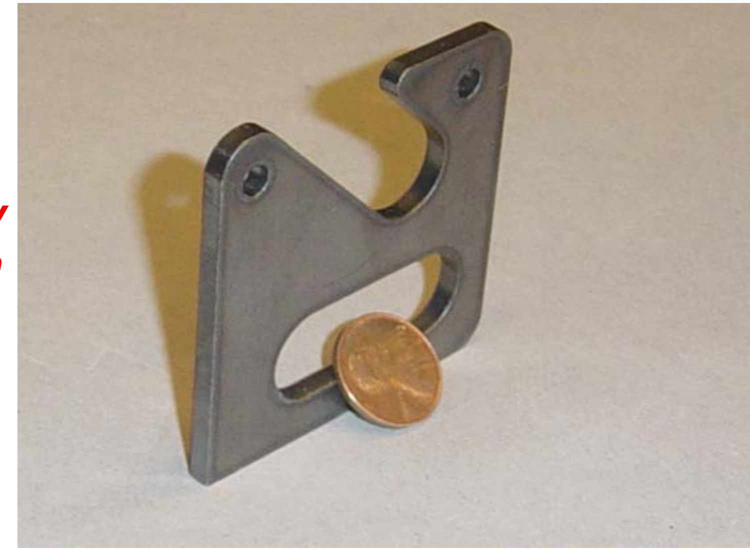
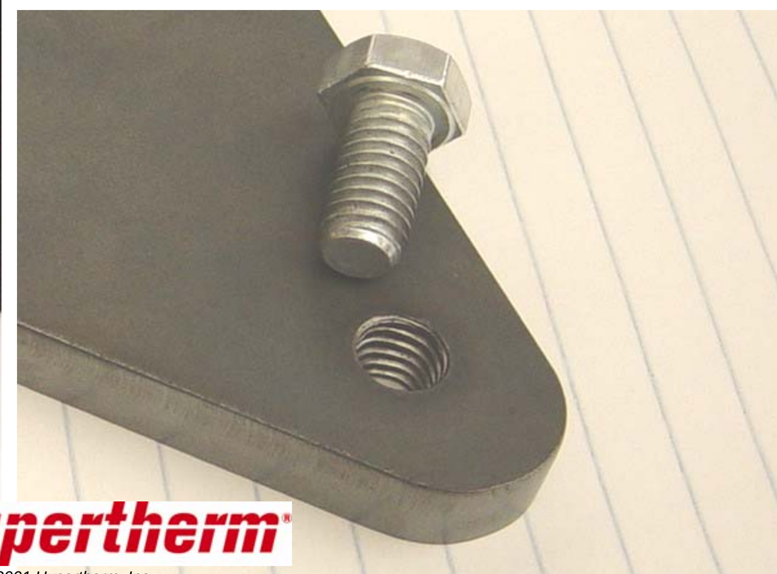
# *Techniques to improve small hole cut quality on carbon steel with a CNC Plasma system*


Presented by Jim Colt Hypertherm Inc.

# Carbon Steel….Hole quality

***This presentation provides suggestions that can improve plasma cut hole quality. All cuts in these photo's were produced with Hypertherm Plasma systems using oxygen and Hypertherm's Long-Life, HyPerformance and HySpeed technologies. Hole quality improvements can be achieved with any plasma system by utilizing these techniques.***





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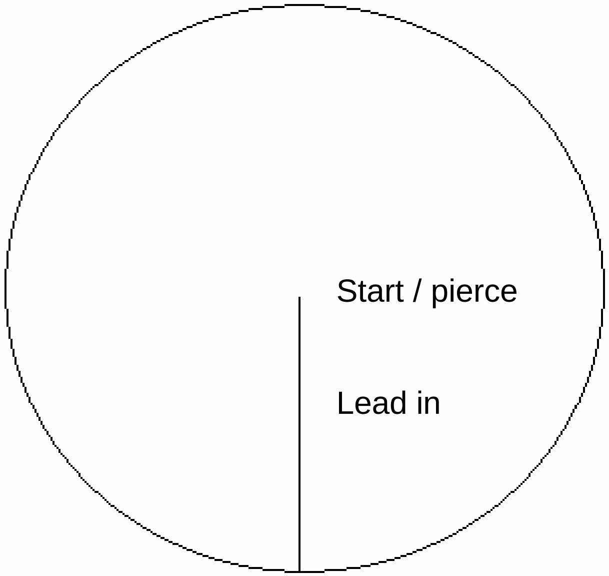
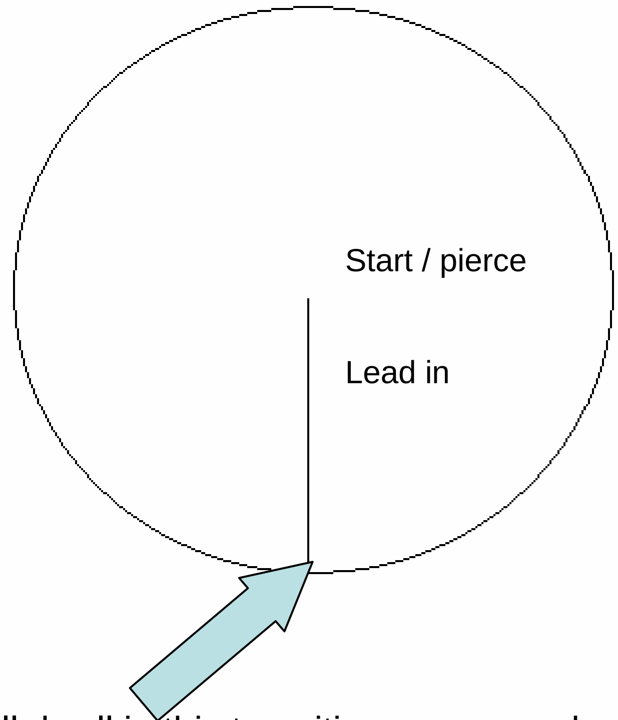
# Best Practice to produce good plasma cut holes




