Hypertherm®

Recommendations for successful thick-metal piercing and cutting

For XPR™ and MAXPRO200™ plasma cutting systems

White paper

Introduction

More skill is necessary to pierce and cut thick-metal alloys with plasma than to pierce and cut thinner metal alloys. This white paper is about the methods and settings that can minimize problems typically associated with thick-metal piercing and cutting.

The methods and settings in this white paper were developed for Hypertherm XPR and MAXPRO200 cutting systems. Unless otherwise specified, for purposes of this white paper "thick metal" is a metal alloy that has a Cut Category of 4 or 5 in the XPR cut charts or that is identified as an edge-start process in the cut charts for other cutting systems. Measurements in this white paper are in U.S. customary units (inches). Metric conversions are included for reference.

The recommendations in this white paper are applicable for multiple phases of thick-metal processes — from the start of a pierce or cut to the end of a cut, including part severance.

This white paper is organized into the following two sections:

- Recommendations for successful piercing on page 2
- Recommendations for successful cutting on page 6

Incorrect methods and settings can give bad results

Incorrect methods and settings can give bad results, including the following:

- Failure to pierce through the workpiece
- Increased risk of damage to the torch and torch shield from ejecting molten metal
- Corners that have badly shaped edges, especially near the bottom of the cut
- Incomplete part severance

Using the methods and settings in this white paper can prevent or decrease the occurrence of these bad results.

This white paper includes recommendations that are related to the following methods and settings:

- Stationary pierce
- Low-transfer / arc-stretch pierce
- Moving pierce
- Double pierce
- Edge start
- Corner cutting
- Cut completion and part severance

Recommendations for successful piercing

The following methods, used alone or in combination with each other and with the recommended settings, give the best results for thick-metal piercing:

- Stationary pierce
- Low-transfer / arc-stretch pierce
- Moving pierce
- Double pierce

Stationary pierce

The stationary pierce is the simplest piercing method. With this method, the torch stays in the same position until the piercing process is complete, usually at the Pierce Height in the cut charts. The following steps give more instruction:

