Rapid Part™ technology

White paper

Introduction

Watching a traditional plasma system as it goes through the cutting process reveals that a considerable percentage of the total cycle time is non-cutting time—the time spent moving from one cut to the next cut; also known as cut-to-cut cycle time.

Hypertherm has responded to industry demand for continuous process improvement with Rapid Part technology: a productivity system that delivers up to a 100% increase in productivity through cut-to-cut cycle time reductions achieved without operator intervention. Rapid Part technology means less cut-to-cut cycle time, maximizing the time the torch is cutting metal and minimizing operating cost.

Rapid Part technology delivers embedded expertise to the plasma cutting process, with benefits including:

- More efficient motion during the cutting process, resulting from CAM software.
- Significant decrease in overall production time.
- Reduced cycle time, producing up to 100% more parts per hour.

System requirements

- Hypertherm HyPerformance® HPRXD® or XPR® X-Definition® plasma system
- ProNest® CAD/CAM nesting software with the Collision Avoidance module
- EDGE® Connect CNC with Phoenix® CNC software
- Sensor® THC

See the section on System Component Variations at the end of this document, or contact your manufacturer for information on enabling Rapid Part with other approved CAM or CNC software.

Technical overview

Product	Deliverable	Benefit	Other system components required to execute	Contribution to cut-to-cut reduction (est. %)*
ProNest software	Apply optimized lead locations.	Minimizes the chance of torch collisions and the distance between the end of one cut and the pierce on the next part. Cycle time savings depend on part geometry and nest configuration.	None	30%
	Apply optimized avoidance paths with partial or full torch raises.	Minimizes the chance of torch collisions and unnecessary torch Z-axis motion. Cycle time savings depend on part geometry and nest configuration.	None	
	Intelligent retract to the next pierce height, based on material and part properties.	Provides a cycle time savings of approximately one second per pierce.	Sensor THC	
	Decides when to skip IHS (Initial Height Sensing).	Minimizes unnecessary torch Z-axis motion. Cycle time savings depend on part geometry and nest configuration.	Sensor THC and EDGE Connect CNC	
EDGE Connect CNC with Phoenix software	Sets the correct torch height control (THC) height settings.	Intelligently follows torch height instructions in the part program generated by ProNest. If no torch height commands are supplied, the CNC uses onboard factory cut charts to establish the torch height. Cycle time savings depend on part geometry and nest configuration.	None	5%
Sensor THC	Rapid vertical (Z-axis) motion.	Torch moves much closer to the plate at high speeds, providing cycle time savings.	None	60%
	Automatic measurement of the plate location and rapid-to-slow speed crossover calibration.	Automatic transition to slow speed and optimum pierce height, reducing IHS time by up to 3 seconds.	None	
HPRXD or XPR X-Definition plasma system	Allows pre-flow during traverse to the next pierce.	Eliminates long purge cycles and machine idle time while it waits for gas pre-flow, saving about 1.3 seconds per pierce.	EDGE Connect CNC	5%

Table 1

*Contribution of a specific product to overall cut-to-cut cycle time reduction will vary by job.

Cut-to-cut cycle time overview

For a typical plasma cutting machine, cut-to-cut cycle time is the sum of all necessary movements between cuts and may be segmented into four primary components:

- Torch retract
- Table motion
- Initial height sensing (IHS)*
- Gas pre-flow*

*Some THCs combine these two steps.

Rapid Part technology reduces cut-to-cut cycle time by up to 80%. Table 2 provides an overview of how Rapid Part technology contributes to each element of cut-to-cut cycle time.

Figure 1. 203 mm (8") flange

1. Torch retract	2. Table motion	3. Initial height sensing	4. Gas pre-flow
Rapid vertical (Z-axis) motion using the Sensor THC intelligently retracts the torch to the next pierce height, based on material and part properties.	Optimized motion instructions programmed using ProNest with the Collision Avoidance optional module, which minimizes the chances of torch collision and the distance between the end of one cut and the pierce on the next part.	Rapid Z-axis motion using the Sensor THC. Automatic fast-to-slow speed crossover calibration. IHS skipped intelligently, based on part geometry and nest configuration.	Completed simultaneously during initial height sensing and during machine motion if IHS is skipped.