- **Ensure that cutting machine has tight mechanical design with minimal backlash**
- **Ensure that machine has excellent acceleration and de-acceleration characteristics**
- **Tune up motion parameters to allow the best acceleration, de-acceleration without compromising the machines ability to stay on path**
- **Ensure that the torch height control gets to the proper cut height before the lead in is complete, and maintains that cut height throughout the hole.**

# Best Practice to produce good plasma cut holes




- Machines with poor acceleration will dwell in this transition area…producing a wider kerf which distorts the hole. On larger holes, this effect is less noticeable, but still present.
- Machines with mechanical backlash will overshoot in this transition, creating a similar effect. (If machine has mechanical backlash it may be best to use a radial lead in.)
- Transition from lead in to cut path is difficult…..the machine has to make a 90 degree turn and accelerate to programmed cutting speed, while maintaining the correct torch to workpiece distance.

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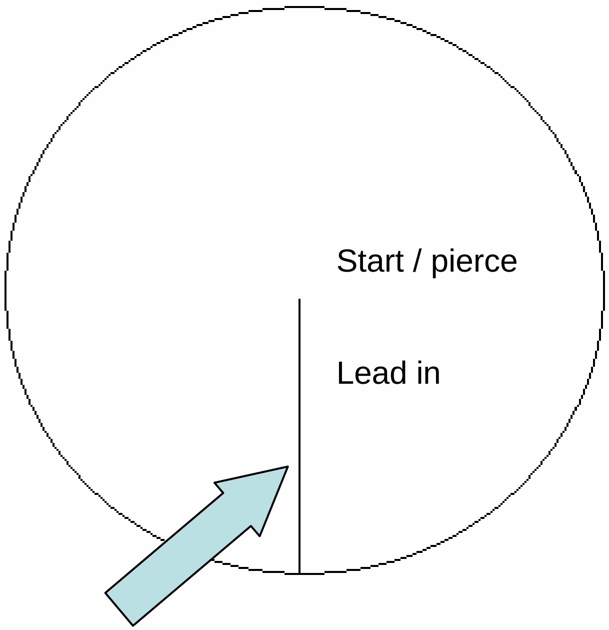
# Best Practice to produce good plasma cut holes




• For cutting machines with excellent motion (acceleration, minimal following error, and smoothness) a straight lead in will produce the best results.

• Ensure that the lead in and pierce delay times are adequately long to allow the torch height control to index from pierce height to cutting height before exiting lead in and starting on the cut path

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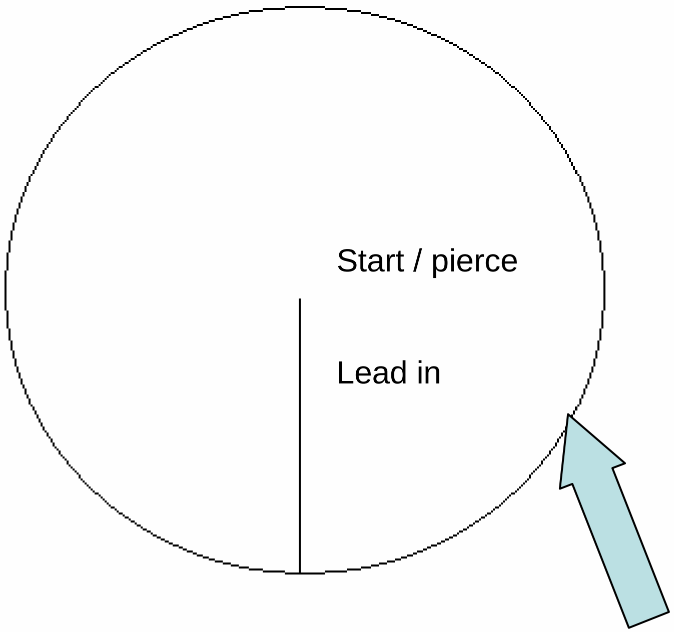


• To minimize taper in a hole…Experiment with cutting the hole at slower than recommended speed…..this allows the lag angle of the arc to straighten, minimizing taper. A good rule of thumb is to cut holes less than 1” diameter at approximately 60% of the recommended cutting speed. (this will vary depending on the material thickness, and the type and power level of the plasma system.

