

Oxyfuel Cutting with Phoenix[®] on an EDGE[®] Connect CNC

Application Note

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Hypertherm, Inc.
21 Great Hollow Road, P.O. Box 5010
Hanover, NH 03755 USA

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Oxyfuel Cutting with Phoenix® on an EDGE® Connect CNC

This document describes the operation, layout, and setup of a sample oxyfuel cutting system. Because of the variation between cutting systems, Hypertherm CNCs provide built-in flexibility for multiple methods of system setup, operation, and part programming. Since all cases cannot be described here, this document makes the following assumptions:

- The cutting operations are being controlled by the CNC, not by a PLC or other external logic.
- The cutting system supports both low preheat and high preheat fuel gas channels.
- The CNC supports on EtherCAT interface to provide sufficient I/O for the oxyfuel application.

In this section you will find:

- An overview of how the CNC executes the oxyfuel process
- An illustration of a sample two-torch system
- Station setup for oxyfuel
- A detailed, step-by-step description of the oxyfuel cut sequence
- Definitions of the inputs and outputs used for oxyfuel cutting systems, and a ladder logic diagram showing the I/O
- Oxyfuel setup instructions for the CNC
- Advanced features for oxyfuel cutting (analog outputs for gas control, process overrides, and staged pierce function)

Related resources

For information about:

- **Oxyfuel process selection variables**, see the *EDGE Connect Programmer's Reference* (809550).
Note: Oxyfuel part programs can use process selection variables to load the cut chart. However, oxyfuel cut charts are not supported in the Cut Pro Wizard.
- **How to set up Phoenix for use with an IHT® M4000 lifter**, refer to the *IHT M4000 Lifter with EDGE® Connect and Phoenix Application Note* (10088915).

Documentation is available at www.hypertherm.com/docs.

Oxyfuel overview

Hypertherm CNCs provide an oxyfuel process that controls fuel gas, pierce-oxygen, and cut-oxygen in several stages. These stages activate outputs to run an oxyfuel cutting system. The CNC executes the oxyfuel cut sequence in this order for each cut. The stages are controlled with timers set on the Oxyfuel Process screen.

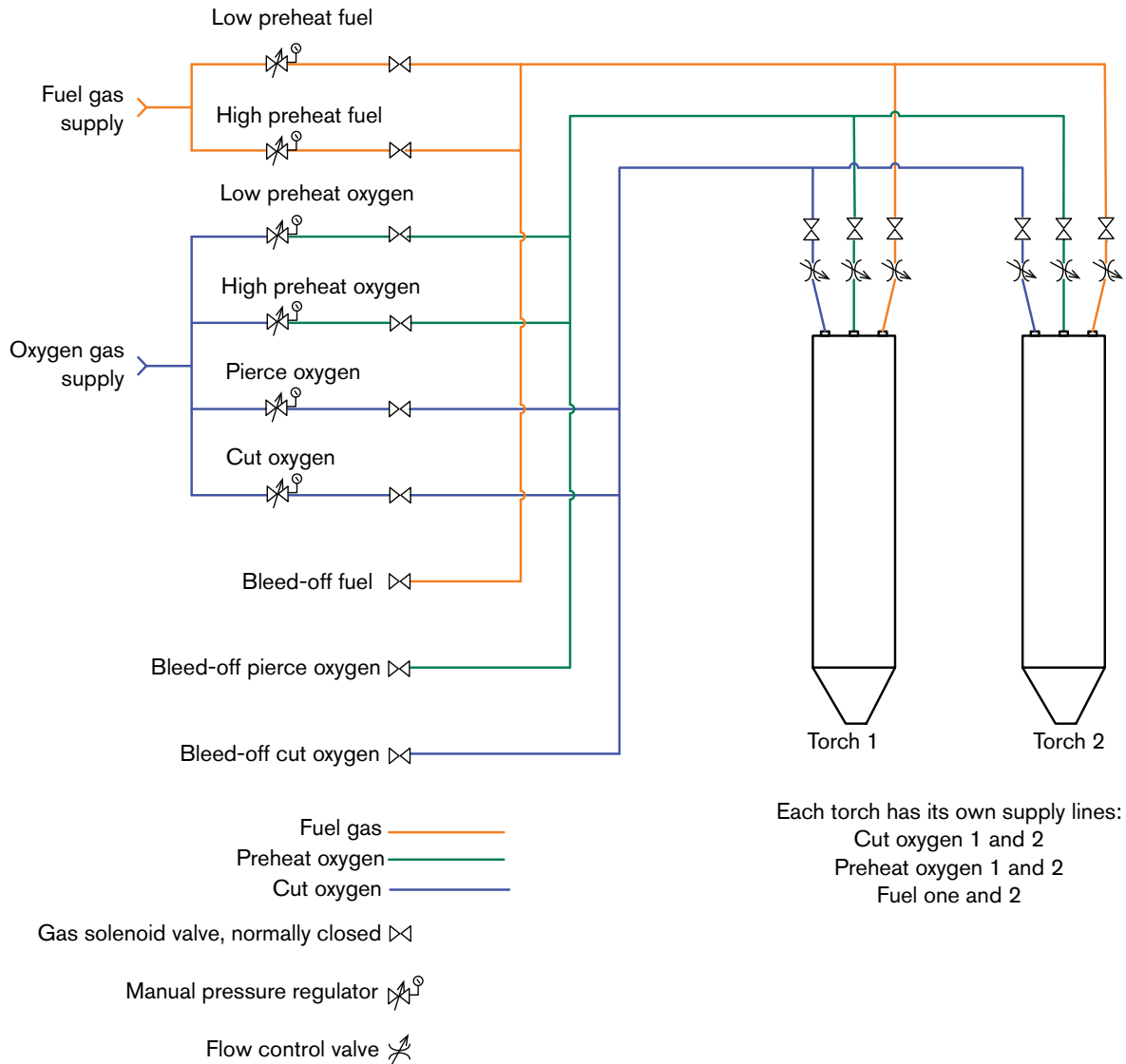
Stage	Output	Definition
Cycle Start	None	Starts the oxyfuel sequence. Upon cycle start, the torch moves to the first pierce point in the part program.
Ignite torch.	Torch Ignition	Operates an igniter circuit used to ignite the torch.
Preheat the workpiece.	Low Preheat Control	Turns on the low pressure fuel gas used to ignite the torch.
	High Preheat Control	Turns on the high pressure fuel gas used to preheat the workpiece and assist in cutting.
Pierce the workpiece.	Pierce Control	Turns on the pierce oxygen, a low pressure oxygen channel that accelerates the preheat process.
Cut the workpiece.	Cut Control	Turns on the cut oxygen, a high pressure oxygen channel for cutting the workpiece.

