✓**SureCut**™

MAXIMIZING PERFORMANCE THROUGH
EMBEDDED EXPERTISE

True Bevel™ technology – XPR™ bevel compensation cut charts

White paper

Introduction

Using plasma systems to perform bevel cutting on specially designed cutting tables (with bevel heads) has been done in the metal cutting industry for years. Many parts that are cut on plasma cutting tables are ultimately beveled in subsequent secondary operations, most often for weld preparation. By using a bevel head, you can eliminate secondary operations and increase productivity.

However, one large obstacle to realizing this gain is that the plasma arc changes its physical behavior as you tilt the torch. Cutting parts that meet the desired size and bevel angles requires compensation adjustments to angle and kerf. The process of determining these compensation values is time-intensive, consumes a large amount of material, and is very iterative. Many operators have found this process to be a significant impediment to maintaining productivity on their bevel cutting table.Some have even given up trying, letting their expensive, automated bevel equipment sit idle.

With True Bevel™ technology, Hypertherm Associates provides you with flexible and adjustable bevel compensation cut charts, or process parameter tables. These tables provide you with compensation values that produce a better first attempt and should require only small adjustments. You can use the True Bevel technology process parameter tables for AC-type bevel heads (tilt-rotate) and with ABXYZ-type bevel heads (tilt-tilt with XYZ compensation), which produce a virtual pivot point.

> **Note:** This white paper assumes that you have validated the bevel head motion and mechanics (and associated transformation equations) before attempting to use the compensation tables. Materials used for the development of this white paper were based on U.S. customary units (inches). Metric conversions are provided for reference.

Minimum requirements for True Bevel technology process parameter tables

The following requirements must be met in order to use the True Bevel technology process parameter tables supplied by Hypertherm Associates:

All users:

- XPR plasma system
- Computer numerically controlled cutting table with an AC-type bevel head (tilt-rotate) or an ABXYZ-type bevel head (tilt-tilt with a virtual bevel pivot point via XYZ compensation) with associated, validated transformation equations
- Microsoft® Excel® 2010 or later
- Microsoft Windows 7® operating system or later

Additional requirements for XPR-only users:

- All the previously listed requirements that apply to all users, plus:
  - Computer Numeric Controller (CNC)
  - Computer Aided Manufacturing (CAM) software to read outputs from the True Bevel technology process parameter tables and output the part program code

Additional requirements only for users of Hypertherm Associates SureCut™ technology:

- All the previously listed requirements that apply to all users, plus:
  - EDGE® Connect with Phoenix® 10 or later
  - ProNest® 2019 v13.04 or later

Bevel cut type definition

Five types of bevel cuts are covered in Hypertherm Associates' True Bevel technology process parameter tables: V cuts, A cuts, Y Top cuts, X cuts, and K cuts. For reference, I cuts (or straight cuts) are also shown. V cuts and A cuts are single-pass bevel cuts. Y Top cuts and X cuts require two passes. K cuts require three passes.

Note: The sequence of the multi-pass cuts affects the results. Hypertherm Associates' True Bevel technology process parameter tables provide values based on cutting from bottom to top.

Figure 1 – V cut bevel

V cut (single pass):

- Conventional "positive" bevel cut
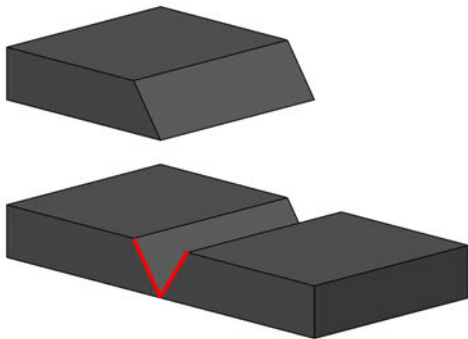- When two V cut edges are aligned for welding, they form a "V"

Figure 2 – A cut bevel

A cut (single pass):

- Conventional "negative" bevel cut
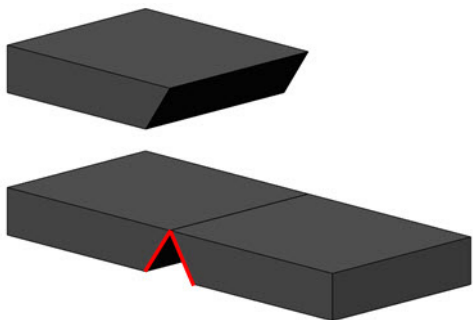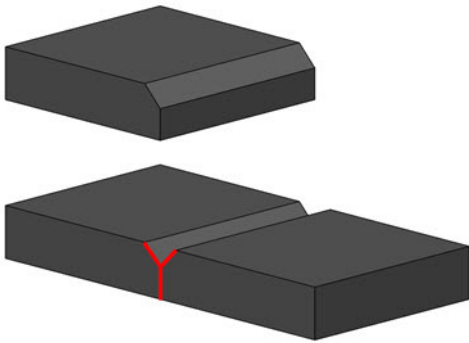- When two A cut edges are aligned for welding, they form an "A"
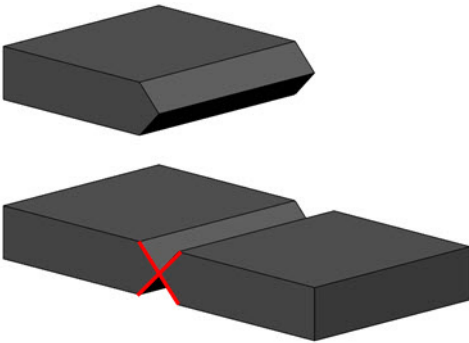
Figure 3 – Y Top bevel

Y Top cut (multi-pass):

- Conventional "straight" cut on the bottom portion of the cut
- Conventional "positive" bevel cut on the top of the part
- When two Y Top cut edges are aligned for welding, they form a "Y"

Figure 4 – X bevel

X cut (multi-pass):

- Conventional "negative" bevel cut on the bottom of the part
- Conventional "positive" bevel cut on the top of the part
- When two X cut edges are aligned for welding, they form a "X"
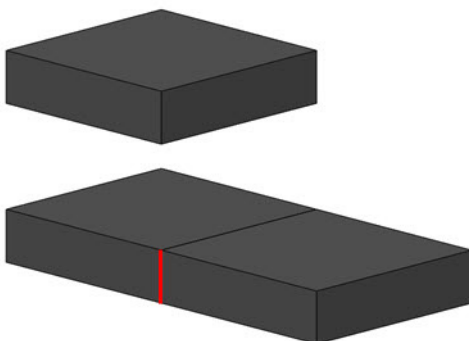
Figure 5 – K bevel

K cut (multi-pass):
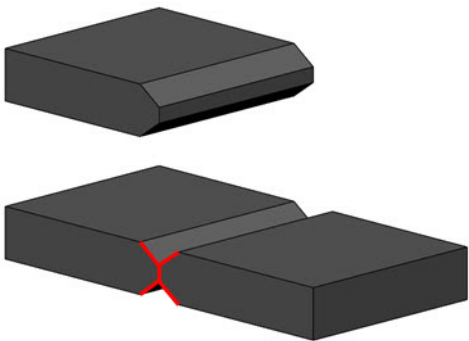
- Conventional "negative" bevel cut on the bottom of the part
- Conventional "straight" cut on the middle portion of the cut
- Conventional "positive" bevel cut on the top of the part

Figure 6 – I cut (straight cut)

I cut (single pass):

- Conventional "straight" cut
- When two I cut edges are aligned for welding, they form an "I"

Plasma bevel cut type differences

The physics involved with plasma bevel cutting can have different results compared to I cutting, including specific cut variations based on whether you are performing V, A, Y, X, or K bevel cuts. These differences are due to changes in the arc attachment point, increased effective cut height, molten metal flow path (for multi-pass bevel cuts), and the effect of gravity on the molten metal flow.

V and A bevel cutting

There are some differences in plasma cutting between V cuts and A cuts:

V cuts:

- Smooth cut edge appearance similar to I cutting (*Figure* 7)
- Sharp bottom edge (acute angle)
- Dropped part that is trapped below the skeleton
- Major size (bottom) of the part that varies with material thickness and angle variation because the torch is following a path on top of the workpiece

A cuts:

- Rougher cut edge appearance (*Figure* 7)
- Rounded top edge (acute angle) due to high temperature gases being blown directly onto the edge
- Dropped part that rests on top of the skeleton
- Minor size (bottom) that varies with material thickness and angle variation because the torch is following a path on top of the workpiece
- Major size that is slightly smaller than the V cut due to rounding of the edge (*Figure 8*)
- Potential inability to achieve 45° for thinner materials
  - The compensation values are as high as +9.9° (meaning a possible angle of 54.9°), which may require the torch to be tilted beyond the physical limits of many bevel heads
  - The torch is designed to go to approximately 52° without affecting the clearance or the effective cut height (or both)

Y Top bevel cutting

In addition to the bevel angle and overall size of the bevel part being cut, Y Top bevel cuts have a straight land portion (or I cut portion) that defines the desired geometry. The land dimension is a parameter that V cuts and A cuts do not have (*Figure 9*).

> **Note:** The sequence of the multi-pass cuts affects the results. Hypertherm's True Bevel technology process parameter tables provide values based on cutting from bottom to top. For a Y Top cut, the land is cut first, followed by the V cut.
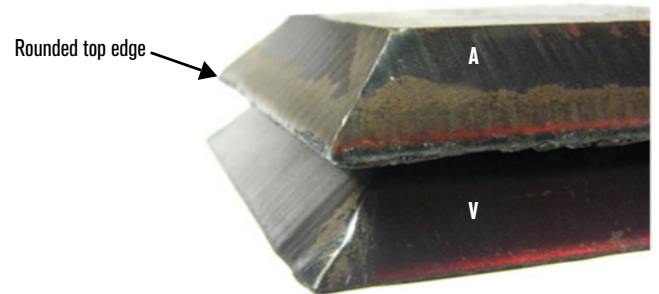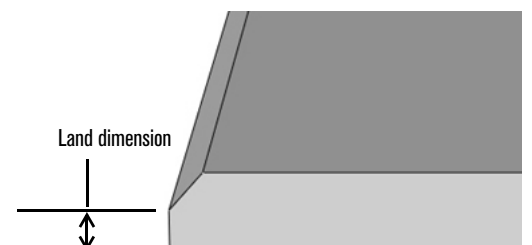
Figure 7 – V cut versus A cut edge comparison

Rounded top edge

A

V

Figure 8 – Part size reduction on an A cut because of top corner rounding

Figure 9 – Y Top land dimension

Land dimension

X bevel cutting

X cuts are defined by the top angle, the bottom angle, and the location of the intersection of these. Hypertherm Associates' True Bevel parameter tables have parameters for symmetric X cuts, where the top angle is the same as the bottom angle and the intersection is in the middle of the thickness. (*Figure 10*)

> **Note:** The sequence of the multi-pass cuts affects the results. Hypertherm Associates' True Bevel technology process parameter tables provide values based on cutting from bottom to top. For an X cut, the A cut is first, then the V cut.

Figure 10 – X dimension and angles
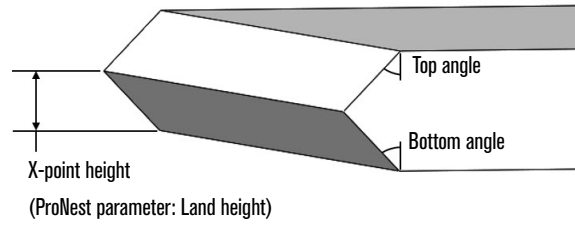
K bevel cutting

K cuts are defined by the top angle, bottom angle, and the land size and height. Hypertherm Associates' True bevel parameter tables have parameters for symmetric K cuts, where the top angle is the same as the bottom angle and the land is in the middle of the thickness. (*Figure 11*)

> **Note:** The sequence of the multi-pass cuts affects the results. Hypertherm Associates' True Bevel technology process parameter tables provide values based on cutting from bottom to top. For a K cut, the A cut is first, then the land cut, then the V cut.