- Cautions: slower speed tends to produce low speed dross. This type of dross is extremely easy to remove, and often is acceptable if the hole quality is improved.
- Slower speed may affect the torch to work distance…with many machines it is best to allow the height to index from pierce to cut height, then freeze the height for the remainder of the hole.

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## Rule of Thumb

"Generally, holes under 1" diameter should be cut at slower speeds to minimize taper"

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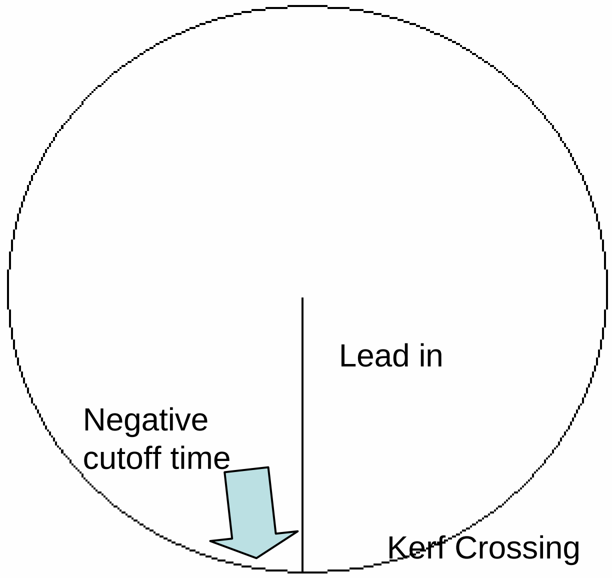
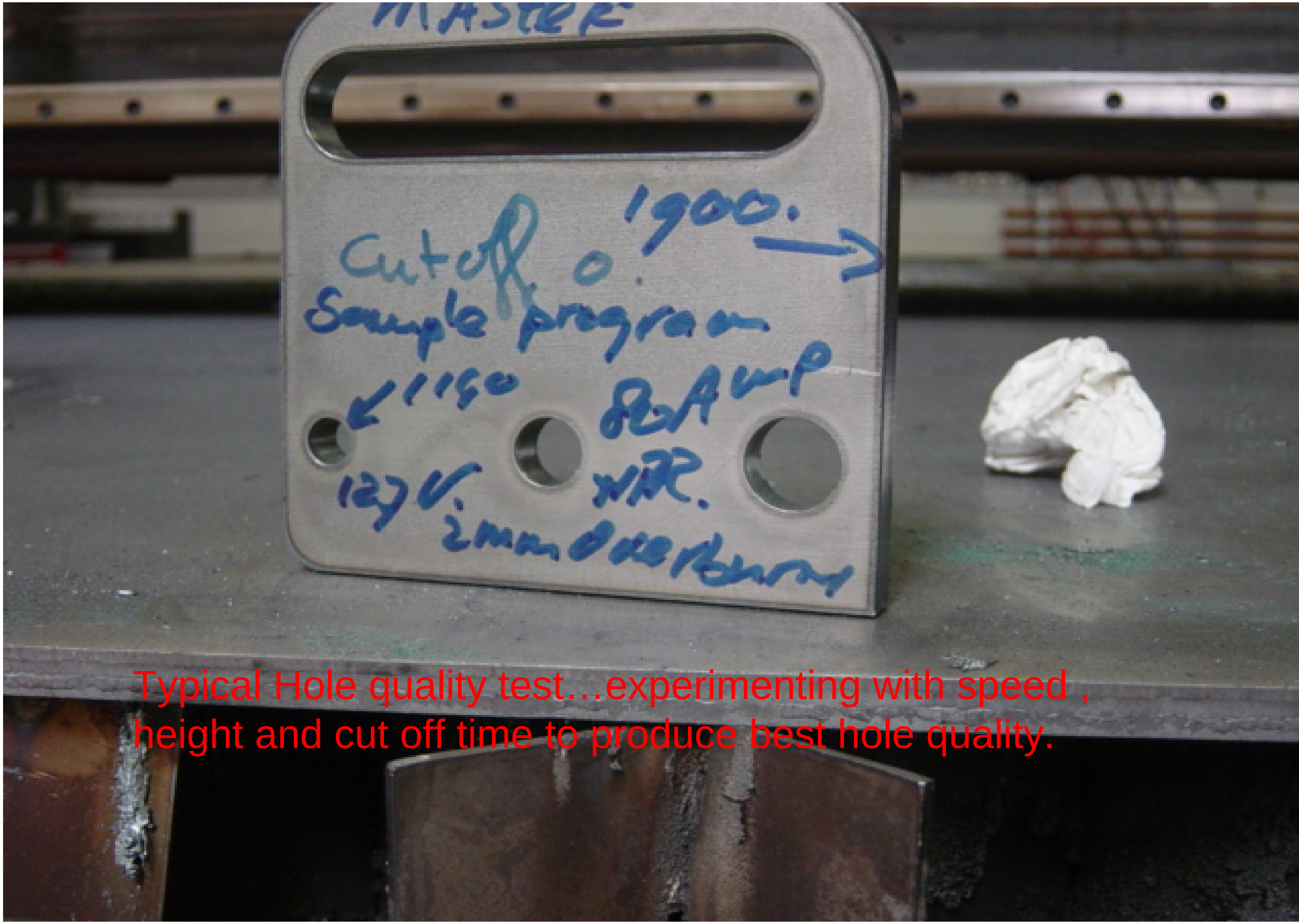
# Best Practice to produce good plasma cut holes