Table 2

With a typical plasma setup, when a cut is completed, the torch retracts from the plate by several inches. After moving to the next pierce location, the torch then performs an initial height sense and goes on to pre-flow the gases for piercing. When timed, this commonly takes 6-7 seconds for each cut-to-cut cycle, which can quickly accumulate to a significant amount of time in a day.

The chart (Fig. 2) shows a break-down of the processing time for a 203 mm (8 in.) flange part (Fig. 1). Note that with typical plasma setups using prior THC technology (such as Command THC), there is a substantial amount of time spent on pre-flow, IHS, and torch retract.

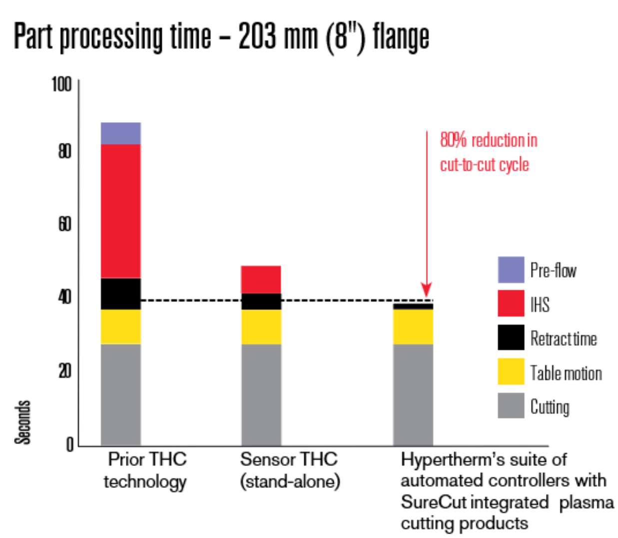

Figure 2

With Rapid Part and the Sensor THC, cut-to-cut cycle time is significantly reduced. On all jobs, cut-to-cut cycle time is improved with Rapid Part, with the most significant productivity gains achieved on nests using thin plate with a high quantity of parts and/or pierces. The more pierces on a given plate, the greater the time savings will be.

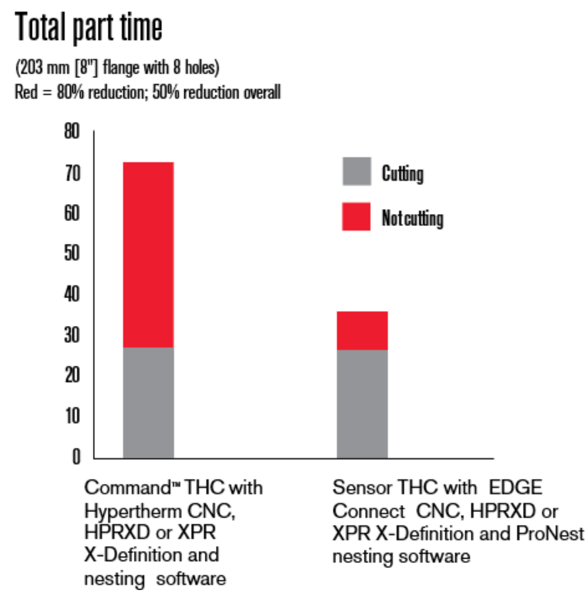

Figure 3

As the charts (Fig. 3, Fig. 4) illustrate, when cutting the 203 mm (8 in.) flange with Rapid Part, cycle time is reduced by 80% and total production time is reduced by 50%. Note that the estimated number of parts that can be cut per day is significantly increased.

Note that different cutting machines inherently exhibit differences in the time taken to complete some of the previously mentioned elements, based on different drive motion capabilities, and so forth.