Note: The Preheat Control output is for use in a system where a low preheat fuel gas channel is not available and one output controls the preheat fuel gas. Use Preheat Control instead of High Preheat Control in this type of system. See *Low preheat fuel gas options* later in this section for more information.

Two-torch oxyfuel system diagram

The following picture shows a sample two-torch oxyfuel system with three gas channels.

Note: This picture is a functional drawing and is not intended as a recommendation for system design. You will need to procure components that are rated for your individual cutting system and your production needs.



Low preheat fuel gas options

Hypertherm CNCs provide the ability to control a low preheat fuel gas channel. This channel can be used in different ways.

- Wire the Low Preheat Select input to the operator console. This input can function as an on/off switch for the oxyfuel system. When Low Preheat Select turns on, the CNC turns on the Low Preheat Control output and opens the low pressure fuel gas channel. In some oxyfuel cutting systems the low pressure fuel gas remains on throughout operation so that the operator can manually change the fuel gas pressure or the torch can remain lit between cuts.
- On the Oxyfuel Process screen, the Low Preheat during Cut parameter forces the Low Preheat Control output to stay on. You can use this method as an alternative to having the Low Preheat Select input wired to the operator console.

Oxyfuel cut sequence

The oxyfuel cut sequence follows these steps. All timers referred to below are located on the Oxyfuel Process screen (**Setups > Process > Oxyfuel**).

The screenshot displays the Oxyfuel Process screen with two red boxes highlighting specific parameter groups. The left box contains timing parameters: Ignition Time (2 sec), Low Preheat Time (2 sec), High Preheat Time (2 sec), Staged Pierce (radio buttons for Off, Mode 1, Mode 2, Mode 3), Pierce Time (2 sec), Moving Pierce Time (2 sec), Creep Time (2 sec), Primary Torch Up Time (2 sec), Primary Torch Down Time (2 sec), Pierce Torch Up Time (2 sec), Pierce Torch Down Time (2 sec), Cut Off Time (2 sec), Bleedoff Time (1 sec), Cut Control Delay (0 sec), and Lifter Low Speed (0 sec). The right box contains control options: Ignitors (radio buttons for No, Yes), Low Preheat During Cut (radio buttons for Off, On), Preheat During Cut (radio buttons for Off, On), and Torch Down During Cut (radio buttons for Off, On). Annotations with arrows point to these boxes: 'These parameters affect the torch for each cut.' points to the right box, and 'These timers sequence the outputs that control the gases and torch movement in the oxyfuel cutting system.' points to the left box. The interface includes a Help button, Apply, Cancel, and OK buttons, a timestamp of 4:30:20 PM, and a Timing Diagram button. At the bottom, there are buttons for Oxy Fuel Cut Chart, Save Data, Load Data, Oxy Fuel, Plasma 1, and Timing Diagram.

To start the oxyfuel cut sequence, select Oxyfuel Cut Mode on the Main screen, load a part file, and press Cycle Start. The torch moves to the first pierce point in the program.

The M07 code (Cut On) runs in the part program. Torch Down output turns on.

- Torch Down output remains on until either the Primary Torch Down Time elapses or the Torch Down Sense input turns on.
- Status Message: *Lowering Torch*

Ignition output turns on.

- Ignition output remains on until the Ignition Time expires.
- Status Message: *Igniting Torch*

Low Preheat Control output turns on if Low Preheat Time is used.

- This output may already be on because the Low Preheat Select input was turned on at the beginning of the sequence.
- Low Preheat Control output remains on until the Low Preheat Time elapses.
- Status Message: *Low Preheat*

High Preheat Control output turns on.