**Kerf Crossing Point…..The most critical component of good hole quality!**

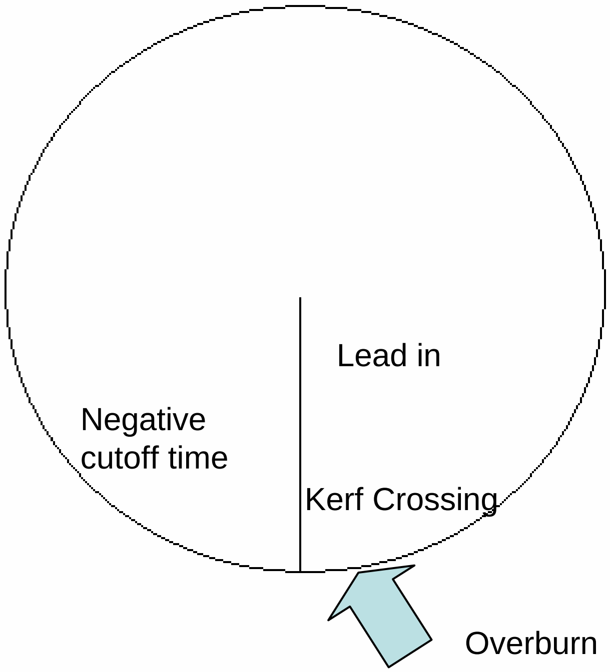
- With plasma systems that incorporate current ramp down at the end of every cut cycle (Hypertherm Long-Life systems including HyDefinition, HyPerformance, HT2000, HT4400) will produce superior holes if the plasma off command is issued before crossing the kerf. Some CNC controllers have a function known as “cut-off” time that allows the plasma to start it’s current rampdown before the end of the part program…allowing full rampdown before the motion stops.

- Some experimentation may be required…ideally the center slug should drop at the same moment that the arc extinguishes…..this produces minimal distortion on the hole, while producing the best possible consumable life for the plasma system.




Typical Hole quality test…experimenting with speed , height and cut off time to produce best hole quality.

# Best Practice to produce good plasma cut holes




• Overburn is a function that extends the radius of a hole beyond 360 degrees…allowing the cut to continue past the kerf crossing and the plasma system rampdown..as opposed to attempting the critical timing of trying to have the arc extinguish at exactly the same moment that the slug drops. This produces hole excellent hole quality, long consumable life and doesn't require critcal timing.

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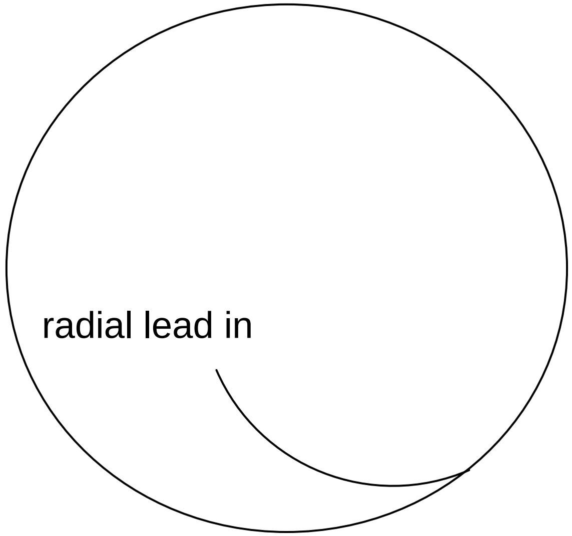
# Best Practice to produce good plasma cut holes

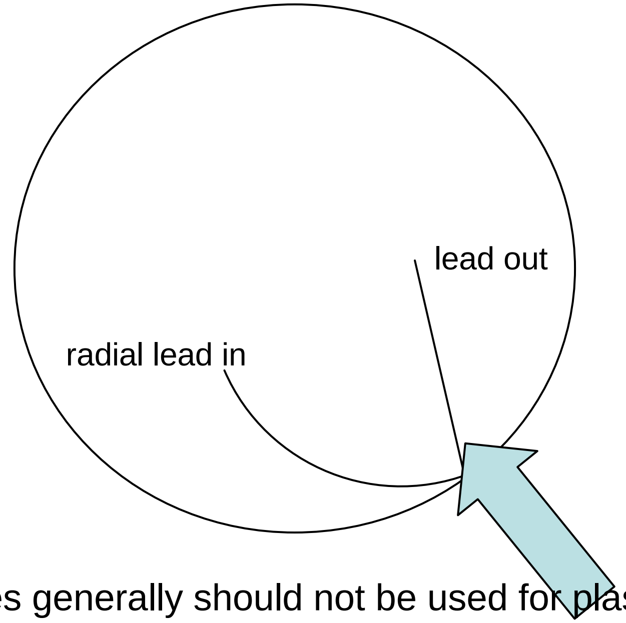



**Radial Lead in…..can produce an internal bump at the kerf crossing point!**

• On a tight machine with good motion characteristics…the common radial lead in can create an internal bump near the end of the cut at the kerf crossing point. This is because the arc gets pulled into the kerf when approaching the lead in at the kerf crossing. With a straight, 90 degree lead in….the arc crosses the kerf with much better stability….minimizing the effect to the edge of the hole.