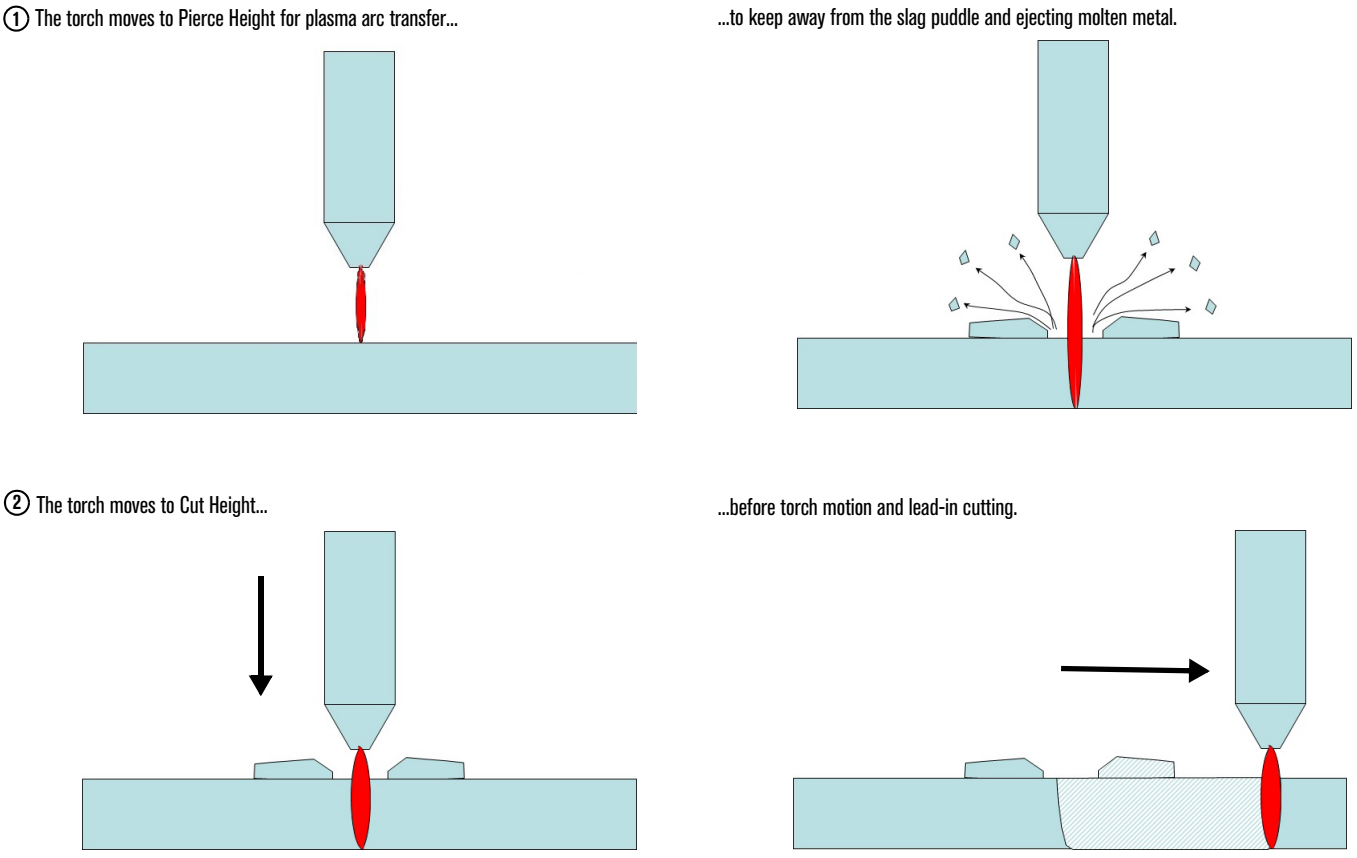
1 The torch moves to the recommended Pierce Height and the plasma arc transfers to the workpiece ①.

2 After the plasma arc pierces the workpiece, the torch moves to the recommended Cut Height ② before the start of cutting.

To keep the torch away from the slag puddle on the surface of the workpiece, the torch stays at an elevated height until it moves above and away from the slag-puddle location.

Figure 1 shows these steps in sequence.

Figure 1



Challenges of the stationary-pierce method include damage to the torch and torch shield.

Low-transfer / arc-stretch pierce

This method is for plasma cutting systems that cannot easily transfer the plasma arc to a workpiece from a larger distance. The following steps give more instruction:

1 The torch moves to the recommended Transfer Height ① and the plasma arc transfers to the workpiece.

2 After the plasma arc transfers to the workpiece, the torch moves to Pierce Height ② and piercing starts. During piercing, the torch height increases. This upward movement of the torch stretches the plasma arc and increases the distance between the torch and the workpiece.

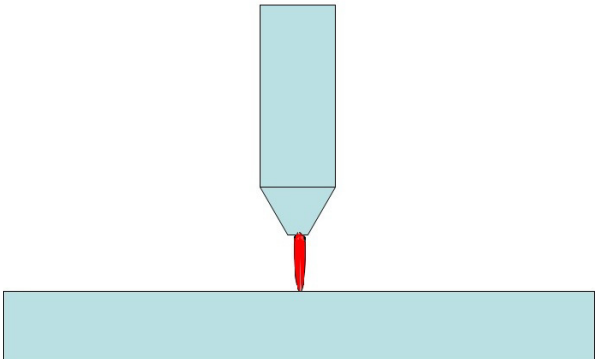
3 The torch stays at Pierce Height. This keeps the torch away from ejecting molten metal ③.

The increased distance between the torch and the workpiece keeps the torch away from ejecting molten metal.