- The preheating of the workpiece occurs to prepare for piercing.
- High Preheat Control output remains in this state until the High Preheat Time elapses or you press Cycle Start. Cycle Start bypasses preheats and allows manual control of piercing.
- To have the High Preheat Control output remain on while piercing *and* cutting, set Preheat During Cut to Yes on the Oxyfuel Process screen. Use this option if the oxyfuel torch requires high pressure fuel gas for cutting.
- Status Message: *High Preheat*

Pierce Control Output turns on.

- Pierce Control output activates the pierce-oxygen channel.
- The Pierce Control output can be used to decrease the preheating time of the workpiece.
- Pierce Control remains on until the Pierce Time elapses.
- High Preheat Control remains on if Preheat During Cut is active.
- Low Preheat remains on.
- Status message: *Piercing*

Cut Control output turns on during piercing.

- The Cut Control output activates the cut-oxygen channel.
- The Cut Control output turns on after the Cut Control Delay time elapses. This timer allows the Pierce Control output time to start piercing the workpiece. Then Cut Control turns on to provide a boost by turning on the cut-oxygen channel.
- Status message: *Piercing*

Creep motion begins when piercing completes.

- Creep motion is a percentage of travel speed set in the Machine Setups > Speeds screen.
- Creep motion continues until the Creep Time elapses.
- Cut Control remains on, Pierce Control turns off, High Preheat remains on if Preheat During Cut is on, and Low Preheat remains on.
- Status Message: *Creeping*

Machine accelerates to the oxyfuel speed (cut speed).

- Cut Control remains on, High Preheat remains on if Preheat During Cut is active, and Low Preheat remains on.
- Status Message: *Cutting*

M08 code (Cut Off) runs in the part program.

- Cut Control shuts off, High Preheat shuts if Preheat During Cut is active, and Low Preheat remains on.
- Low Preheat prevents the flame from extinguishing.

Torch Up output turns on.

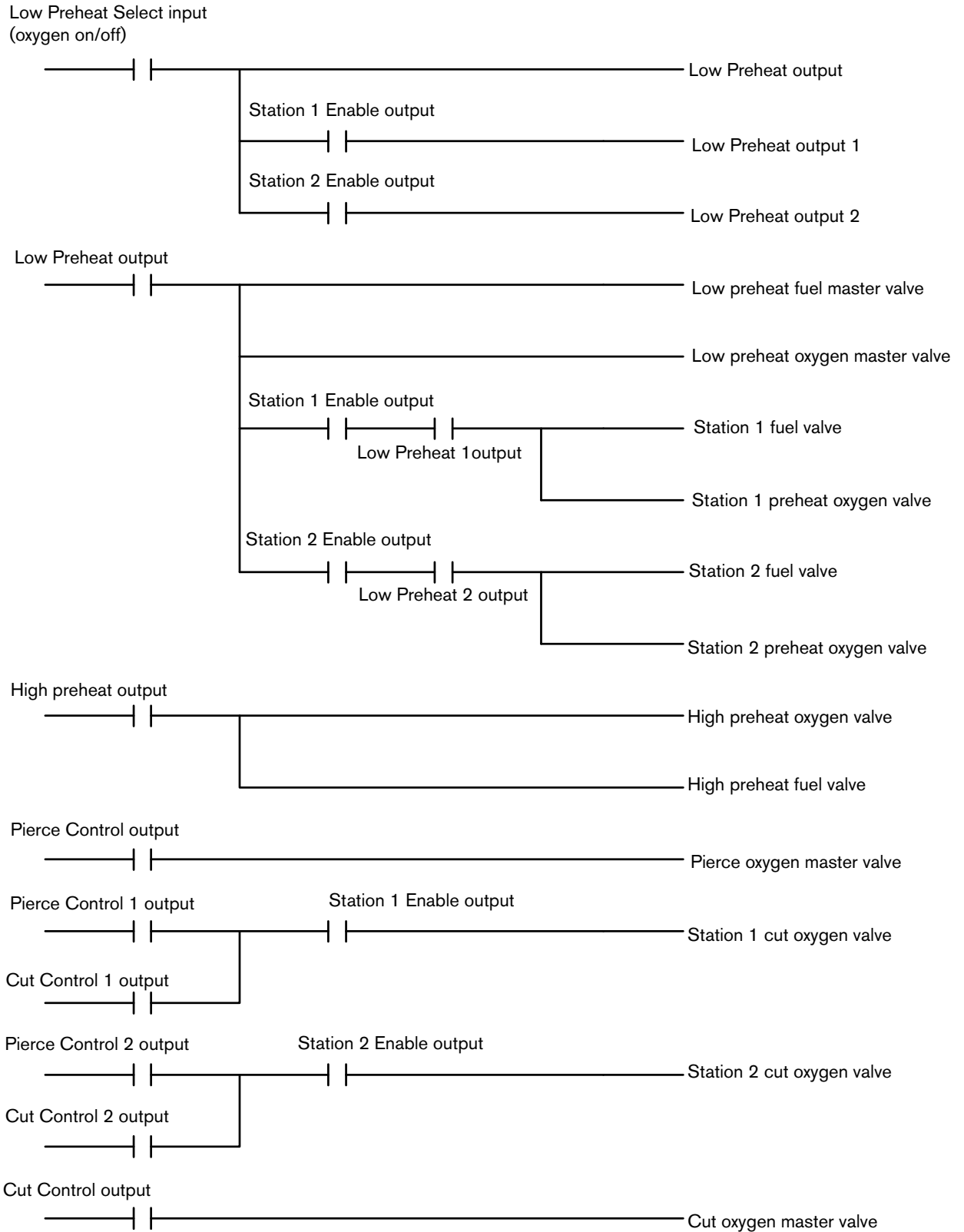
- Torch Up output remains on until the Primary Torch Up Time elapses or until Torch Up Sense input activates, whichever occurs first.
- Status Message: *Raising Torch*

Torch rapid traverses to the next pierce point.