• On machines that have mechanical backlash, or poor acceleration, the radial lead in may produce better hole quality than a straight lead in.

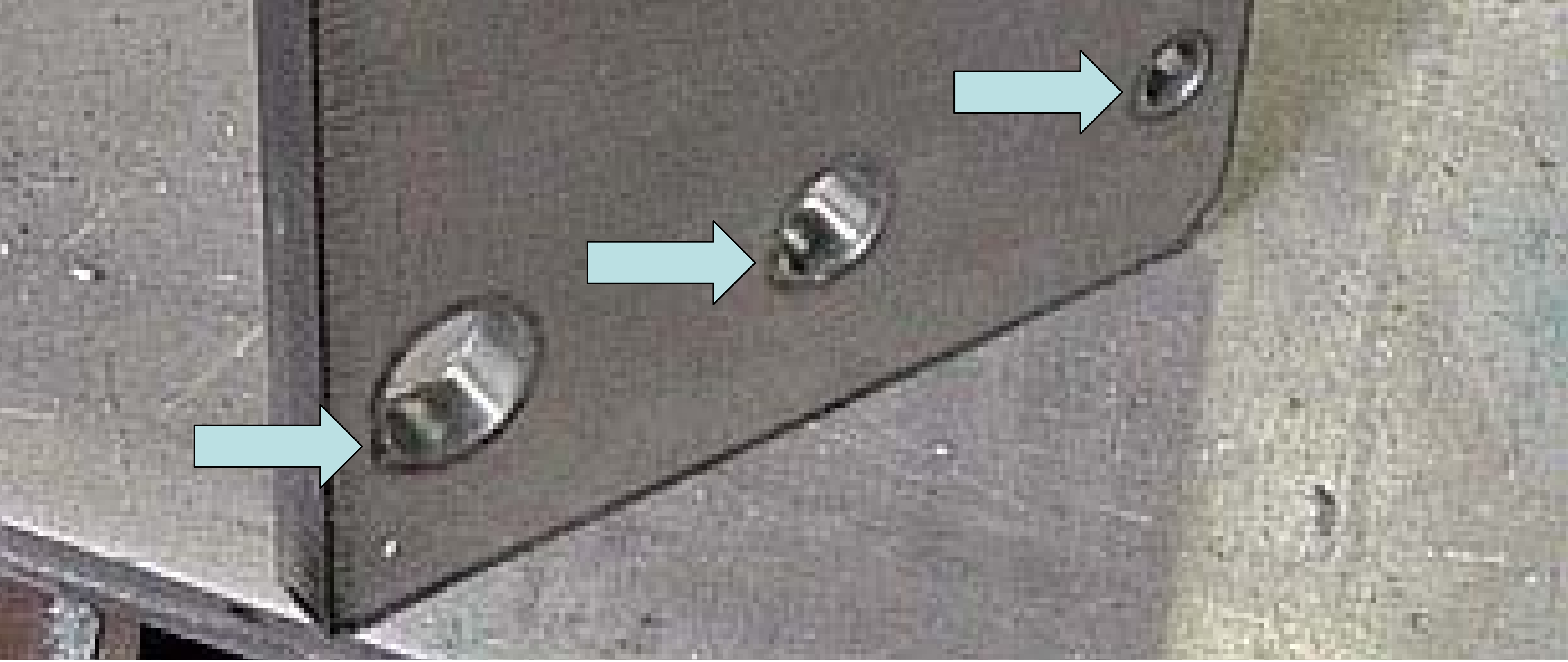
# Best Practice to produce good plasma cut holes




• Lead outs for holes generally should not be used for plasma cutting as they cause the plasma arc to instantly extinguish as soon as the slug drops from the hole. This disallows the end of cut ramp down that maximizes consumable life in many modern plasma systems.

• A lead out can also cause the arc to transfer to the part as soon as the slug drops….creating a divot on the edge of the hole.

• It is preferable to use a negative cut off time to critically time the arc rampdown to be complete at the moment the slug drops. If use of the cutoff time function is not available, then a programmed overburn usually produces adequate results.



## Indication of improper negative cutoff time……or using a lead out on holes!

The arrows indicate a small arc spot on the bottom of a plate that either had a lead out programmed…..or had improper negative cut off time programmed.

• The arc mark is caused by the plasma arc transferring to the metal on the outer edge of the hole after the slug drops.

• If a negative cutoff time is used that accurately extiguishes the arc at the moment the slug drops, this arc burn can be eliminated.