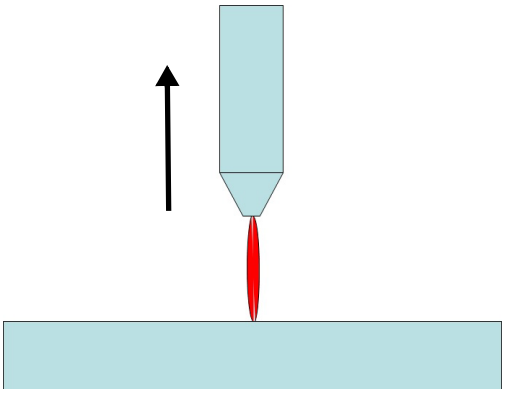
Figure 2 shows these steps in sequence.

Figure 2

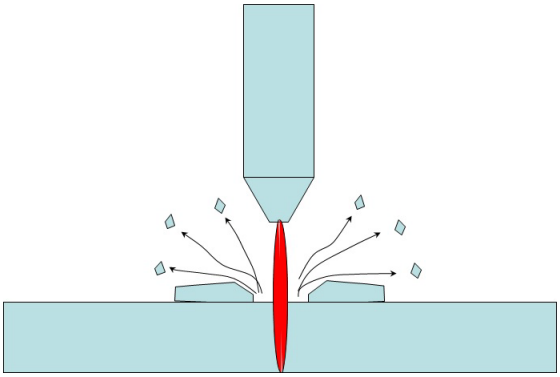
① Start with Transfer Height to transfer the plasma arc.



② Move the torch to Pierce Height.



③ Stay at Pierce Height to keep the torch away from ejecting molten metal.



A primary challenge of the low-transfer / arc-stretch method is that the elevated torch height, together with the depth of the hole, can cause voltages to increase to very high levels. This increases the risk that the plasma arc will decrease in energy and extinguish (or snap out). Although the risk for damage to the torch and torch shield is decreased with higher pierce heights, the pierce times are usually longer and not all lifters and controllers can do low-transfer / arc-stretch piercing.

Moving pierce

This method can help with the removal of molten metal. During a moving pierce, the torch is set above and away from the intended pierce location. The following steps give more instruction:

1 The plasma arc transfers to the workpiece ① and piercing starts.

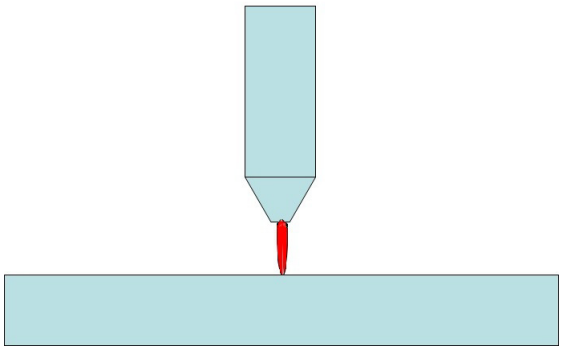
2 During piercing, the torch moves horizontally ②, which increases the depth of the plasma arc. Torch motion continues until the plasma arc pierces through the workpiece ③.

Torch movement makes a trough that moves the molten metal away from the torch, in the opposite direction of torch motion, instead of directly onto the torch.

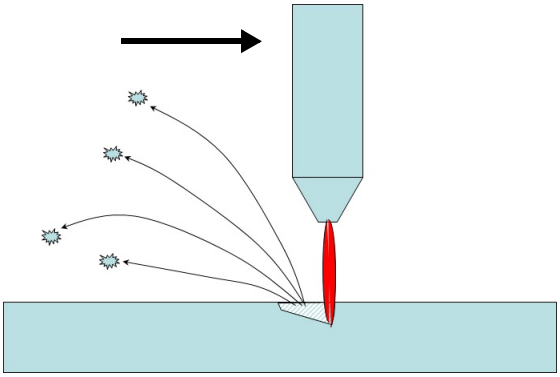
Figure 3 shows these steps in sequence.