Figure 11 – K land dimension, land height, and angles
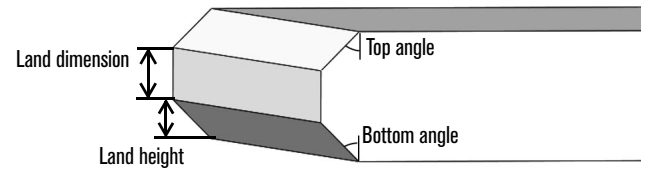
Thickness coverage

Hypertherm Associates' True Bevel technology process parameter tables contain values for mild steel thicknesses ranging from 0.25 inch (6 mm) to 1.5 inches (38 mm) for V cuts, A cuts, and Y Top cuts. This thickness range is covered through the range of bevel processes (80 A to 300 A for mild steel). The thickness/process combinations displayed in *Table 1* and *Table 2* were chosen based on the ability of the process to support bevel cutting up to 50° for V and Y Top.

Table 1 – Thickness coverage for V cuts, A cuts, and Y Top cuts – English units (inches)

	0.250	0.312	0.375	0.500	0.625	0.750	0.875	1.000	1.250	1.500
80 A	✔	✔	✔							
130 A		✔	✔	✔	✔					
170 A				✔	✔	✔	✔			
300 A								✔	✔	✔

Table 2 – Thickness coverage for V cuts, A cuts, and Y Top cuts – metric units (mm)

	6	8	10	12	15	19	20	22	25	32	38
80 A	✔	✔	✔								
130 A		✔	✔	✔	✔						
170 A				✔	✔	✔	✔	✔			
300 A									✔	✔	✔

Hypertherm Associates' True Bevel technology process parameter tables contain values for mild steel thicknesses ranging from 0.5 inch (12 mm) to 1.5 inches (38 mm) for X cuts. This thickness range is covered through the range of bevel processes (170 A to 300 A for mild steel). The thickness/process combinations displayed in *Table 3* and *Table 4* were chosen based on the ability of the process to support bevel cutting up to 45° for X.

Table 3 – Thickness coverage for X cuts – English units (inches)

	0.500	0.625	0.750	0.875	1.000	1.250	1.500
170 A	✔	✔	✔	✔			
300 A					✔	✔	✔

Table 4 – Thickness coverage for X cuts – metric units (mm)

	12	15	19	20	22	25	32	38
170 A	✔	✔	✔	✔	✔			
300 A						✔	✔	✔

Hypertherm Associates' True Bevel technology process parameter tables contain values for mild steel thicknesses ranging from 0.625 inch (15 mm) to 1.5 inches (38 mm) for K cuts. This thickness range is covered through the range of bevel processes (170 A to 300 A for mild steel). The thickness/process combinations displayed in *Table 5* and *Table 6* were chosen based on the ability of the process to support bevel cutting up to 45° for K.

Table 5 – Thickness coverage for K cuts – English units (inches)

	0.625	0.750	0.875	1.000	1.250	1.500
170 A	✔	✔	✔			
300 A				✔	✔	✔

Table 6 – Thickness coverage for K cuts – metric units (mm)

	15	19	20	22	25	32	38
170 A	✔	✔	✔	✔			
300 A					✔	✔	✔

Bevel angle and land density coverage

Hypertherm Associates' True Bevel technology process parameter tables contain values for different angles and land dimensions based on the type of bevel cut.
Table 7 – Table 10 show the lab tested combinations of angles and lands.

The bevel parameters for the V cuts, A cuts, and Y Top cuts are dynamic. With dynamic parameters you can add other angles and land dimensions within the specified ranges into the True Bevel technology process parameter tables for more flexibility. The tables automatically provide newly calculated output values for angle compensation, kerf, cut height, cut speed, and arc voltage.

The bevel parameters for the X cuts and K cuts are static. With static parameters, the parameters are only tested with that specific angle or land. You can add other angles or lands, but they could be inaccurate. Hypertherm recommends that you do your own testing.

The angle sign convention is based on whether the top angle (V cut) is considered to be positive or negative by the bevel head. You can automatically set the angle sign within the True Bevel technology process parameter table by selecting the proper top angle orientation (positive or negative) for your bevel head within the table (*Figure 25* on page 20). The correct signs are then applied to all of the angles.

Table 7 – V cut and A cut angle coverage

V cut angle*	-50°	-45°	-40°	-37.5°	-35°	-30°	-27.5°	-25°	-22.5°	-20°	-17.5°	-15°
A cut angle*		45°	40°	37.5°	35°	30°	27.5°	25°	22.5°	20°	17.5°	15°

* Angle signs based on negative bias head.

Table 8 – Y Top cut angle and land coverage

Angle*	-50°			-45°			-37.5°			-30°			-27.5°			-22.5°		
Land dimension	20%	35%	50%	20%	35%	50%	20%	35%	50%	20%	35%	50%	20%	35%	50%	20%	35%	50%

* Angle signs based on negative bias head.

Table 9 – X cut angle coverage

Top pass angle*	-45°	-40°	-37.5°	-35°	-30°
Bottom pass angle*	45°	40°	37.5°	35°	30°

* Angle signs based on negative bias head.

Table 10 – K cut angle and land coverage

Top pass angle*	-45°			-37.5°			-35°			-30°		
Bottom pass angle*	45°			37.5°			35°			30°		
Land dimension	10%	20%	35%	10%	20%	35%	10%	20%	35%	10%	20%	35%

* Angle signs based on negative bias head.

Bevel head geometry and nomenclature

The following parameters affect the values in the True Bevel technology process parameter tables:

- Clearance
- Bevel pivot point
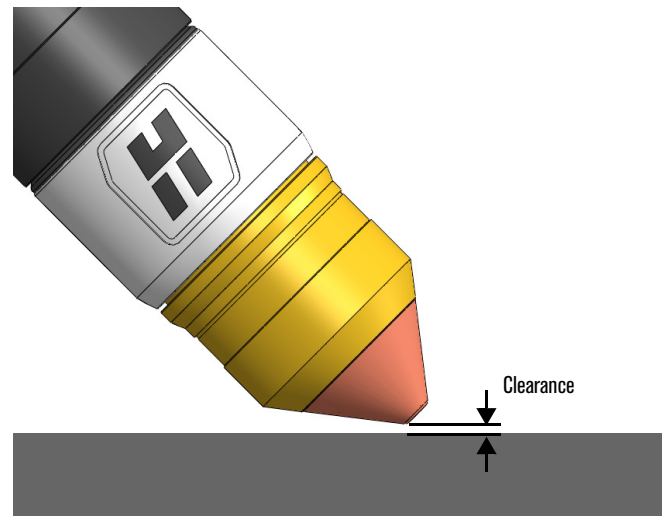- Torch pivot length (TPL)

Clearance

Clearance is the desired minimum distance between the torch and the top of the workpiece. The default recommended value in the True Bevel technology process parameter tables for clearance is 0.100 inches (2.5 mm), with a recommended range of 0.080 to 0.160 inches (2 mm to 4 mm).

Higher clearances reduce the likelihood of torch collisions, but they also result in higher effective cut heights (which may produce lower edge quality and require higher angle compensations) and higher cutting voltages (which could affect the duty cycle of the power supply). Hypertherm Associates recommends that you first cut with the default torch clearance settings and adjust only as needed. The True Bevel technology process parameter tables enable you to individually change the torch clearances based on amperage.

Other relevant parameters include:

- Process shift
- Process compensation
- Bevel pivot length – this applies only to ABXYZ-type bevel heads
- Maximum tilt angle

**Figure 12** – Definition of clearance

Clearance

Bevel pivot point and torch pivot length (TPL)

The bevel pivot point is the point in three-dimensional space that the bevel head tilts around (rotation point) and is typically located at the tip of the torch (or the end of the shield) in many bevel heads.

The torch pivot length (TPL) is the relationship of the distance between the torch and the bevel pivot point on the bevel head.

Proper positioning of the torch relative to the bevel pivot point is essential to achieving acceptable results with minimal material waste. *Figure 13* shows the bevel pivot point located at the tip of a 170 A O_2/Air shield, as well as the result of tilting the torch 45° around the bevel pivot point.
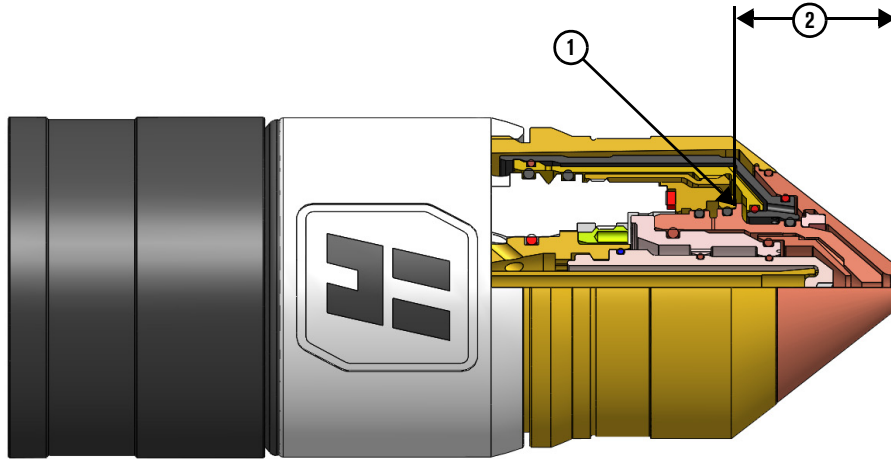
Figure 13 – Example of the bevel pivot point located at the tip of a 170 A shield
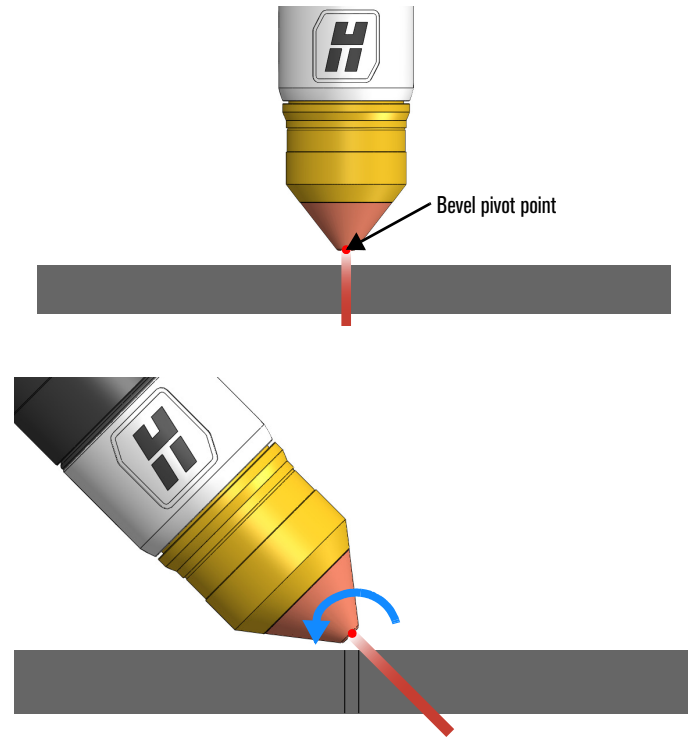
Bevel pivot point

For the purposes of the True Bevel technology process parameter tables, the torch pivot length (TPL) is defined as the distance from the bevel head pivot point to the nozzle seat in the torch.

As an example, if the torch was positioned within the bevel head such that the bevel pivot point was located at the tip of the 170 A O_2/Air shield, the TPL would be 1.062 inches (26.97 mm), as shown in *Figure 14*. For a method of determining the TPL, refer to the section *Determining torch pivot length (TPL)* on page 18.

Figure 14 – Example of the TPL for the bevel pivot point located at the tip of a 170 A shield

1	The TPL in the True Bevel technology process parameter tables is measured from the nozzle seat
2	1.062 inches (26.97 mm)

Process shift

Process shift occurs when the plasma arc moves across the top of the workpiece during the tilting of the torch. For example, *Figure 16* on page 13 shows a 0.201 inch (5.11 mm) process shift resulting from a bevel pivot point located at the tip of the 170 A O$_2$/Air shield (with a torch pivot length [TPL] of 1.062 inches [26.97 mm]) and tilted to 45° while maintaining a 0.100 inch (2.5 mm) clearance. *Figure 15* displays a plot illustrating how the process shift values for the 1.062 inch TPL increase with torch tilt.

An optimal location exists for the torch relative to the bevel head pivot point that minimizes process shift across all bevel processes and angles. This optimal location is defined by a TPL of 1.333 inches (33.86 mm), which places the bevel pivot point 0.271 inches (6.88 mm) beyond the 170 A O$_2$/Air shield tip.

