to the types, thickness, and shapes of the cutting material even for the same types of cutting.

Oxygen — Approximately 1 kgf for soft materials (outline), 2 kgf for small hole cutting, and 3 kgf for stainless cutting
(7 kgf for thick material) should be applied.

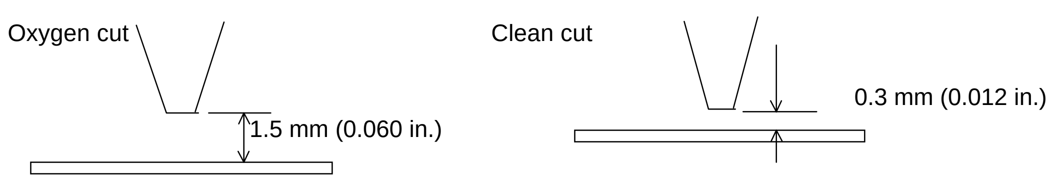
Nitrogen — 7 to 8 kgf should be applied for stainless cutting.

Air — 7 to 8 kgf should be applied for stainless and aluminum cutting .

Nozzle Gap

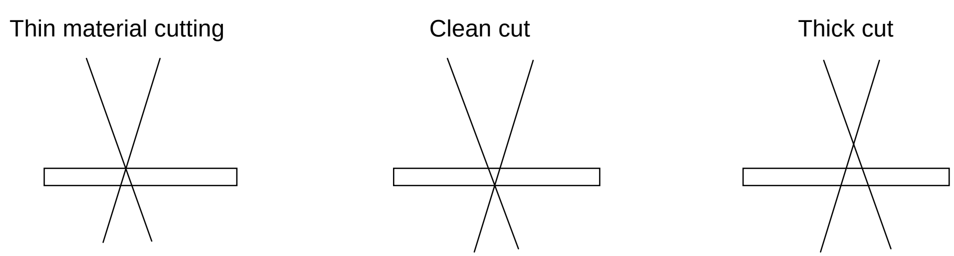
Nozzle Gap is the distance between the tip of the nozzle and the material surface.
Generally, the nozzle gap should be about 1.5 mm. However, when you are performing high-pressure assist gas (stainless or aluminum) cut, much smaller nozzle gap (0.3 to 0.5 mm) is recommended.

The smaller nozzle gap uses assist gas more efficiently.



Focus point

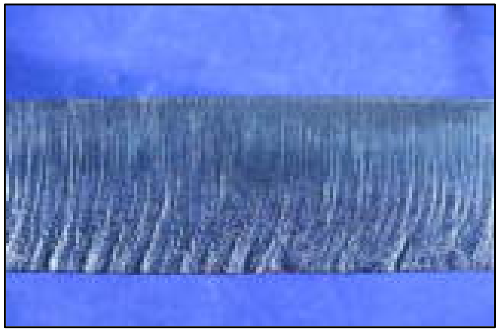
The focus point will differ depending on the types of the lens and/or the types and thickness of the cutting materials.



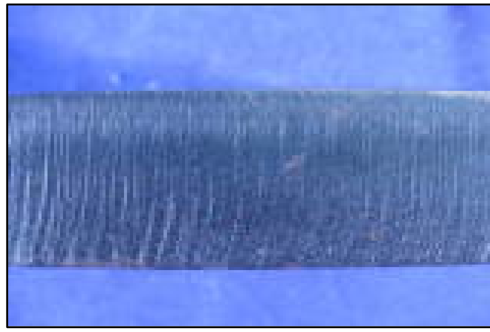
Effects of Parameters in different types of Cutting