Figure 3

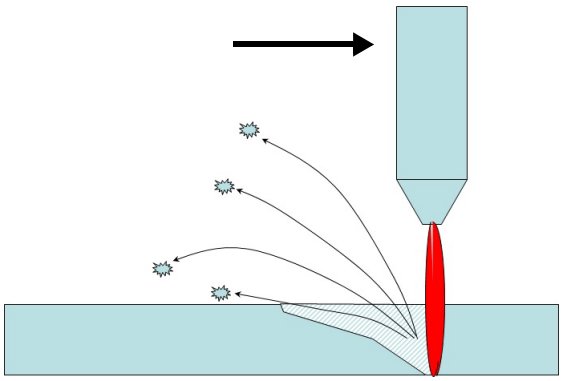
① Transfer the plasma arc to the workpiece.



② Start torch motion during piercing.



③ Continue torch motion until the plasma arc pierces through the workpiece.



The moving-pierce method requires careful monitoring. Operators who use this method must make sure that lead-in lengths are long enough for the plasma arc to fully pierce the workpiece, and look for “rooster tail” sparks that can spray off of the cutting table and potentially cause a fire.

Double pierce

This method can help with the removal of molten metal and energy transfer. The following steps give more instruction:

1 The torch moves to the Maximum Transfer Height and the plasma arc transfers to the workpiece. After plasma arc transfer, the torch moves to the recommended Pierce Height and piercing starts.

2 Piercing continues until molten metal starts to eject in the direction of the torch ①. Usually, this occurs when the plasma arc has pierced through approximately 50% of the workpiece.

3 When molten metal starts to eject, stop the plasma arc ② and remove the slag puddle from the workpiece.

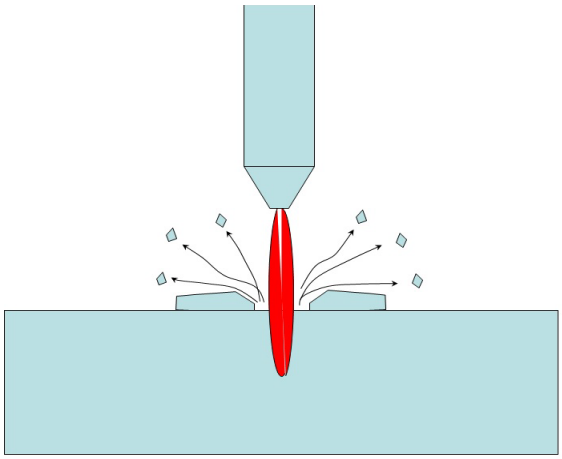
4 Move the torch near the edge of the first, partially pierced hole, as though for an edge start ③. Start piercing again ④.

Moving the torch near the edge of the partially pierced hole causes the molten metal to eject away from the torch during piercing.

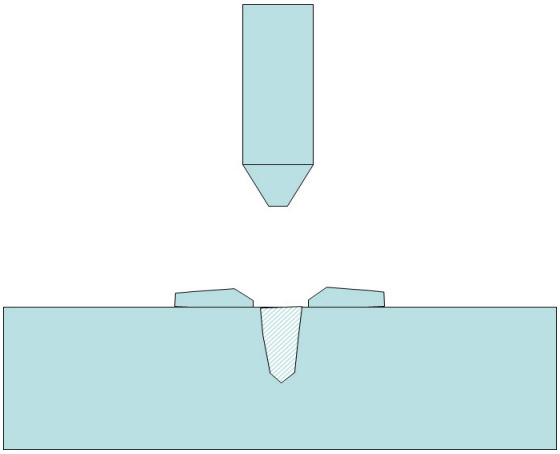
Figure 4 shows these steps in sequence.