As an example, *Figure 15* plots the process shift for both the tip of the 170 A O$_2$/Air shield (1.062 inch TPL) and for the optimal TPL of 1.333 inches. *Figure 17* on page 13 shows a 0.009 inch (0.23 mm) process shift that results from the optimal TPL of 1.333 inches (33.86 mm).

Figure 15 – Process shift versus bevel angle – optimal TPL of 1.333 inches

Process shift versus bevel angle
Based on torch pivot length (TPL)
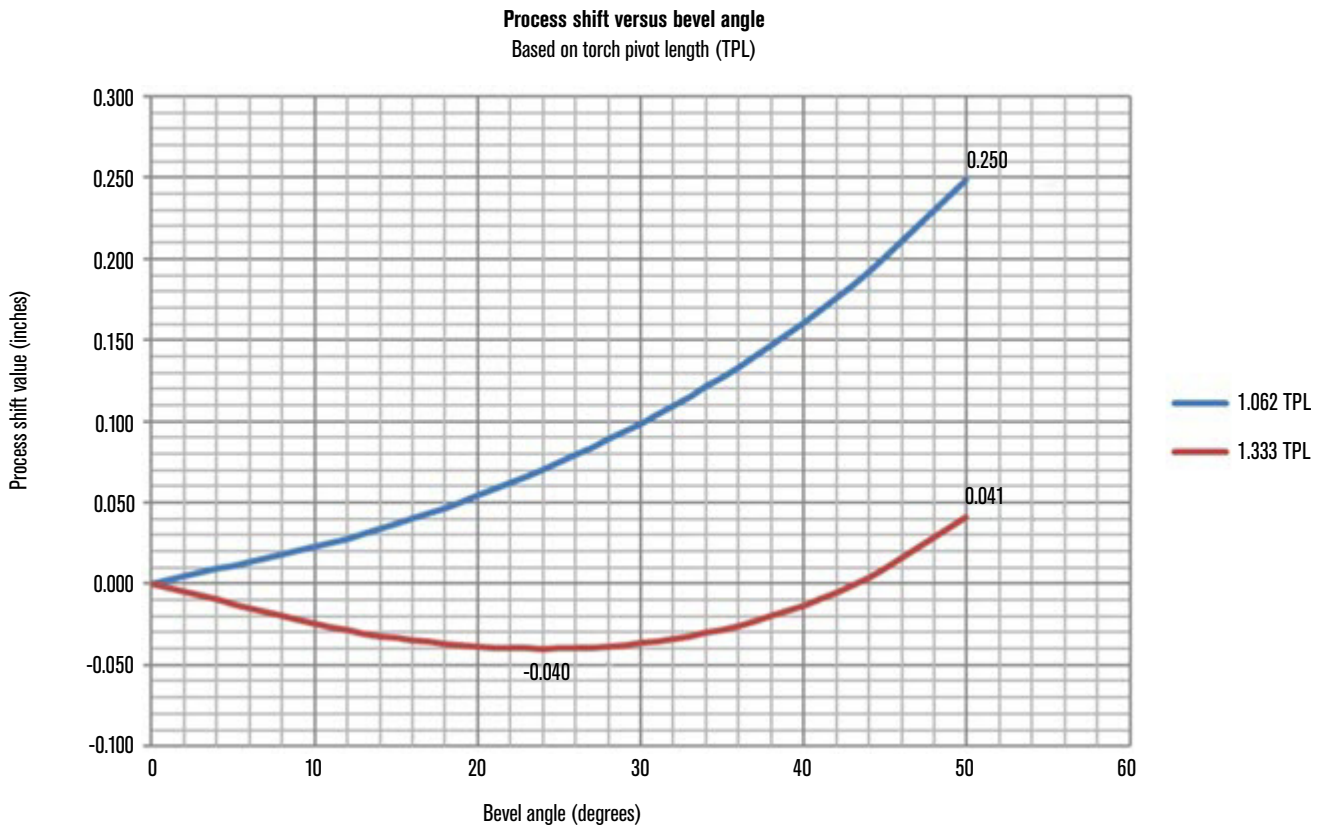
Figure 16 – Effect of the TPL on process shift when TPL equals 1.062 inches (26.97 mm)
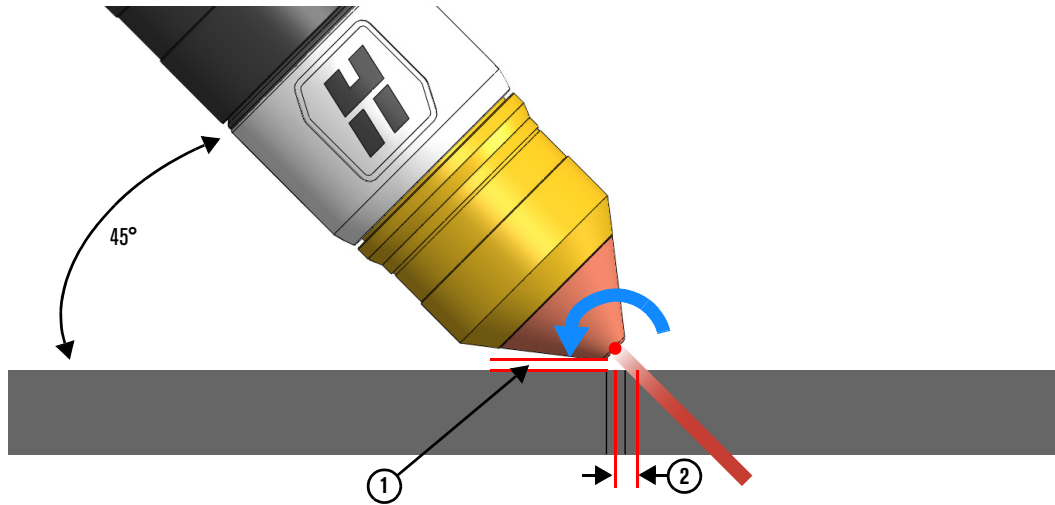
1	Minimum clearance of 0.1 inches (2.54 mm)
2	Process shift of 0.201 inches (5.11 mm)

Figure 17 – Effect of the TPL on process shift when TPL equals 1.333 inches (33.86 mm)
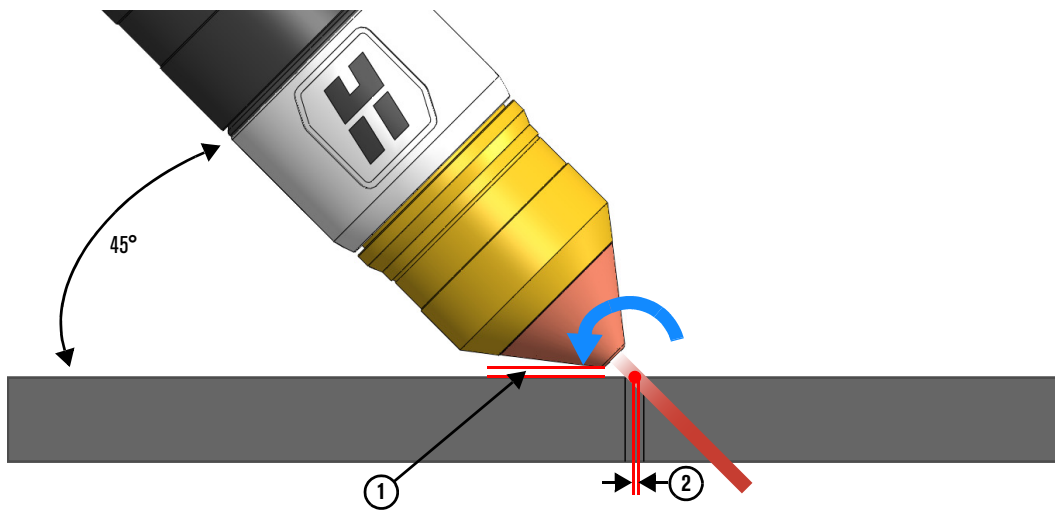
1	Minimum clearance of 0.1 inches (2.54 mm)
2	Process shift of 0.009 inches (0.23 mm)

Process compensation

Process compensation is an adjustment made to the torch path to compensate for the process shift. You can apply this adjustment to the raw tool path by adding the process compensation value in your CAM software, or you can add the process compensation (multiplied by two) to the kerf value. Hypertherm Associates' ProNest software applies the process compensation values to the raw tool path automatically.

> **Note:** Adding twice the process compensation value to the kerf value will not work for many CNCs because negative kerf values can result and may not be supported.

Bevel pivot length

For the purposes of the True Bevel technology process parameter tables, bevel pivot length is defined as the distance from the tip of a loaded 170 A O_2/Air torch shield to the mechanical rotation point for an ABXYZ-type bevel head. (This type of bevel head uses the X, Y, and Z axes to create a virtual bevel pivot point).

If you use this type of head with a Hypertherm EDGE Connect CNC, you can use the Bevel Pivot Length field in the CNC. The value you enter in this field should be the distance from the 170 A O_2/Air shield tip to the mechanical rotation point of the bevel head (*Figure 18*). The bevel pivot length value is already available in some setups with the EDGE Connect CNC.

Special ABXYZ case: adding cut height to the bevel pivot length

For ABXYZ-type bevel heads, it is possible to maintain the virtual bevel pivot point such that it is always located at the top of the workpiece. This is accomplished by taking the cut height that is passed to the CNC through the part program code and adding that cut height to the bevel pivot length stored in the CNC.

If the default bevel pivot length is the tip of the shield of the loaded 170 A O_2/Air consumables, adding the cut height transfers the virtual bevel pivot point from the tip of the shield to top of the workpiece (*Figure 19*). This eliminates the need for process compensation and also maximizes workpiece utilization because there is no shift of the arc across the top of the workpiece as the torch tilts (*Figure 20* on page 15 and *Figure 21* on page 15).

Figure 18 – Bevel pivot length for an ABXYZ bevel head
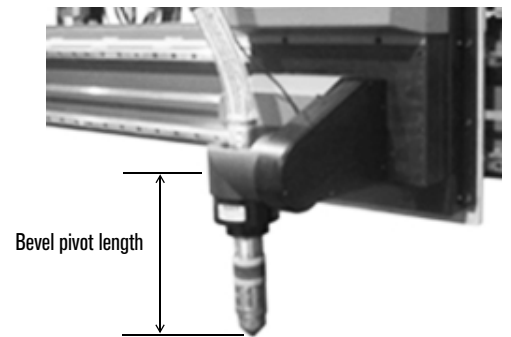
Figure 19 – Virtual bevel pivot point moved to the top of the workpiece by adding cut height to the bevel pivot length
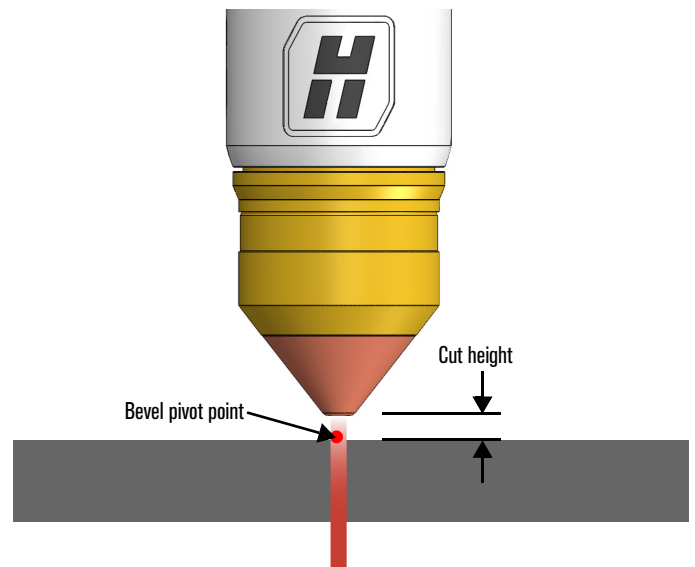
Figure 20 – Elimination of process shift by adding cut height to the bevel pivot length
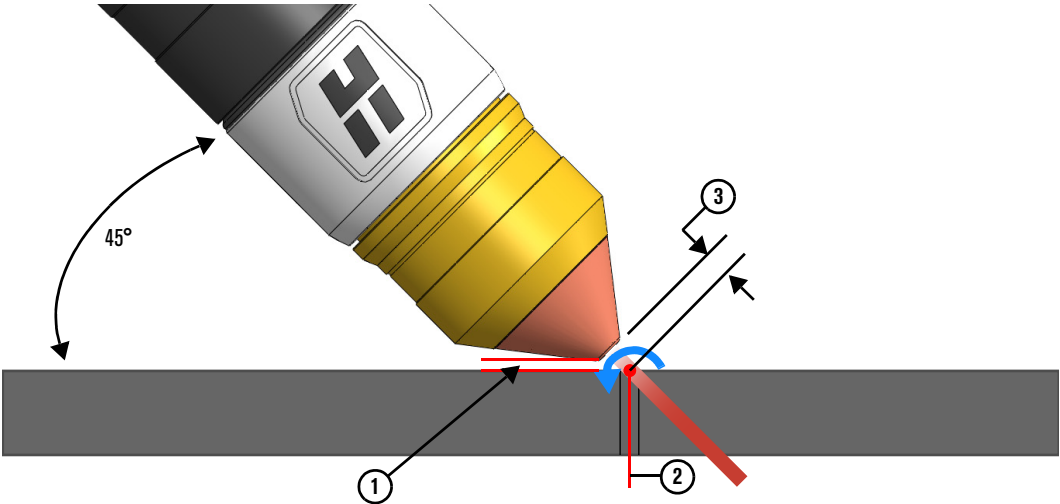
1	Minimum clearance of 0.1 inches (2.54 mm)
2	0 (zero) process shift
3	Cut height