Thick Material Cutting

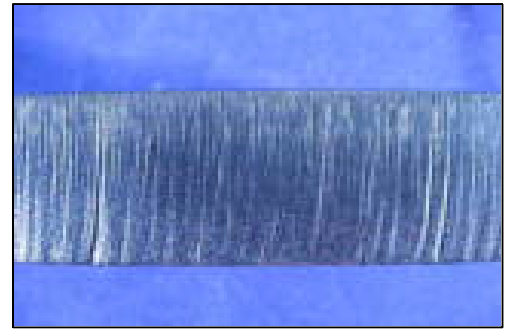
power too low



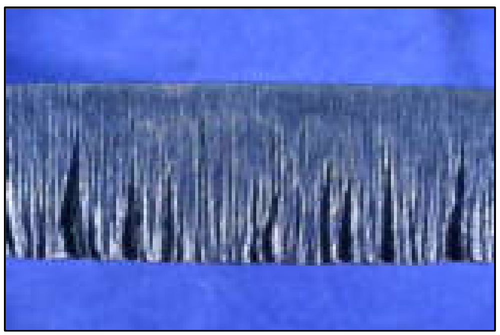
proper power



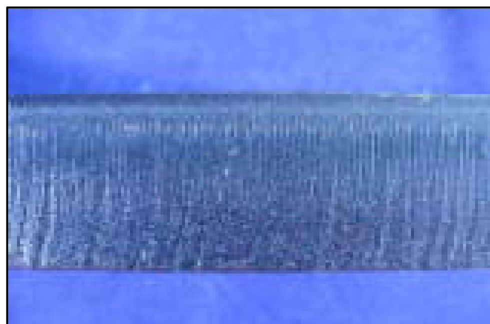
too much power



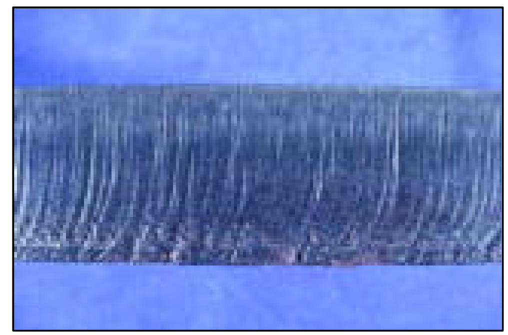
Low speed



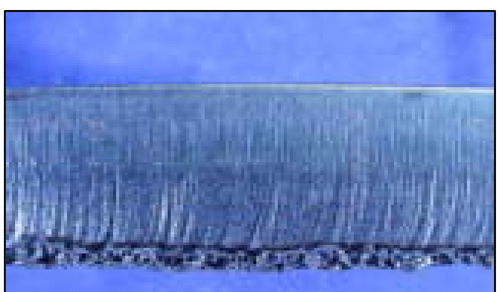
Appropriate speed



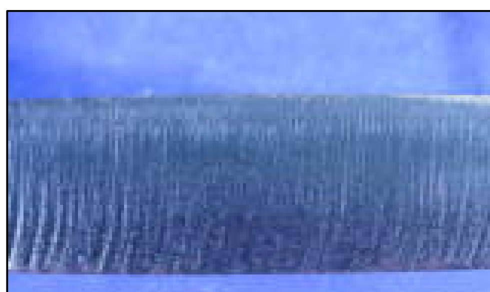
High speed



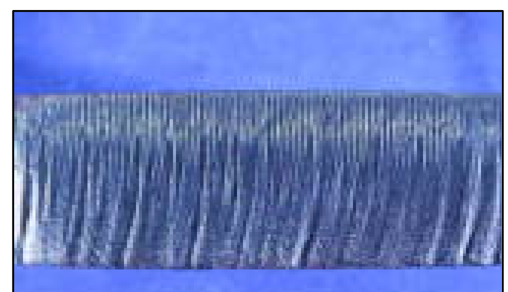
Low focus



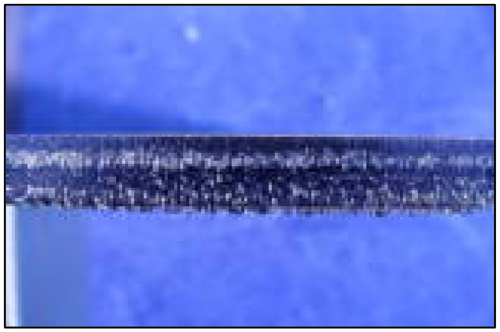
Appropriate focus



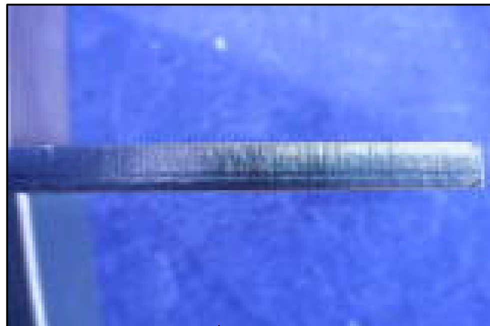
High focus



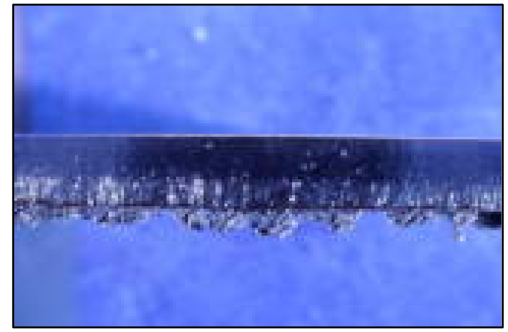
Low power



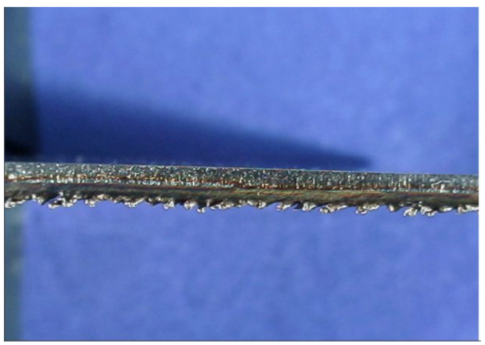
correct power



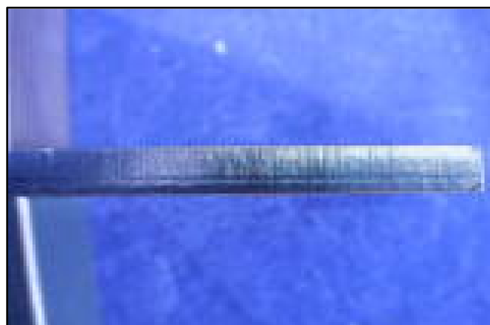
excessive power