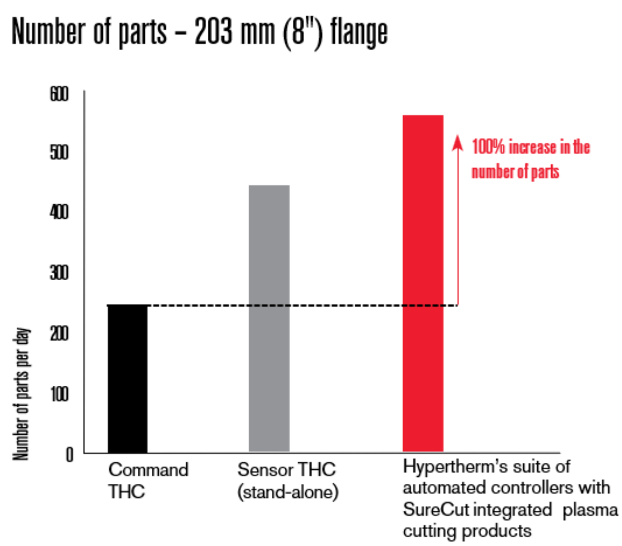

Figure 4

System technical overview

The following sections provide details of how each system component operates to deliver its Rapid Part contribution.

Note terminology differences between ProNest and Phoenix when referring to Z-axis torch movement. The NC command is included in the table as well:

ProNest	Phoenix	NC Command
Partial Raise	Transfer Height	M08 RT
Full Raise	Retract Height	M08

Table 3. Terminology mapping between ProNest and Phoenix

ProNest nesting software

Use of ProNest nesting software, with its optional Collision Avoidance module, to automatically output nests that have optimized table motions and torch retract commands between parts, without need for operator intervention:

Optimized table motion instructions

- Part and profile sequencing
  - Optimizes the interior profile (holes, slots, and other cut-out shapes) cut sequence and nest cut sequence so that the occurrence of a potential torch crash is minimized.
- Lead placements
  - Repositions the interior leads on parts so that the distance between the end of one cut and the pierce on the next part is optimized (actual benefit depends on the part size and number of the internal features).
  - Repositions the exterior leads on parts to reduce the need for full torch retracts, plus the distance between the end of one cut and the pierce on the next part is minimized. Additional productivity gains may result from minimized torch collisions that can lead to torch damage and production downtime.
  - A combination of re-routing traverse motions and full or partial raises of the cutting head to avoid areas on the nest where potential torch damage and production downtime can occur due to tip-ups or plate warping.

IHS skipped intelligently

- ProNest's built-in Hypertherm process expertise contributes to intelligent torch retract to the next pierce height, based on material and part properties.
  - ProNest machine configurations for XPR and HPR plasma machines use factory tested torch height parameters from the Process Parameters spreadsheet (Fig. 5). Torch retract time is minimized by only partially retracting to the next pierce (transfer) height instead of performing a full retract. This saves approximately one second per pierce, when implemented.

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Process Parameters

Overrides

Arc Voltage	Arc Voltage Override	Transfer Height	Transfer Height Override	Pierce Height	Pierce Height Override	Pierce Time	Pierce Time Override	Edge Pierce Time	Cut Height	Cut Height Override	Cut Current	Cut Current Override	Shield Pierce Flow	Shield Pierce Flow Override
147		0.30		0.30		1.00		0.50	0.15		130		37	
147		0.30		0.30		1.00		0.50	0.15		130		37	
147		0.30		0.30		1.00		0.50	0.15		130		37	
147		0.30		0.30		1.00		0.50	0.15		130		37	

Figure 5

Fig. 5 is an excerpt of a Process Parameter table. Notice the Overrides columns containing arc voltage, transfer height, pierce height, and cut height parameters.

In the Advanced section of the Process Parameters spreadsheet is the “IHS Distance” column, which specifies the maximum distance the torch can move before doing initial height sensing again; in other words, the maximum distance the torch can travel between initial height sense commands (M07 HS).

Activating Collision Avoidance

Collision Avoidance is activated in ProNest settings, with the choice to use a settings table, or to use general settings (Fig. 6). When using a settings table, Collision Avoidance parameters can vary and are applied to nests with specific materials and thicknesses (if a record match cannot be made, general settings are used instead; refer to the ProNest Help on record matching for more information). When general settings are used, the parameters specified in the settings are applied to nests with any material and thickness.