Figure 21 – Process shift versus bevel angle – adding cut height to the bevel pivot length for an ABXYZ head

Process shift versus bevel angle
Based on torch pivot length (TPL)

1.062 TPL

1.333 TPL

Add cut height to bevel pivot length
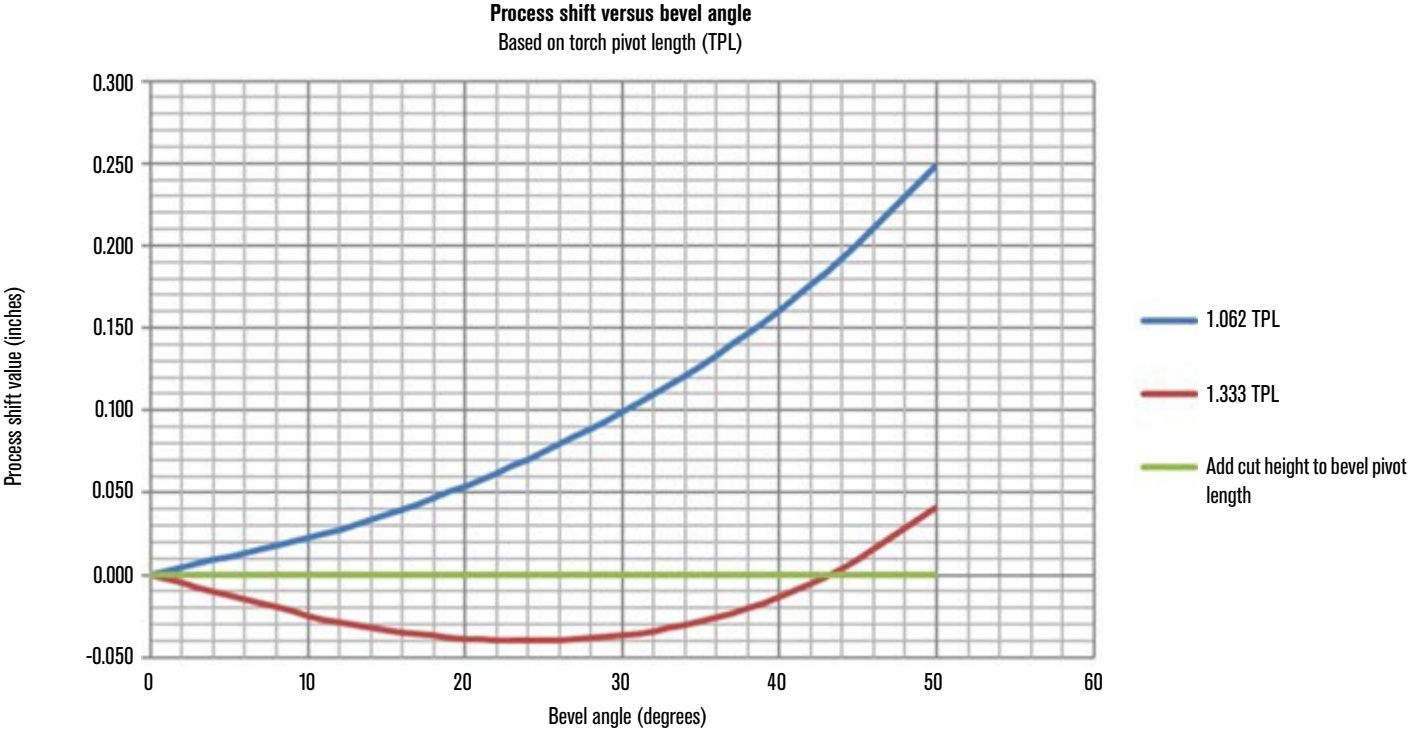
Because the default bevel pivot length value is based on the 170 A O_2/Air bevel consumable length, when you use other processes (for example, 80 A) the bevel pivot length value in the CNC needs to be adjusted to compensate for the different lengths.

The Hypertherm EDGE Connect CNC can automatically adjust the bevel pivot length value temporarily by adding or subtracting the difference in the length of the consumable sets. This difference (or delta) value can be passed through the part program code with a G93 command (Bevel Consumable Correction) at the beginning of the program. For example, for 80 A O_2/Air use the command G93 X0.058.

Table 11 contains the length differences for the bevel processes (a positive value means the consumables are longer).

Note: The True Bevel technology process parameter tables for ProNest users automatically generate the G93 command.

Table 11 – Bevel consumable length differences relative to 170 A O_2/Air

Bevel process	80 A O_2/Air	130 A O_2/Air	170 A O_2/Air	300 A O_2/Air
Consumable length delta (inches)	0.058	0.030	0.000	-0.007
Consumable length delta (mm)	1.47	0.76	0.00	-0.18

Maximum tilt angle

By inserting the desired maximum tilt angle into the True Bevel technology process parameter table, you can limit the maximum tilt such that a commanded tilt will not exceed the capabilities of the bevel head. Doing so "clips" the tilt commands to the value you specified.

For the bevel consumables, the maximum recommended tilt is 52.0° at a clearance of 0.1 inches (2.5 mm). You can select a higher maximum tilt angle if it is within the capabilities of the bevel head and if an increased minimum clearance value is also entered.

Top angle orientation

Top angle orientation is based on how the bevel head reacts when commanded to tilt to either a positive or negative angle command. For example, if a bevel head is commanded to tilt to a positive 45° angle and the result is a 45° V cut (or top bevel cut), the head is considered to have a positive top angle orientation. If the result of the positive 45° angle command is a 45° A cut, the head is considered to have a negative top angle orientation.

Installing the bevel process parameter files

To implement Hypertherm Associates' True Bevel technology process parameter tables, you will install one of eight possible Microsoft Excel spreadsheet files as well as a related dynamic link library (DLL) file. The bevel process parameter spreadsheet that you use is determined by the type of bevel motion system that you are using, as well as your CAM software and CNC setup.

The spreadsheet files contain Hypertherm Associates' True Bevel process parameter cut chart data and are provided for use with Hypertherm Associates ProNest nesting software and/or plasma systems at no additional charge to users. Four of the spreadsheet files are formatted to work with the ProNest nesting software, while the other four include only the necessary bevel process parameter information and are designed for XPR-only users to be used with other CAM and/or CNC packages.

In addition, this paper refers to the following two bevel head classifications as a way to indicate the type of bevel head being used:

- *ABXYZ with Add Cut Height to Bevel Pivot Length enabled*
- *All Other*

Four of the True Bevel technology process parameter spreadsheet files are designed for the ABXYZ with *Add Cut Height to Bevel Pivot Length enabled* classification, and four are designed for the *All Other* classifications.

The DLL file is required in all cases. There are two DLL files, one for 32-bit Microsoft Windows operating systems and the other for 64-bit. To use the True Bevel technology process parameter data, the correct spreadsheet and DLL file must be installed on the computer.

Table 12 shows the eight spreadsheet files and both DLL files. Of the ten files listed in this table, only one spreadsheet and one DLL are required to fully utilize the benefits of the True Bevel technology process parameter tables.

Table 12 – True Bevel technology process parameter table spreadsheet and DLL files

Part number	Description of file	User setup
080031	ABXYZ English ProNest Bevel Compensation spreadsheet file	English units *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* With ProNest
080032	AC English ProNest Bevel Compensation spreadsheet file	English units *All Others* With ProNest
080033	ABXYZ Metric ProNest Bevel Compensation spreadsheet file	Metric units *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* With ProNest
080034	AC Metric ProNest Bevel Compensation spreadsheet file	Metric units *All Others* With ProNest
080035	ABXYZ English XPR-only Bevel Compensation spreadsheet file	English units *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* XPR only
080036	AC English XPR-only Bevel Compensation spreadsheet file	English units *All Others* XPR only
080037	ABXYZ Metric XPR-only Bevel Compensation spreadsheet file	Metric units *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* XPR only

Table 12 – True Bevel technology process parameter table spreadsheet and DLL files

Part number	Description of file	User setup
080038	AC Metric XPR-only Bevel Compensation spreadsheet file	Metric units *All Others* XPR only
081342	Bevel Cutting Parameters DLL file for 32-bit	All users with 32-bit versions of Windows 7 or later
081343	Bevel Cutting Parameters 64 DLL file for 64-bit	All users with 64-bit versions of Windows 7 or later

Installation procedure

Contact your Hypertherm Associates representative for details on or assistance with the installation procedure.

Determining torch pivot length (TPL)

Note: This section covers one procedure for determining TPL; other methods can also be used successfully. This procedure assumes that the bevel head mechanics have been verified and that, when commanded, the bevel head can accurately achieve the desired angle.

If you do not know the TPL, you can determine it if the CNC can display the lifter axis (Z axis) values on the screen. This method uses a designed tool that incorporates a precision tooling ball accurately positioned. Hypertherm Associates offers a bevel head alignment tool (428645) that can be used for this process. This tool has a shoulder that engages the nozzle seat in the torch. The retaining cap retains the tool. At the opposite end of the tool, a tooling ball is positioned at a known distance from the tool shoulder to the center of the sphere. This distance is referred to as the *ToolDistanceToSphereCenter* dimension. The nominal *ToolDistanceToSphereCenter* dimension for the Hypertherm 428645 tool is 1.257 inches (31.92 mm).

Note: A similar bevel head alignment tool can be used as long as you know the dimensions of the tool (that is, the *ToolDistanceToSphereCenter* dimension).

To determine the TPL (once you know the *ToolDistanceToSphereCenter* dimension for your bevel head alignment tool):

1 After the torch is installed into the bevel head, the tool is installed into the torch such that the shoulder is snug against the electrode seat within the torch.

2 The lifter is lowered until the tooling ball comes into contact with a level workpiece surface (or feeler gauge) on the cutting table and the CNC records the Z value ($Z_{0°}$). (*Figure 22.*)

3 The torch is raised and is commanded to tilt to a specific angle (for example, 45°).

4 The lifter is again lowered until the tooling ball comes into contact at approximately the same location of the level workpiece surface (or feeler gauge), and again the CNC records the Z value (Z_α). (*Figure 23.*)

5 Assuming the positive Z axis direction is down, you can use the following equation to determine the TPL:

$$TPL = \left(\frac{Z_{0°} - Z_\alpha}{1 - \cos(\alpha)} \right) + ToolDistanceToSphereCenter$$

If the downward Z axis direction is negative, you will need to switch the two Z terms in this equation ($Z_\alpha - Z_{0°}$).