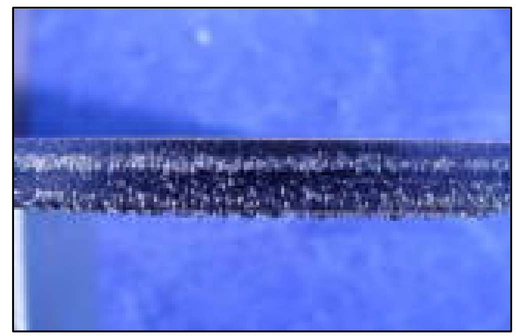
gas pressure too low



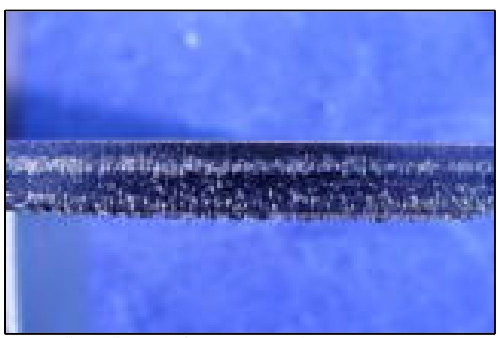
gas pressure correct



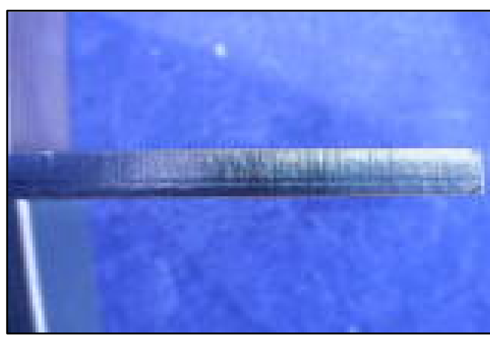
excessive gas pressure



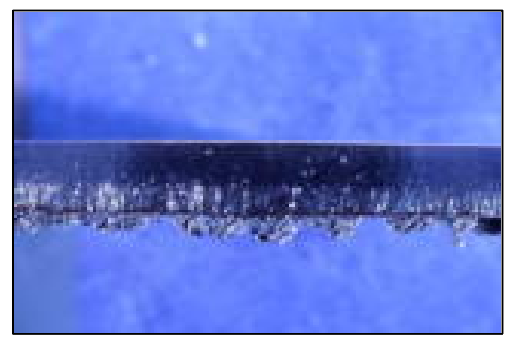
focus too low



correct focus



focus too high



How to Improve Cutting

1. Piercing Problems
2. Uneven cut
3. Melting Corners/Edges
4. Sliding, slag, burning
5. Dross
6. Cannot cut (burning, gouging)
7. Cutting is not stable
8. Cannot cut after piercing

*Please be sure to check the following before changing the cutting conditions.
Bad cut may result even if you select appropriate cutting conditions if you don't check the following.