Figure 4

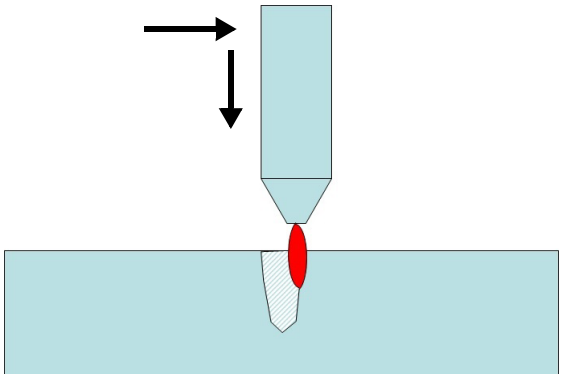
① Use Pierce Height for piercing. Continue until molten metal starts to eject.



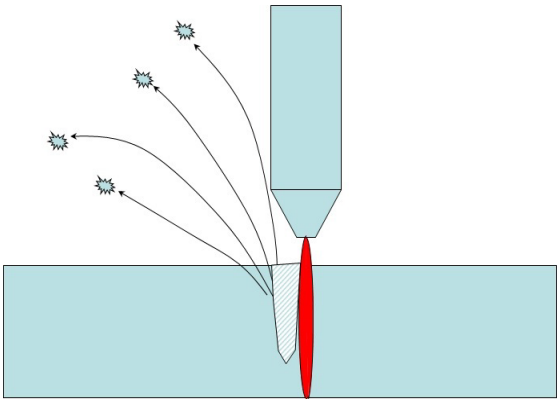
② When molten metal starts to eject, stop the plasma arc and remove the slag puddle.



③ Move the torch to the edge of the partial hole before starting to pierce again.



④ Continue piercing as molten metal ejects away from the torch.



The double-pierce method can increase the piercing capability of a cutting system. But it can also cause larger pierce holes, increased workpiece waste, and much longer piercing times.

Reference

Piercing of a metal slab by a plasma jet during plasma arc cutting, V. A. Nemchinsky, W. S. Severance, and M. S. Showalter, 1998.

The following methods, used alone or in combination with each other and with the recommended settings, give the best results for thick-metal cutting:

- Edge start
- Corner cutting
- Cut completion and part severance

Edge start

Use an edge start when the plasma process is outside of the maximum pierce capacity for the metal alloy to be cut. In general, use an edge start for a metal alloy that has a Cut Category of 4 or 5 in the XPR cut charts or that is identified as an edge-start process in the cut charts for other cutting systems.

Successful edge starts have the following conditions:

- Correct torch position
- Correct motion-delay setting
- Decreased initial (lead-in) cut speed

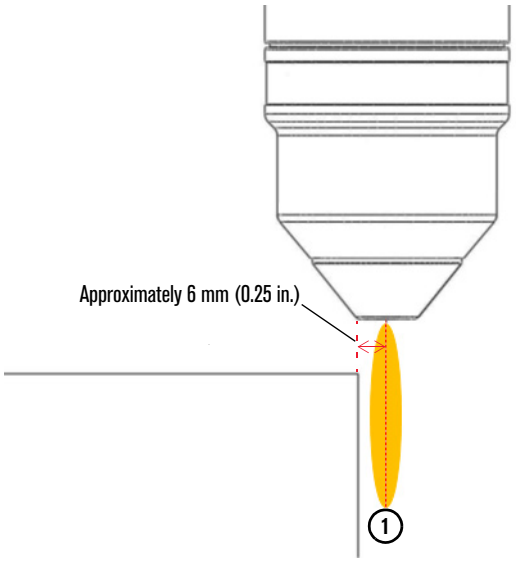
Torch position

Correct torch position is important for a successful edge start, especially on a rough workpiece edge. A good torch position lets the molten metal move down most of the workpiece edge before torch motion.

For a successful edge-start, do the following:

- Use the Cut Height settings in the cut chart.
- Make sure that the torch centerline ① is approximately 6 mm (0.25 in.) from the workpiece edge so that the face of the torch shield aligns with the workpiece edge, as shown in Figure 5.

Figure 5 – Correct torch position



Motion-delay setting

The best motion-delay setting for a successful edge-start gives the plasma arc sufficient time to melt most of the workpiece edge before torch motion.