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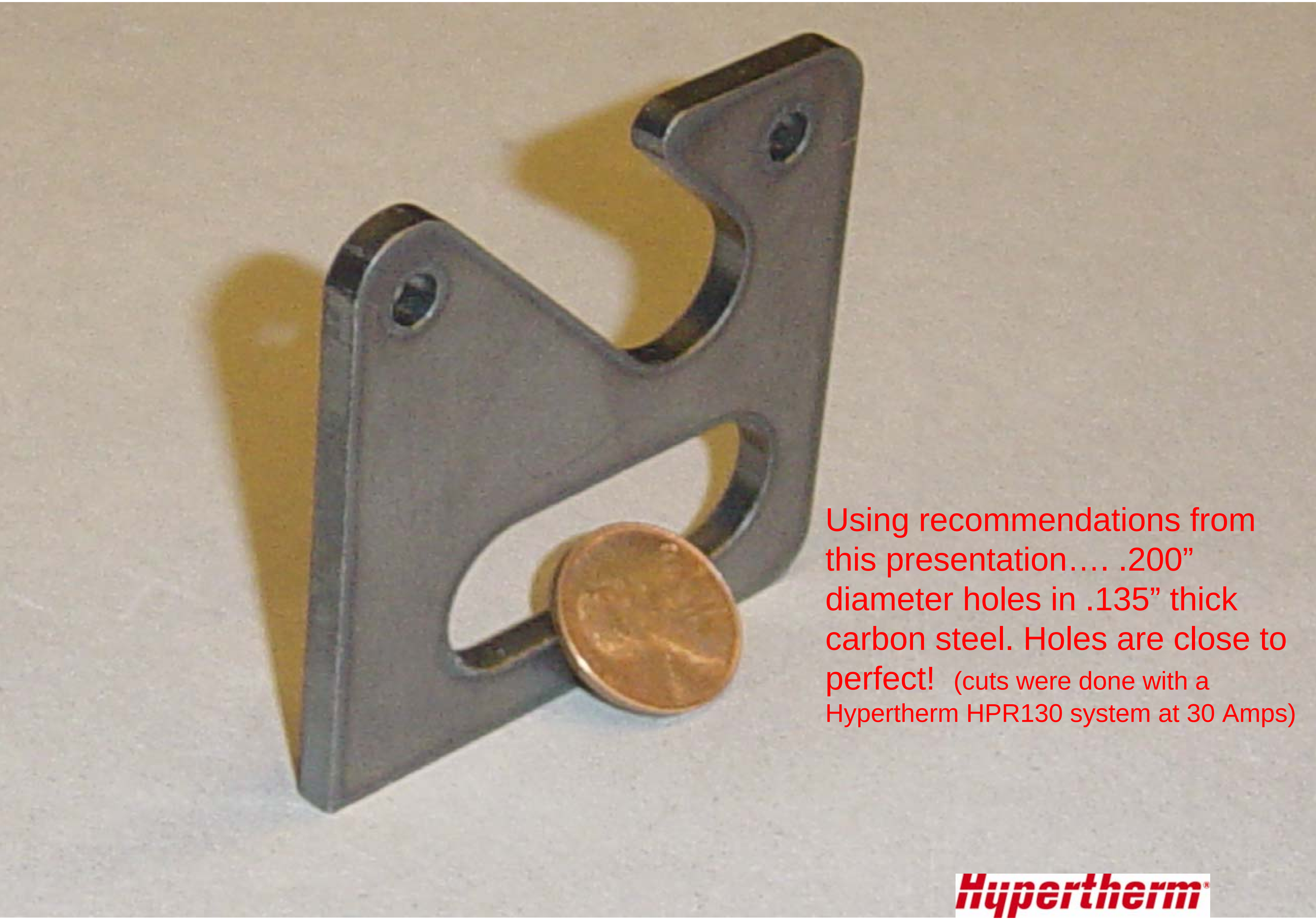

Using recommendations from this presentation…. .200" diameter holes in .135" thick carbon steel. Holes are close to perfect! (cuts were done with a Hypertherm HPR130 system at 30 Amps)