Lens - Use the right type of lens for the thickness of the cutting material. Be sure to clean the lens before cutting.
Focus Point - Use only an appropriate focus point for the types of the cutting and the types of the cutting material.
Nozzle - Be sure to replace the nozzle if the tip of the nozzle is damaged (scratch, deformed, etc.)
Beam centering - Bad cut (dross may be left on only one surface, rough surface, etc.) may occur if the beam is not centered in the nozzle.

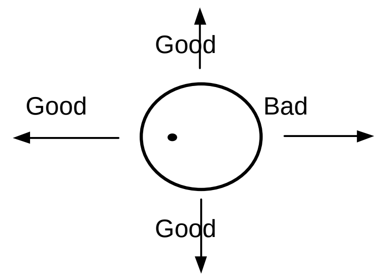
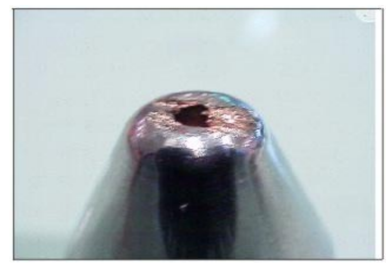
*Notes on Changing Cutting Conditions
Be sure to change cutting conditions one by one. (You won't be able to pin point the cause of the problem(s) if you change multiple conditions at a time).