The parameters that are used to define the logic of when the part program should do a Full Raise (Retract Height) or Partial Raise (Transfer Height) are in the Collision Avoidance spreadsheet.

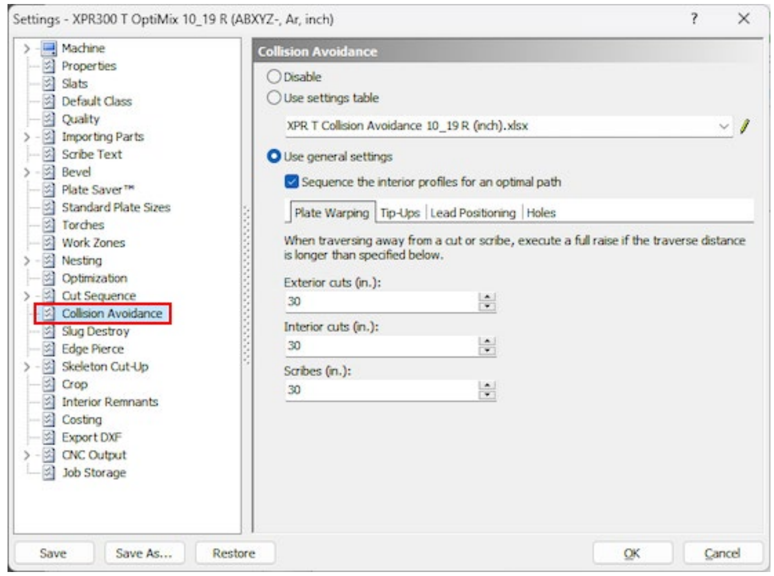

Figure 6

Collision Avoidance settings

When Collision Avoidance is enabled, these options are available in general settings and the settings table:

- **Sequence the interior profiles for an optimal path** – When selected, Collision Avoidance will re-sequence the interior profiles for each part to avoid potential collisions.
- **Plate Warping** – Set the maximum travel length from the end of one profile to the start of the next. When this length is exceeded, a full raise command will be issued (M08); when the length is not exceeded, a partial retract is issued instead (M08 RT). The maximum travel length can be specified for exterior cuts, interior cut profiles, and scribes.
- **Tip-Ups** – In addition to torch diameter and full and partial raise/lower time settings, this section includes options for avoiding profiles based on size and setting a maximum number of avoidance paths (traverse motions) allowed around a profile that has already been cut. An avoidance ratio percentage setting is also available, which is used to determine if an avoidance path or a direct full raise path should be used in each situation.
- **Lead Positioning** – These settings control when and where leads can be moved and trimmed for avoidance. Leads can be locked in Modify Leads mode or Advanced Edit, which prevents the leads from being moved by Collision Avoidance or other nest processing routines in ProNest.
- **Holes** – Reduce possible torch crashes by sequencing interior cut-outs based on size ranges for small, medium, and large holes (with smaller holes being cut first) and proximity to other holes.

Full descriptions of Collision Avoidance settings can be found in the ProNest User Manual.

Torch path adjustments in Collision Avoidance mode

When needed, you can adjust specific paths in Collision Avoidance mode by creating a direct path or enforcing a full raise or partial raise on one or more paths (Fig. 7). Full raises are indicated with a solid line; partial raises are indicated with a dashed line.

Paths can be moved in Collision Avoidance mode by clicking and dragging a path, or by clicking and dragging the end point of a profile, which physically moves the leads on the profile as well.