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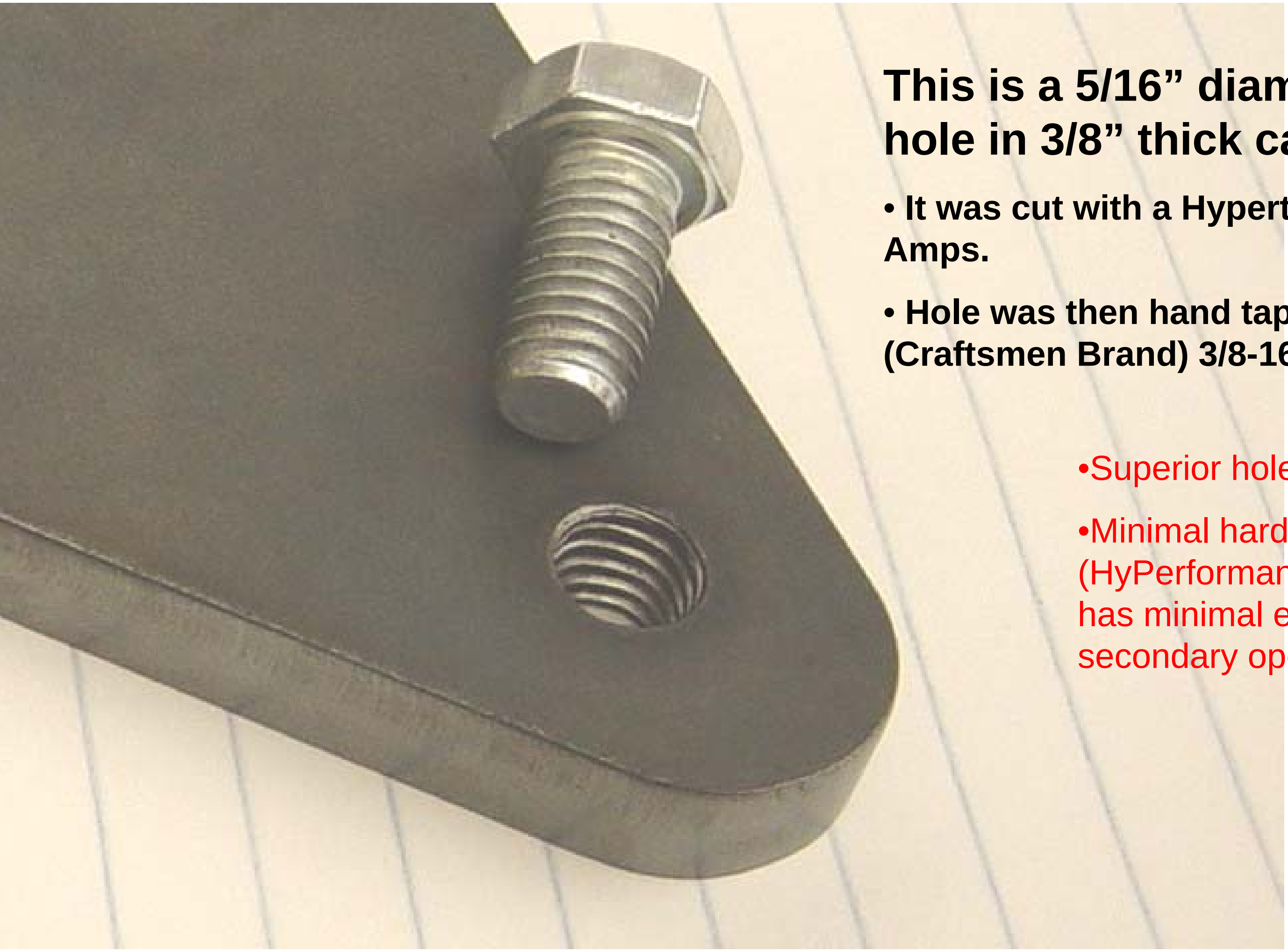

**This is a 5/16” diameter plasma cut hole in 3/8” thick carbon steel plate!**

- **It was cut with a Hypertherm HPR130 at 80 Amps.**
- **Hole was then hand tapped with a standard (Craftsmen Brand) 3/8-16 tap.**

•Superior hole quality

•Minimal hardening of the material (HyPerformance oxygen cutting process) has minimal effect on tool wear for secondary operations.