I. Soft Materials Cutting

1. Piercing Problems

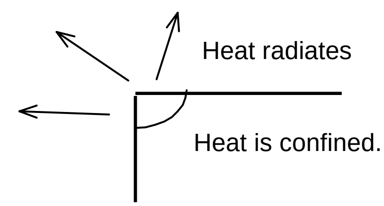
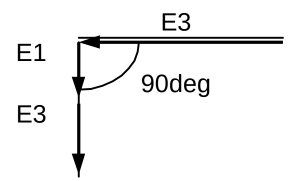
	Problem	Cause	Solution	Note
oxygen piercing'	Emit pale light and does not pierce.	Thin oxygen	Allow time to switch gas	If you change gas (from N_2 to O_2 or from Air to O_2) while you are cutting, O_2 concentration may drop due to the residual gas in the cutting head. Please make sure to perform a "gas flow" (test) before cutting, or allow some time (a few seconds) for switching gas while piercing so that the O_2 concentration will stabilize.
	Does not pierce	Not enough time for piercing	Apply longer time for piercing	Set a longer time for piercing. Measure time for an actual piercing and set the time piercing. Increase the initial output (duty) by less than 5%.
		Piercing output (duty) is too low	Increase piercing output (duty)	
		Oxidization speed is different for different cutting materials.		
	Pierced area blows up.	Not enough time for piercing.	Apply longer timer for piercing.	Set a longer time for piercing. Measure time for an actual piercing and set the time piercing.
		Piercing output (duty) is too high.	Decrease piercing output (duty).	Reduce the initial output (duty) by less than 5%.
		Piercing gas pressure is too high.	Lower piercing gas pressure.	Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf, Medium thickness material 0.1 - 0.2 kgf.
		Frequency is too high.	Lower frequency.	Lower 200Hz to 100 Hz, Lower 20Hz to 10Hz, Lower 90Hz to 50 Hz.
	Takes too long time for piercing.	Piercing output (duty) is too low.	Increase piercing output (duty).	Increase the initial output (duty) by less than 5%. Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf, Medium thickness material 0.1 - 0.2 kgf.
		Piercing gas pressure is too low.	Increase piercing gas pressure.	

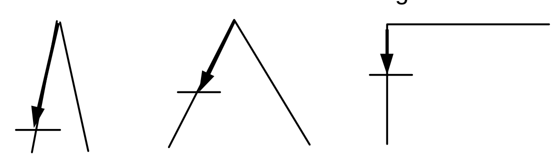
Uneven cut

	Problem	Cause	Solution	Note
Oxygen cut	Problem: The cutting surface is rough (or dross remains) only on one side or in only one cutting direction 	The nozzle is off center. The nozzle is deformed (or damaged or scratched)	Set the nozzle to the center. Replace nozzle.	If the nozzle is off center or the nozzle is deformed (or tip is damaged, deformed opening), the assist gas will not flow properly and will cause cutting as the figure below:   Handle nozzles with care as spatter can easily stick on to nozzles.

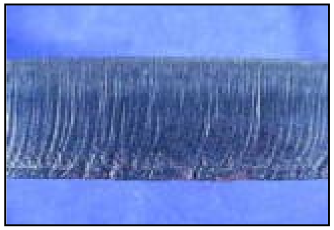
Melting Corners/Edges

<table>
<tr><th></th><th>Problem</th><th>Cause</th><th>Solution</th><th>Note</th></tr>
<tr><td rowspan="2">Oxygen cut</td><td rowspan="2">It melts corners</td><td>Speed for cutting condition is set too fast</td><td>Lower E code by one rank.

Perform the R process for 10% of the thickness of the cutting material</td><td>If you keep the same cutting condition as the condition for the straight cutting, corners may melt due to too much heat.

</td></tr>
<tr><td>Corner processing is not performed</td><td>Perform a corner processing</td><td>Be sure to use corner (Edge) control when you cut corners less than approximately 90 degree.


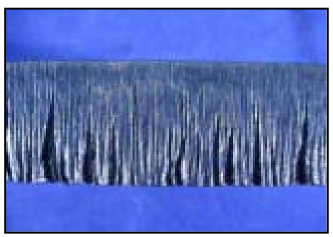
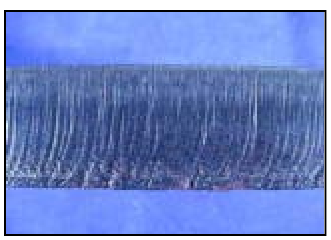
You may have to modify the return distance for the corners that have different angles.
</td></tr>
</table>

Sliding, ?????