- Low Preheat is still active due to Low Preheat Select input.
- Status Message: *Traversing*

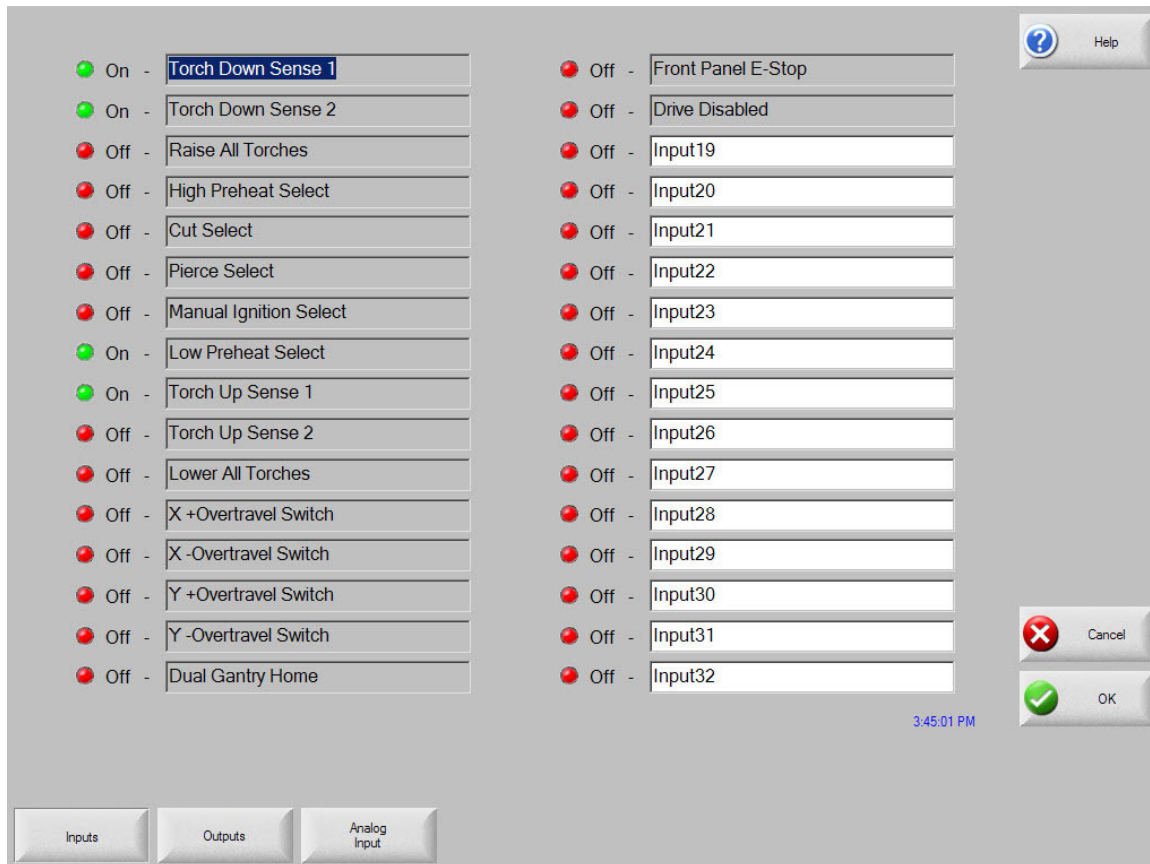
The entire process repeats when the torch moves to the next pierce point.

An oxyfuel ladder logic diagram is shown below. Each “rung” in the ladder shows the internal logic of the CNC I/O and how it would control the fuel gas and oxygen valves in an oxyfuel cutting system.



Oxyfuel inputs

Oxyfuel inputs can be used for switches on an operator console to control the oxyfuel cutting system. The screen below shows an example of input assignments for an oxyfuel cutting system with two torches.



Low Preheat Select: This input can be used as an oxyfuel on/off switch on the operator console of the CNC (a momentary push-button or a single-pole, single-throw (SPST) toggle switch). This input turns on the Low Preheat output while the switch remains in the ON position. With this input on, low pressure fuel gas will be delivered to the torch, and can be manually adjusted.

Cut Select: This input can be used as an ON/OFF switch on the operator console of the CNC (a momentary push-button or SPST toggle switch). This input turns on the Cut Control output while the switch remains in the ON position. With this input on, high pressure oxygen will be delivered to the torch and can be manually adjusted.

WARNING!

THE CUT SELECT INPUT AFFECTS ALL STATIONS. DO NOT LEAVE THE INPUT ON UNLESS INTENTIONAL CUTTING IS DESIRED. IF A PLASMA STATION IS ACTIVE, OR BECOMES ACTIVE WHILE THE CUT SELECT INPUT IS ON, THE STATION'S TORCH WILL IMMEDIATELY RECEIVE THE CUT CONTROL OUTPUT AND FIRE.