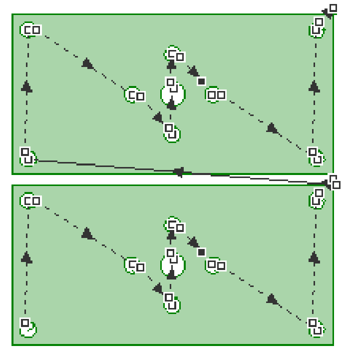

Figure 7

CNC Output settings

CNC Output settings in ProNest must also be configured to manipulate IHS routine and torch retract commands. On the Post Processor Settings page beneath CNC Output, these settings must be selected for Rapid Part technology (Fig. 8). Collision Avoidance logic determines when to apply commands from these settings:

- *Allow HS to force IHS* – "HS" can be added to M07 commands to force IHS.
  Allow RT for partial retract – "RT" can be added to M08 commands to maintain the torch at Transfer Height.
  To get standard M08 commands without "RT", clear "Allow RT for partial retract".
- *Allow RF to force full retract* – "RF" can be added to M08 commands to raise the torch to the Full Retract height.
  To get standard M08 commands without "RR", clear "Allow RF to force full retract".

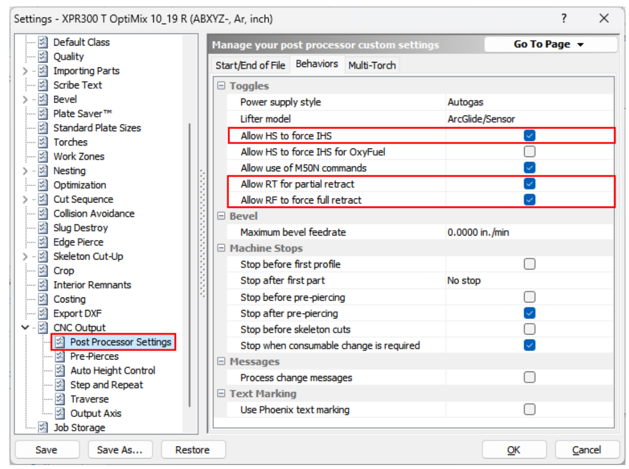

Figure 5

Example 1:

When parts are added to the nest without Collision Avoidance enabled (Fig. 9):

- Lead locations are set to the standard position. This means the torch head may cross directly over previously cut holes in its path. This method would require a full head raise to avoid collisions from tip ups.
- External lead locations are not positioned for the shortest traverse time.
- Internal cut sequence uses a standard method according to Cut Sequence settings in ProNest, which may not be optimal. For example, the sequence for a given part may not finish in a location that is close to the next part.

With Collision Avoidance enabled (Fig. 10):

- Lead locations are now positioned to always be moving away from the previously cut holes. The head is no longer in danger of collisions from tip-ups. This allows for a safe head down motion throughout the cut.

- External leads are now positioned closer to the next part to minimize traverse time.
- Interior profile cut sequence is optimized for the start and end points that best support collision avoidance and minimal traverse time, relative to the exterior lead location.

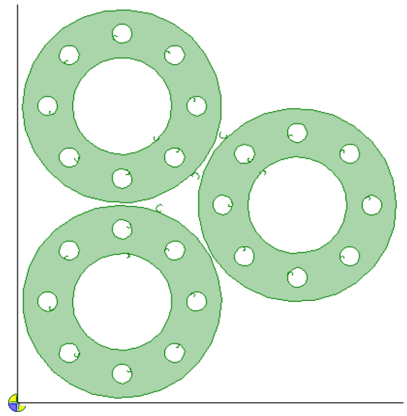

Figure 9

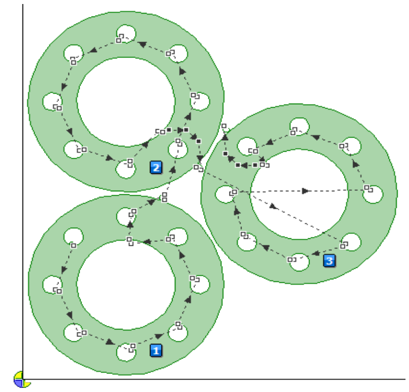

Figure 10

Example 2:

Without Collision Avoidance enabled, the profile cut sequence for this artistic part is shown in Fig. 11. This nest is using the cut sequence interior profile option **Find the best strategy** in ProNest.