Example:

While using the Hypertherm 428645 tool, you record the $Z_{0°}$ value as 2.900 inches. The torch is tilted to 45°, and you record the $Z_{45°}$ value to be 2.875 inches. The TPL you enter into the True Bevel technology process parameter tables would then be 1.343 inches, as follows:

$$TPL = \left(\frac{2.900 - 2.875}{1 - \cos 45°} \right) + 1.257 = 1.343 \ inches$$

Figure 22 – Example of using a bevel head alignment tool for determining $Z_{0°}$
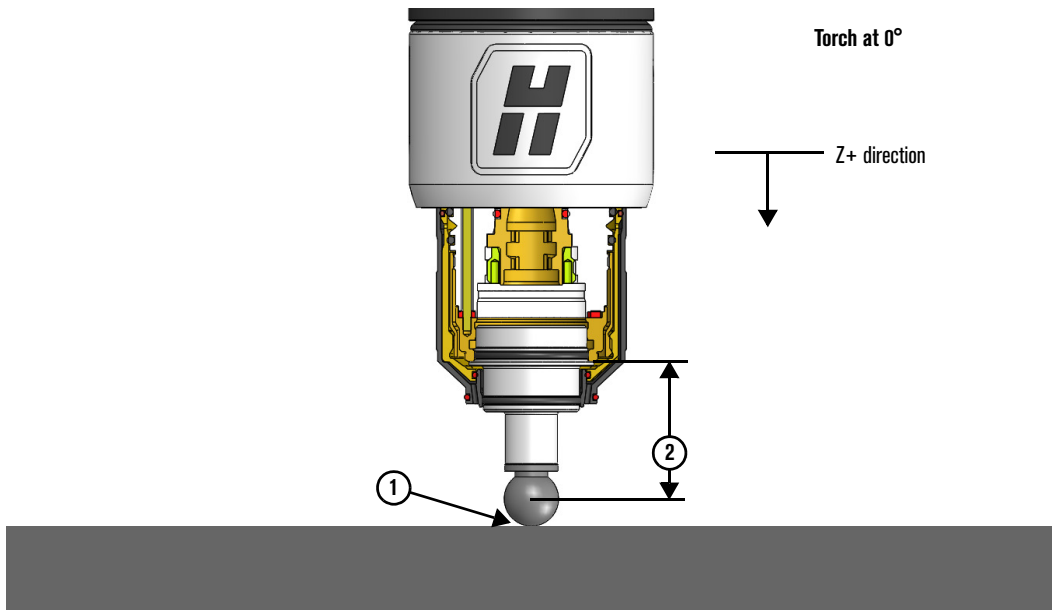
Torch at 0°

Z+ direction

2

1

1   Record the Z value from the CNC as the sphere contacts the workpiece

2   *ToolDistanceToSphereCenter*

Figure 23 – Example of using a bevel head alignment tool for determining $Z_{45°}$
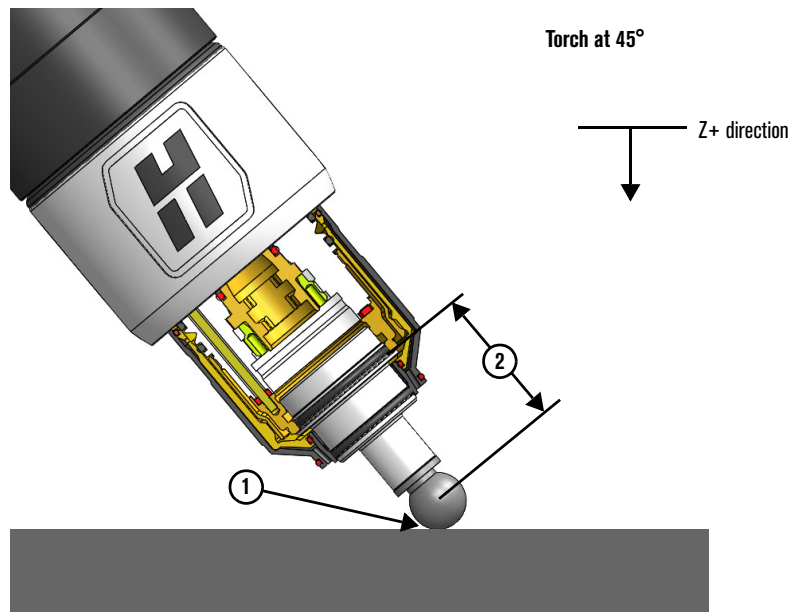
Torch at 45°

Z+ direction

2

1

1   Record the Z value from the CNC as the sphere contacts the workpiece

2   *ToolDistanceToSphereCenter*

As explained in the section *Installing the bevel process parameter files* on page 17, this paper uses the following two bevel head classifications to indicate the type of bevel head being used:

- ABXYZ with Add Cut Height to Bevel Pivot Length enabled

- All Other

For the *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* classification, no process compensation values are used when creating the output part program.

For the *All Other* classification, process compensation values are calculated based on the fixed TPL value entered into the spreadsheet.

To use the True Bevel technology process parameter data, you must have the correct spreadsheet and DLL file installed on the computer.

Hypertherm bevel ribbon

The True Bevel process parameter spreadsheets have a Hypertherm Associates Bevel ribbon. The following features are available in the ribbon.

Figure 24
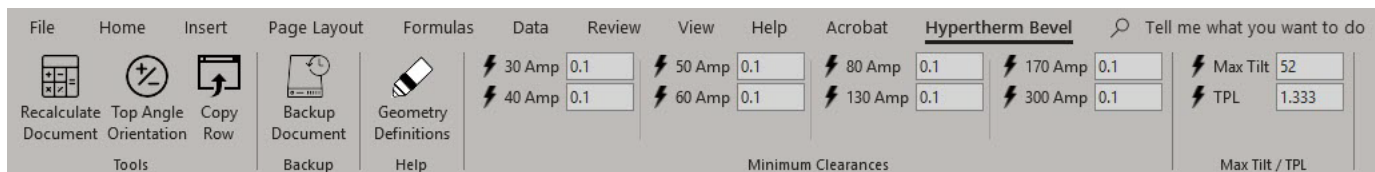
- **Recalculate Document** – Forces a recalculation of all of the values in the spreadsheet file.

- **Top Angle Orientation** – Changes the top angle orientation from positive to negative or negative to positive. See *Getting started* on page 20.

- **Copy Row** – Inserts a copy of the data from the selected row to the row below the selected row. The new row is highlighted yellow to indicate that it is a user created row.

- **Backup Document** – Creates a backup of the document in the active directory with a time stamp.

- **Geometry Definitions** – Opens a ProNest help page about the XPR torch geometry definitions.

- **Minimum Clearances** – Sets the minimum clearances for each amperage. See *Getting started* on page 20.

- **Max Tilt / TPL** – Sets the maximum tilt angle and torch pivot length (TPL). See *Getting started* on page 20.

Getting started

1 Open the True Bevel technology process parameter spreadsheet.

2 If prompted in Excel, be sure to enable macros, as this allows the spreadsheet file to reference the installed DLL file for any changes made in the spreadsheet.

> **Note:** If necessary, in Excel you will need to set the location of the spreadsheet as a trusted location, so that the macros can run without errors.

3 Choose the proper top angle orientation (positive or negative) for each (*Figure 25*). (See *Top angle orientation* on page 16.) You should need to make this selection only once.

Figure 25 – Top angle orientation selection

4 Set the desired minimum clearances (**Minimum Clearances**) for each process (*Figure 26*). The recommended clearance value range is 0.080 inches (2 mm) to 0.160 inches (4 mm); however, the recommended and default clearance value is 0.100 inches (2.5 mm).

If torch collisions are occurring, increasing the minimum clearance value will generate new cut heights and arc voltages to raise the torch farther from the workpiece without affecting part size. Hypertherm Associates recommends:

– Changing the minimum clearance value only after cutting sample parts.

– Conducting proper arc voltage calibration prior to changing the minimum clearance if the cutting system does not use sampled arc voltage (or a similar technology). Otherwise, the torch collisions may be caused by improper arc voltage rather than improper clearance.

5 Set the torch pivot length (TPL) value for the bevel head and torch combination (*Figure 26*). This applies only to AC-type bevel heads and bevel heads that fall under the *All Others* classification.

6 Set the maximum tilt angle (**Max Tilt**) for the bevel head (*Figure 26*). This is the maximum angle that will be programmed in a part program.

Figure 26 – Setting minimum clearance, TPL (AC-type and *All Others* only), and maximum tilt angle
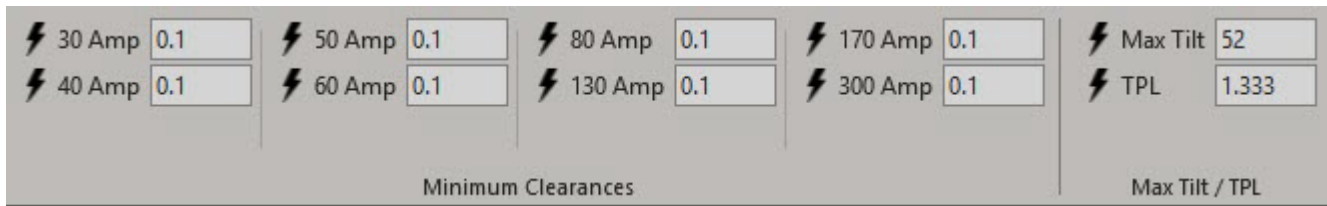
Note: For thin materials and high angles, head angles in excess of 48° are sometimes required to obtain the correct angle on the part. Many heads, however, cannot tilt over 45° to 48°. When the maximum tilt angle limits the tilt angle output, the row will be formatted with a red color background and a white font in the spreadsheet to indicate that the "Output Angle" has been clipped (*Figure 27*). When the output angles are clipped, you may not be able to achieve the desired angle in the cut.

Figure 27 – Maximum tilt angle causing clipped tilt angle output

Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate	Base Kerf	Calculated Kerf	Kerf	Calculated Angle Adjustment	Manual Angle Adjustment	Angle Adjustment	Output Angle (Information Only)
MS	0.2500	80Amp O2/Air [True Bevel]	0.0	*	0.0			110.00	110.00	110.00	0.075		0.075			0.00	0.00
MS	0.2500	80Amp O2/Air [True Bevel]	0.0	y	0.0			110.00	110.00	110.00	0.075		0.075			0.00	0.00
MS	0.2500	80Amp O2/Air [True Bevel]	0.0	k	0.0			110.00	110.00	110.00	0.075		0.075			0.00	0.00
MS	0.2500	80Amp O2/Air [True Bevel]	45.0	a	45.0			110.00	69.20	69.20	0.075	0.155	0.155	9.89		7.00	52.00
MS	0.2500	80Amp O2/Air [True Bevel]	40.0	a	40.0			110.00	73.60	73.60	0.075	0.146	0.146	9.63		9.63	49.63

True Bevel technology process parameter table values

For XPR-only users, the bevel process parameter spreadsheet outputs the required process parameters to successfully locate the torch and produce the desired bevel cut outcome based on the user inputs. The XPR-only parameters are shown in *Table 13*.

> **Note:** ProNest users have additional process and loop details to fully define the bevel cutting process.

Table 13 – Description of bevel process parameters (XPR-only users)

Parameter	Description	Type	Category
Material	Material type (currently supporting only mild steel [MS])	User editable – must match the cut spreadsheet	Part attributes
Thickness	Material thickness (inches or mm)	User editable – must match the cut spreadsheet	Part attributes
Class	Process current level and gas types **Note:** Classes with "True Bevel" indicate True Bevel cut charts at factory-tested bevel angles and thicknesses.	User editable – must match the cut spreadsheet	Part attributes
Target Bevel Angle	Desired bevel angle (absolute value, no sign association) (degrees)	User editable	Bevel attributes
Bevel Type	V cut (v), A cut (a), Y Top cut (y), I cut (*), X cut (x), K cut (k)	User editable	Bevel attributes
Bevel Angle	Desired bevel angle with appropriate sign applied based on the Top Angle Orientation selection. This value combined with the Angle Adjustment is needed for the output part program code (degrees).	Calculated	Bevel attributes
Land Dimension	Desired land dimension for Y Top cuts and K cuts (inches or mm)	User editable	Bevel attributes
LeadIn Feedrate	No values supplied – use the value from the Feedrate column. You can edit this value if you need a specific feedrate for a lead-in.	User editable	Feedrate controls
Base Feedrate	Feedrate for I cuts (ipm or mm/min)	Calculated	Feedrate controls
Calculated Feedrate	Calculated feedrate for the desired bevel cut (ipm or mm/min)	Calculated	Feedrate controls
Feedrate	Equals the Calculated Feedrate. This value is needed for the output part program code (ipm or mm/min).	User editable	Feedrate controls
Base Kerf	Recommended kerf value for I cuts (inches or mm)	Calculated	Kerf controls
Calculated Kerf	Calculated kerf value for the desired bevel cut (inches or mm)	Calculated	Kerf controls
Kerf	Calculated kerf value that uses the Base Kerf and Calculated Kerf. This value is needed for the output part program code (inches or mm).	User editable	Kerf controls
Calculated Angle Adjustment	Calculated angle adjustment value for the desired bevel cut (degrees)	Calculated	Angle adjustments
Manual Angle Adjustment	Desired angle adjustment (degrees)	User editable	Angle adjustments
Angle Adjustment	Calculated angle compensation for the desired bevel cut with the appropriate sign applied based on the Top Angle Orientation selection. This value combined with the Bevel Angle are needed for the output part program code (degrees).	Calculated	Angle adjustments
Output Angle [Information Only]	Calculated output angle value (degrees). This is a display only value.	Informational	Angle adjustments
Manual Process Compensation	Manual adjustment for the Process Compensation	User editable	Part size adjustment