High Preheat Select: This input can be used as an ON/OFF switch on the operator console of the CNC (a momentary push-button or SPST toggle switch). This input turns on the High Preheat output while the switch remains in the ON position. With this input ON, high pressure fuel gas will be delivered to the torch and can be manually adjusted.

Manual Ignition Select: This input can be used as an ignition switch (a momentary push-button) on the operator console of the CNC. It turns on the ignition output while the input is ON. This input can also be used to manually turn on the ignitors.

Lower Torch / Lower All Torches: This input can be a toggle switch that turns on the Torch Down output. The Torch Down output signals the oxyfuel torch lifter to lower the torch.

Raise Torch / Raise All Torches: This input can be used as a toggle switch that turns on the Torch Up output. The Torch Up output signals the oxyfuel torch lifter to raise the torch.

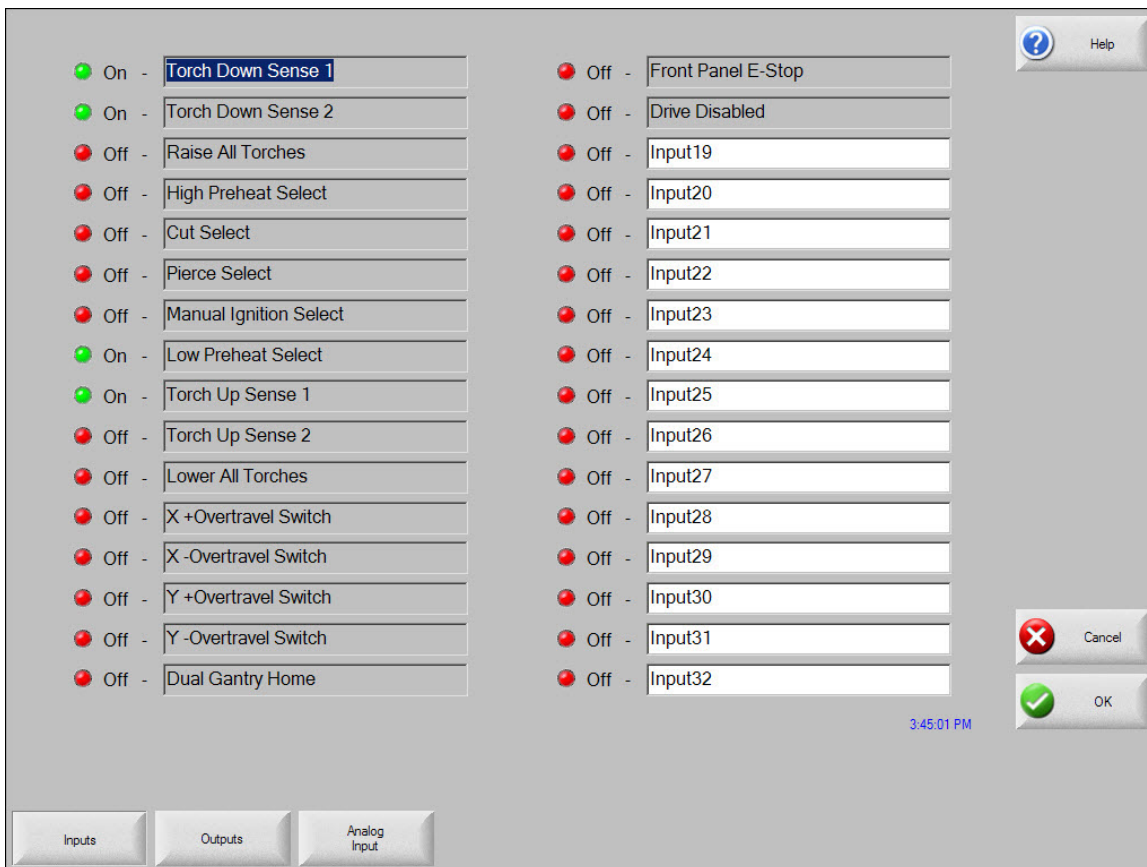
Torch Down Sense: When this input turns on, the CNC turns off the Torch Down output. This input is used with a lower limit switch or proximity switch on the oxyfuel torch lifter, but not as a safety switch. The Torch Down Sense input does not cause a fault on the CNC.

Torch Up Sense: When this input turns on, the CNC turns off the Torch Up output. This input is used as an upper limit switch proximity switch on the oxyfuel torch lifter, but not as a safety switch. The Torch Down Sense input does not cause a fault on the CNC.

Oxyfuel outputs

The oxyfuel outputs are controlled by timers on the Oxyfuel Process screen. The screen below shows an example of output assignments for an oxyfuel cutting system with two torches.

Note: In a cutting system that combines plasma and oxyfuel, when assigning I/O for oxyfuel cutting stations, use numbered I/O 9 – 20.



Torch ignition: Activates torch ignitors.

Timer: Ignition Time specifies the time the oxyfuel ignitor is turned on when igniting the flame.

Low preheat control: Activates the low pressure fuel gas channel.