	Problem	Cause	Solution	Note
Oxygen cut		Output (duty) is too low.	Increase output (duty).	Increase output (duty) by 10%.
		Speed is too high.	Lower speed.	Lower speed by 10%.
		Gas pressure is too low.	Increase gas pressure.	Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf, Medium thickness material 0.1 - 0.2 kgf.
		Focus too low	raise focus	raise by 0.5 mm
		Output (duty) is too low. Gas pressure is too low.	Increase output (duty). Increase gas pressure.	Increase output (duty) by 10%. Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf, Medium thickness material 0.1 - 0.2 kgf.

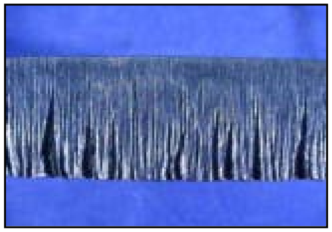
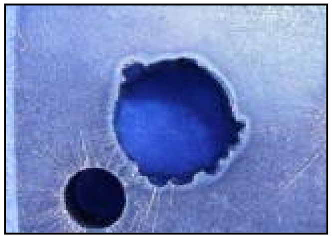
*If the Sliding (?) is too big, the cut material size will be

Dross

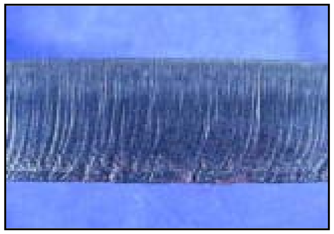
	Problem	Cause	Solution	Note
Burning	 Burning	Gas pressure is high	Lower gas pressure.	Lower gas pressure by 0.2 to 0.3 kgf.
		Speed is too low for the selected output (duty)	Lower output (duty) or increase speed.	Lower output (duty) by 10% or increase speed by 10%
	 Gouging	Output (duty) is too low.	Increase output (duty).	Increase output (duty) by 10%.
		Speed is too high for the selected output (duty).	Increase output (duty) or lower speed.	Increase output (duty) by 10% or lower speed by 10%

Cannot cut (burning, gouging)

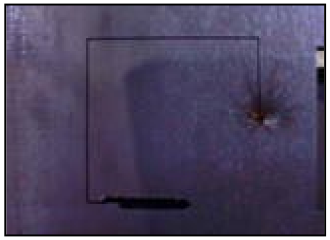
Burning

	Problem	Cause	Solution	Note
Oxygen Cut		Speed is too slow for the output (duty).	Lower output (duty) or increase speed.	Lower output (duty) by 10% or increase speed by 10%.
		Focus is off.	Correct focus.	Adjust the focus by moving it up and down by 0.5 mm.
		The gas pressure is too high.	Lower the gas pressure.	Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf. Medium thickness material 0.1 - 0.2 kgf
		The cutting condition is not appropriately set for the shape of the cutting material	Lower the E code by one rank.	It is very easy to get a burning on the holes and edges as the heat tends to be confined in the small area.

Gouging

	Problem	Cause	Solution	Note
Oxygen Cut		Speed is too high for the output (duty).	Increase output (duty) or decrease speed.	Increase output (duty) by 10% or decrease speed by 10%.
		The gas pressure is too low.	Increase the gas pressure.	Thin materials 0.5 - 1.0 kgf, Thick materials 0.1 - 0.2 kgf, Medium thickness material 0.1 - 0.2 kgf

Unstable Cutting

	Problem	Cause	Solution	Note
Oxygen cut	Cutting stops. 	Straight cut: The lens focus moved due to the lens getting hot and distorting.	Clean or replace lens.	You should clean lens before operation every day. You should replace lenses if they are too dirty.
		Corner: The output (duty) is too high for the selected speed	Increase speed or lower output (duty).	Increase speed by 10% or lower output (duty) by 10%.

Cannot cut after piercing

	Problem	Cause	Solution	Note
Oxygen cut (soft steel materials), Thick materials		Material is not set as "Thick" in the cutting data page.	Set the cutting data page "Mtrl info" to Thick". Use Approach Control.	If Mtrl info is not set for Thick, the pierced opening will be very small and the gas flow will be very little. If the gas flow is too little, the cut will tend to gouge.