Table 13 – Description of bevel process parameters (XPR-only users)

Parameter	Description	Type	Category
Process Compensation	Process shift adjustment. The default value for *ABXYZ with Add Cut Height to Bevel Pivot Length enabled* bevel head types is blank because there is no process shift (inches or mm).	Calculated	Part size adjustment
Record ID	XPR cut process ID	Informational	–
AHC Delay Distance	Distance from start of profile to travel before turning on Auto Height Control	User editable	Process parameters and overrides
Consumable Correction	Accounts for the size of the torch assembly, based on 170 A consumables	Calculated	Process parameters and overrides
Arc Voltage	Standard arc voltage based on I cut values.	Informational	Process parameters and overrides
Arc Voltage Override	Calculated arc voltage based on cut speed, cut height, and effective material thickness. This value may be needed for the output part program code (volts). **Note:** The calculated values are based on new consumables and a laboratory setup. Some compensation may need to be done to account for machine differences. If sample arc voltage routines are not used, the operator will need to make adjustments to the arc voltage as the consumables wear in order maintain part size.	Calculated for True Bevel compatible rows. User editable	Process parameters and overrides
Transfer Height	Height of the torch for transferring the arc to the workpiece. This value is needed for the output part program code.	Calculated	Process parameters and overrides
Transfer Height Override	Desired transfer height override value (inches or mm)	User editable	Process parameters and overrides
Pierce Height	Height of the torch during piercing operation. This value is needed for the output part program code.	Informational	Process parameters and overrides
Pierce Height Override	Desired pierce height override value (inches or mm)	User editable	Process parameters and overrides
Pierce Time	Delay time for the arc to penetrate the workpiece. This value is needed for the output part program code (seconds).	Informational	Process parameters and overrides
Pierce Time Override	Desired pierce time override value (seconds)	User editable	Process parameters and overrides
Cut Height	Standard cut height based on I cut values	Informational	Process parameters and overrides
Cut Height Override	Calculated cut height that provides the minimum desired clearance at the desired bevel angle while maintaining the cut height as close as possible to the cut height value for the effective thickness being cut. This value is needed for the output part program code (inches or mm).	Calculated for True Bevel compatible rows. User editable	Process parameters and overrides
Cut Current	Cut current based on the selected process	Informational	Process parameters and overrides
Cut Current Override	End user override for cut current value	User editable	Process parameters and overrides
Shield Pierce Flow	Shield gas flow rate during pierce	Informational	Process parameters and overrides
Shield Pierce Flow Override	End user override for shield gas flow rate during pierce	User editable	Process parameters and overrides
Plasma Cut Flow	Gas flow rate during cut	Informational	Process parameters and overrides

Table 13 – Description of bevel process parameters (XPR-only users)

Parameter	Description	Type	Category
Plasma Cut Flow Override	End user override for gas flow rate during cut	User editable	Process parameters and overrides
Shield Cut Flow	Shield gas flow rate during cut	Informational	Process parameters and overrides
Shield Cut Flow Override	End user override for shield gas flow rate during cut	User editable	Process parameters and overrides
Mix H2 Flow	Mix H_2 flow rate	Informational	Process parameters and overrides
Mix H2 Flow Override	End user override for mix H_2 flow rate	User editable	Process parameters and overrides
Mix Ar Flow	Mix Ar flow rate	Informational	Process parameters and overrides
Mix Ar Flow Override	End user override for mix Ar flow rate	User editable	Process parameters and overrides
Mix N2 Flow	Mix N_2 flow rate	Informational	Process parameters and overrides
Mix N2 Flow Override	End user override for N_2 flow rate	User editable	Process parameters and overrides
Loop Scale	Size of the Loop macro	User editable	Bevel loop
Loop Macro	Name of the Loop macro	User editable	Bevel loop
CornerIn Name	Name of the CornerIn bevel macro	User editable	Corner lead
CornerIn Scale	Size of the CornerIn bevel macro	User editable	Corner lead
CornerIn Angle	Angle of the CornerIn bevel macro	User editable	Corner lead
CornerIn Extension	Extension on the CornerIn bevel macro	User editable	Corner lead
CornerOut Name	Name of the CornerOut bevel macro	User editable	Corner lead
CornerOut Scale	Size of the CornerOut bevel macro	User editable	Corner lead
CornerOut Angle	Angle of the CornerOut bevel macro	User editable	Corner lead
CornerOut Extension	Extension on the CornerOut bevel macro	User editable	Corner lead
CornerOut Overtravel	Overtravel on the CornerOut bevel macro	User editable	Corner lead
SideIn Name	Name of the SideIn bevel macro	User editable	Side lead
SideIn Scale	Size of the SideIn bevel macro	User editable	Side lead
SideIn Angle	Angle of the SideIn bevel macro	User editable	Side lead
SideIn Extension	Extension on the SideIn bevel macro	User editable	Side lead
SideOut Name	Name of the SideOut bevel macro	User editable	Side lead

Table 13 – Description of bevel process parameters (XPR-only users)

Parameter	Description	Type	Category
SideOut Scale	Size of the SideOut bevel macro	User editable	Side lead
SideOut Angle	Angle of the SideOut bevel macro	User editable	Side lead
SideOut Extension	Extension on the SideOut bevel macro	User editable	Side lead
SideOut Overtravel	Overtravel on the SideOut bevel macro	User editable	Side lead
Bridge Macro	Name of the Bridge macro	User editable	Bevel advanced
Blind In Name	Name of the Blind macro lead-in when a blind bevel is the first entity to cut	User editable	Bevel advanced
Blind In Scale	Lead-in size for the Blind macro when a blind bevel is the first entity to cut (inches or mm)	User editable	Bevel advanced
Blind Leadin Angle	Lead-in angle for the Blind macro when a blind bevel is the last entity to cut	User editable	Bevel advanced
Blind Out Name	Lead-out name for the Blind macro when a blind bevel is the last entity to cut	User editable	Bevel advanced
Blind Out Scale	Lead-out size for the Blind macro when a blind bevel is the last entity to cut (inches or mm)	User editable	Bevel advanced
Blind Leadout Angle	Lead-out angle for the Blind macro when a blind bevel is the last entity to cut	User editable	Bevel advanced
Blind Start Loop Macro	Name of the Blind Start macro	User editable	Bevel advanced
Blind Start Loop Scale	Size of the Blind Start (inches or mm)	User editable	Bevel advanced
Blind End Loop Macro	Name of the Blind End macro	User editable	Bevel advanced
Blind End Loop Scale	Size of the Blind End (inches or mm)	User editable	Bevel advanced
Bevel A Deg Per Sec	Recommended tilt speed. This value may be needed for the output of the part program code (degrees/second).	Calculated / User editable	Bevel advanced
Pierce Radius	Size of the pre-pierce radius	User editable	Bevel advanced
FA	Rate of the feedrate transitions	Calculated	Bevel advanced
Error Check	Determines if there is an Excel macro error present in the spreadsheet	Calculated	Bevel advanced
IHS Distance	Distance before re-sampling the torch height	Calculated / User editable	Bevel advanced

Additional Y Top cut and K cut outputs

In addition to the parameters listed previously, multi-pass bevel cuts have parameters specifically related to the I cut portion of the bevel cut. In the spreadsheet, these values are found in the gray header area for the thickness section in the y-0 row, as shown in *Figure 28*.

Outputs for the I portion of the Y Top cut should be taken from the y-0 row. Outputs for the I portion of the K cut should be taken from the k-0 row.

Note: The sequence of the multi-pass cuts affects the results. The True Bevel technology process parameter tables provide values based on cutting from bottom to top.

Figure 28 – I cut portion of Y Top cut and K cut

Part Attributes			Bevel				Feedrate Controls				Kerf Controls			Angle Adjustments				
Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate	Base Kerf	Calculated Kerf	Kerf	Calculated Angle Adjustment	Manual Angle Adjustment	Angle Adjustment	Output Angle [Information Only]	Manual Process Compensation
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	*	0.0			75.00	75.00	75.00	0.083		0.083			0.00		
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	y	0.0			75.00	75.00	75.00	0.083		0.083			0.00		
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	k	0.0			75.00	75.00	75.00	0.083		0.083			0.00		

Making modifications to the True Bevel technology process parameter tables

The True Bevel technology process parameter tables include a relatively dense range of angles along with three different land sizes that should be sufficient for most beveling needs. However, if you need a different angle or land size, you can modify the spreadsheet. For best results, Hypertherm Associates recommends staying within the range of angles and lands that are currently in the spreadsheet (in other words, extrapolation results are unknown). You can perform modifications using either of the following two methods:

▪ Altering an existing row: change the values in the input columns for **Target Bevel Angle**, **Bevel Type**, and/or **Land Dimension** – the spreadsheet will generate new output values based on the new inputs

- Copying and inserting a new row: after you insert a row, enter the desired values into the user editable columns – the spreadsheet will generate new calculated values based on the inputs

Additional modifications are also possible, such as modifying the desired minimum clearance values.

Note: Calculated outputs based on adding new thicknesses, material types, or classes to the spreadsheet are not supported.

Making final adjustments (if necessary)

The values in the True Bevel technology process parameter tables should result in a part that is close to the desired dimensions, but some fine tuning may be necessary. Use the guidelines in the following section to make the final adjustments. Before performing any tests, check to make sure that the workpiece is level.

Note: Actual results will vary based on bevel head performance. Consult your bevel head table manufacturer to determine the expected tolerance levels that can be achieved with your system. In addition to plasma variability, many other factors will determine the capability of your system, including table motion, bevel head motion, transformation equations, lifter performance, and arc voltage control.

V cuts and A cuts

1 Bevel angle adjustment (*Figure 29*):

   a After cutting a test part from a level workpiece, measure the angle and determine the difference between the measured angle and the desired angle.

   b Add the difference to the **Manual Angle Adjustment** column in the spreadsheet.

   – You can put in a positive (+) or negative (-) value.

   – Notice that the **Angle Adjustment** column updates when you update the **Manual Angle Adjustment** column.

   – During output, this column adds to or subtracts from the **Bevel Angle** column. The **Bevel Angle** column gives you the final angle during output.

   c Recut the part with the new setting to verify that the angle is now correct before proceeding to the next step.

   d If the angle is not correct, repeat *step 1*.

Figure 29 – V cut and A cut bevel angle

Bevel angle

2 Part size adjustment (*Figure 30* and *Figure 31*):

a After you have achieved the desired angle, measure the size of the part and determine the difference between the measured size and the desired size.

b Add the difference to the **Manual Process Compensation** column in the spreadsheet.

– You can put in a positive (+) or negative (-) value.

– Notice that the **Process Compensation** column updates when you update the **Manual Process Compensation** column.

– This column adds to or subtracts from the location of the bevel pass to adjust the part size.

c Recut the part with the new setting to verify that the size is now correct.

d If the size is not correct, repeat *step 2*.