Timers:

- Low Preheat Time specifies the number of seconds to preheat the workpiece before piercing using the low pressure fuel gas channel.
- Ignitors: Set Ignitors to No and Ignition Time to 0 to activate the Low Preheat Control output at the end of a cut and keep the torch lit during rapid traverse. Set Ignitors to Yes to turn off the Low Preheat Control output and re-ignite the flame at each next pierce point.
- Low Preheat During Cut specifies whether the Low Preheat is left on during cutting.

High preheat control: Activates the high pressure fuel gas channel.

Timers:

- High Preheat Time specifies the number of seconds to preheat the workpiece before piercing using the high pressure fuel gas channel.
- Preheat During Cut specifies whether the Preheat is left on during cutting.

Notes:

- When you run the part, you can use the Set, Extend, or Release soft keys to change either the Low or High Preheat time. To bypass the preheat timers completely, press Cycle Start twice.
- If the cutting system does not support the Low Preheat Control output, then High Preheat Control is used to keep the torch lit during rapid traverse when Ignitors is set to No and Ignition Time to 0.

Pierce control: Turns on the pierce oxygen, a low pressure oxygen channel that accelerates the preheat process.

Timers:

- Pierce Time specifies the number of seconds the Pierce Control output is on before lowering the torch to the cut height.
- Moving Pierce Time allows X/Y motion and specifies the number of seconds the Pierce Control output remains on.

Torch Up: Activates a relay for a non-servo motor to move the torch up.

Timers:

- Primary Torch Up Time specifies the number of seconds to raise the torch after completing each cut. The torch continues raising until this time elapses or the lifter reaches a limit switch that activates the Torch Up Sense input.
- Pierce Torch Up Time Sets the time for torch lift after piercing to clear a pierce puddle.

Torch Down: Activates a relay for a non-servo motor to move the torch up.

Timers:

- Primary Torch Down Time specifies the number of seconds to lower the torch at the beginning of each cut after torch ignition. The torch continues to lower until this time expires or the lifter reaches a limit switch that activates the Torch Down Sense input.
- Pierce Torch Down Time specifies the number of seconds to lower the torch for cutting. This timer should allow the torch to reach the cut height.

- Torch Down During Cut specifies whether the Torch Down output is left on during cutting. This parameter is can be used with a pneumatic lifter.

Cut Control: Activates the cut oxygen channel, a high pressure oxygen channel for cutting the workpiece.

Timers:

- Cut Off Time specifies the number of seconds for the Cut Control output to remain on at the end of a cut. Allows the torch to finish its cut and removes any lag (a slight angle that is created when the flame meets metal and bends). Using the Cut Off time provides time for the flame to become perpendicular before it is turned off.
- Cut Control Delay specifies the number of seconds the CNC waits before turning on the Cut Control output during piercing.

Bleed-off Gas: Controls a valve used to purge gas from the torch.

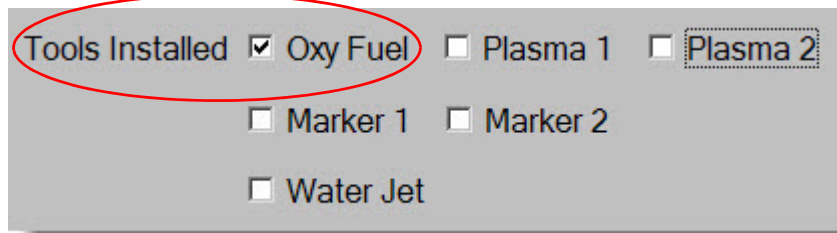
Timer: Bleed-off Time specifies the number of seconds the torch pauses to purge gas at the end of a cut before traversing to the next cut. This timer can overlap the Primary Torch Up timer.

Lifter Low Speed: Turns on with the Torch Down and Torch Up numbered I/O and allows a fine jog adjustment when the torch is near the workpiece. Lifter Low Speed turns off when the Lifter Low Speed time elapses.

Timer: Lifter Low Speed specifies the number of seconds for the Lifter Low Speed output to be on. The value for this timer should be less than the value for the Primary Torch Up Time and Primary Torch Down Time values.

Setting up oxyfuel

1. In the Special Setups screen (Setups > Password > Special Setups) select Oxyfuel as a Tool Installed.



This selection activates oxyfuel as a Cut Mode, and activates the Oxyfuel Process screen and the Oxyfuel Cut Chart.

2. In the I/O screen (**Setups > Password > Machine Setups > Digital I/O**), assign the inputs and outputs for your oxyfuel cutting system.

The I/O assignments for the system depend on the number of oxyfuel torches and whether the CNC will be operating all the torches independently. Use the numbered I/O to operate each oxyfuel torch independently. Assign Station Select inputs if numbered I/O are used, one input for each station.

Note: If the system does not use ignitors to light the oxyfuel torches, do not assign the Ignition output.

3. In the Oxyfuel Process screen, enter timer values for all preheats, piercing, creeping, and torch up/down movement. (Setups > Process > Oxyfuel).

Select Yes to Ignitors if you will use the Ignitor output at every pierce point. If you will be using the Manual Ignition Select input to ignite all torches, select No to Ignitors.

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The Oxyfuel Process screen is shown below.