II. Stainless Cutting

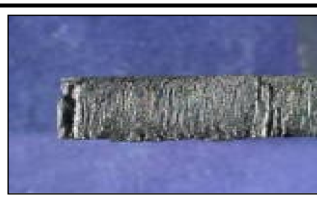
1. Piercing Problems

	Problems	Cause	Solution	Note
Nitrogen Piercing Easy Piercing	Emit pale light and does not pierce	Piercing gas pressure is too high.	Lower piercing gas pressure.	Lower piercing gas pressure for 0.2 to 0.3 kgf.
	Does not pierce.	Piercing output (duty) is too low	Increase piercing output (duty).	Increase the initial output (duty) by less than 5%.
		Not enough time is applied for piercing.	Increase piercing time.	Set a longer time for piercing. Measure time for an actual piercing and set the time piercing.
	Takes too long time for piercing.	Piercing gas pressure is too high.	Lower piercing gas pressure.	Lower gas pressure for 0.2 to 0.3 kgf.
		Piercing output (duty) is too low.	Increase piercing output (duty).	Increase the initial output (duty) by less than 5%.

2. Uneven cut

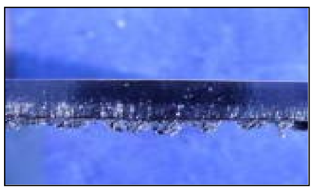
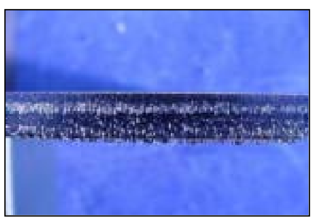
Solutions are the same as the ones for Soft Material Cutting.

3. Sliding, burning, ragged cut

	Problem	Cause	Solution	Note
Oxygen cut		Output (duty) is too high.	Lower output (duty).	Decrease output (duty) by 10%.
		Gas pressure is too low.	Increase gas pressure.	Increase gas pressure for 0.2 to 0.3 kgf.
		Speed is too high and the output (duty) is too high.	Lower speed and decrease output (duty).	Lower speed for 10% and decrease output (duty) for 10%.
		Frequency is too high.	Lower frequency.	Lower frequency by 10%.

If sliding (?) is too big, the size of the cut material will be different between the top surface and the bottom surface).

4. Dross

	Problem	Cause	Solution	Note
Oxygen Cut				Solution is the same as the one for the soft material cutting. Stainless / Oxygen cut will leave some dross or slag. You can reduce the amount of dross by applying anti-dross solution to the back of the material.
Clean Cut Easy Cut Air Cut	Big pieces of dross 	Speed is too low for the selected output (duty).	Decrease output (duty) or increase speed	Decrease output (duty) by 10% or increase speed by 10%.
		Focus point is too high.	Lower the focus point.	Lower the focus point by 0.5mm.
		Gas pressure is too low.	Increase gas pressure.	Set the gas pressure to 7 to 8 kgf.
		Diameter of the nozzle is too small.	Replace the nozzle with bigger diameter.	Replace the 2mm nozzle with a 3mm diameter nozzle.
	Small dross 	Focus point is too low.	Raise the focus point.	Raise the focus point by 0.5mm.
		Speed is too high for the selected output (duty).	Increase output (duty) or lower speed.	Increase output (duty) by 10% or lower speed by 10%.
		Diameter of the nozzle is too big.	Replace the nozzle with smaller diameter.	Replace the 3mm diameter nozzle with a 2mm diameter nozzle.

5. Cannot Cut

Gouging

	Problem	Cause	Solution	Note
		Speed is too high for the selected output (duty).	Increase output (duty) or lower speed.	Increase output (duty) by 10% or Decrease speed by 10%
		Gas pressure is too low.	Increase gas pressure.	Set gas pressure to 7 to 8 kgf.