When Collision Avoidance is enabled, cut sequence settings are used to initially create a sequence for the nest, and then potential tip-ups and lead placement from one profile to the next are considered when adjusting the cut sequence and torch path. Leads may be moved or trimmed if needed for avoidance. Fig. 12 shows partial and full raises applied to the sequence. Fig. 13 shows the resulting profile cut sequence after applying Collision Avoidance.

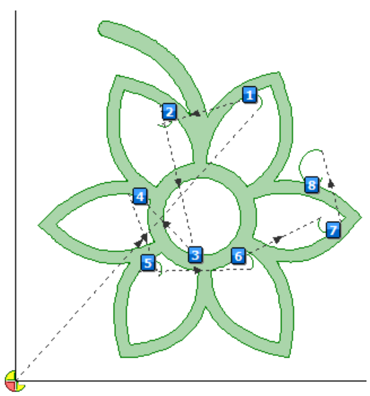

Figure 6

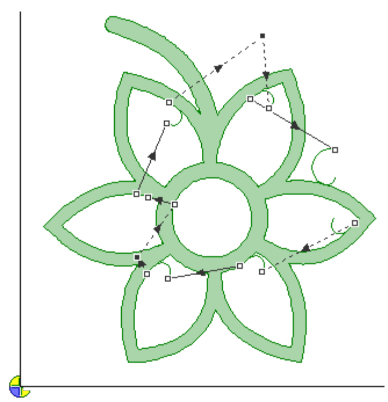

Figure 7

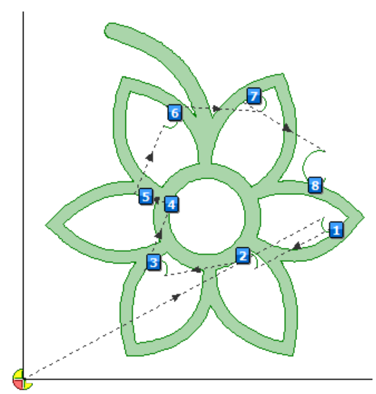

Figure 8

Differences in NC output include G00 and G01 motions with varying coordinates, and, with Collision Avoidance enabled, an M50 (disable THC) command replaces an M51 (enable THC) after the first M07 HS. Additionally, RT is added to some M08 (M08 RT, retract to transfer height) commands. In Collision Avoidance mode, the full raises between profiles 2 and 3, 5 and 6, and 7 and 8 can be changed to partial raises, which further reduces the cut-to-cut cycle time.

Note that differences in sequencing, torch paths, and NC output depend on the settings of your machine in ProNest and each nest.

Phoenix CNC software

Configurations in Phoenix CNC software are required to fully utilize the capabilities of Collision Avoidance from ProNest.

- EIA M07/M09 HS IHS Override and M08/M10 Retract Override options must be enabled in the Setup soft key (Fig. 14).

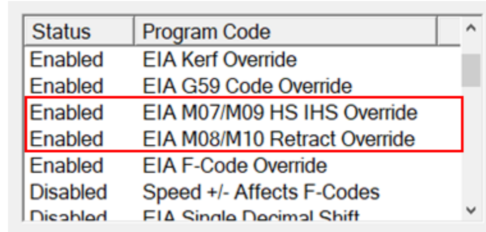

Figure 9

- The Process screen should use the option **Default All Parameters** (Fig. 15) as a starting point to enable Rapid Part. Using Default All Parameters ensures, for example, that Preflow During IHS is ON to save time by reducing the delay caused by purge times.
  If you have dialed in some of these parameters and would like to make changes, clear the parameter, and enter a value. The value that you enter shows in blue font.

- **Skip IHS Within** – This option optimizes production by reducing the time between cuts. If the distance between the end of a cut and the next start point is within this specified distance, then the THC skips the IHS. This allows the torch to retract to the Transfer Height (M08 RT command) and skips contact with the workpiece before piercing. A non-zero value must be used to activate this setting; when set to 0, IHS will never be skipped. To use the default value, the checkbox must be selected.
  Some scenarios may cause Skip IHS to be ignored; refer to the *EDGE Connect Installation and Setup Manual* (809340) available at www.hypertherm.com/docs for more information.