The screenshot displays the Oxyfuel Process configuration screen. It features a grid of input fields for time settings and radio button options for modes and preheat. The settings are as follows:

Parameter	Value	Unit
Ignition Time	2	sec
Low Preheat Time	2	sec
High Preheat Time	2	sec
Pierce Time	2	sec
Moving Pierce Time	2	sec
Creep Time	2	sec
Primary Torch Up Time	2	sec
Primary Torch Down Time	2	sec
Pierce Torch Up Time	2	sec
Pierce Torch Down Time	2	sec
Cut Off Time	2	sec
Bleedoff Time	1	sec
Cut Control Delay	0	sec
Lifter Low Speed	0	sec

Mode and Preheat Settings:

- Staged Pierce: Off, Mode 1, Mode 2, Mode 3
- Ignitors: No, Yes
- Low Preheat During Cut: Off, On
- Preheat During Cut: Off, On
- Torch Down During Cut: Off, On

Control Buttons and Elements:

- Buttons: Oxy Fuel Cut Chart, Save Data, Load Data, Oxy Fuel, Plasma 1, Apply, Cancel, OK, Timing Diagram.
- Help icon (question mark) and a Help label.
- Time display: 4:30:20 PM.

Oxyfuel cut chart

The CNC provides cut charts for oxyfuel cutting systems. The cut charts are specific to the type of torch used on the oxyfuel cutting system.

If your cutting system is using proportional regulators on analog inputs (described in the next section), the gas pressures in the cut chart are transferred to the Oxyfuel Process screen.

Oxy Fuel Cut Chart - Rev 0

Process Selection

Torch Type: Harris Model 98

Material Type: Mild Steel

Specific Material: None

Fuel Gas: Propane

Material Thickness: 1mm

Tip Size: 5/0

Cutting Tip: 6290-VVC

	Preheat		Pierce	Cut
	Low	High		
Oxygen	0.4	0.7	1.5	4 bar
Fuel Gas	0.03	0.2		bar

Cut Speed: 750 mmpm

Kerf: 1.3 mm

High Preheat Time: 10 sec

Pierce Time: 0.5 sec

Moving Pierce Time: 0 sec

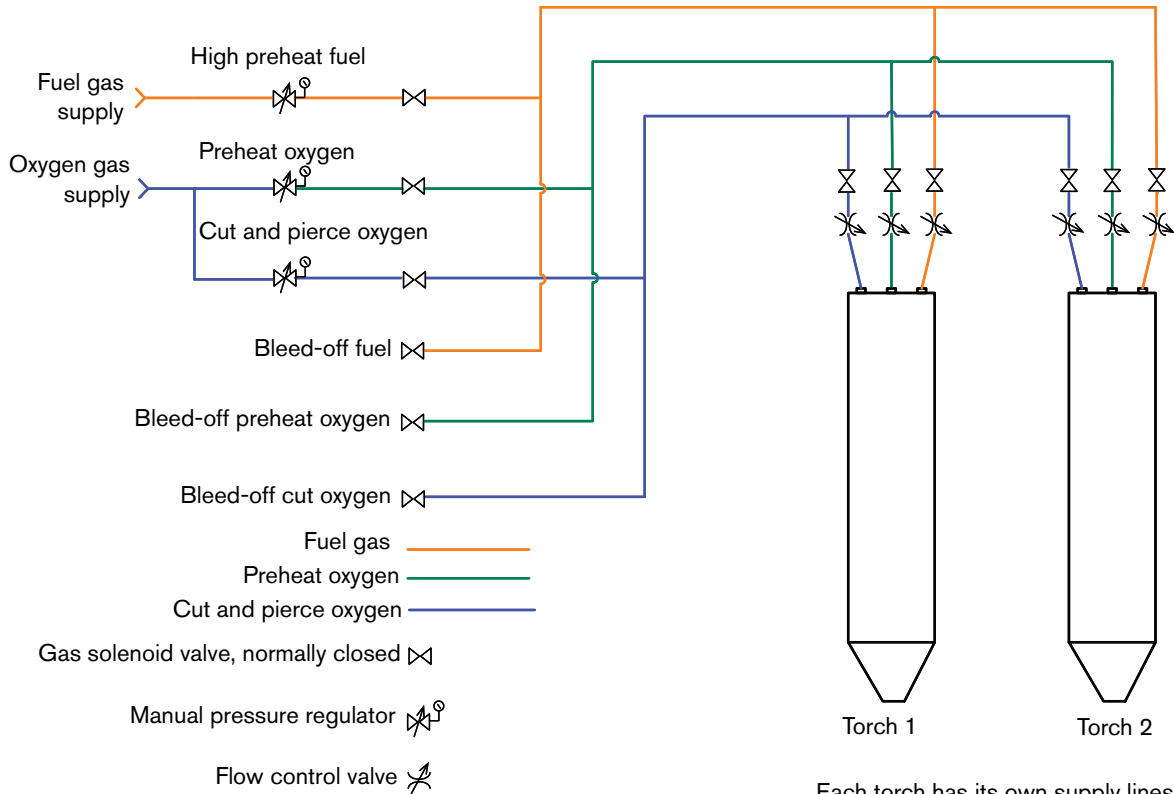
Creep Time: 0 sec

Buttons: Save Process, Reset Process, Save Cut Charts, Load Cut Charts, Change Consumables, Help, Cancel, OK

Timestamp: 10:54:32 AM

Controlling proportional gas regulators with analog outputs

Hypertherm CNCs provide analog outputs that can control proportional gas regulators. Using this strategy allows you to reduce the number of regulators needed for the gas delivery system from six as shown earlier in this section, to three as shown below. Analog outputs are available for three channels: fuel gas, preheat oxygen, and pierce/cut oxygen.