Note: When you measure the size of A cut parts, Hypertherm recommends that you take measurements at the minor side of the part (due to corner rounding), or, if possible, that you take measurements to the theoretical corner. Measuring the size of V cut parts can be done at either the minor or the major side of the part, but for best results the minor side should be used to eliminate error due to material thickness variations.
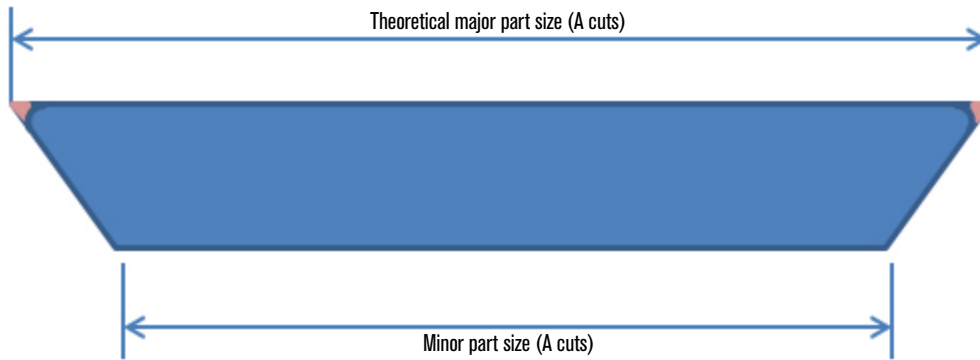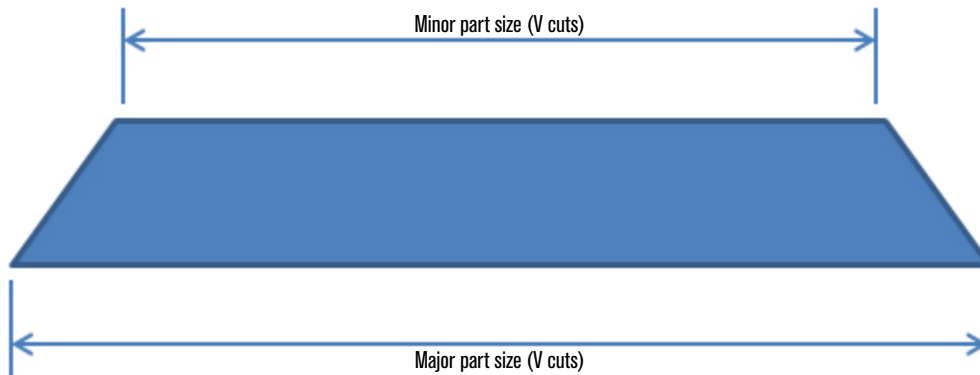
Figure 30 – A cut part size

Theoretical major part size (A cuts)

Minor part size (A cuts)

Figure 31 – V cut part size

Minor part size (V cuts)

Major part size (V cuts)

3 Save the spreadsheet file.

Y Top cuts

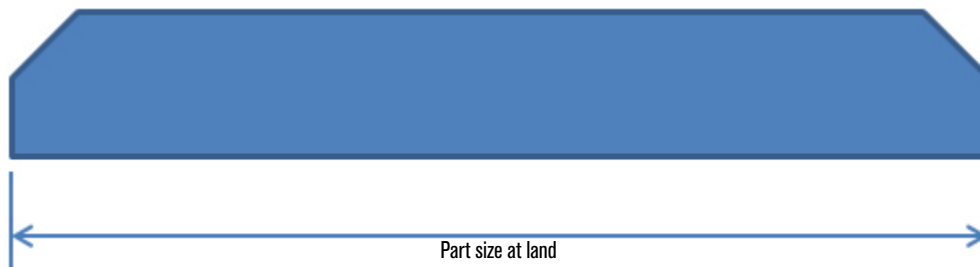**1** Part size at land adjustment (*Figure 32*):

a After cutting a test part from a level workpiece, measure the part size at the land.

Note: If there is no land, adjust the Manual Process Compensation until you get a measurable land. Usually, this requires a positive adjustment to the process compensation. After you get a measurable land, follow the adjustment procedure.

b Calculate the difference between the measured size and the desired size.

c Add the difference to the **Manual Process Compensation** column in the gray header area of the spreadsheet for the thickness section in the y-0° row, as shown in *Figure 35* on page 30 (note that process compensation is applied per side).

– You can put in a positive (+) or negative (-) value.

– Notice that the **Process Compensation** column updates when you update the **Manual Process Compensation** column.

– This column adds to or subtracts from the location of the bevel pass to adjust the part size.

d Recut the part with the new setting to verify that the size is now correct.

e If the size is not correct, repeat *step 1*.

Figure 32 – Y Top cut part size at land

Part size at land

2 Part angle adjustment (*Figure 33*):

a After you have achieved the desired part size at land, measure the angle of the bevel.

b Calculate the difference between the measured angle and the desired angle.

c Add the difference to the **Manual Angle Adjustment** column in the spreadsheet.

– You can put in a positive (+) or negative (-) value.

– Notice that the **Angle Adjustment** column updates when you update the **Manual Angle Adjustment** column.

– During output, this column adds to or subtracts from the **Bevel Angle** column. The **Bevel Angle** column gives you the final angle during output.

d Recut the part with the new setting to verify that the angle is now correct before proceeding to the next step.

e If the angle is not correct, repeat *step 2*.

Figure 33 – Y Top cut bevel angle

Bevel angle

3 Part land dimension adjustment (*Figure 34*):

a After you have achieved the desired angle, measure the land dimension.

b Calculate the difference between the measured land dimension and your desired land dimension.

c Use the following formula to calculate the adjustment to the process compensation:

Process Compensation Adjustment =

Land Dimension Difference$(\tan[\alpha])$

Note: The sequence of the multi-pass cuts affects the results. Hypertherm's True Bevel technology process parameter tables provide values based on cutting from bottom to top. For a Y Top cut, the land is cut first, followed by the V cut.

where α = the actual angle.

d Add the calculated adjustment value to or subtract it from the value displayed in the **Manual Process Compensation** column in the spreadsheet, and overwrite the value in the cell with the new adjustment value.

e Recut the part with the new setting to verify that the land dimension is now correct.

f If the land dimension is not correct, repeat *step 3*.

Figure 34 – Y Top cut land dimension

Land dimension

Figure 35 – Y cut part size at land adjustment using process compensation

| Part Attributes			Bevel				Feedrate Controls				Kerf Controls			Angle Adjustments				
Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate	Base Kerf	Calculated Kerf	Kerf	Calculated Angle Adjustment	Manual Angle Adjustment	Angle Adjustment	Output Angle [Information Only]	Manual Process Compensation
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	*	0.0			75.00	75.00	75.00	0.083		0.083			0.00		
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	y	0.0			75.00	75.00	75.00	0.083		0.083			0.00		0.015
MS	0.3750	80Amp O2/Air [True Bevel]	0.0	k	0.0			75.00	75.00	75.00	0.083		0.083			0.00		
MS	0.3750	80Amp O2/Air [True Bevel]	45.0	a	45.0			75.00	32.20	32.20	0.083	0.189	0.189	4.32		4.32		
MS	0.3750	80Amp O2/Air [True Bevel]	40.0	a	40.0			75.00	40.40	40.40	0.083	0.143	0.143	3.90		3.90		

4 Save the spreadsheet file.

X cuts

1 Bevel angle adjustments for bottom and top (*Figure 36*):

    a After cutting a test part from a level workpiece, measure the top and bottom bevel angles.

    b Calculate the difference between the measured angles and the desired angles for the bottom and top bevel angles.

    c Add the calculated differences to the value in the **Manual Angle Adjustment** column in the bottom and top bevel rows in the spreadsheet, and overwrite the value in the cell with the new value.

    – You can put in a positive (+) or negative (-) value.

    Note: The sequence of the multi-pass cuts affects the results. Hypertherm Associates' True Bevel technology process parameter tables provide values based on cutting from bottom to top. For an X cut, the V cut is first, followed by the A cut.

– Notice that the **Angle Adjustment** column updates when you update the **Manual Angle Adjustment** column.

– During output, this column adds to or subtracts from the **Bevel Angle** column. The **Bevel Angle** column shows you the final angle during output.

    d Recut the part with the new settings to verify that the angles are now correct before proceeding to the next step.

    e If either angle is not correct, repeat *step 1*.

Figure 36 – X cut adjustments
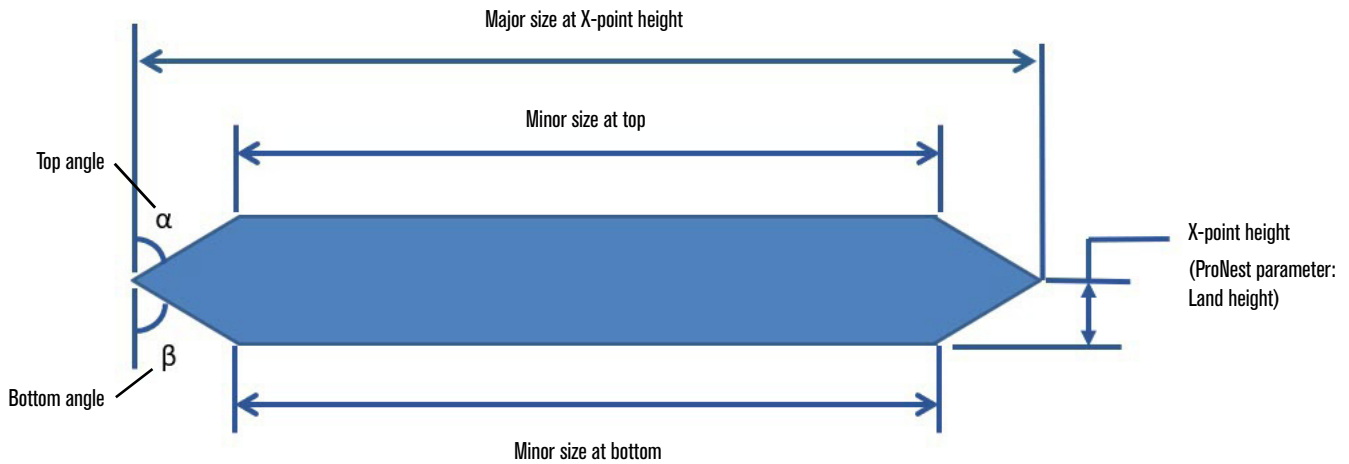
2 Part size adjustment for top and bottom (*Figure 36*):

a After you have achieved the desired bevel angles, measure the minor size of the part for the top and bottom passes

b Calculate the difference between the measured sizes and the desired sizes for the top and bottom passes. Desired sizes can be calculated using the following formulas:

Desired minor size at the top =
Desired major size – 2(tan[α]) x (Thickness – Desired X-point height)

where α = the actual top angle.

Desired minor size at the bottom =
Desired major size – 2(tan[ß]) x (Desired X-point height)

where ß = the actual bottom angle.

c Add the calculated difference to the **Manual Process Compensation** column in the top and bottom bevel rows in the spreadsheet, and overwrite the value in the cell with the new value.

– You can put in a positive (+) or negative (-) value.

– Notice that the **Process Compensation** column updates when you update the **Manual Process Compensation** column.

– This column adds to or subtracts from the location of the bevel pass to adjust the part size.

d Recut the part with the new setting to verify that the size is now correct.

e If either size is not correct, repeat *step 2*.

Figure 37 – X cut size adjustment using process compensation

Part Attributes			Bevel					Feedrate Control				Kerf Controls			Angle Adjustments				
Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Land Height	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate	Base Kerf	Calculated Kerf	Kerf	Calculated Angle Adjustment	Manual Angle Adjustment	Angle Adjustment	Output Angle [Information Only]	Manual Process Compensation
MS	0.750	170Amp O2/Air [True Bevel]	45	x	45		0.375		65.000	34.400	34.400	0.127	0.198	0.198	0.83		0.83	45.83	
MS	0.750	170Amp O2/Air [True Bevel]	-45	x	-45		0.375		65.000	36.800	36.800	0.127	0.227	0.227	0.91		0.91	-44.0(	0.015
MS	0.750	170Amp O2/Air [True Bevel]	40	x	40		0.375		65.000	41.200	41.200	0.127	0.169	0.169	0.79		0.78	40.78	
MS	0.750	170Amp O2/Air [True Bevel]	-40	x	-40		0.375		65.000	43.100	43.100	0.127	0.193	0.193	0.66		0.66	-39.34	
MS	0.750	170Amp O2/Air [True Bevel]	37.5	x	37.5		0.375		65.000	44.000	44.000	0.127	0.161	0.161	1.11		1.11	38.61	

K cuts

1 Part size at land adjustment (*Figure 39*):

a After cutting a test part from a level workpiece, measure the part size at the land.

Note: If there is no land, adjust the Manual Process Compensation for the top and bottom cuts until you get a measurable land. Usually, this requires positive adjustments to the process compensations. After you get a measurable land, follow the adjustment procedure.

b Calculate the difference between the measured size and the desired size.

c Add the difference to the **Manual Process Compensation** column in the gray header area of the spreadsheet for the thickness section in the k-0° row, as shown in *Figure 38*.

– Process compensation is applied per side.

– You can put in a positive (+) or negative (-) value.