If torch motion starts before a sufficient downward flow of the molten metal, the plasma arc does not sever the workpiece. Instead, molten metal ejects in arches of sparks that resemble a “rooster tail.”

For XPR and MAXPRO200 cutting systems, refer to the Pierce Delay column in the cut charts for the recommended motion-delay settings.

Some adjustments to motion-delay settings can be necessary, based on the process application and the type of metal alloy to be cut.

Decreased initial (lead-in) cut speed

Correct lead-in method is necessary for successful edge starts. Use a decreased initial (lead-in) cut speed for a distance of at least 1.5 to 2 times the kerf value before the start of torch motion at 100% Cut Speed. The recommended lead-in Cut Speed is 75%.

Corner cutting

Because of the extreme lag near the bottom portion of the plasma arc during thick-metal cutting, the edges of corners can lose their shape, especially near the bottom of the cut.

The following methods can keep the occurrence of badly shaped corners to a minimum:

- Rounded off corners
- Decreased cut speeds
- Delayed torch motion

Rounded off corners

Make sure that corners that have an angle of 90° or less are rounded off. In general, make sure that the corner radius is equal to or larger than the kerf value (larger is better).

Decreased cut speeds

Decrease torch motion to 75% Cut Speed as the torch comes near the corner and when the distance between the torch and the corner is approximately 1.5 to 2 times the kerf value.

Delayed torch motion

When the plasma arc is mid-corner, stop torch motion for approximately one second. This lets the bottom portion of the plasma arc “catch up” to the top.

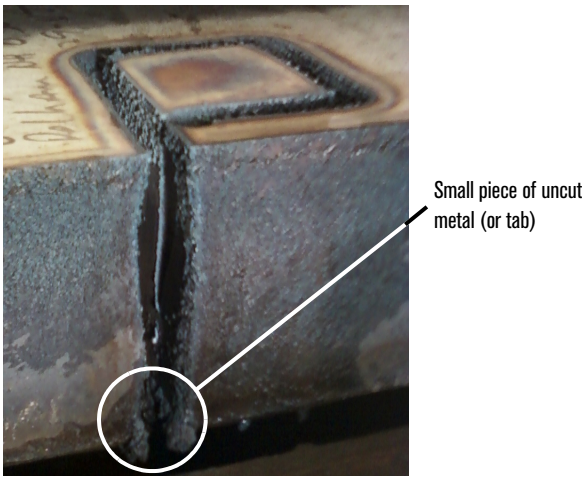
After approximately one second, start torch motion again at 75% Cut Speed. Continue at 75% Cut Speed through the corner and for a distance of approximately 1.5 to 2 times the kerf values after the corner exit.

Cut completion and part severance

Correct lead-out method is necessary for successful cut completion and part severance, especially for a metal alloy that has a Cut Category of 4 or 5 in the XPR cut charts or that is identified as an edge-start process in the cut charts for other cutting systems.

When cutting across a kerf during thick-metal cutting, the plasma arc can move away (or jump) to the other side of the kerf before cutting is completed. This type of movement can leave a small piece of uncut metal at the bottom of the cut, as shown in Figure 6.

Figure 6 – Example of a small piece of uncut metal (or tab) that prevents part severance



A jumping plasma arc stops cutting, which can cause a small piece of uncut metal (or tab) to stay attached to the workpiece. Tab attachment can prevent part severance from the workpiece, as shown in Figure 7.

Figure 7 – Example of an HPRXD plasma arc that moves away (or jumps) from the workpiece edge



The bad effects of a jumping plasma arc can be kept to a minimum by using a decreased cut speed, which is effective for all thick-metal alloys.

When cut completion or part severance is not easy because of tab attachment, use 75% Cut Speed for the last 12 mm – 25 mm (0.50 in. – 1 in.) of cutting. **For this method to give a satisfactory result, the cutting table motion must continue through the workpiece edge.**

Find additional information at www.hypertherm.com

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