- **Transfer Height** – Transfer Height is the height of the torch when it first transfers to the workpiece, prior to stretching the arc to Pierce Height. Transfer Height refers to the height the THC moves to when an M08 RT command is used. To use the default value, the checkbox must be selected.

Figure 11

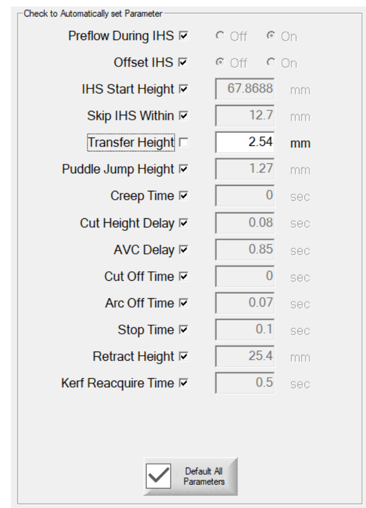

Figure 10

Notes:

- For HPRXD, enter the Transfer Height as a percentage of the cut height. The percentage can be 25%– 600% of Cut Height (this percentage varies based on the version of Phoenix in use).
- When overriding Cut Height on the Process screen, Pierce Height and Transfer Height automatically adjust in proportion. If you want specific values for Pierce Height and Transfer Height, enter them as absolute values in inches or millimeters after adjusting the Cut Height.

- **Retract Height –** Retract Height is the distance the torch will raise above the workpiece at the end of a cut, which occurs after an M08 command.

Figure 12

- **Sample Voltage –** When Sample Voltage is ON, the THC measures the voltage at the end of the AVC Delay. Then, this voltage is used as a set point for the remainder of the cut. This occurs after the Cut Height Delay and AVC Delay have completed. When Sample Voltage is OFF, the Set Arc Voltage is used as the set point for torch height control.
  For the sample voltage to be taken:
  - Height Control must be in Automatic Mode,
  - Voltage Control must be ON,
  - THC Disabled status bit must be OFF, and
  - THC Tracking Voltage status bit ON.

After sample voltage occurs, a new sample is not required again until one of these conditions is met:
  - The THC has been idle for greater than 30 seconds.
  - Plasma has been turned OFF remotely since the last sample.
  - The active process has changed (for example, Plasma1 to Plasma2).
  - The arc voltage value in the current process is different from the previous start, which may occur when a different cut chart is used or when arc voltage is overridden (G59 V600 or M07 AVO).

Sensor THC

The Sensor THC works seamlessly with ProNest, the EDGE Connect CNC, and HPRXD or XPR X-Definition plasma system to perform the following:

- Executes the optimized motion routines defined by ProNest and processed by the EDGE Connect CNC to deliver:
  - Rapid Z-axis motion
  - Automatic rapid-to-slow speed crossover calibration
  - IHS skipped intelligently, based on part geometry and nest configuration

The following items describe how the THC's automated functionality operates.

Rapid Z-axis motion

During torch retract, motion (stroke) speed of the Sensor THC reaches 25.400 mm/min (1000 in/min). This rapid motion speed results in a retract time reduction of more than 0.5 second per full retract.

Automatic rapid-to-slow speed crossover calibration

Typically, a torch height control moves down very rapidly towards the plate until it reaches a certain distance, when its speed slows dramatically. Many torch height controls use a fixed distance to the cutting table, not the actual plate location to establish the distance from the plate where the speed slows. This distance is set by the cutting machine installer. While operators have control over this setting, few actually optimize it for each plate thickness, as forgetting to change it for thick plates can damage the torch. As a result, for thick plates, the torch may slow down 12.5 mm (0.5 in.) above the plate but when a thin plate is loaded on the table, this distance at which the torch speed slows may be up to 63 mm (2.5 in.) above the plate, drastically increasing the cut-to-cut cycle time. The "Auto IHS Start Height" option is also available in the Special Setup screen of Phoenix. When enabled, this setting allows IHS Start Height to be calculated based on Sensor THC settings: Maximum Machine Speed, Fast Speed, and THC Acceleration. In most cases, the Auto IHS Start Height is the best calculated value for fast setup with optimal times, while also ensuring the lifter has enough distance/time from the plate during IHS to reliably find the top of the plate.