– Notice that the **Process Compensation** column updates when you update the **Manual Process Compensation** column.

– This column adds to or subtracts from the location of the bevel pass to adjust the part size.

d Recut the part with the new setting to verify that the size is now correct.

e If the size is not correct, repeat *step 1*.

Figure 38 – K cut part size at land adjustment using process compensation

| Part Attributes			Bevel					Feedrate Controls				Kerf Controls			Angle Adjustments				
Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Land Height	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate	Base Kerf	Calculated Kerf	Kerf	Calculated Angle Adjustment	Manual Angle Adjustment	Angle Adjustment	Output Angle (Information Only)	Manual Process Compensation
MS	0.750	170Amp O2/Air [True Bevel]	45 k		45	0.250	0.250		65.000	32.200	32.200	0.127	0.220	0.220	2.43		2.43	47.43	
MS	0.750	170Amp O2/Air [True Bevel]	-45 k		-45	0.250	0.250		65.000	39.200	39.200	0.127	0.285	0.285	2.65		2.65	-42.3	0.015
MS	0.750	170Amp O2/Air [True Bevel]	37.5 k		37.5	0.250	0.250		65.000	44.400	44.400	0.127	0.133	0.133	0.78		0.78	38.28	
MS	0.750	170Amp O2/Air [True Bevel]	-37.5 k		-37.5	0.250	0.250		65.000	48.500	48.500	0.127	0.247	0.247	2.71		2.71	-34.79	
MS	0.750	170Amp O2/Air [True Bevel]	30 k		30	0.250	0.250		65.000	51.100	51.100	0.127	0.158	0.158	2.27		2.27	32.27	

2 Bevel angle adjustments for bottom and top (*Figure 39*):

a After you have achieved the desired part size at land, measure the top and bottom bevel angles.

b Calculate the difference between the measured angles and the desired angles for the bottom and top bevel angles.

c Add the calculated difference to the value in the **Manual Angle Adjustment** column in the bottom and top bevel rows in the spreadsheet, and overwrite the value in the cell with the new value.

– You can put in a positive (+) or negative (-) value.

– Notice that the **Angle Adjustment** column updates when you update the **Manual Angle Adjustment** column.

– During output, this column adds to or subtracts from the **Bevel Angle** column. The **Bevel Angle** column shows you the final angle during output.

d Recut the part with the new setting to verify that the angles are now correct before proceeding to the next steps.

e If either angle is not correct, repeat *step 2*.

Figure 39 – K cut adjustments

Top angle
Part size at land
α
Land dimension
Bottom angle
β
Land height
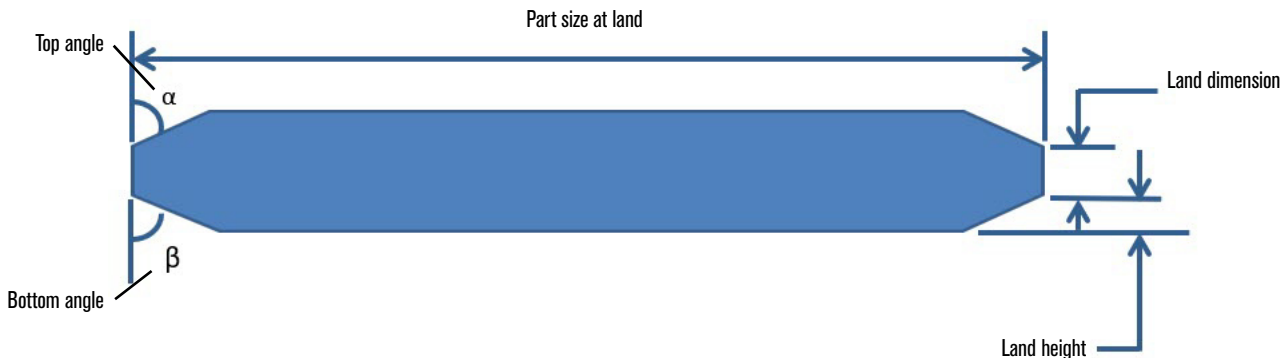
3 Part land height adjustment (*Figure 39*):

a After you have achieved the desired part size at the land and desired angles, measure the land height

b Calculate the difference between the measured land height and your desired land height.

c Use the following formula to calculate the adjustment to the process compensation for the bottom pass:

Process Compensation Adjustment =

Land height Difference(tan[ß])

4 Part land dimension adjustment (*Figure 39*):

a After you have achieved the desired part size at the land, angles and land height, measure the land dimension

b Calculate the difference between the measured land size and your desired land size.

c Use the following formula to calculate the adjustment to the process compensation for the bottom pass:

Process Compensation Adjustment =

Land Dimension Difference(tan[α])

5 Save the spreadsheet file.

where ß = the actual bottom angle.

d Add the calculated adjustment value to or subtract it from the value displayed in the **Manual Process Compensation** column in the bottom pass row of K, and overwrite the value in the cell with the new adjustment value.

e Recut the part with the new setting to verify that the land height is now correct.

f If the land height is not correct, repeat *step 3*.

where α = the actual top angle.

d Add the calculated adjustment value to or subtract it from the value displayed in the **Manual Process Compensation** column in the top pass row of K, and overwrite the value in the cell with the new adjustment value.

e Recut the part with the new setting to verify that the land dimension is now correct.

f If the land dimension is not correct, repeat *step 4*.

How to add a new X bevel record

When you want to add an X cut to the spreadsheet file, you must add two new X cut records. One record has the positive bevel angle, and the other has the negative bevel angle.

You need to do testing to make sure that you have the correct values in your spreadsheet.

1 Save or create a backup of the spreadsheet.

2 Select the A cut row with the angle that you want to use, and insert a blank row below the row.

> **Note:** In this example, we use the MS 0.3125 80Amp O2/Air (True Bevel) 45 degree V and A bevel types.

3 Copy the A cut row.

4 Select the blank row that you inserted in *step 2*.

5 Use **Paste as Special** > **Values**.

> **Note:** If you use **Paste**, the formulas are copied. You do not want the formulas copied for this use.

6 Select the V cut row with the angle that you want to use, and insert a blank row below the row.

7 Copy the V cut row.

8 Select the blank row that you inserted in *step 6*.

9 Use **Paste as Special** > **Values**.

> **Note:** If you use **Paste**, the formulas are copied. You do not want the formulas copied for this use.

10 In the new rows, make sure that the **Bevel Type** is set to **x**.

> **Note:** You use these new X rows, to change your process parameters.

Figure 40 – New X bevel rows

Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Land Height	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate
MS	0.313	80Amp O2/Air [True Bevel]	0	k	0				96.000	96.000	96.000
MS	0.313	80Amp O2/Air [True Bevel]	45	a	45				96.000	42.600	42.600
MS	0.313	80Amp O2/Air [True Bevel]	45	x	45				96.000	48.000	48.000
MS	0.313	80Amp O2/Air [True Bevel]	40	a	40				96.000	52.000	52.000
MS	0.313	80Amp O2/Air [True Bevel]	37.5	a	37.5				96.000	56.600	56.600
MS	0.313	80Amp O2/Air [True Bevel]	35	a	35				96.000	61.100	61.100
MS	0.313	80Amp O2/Air [True Bevel]	30	a	30				96.000	69.300	69.300
MS	0.313	80Amp O2/Air [True Bevel]	27.5	a	27.5				96.000	73.000	73.000
MS	0.313	80Amp O2/Air [True Bevel]	25	a	25				96.000	76.300	76.300
MS	0.313	80Amp O2/Air [True Bevel]	22.5	a	22.5				96.000	79.300	79.300
MS	0.313	80Amp O2/Air [True Bevel]	20	a	20				96.000	81.900	81.900
MS	0.313	80Amp O2/Air [True Bevel]	17.5	a	17.5				96.000	84.200	84.200
MS	0.313	80Amp O2/Air [True Bevel]	15	a	15				96.000	86.100	86.100
MS	0.313	80Amp O2/Air [True Bevel]	50	v	-50				96.000	46.000	46.000
MS	0.313	80Amp O2/Air [True Bevel]	45	v	-45				96.000	54.200	54.200
MS	0.313	80Amp O2/Air [True Bevel]	45	x	-45				96.000	48.000	48.000
MS	0.313	80Amp O2/Air [True Bevel]	40	v	-40				96.000	61.800	61.800

11 Save the spreadsheet file.

How to add a new K bevel record

When you want to add a K cut to the spreadsheet file, you must add two new K cut records for each Land Dimension. This makes sure that you get the correct record match. It also allows you to make different adjustments to the feedrates, process compensation, angle adjustment, per different land size.

You need to do testing to make sure that you have the correct values in your spreadsheet.

1 Save or create a backup of the spreadsheet.

2 Select the A cut row with the angle that you want to use, and insert a blank row below the row.

> **Note:** In this example, we use the MS 0.3125 80Amp O2/Air (True Bevel) 45 degree V and A bevel types.

3 Copy the A cut row.

4 Select the blank row that you inserted in *step 2*.

5 Use **Paste as Special** > **Values**.

> **Note:** If you use **Paste**, the formulas are copied. You do not want the formulas copied for this use.

6 Select the V cut row with the angle that you want to use, and insert a blank row below the row.

7 Copy the V cut row.

8 Select the blank row that you inserted in *step 6*.

9 Use **Paste as Special** > **Values**.

> **Note:** If you use **Paste**, the formulas are copied. You do not want the formulas copied for this use.

10 In the new rows, make sure that the **Bevel Type** is set to **k** and specify the **Land Dimension**.

> **Note:** You use these new K rows, to change your process parameters.

Figure 41 – New K bevel rows

Material	Thickness	Class	Target Bevel Angle	Bevel Type	Bevel Angle	Land Dimension	Land Height	Lead In Feedrate	Base Feedrate	Calculated Feedrate	Feedrate
MS	0.313	80Amp O2/Air [True Bevel]	0	k	0				96.000	96.000	96.000
MS	0.313	80Amp O2/Air [True Bevel]	45	a	45				96.000	42.600	42.600
MS	0.313	80Amp O2/Air [True Bevel]	45	k	45	0.100	0.106		96.000	48.000	48.000
MS	0.313	80Amp O2/Air [True Bevel]	40	a	40				96.000	52.000	52.000
MS	0.313	80Amp O2/Air [True Bevel]	37.5	a	37.5				96.000	56.600	56.600
MS	0.313	80Amp O2/Air [True Bevel]	35	a	35				96.000	61.100	61.100
MS	0.313	80Amp O2/Air [True Bevel]	30	a	30				96.000	69.300	69.300
MS	0.313	80Amp O2/Air [True Bevel]	27.5	a	27.5				96.000	73.000	73.000
MS	0.313	80Amp O2/Air [True Bevel]	25	a	25				96.000	76.300	76.300
MS	0.313	80Amp O2/Air [True Bevel]	22.5	a	22.5				96.000	79.300	79.300
MS	0.313	80Amp O2/Air [True Bevel]	20	a	20				96.000	81.900	81.900
MS	0.313	80Amp O2/Air [True Bevel]	17.5	a	17.5				96.000	84.200	84.200
MS	0.313	80Amp O2/Air [True Bevel]	15	a	15				96.000	86.100	86.100
MS	0.313	80Amp O2/Air [True Bevel]	50	v	-50				96.000	46.000	46.000
MS	0.313	80Amp O2/Air [True Bevel]	45	v	-45				96.000	54.200	54.200
MS	0.313	80Amp O2/Air [True Bevel]	45	k	-45	0.100	0.106		96.000	48.000	48.000
MS	0.313	80Amp O2/Air [True Bevel]	40	v	-40				96.000	61.800	61.800

11 Save the spreadsheet file.

Other Hypertherm bevel accessories

Hypertherm Associates offers accessories specifically designed for bevel and robotic applications.

- Bevel head alignment tool (428645)

  – Use this tool to determine the bevel pivot point. (See *Determining torch pivot length (TPL)* on page 18.)

- Rotational mounting sleeve and bracket (short: 420788, standard: 420789, extended: 420790)

  – The rotational sleeve is designed for use in applications where the torch leads are twisted repeatedly.

Find additional information on True Bevel at www.hypertherm.com/truebevel

As 100% Associate owners, we are all focused on delivering a superior customer experience. www.hyperthermassociates.com/ownership

Environmental stewardship is one of Hypertherm Associates' core values. www.hyperthermassociates.com/environment

HYPERTHERM ASSOCIATES™

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