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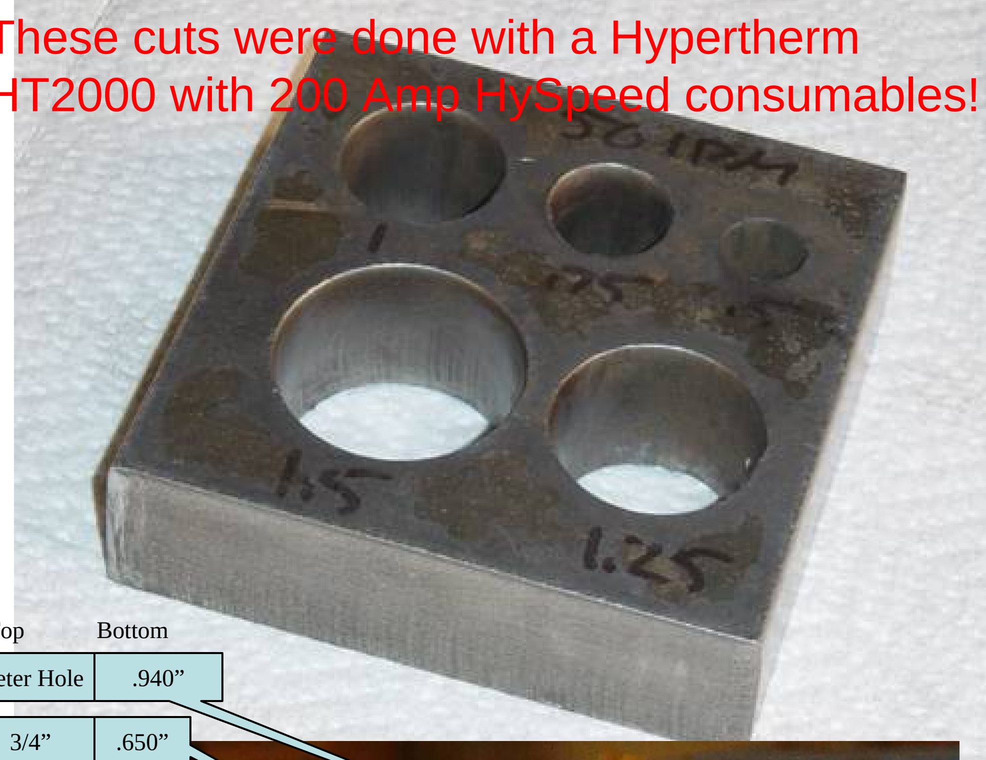
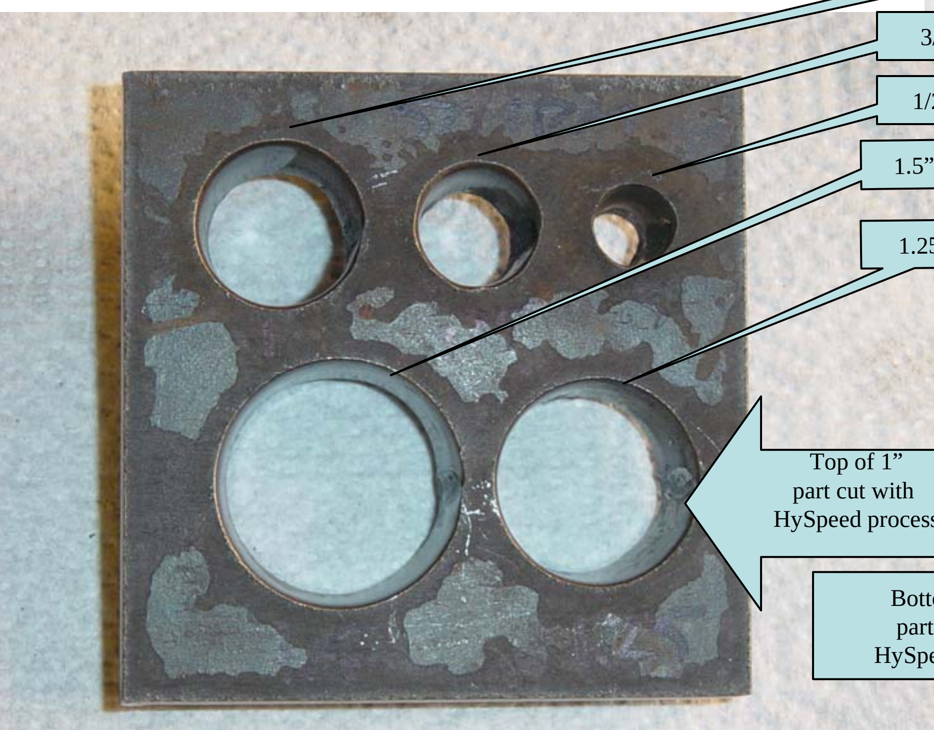
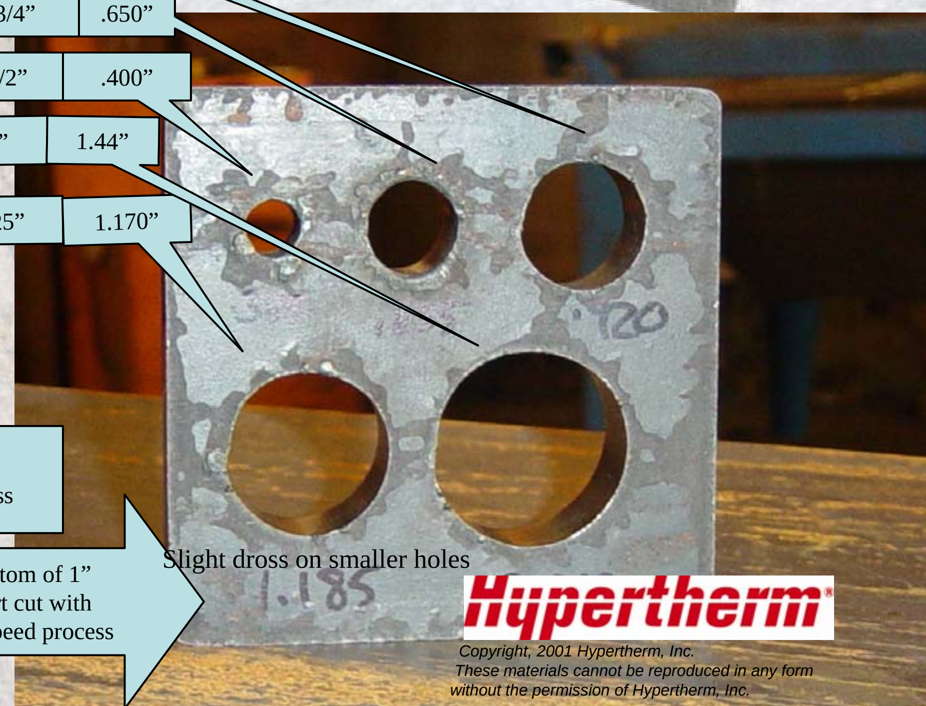
# 1” thick carbon steel cut with HySpeed process at 50 IPM.

- Minimal Taper On Holes
- Holes are relatively round, top and bottom
- With good motion control, a 1/2” diameter hole will be approx. 7/16” diameter on the bottom!
- 1.5” diameter hole will have almost 1.5” dimension on bottom!

These cuts were done with a Hypertherm HT2000 with 200 Amp HySpeed consumables!








| Top | Bottom |
| --- | --- |
| 1” Diameter Hole | .940” |
| 3/4” | .650” |
| 1/2” | .400” |
| 1.5” | 1.44” |
| 1.25” | 1.170” |

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