The Sensor THC automatically calibrates this rapid-to-slow speed crossover during the initial height sense (IHS) on the plate by sensing the plate's actual location, making sure that it does not slow down until 12.5 mm (0.5 in.) above the plate, no matter the plate thickness. This can save as much as 1 second during IHS.

As a safety measure, the Sensor THC automatic crossover height calibration resets if the THC has not been cutting for thirty seconds or more, or if the torch has been manually jogged in the raise or lower position. Essentially, if the system determines there might be a risk of collision, the Sensor THC will approach the plate slowly on the first pierce.

IHS skipped intelligently

During IHS, the THC moves slowly when it finds the plate for the first pierce. Each subsequent IHS is much quicker using this initial calibration, allowing for minimized cut-to-cut cycle time without the risk of torch collision. The THC will perform an IHS on the first few pierces while it obtains the initial samples for the arc voltage setting of the THC. IHS is very rapid, but skipping IHS altogether is even faster. Gas pre-flow for the torch is accomplished during the torch rapid movement and the torch retracts only when it believes there may be a risk of collision, otherwise it retracts just to the Transfer Height of the next pierce. This capability is enabled using the Collision Avoidance feature in ProNest. After the first part is cut, the torch retracts fully to ensure it clears the part, but still skips IHS for the next part.

EDGE Connect CNC

The EDGE Connect CNC receives and processes the NC file for the job created by ProNest. The CNC also communicates with the Sensor THC and HPRXD or XPR X-Definition plasma system to help ensure successful job completion. Specifically, the EDGE Connect CNC offers the following contributions to Rapid Part technology:

- Execute the optimized motion routines defined by ProNest nesting and process optimization software.
- Instruct the Sensor THC to retract to the next Transfer Height or Retract Height, when called for by the part program.
- Instruct the HPRXD or XPR X-Definition plasma system to pre-flow gases during table motion, ensuring the plasma system is ready to fire immediately after moving into position.

HyPerformance HPRXD or XPR X-Definition plasma system

The HPRXD or XPR X-Definition allows the plasma system to support faster gas pre-flow cycles, an element of reduced cut-to-cut cycle time discussed in the THC section.

- Designed to fire quickly, contributing to reduced purge cycles.

ProNest	EDGE Connect CNC	Sensor THC	HPRXD or XPR X-Definition	
•				Intelligent lead location
•				Intelligent motion path
•		•		Intelligent retract height
•	•	•	•	Skip IHS
	•		•	Pre-flow during traverse
		•		Rapid Z-axis motion
	•	•		Intelligent plate location measurement and rapid-to-slow speed crossover calibration
			•	Designed to fire the torch quickly
30%	5%	60%	5%	Estimated contribution to Rapid Part technology

Table 4

System component variations

Use of Hypertherm's ProNest nesting software, EDGE Connect CNC, Phoenix CNC software, Sensor THC, and HPRXD or XPR X-Definition plasma system, working together, provide the full benefits of cut-to-cut cycle time reduction. However, as detailed in Table 1, a significant percentage of overall cycle time savings may be achieved without use of all system components used to deliver Rapid Part technology.

For certain users, operating a partial system to achieve a majority percentage of cycle time benefits may be a logical decision. For example, a user has an established relationship with a machine OEM who does not incorporate a full Hypertherm integrated solution to their machine and instead produces their own nesting software or CNC.

Depending on configuration, the machine could still deliver excellent productivity gains.

Conversely, users owning machines incorporating prior Hypertherm technology, such as a Sensor THC, may be in an excellent position to retrofit their machine with the latest Hypertherm components that deliver the full Rapid Part experience at an easily justifiable return on investment.

Refer to Table 1 for details of what is gained and lost when using different component configurations, or Table 4 for the simplified overview.

See Rapid Part in action at www.hypertherm.com/rapidpart