6. Unstable Cutting

	Problem	Cause	Solution	Note
Oxygen cut	Explodes while cutting.	Output (duty) is too low for the selected speed.	Lower speed or increase output (duty).	Increase output (duty) by 10% or decrease speed by 10%.
Clean Cut	Cutting stops 	The lens focus point moves due to the lens getting hot and distorting.	Clean or replace lens.	You should clean lens before operation every day. You should replace lenses if they are too dirty. (begin cut with focus set to the bottom of acceptable operating range)

7. Can't cut after piercing

	Problem	Cause	Solution	Note
Clean cut	cut failure on lead-in plasma at lead-in	Pierce mound, Pierce whiskers Excessive gas pressure Oxidization of the piercing area	Lower output (duty) and increase time for piercing. reduce gas pressure for lead-in	Lower the initial output (duty) by 10% and make 2 to 3 seconds longer for piercing time.

III. Aluminum Cutting

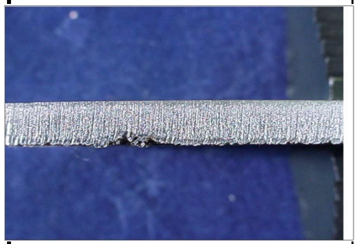
1. Piercing Problem

	Problem	Cause	Solution	Note
	Emit pale light and does not pierce.	Pierce gas pressure is too high.	Lower gas pressure.	Lower gas pressure by 0.2 to 0.3 kgf. (NOTE: the light is from a "plasma" (ionized gas), which absorbs the beam energy and blocks it from the material.
	Does not pierce.	Piercing output (duty) is too low.	Increase output (duty).	Increase the initial output (duty) by less than 5%.
		Thin oxygen	Allow time to switch gas.	If you change gas (from N_2 to O_2 or from Air to O_2) while you are cutting, O_2 concentration may drop due to the residual gas in the cutting head. Please make sure to perform a “gas flow” (check) before cutting, or allow some time (a few seconds) for switching gas while piercing so that the O_2 concentration can stabilize.
	Takes too long time to pierce.	Piercing output (duty) is too low.	Increase piercing output (duty).	Increase the initial output (duty) by less than 5%.

2. Uneven cut

Solutions are the same as the ones for Soft Material Cutting.

3. Sliding, gouging

	Problem	Cause	Solution	Note
Aluminum cut		Speed is too high.	Lower speed.	Lower speed by 10%.

*If the sliding (?) is too big, the cut material size will be different between the top surface and the bottom surface.

4. Dross

	Problem	Cause	Solution	Note
Aluminum cut				You can reduce the amount of dross by applying a plastic sheet on the back side of the material.

5. Cannot cut

Gouging

	Problem	Cause	Solution	Note
Aluminum cut	(no photo)	Speed is too high for the selected output (duty).	Increase output (duty) or lower speed.	Increase output (duty) by 10% or lower speed by 10%.
		Gas pressure is too low.	Increase gas pressure.	Set gas pressure at 7 to 8 kgf.

6. Uneven cut

	Problem	Cause	Solution	Note
Aluminum cut		Straight cut: The lens focus is moved due to the heat bending of the lens.	Clean the focus lens or replace the lens.	You should clean lens before operation every day. You should replace lenses if they are too dirty.
		Corners: failure of the gas / drag line to catch up with cut motion.	use edge control or a slower E-code	

7. Cannot cut after piercing

	Problem	Cause	Solution	Note
Aluminum cut		Pierce no hige (?) Pierce mound pierce whiskers gas flow / Oxidization of the piercing area	Lower output (duty) and allow more time for piercing. reduce gas pressure and / or feedrate for lead-in.	Lower the initial output (duty) by 10% and set a longer time for piercing. Measure time for an actual piercing and set the time piercing. Can use Oxygen for initial lead-in, to slice through debris on surface. Can raise nozzle standoff (on lead-in) to avoid sensor fault.