Each torch has its own supply lines:
 Cut oxygen 1 and 2
 Preheat oxygen 1 and 2
 Fuel 1 and 2

Setting up analog outputs

The CNC supplies a scaled reference output that the networked analog output modules use to generate the actual analog output. For each analog output you will need to enter the maximum regulator pressure. The CNC then calculates the voltage to correspond to pressure settings from 0 to the maximum pressure. There is no feedback to the CNC to control accuracy.

1. Select **Setup** > **Password** > **Machine Setup** > **Analog I/O**.

The screenshot shows the 'Analog I/O' configuration window. It is divided into 'Inputs' and 'Outputs' sections. In the 'Outputs' section, 'Cut Oxygen' is selected from a dropdown menu, and its value is set to 130 psig. Below this, there are radio buttons for 'Speed Pots Enabled' (set to 'Yes') and several override settings: Trial Override (0 to 120%), Oxy Fuel Override (0 to 120%), Plasma Override (70 to 130%), Laser Override (0 to 120%), and Waterjet Override (0 to 120%). The interface includes a 'Help' button, 'Cancel', 'OK', and 'Laser Mapping' buttons, and a timestamp of 3:23:44 PM. At the bottom, there are navigation buttons for 'Machine', 'Speeds', 'Digital I/O', 'Analog I/O', 'EtherCAT', and 'Axes'.

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2. Select the gas channel and assign an analog output and maximum pressure for it. The channels are listed in groups. Each channel in each group should be selected and matched with an analog output. The CNC transfers these channels and pressures to the Oxyfuel Process screen.

Oxyfuel torch pressures	Analog outputs to assign
Standard	Cut Oxygen Preheat Oxygen Preheat Fuel
Triple bevel torch 2	Cut Oxygen TBT 2 Preheat Oxygen TBT 2 Preheat Fuel TBT 2
Triple bevel torch 3	Cut Oxygen TBT 3 Preheat Oxygen TBT 3 Preheat Fuel TBT 3
Triple bevel preheat torch	Preheat Oxygen TBPT Preheat Fuel TBPT

Setting gas pressures from the CNC

You can adjust the pressures on the Oxyfuel Process screen. Each pressure has a ramp-up time. The oxyfuel cut chart provides the starting set of values.

When adjusting the gas pressures or timers, use the **Apply** soft key to send the pressures to the cutting system. As you are fine-tuning the system for your requirements, you can select **Apply**, change the pressures on the screen, and select **Apply** again without exiting the screen.

Ignition Time	<input type="text" value="0"/> sec	Ignitors	<input checked="" type="radio"/> No <input type="radio"/> Yes	Help
Low Preheat Time	<input type="text" value="0"/> sec	Low Preheat During Cut	<input checked="" type="radio"/> Off <input type="radio"/> On	
High Preheat Time	<input type="text" value="30"/> sec	Preheat During Cut	<input checked="" type="radio"/> Off <input type="radio"/> On	
Staged Pierce	<input checked="" type="radio"/> Off <input type="radio"/> Mode 1 <input type="radio"/> Mode 2 <input type="radio"/> Mode 3	Torch Down During Cut	<input checked="" type="radio"/> Off <input type="radio"/> On	
Pierce Time	<input type="text" value="0"/> sec	Oxy Torch Pressures	Standard	
Moving Pierce Time	<input type="text" value="0"/> sec	Oxy Cut Pressure	<input type="text" value="50"/> psi	
Creep Time	<input type="text" value="6"/> sec	Oxy Ramp Up Time	<input type="text" value="5"/> sec	
Primary Torch Up Time	<input type="text" value="0"/> sec	Preheat Low Pressure	<input type="text" value="12"/> psi	
Primary Torch Down Time	<input type="text" value="0"/> sec	Preheat High Pressure	<input type="text" value="15"/> psi	
Pierce Torch Up Time	<input type="text" value="0"/> sec	Preheat Ramp Up Time	<input type="text" value="1.5"/> sec	
Pierce Torch Down Time	<input type="text" value="0"/> sec	Preheat Ramp Down Time	<input type="text" value="4"/> sec	
Cut Off Time	<input type="text" value="0"/> sec	Fuel Low Pressure	<input type="text" value="7"/> psi	
Bleedoff Time	<input type="text" value="1"/> sec	Fuel High Pressure	<input type="text" value="10"/> psi	
Cut Control Delay	<input type="text" value="0"/> sec	Fuel Ramp Up Time	<input type="text" value="1.5"/> sec	
Lifter Low Speed	<input type="text" value="0"/> sec	Fuel Ramp Down Time	<input type="text" value="2.5"/> sec	
		Pierce Pressure	<input type="text" value="0"/> psi	
		Pierce Ramp Up Time	<input type="text" value="0"/> sec	

10:01:37 AM

Save Data Load Data

Oxy Fuel

Timing Diagram

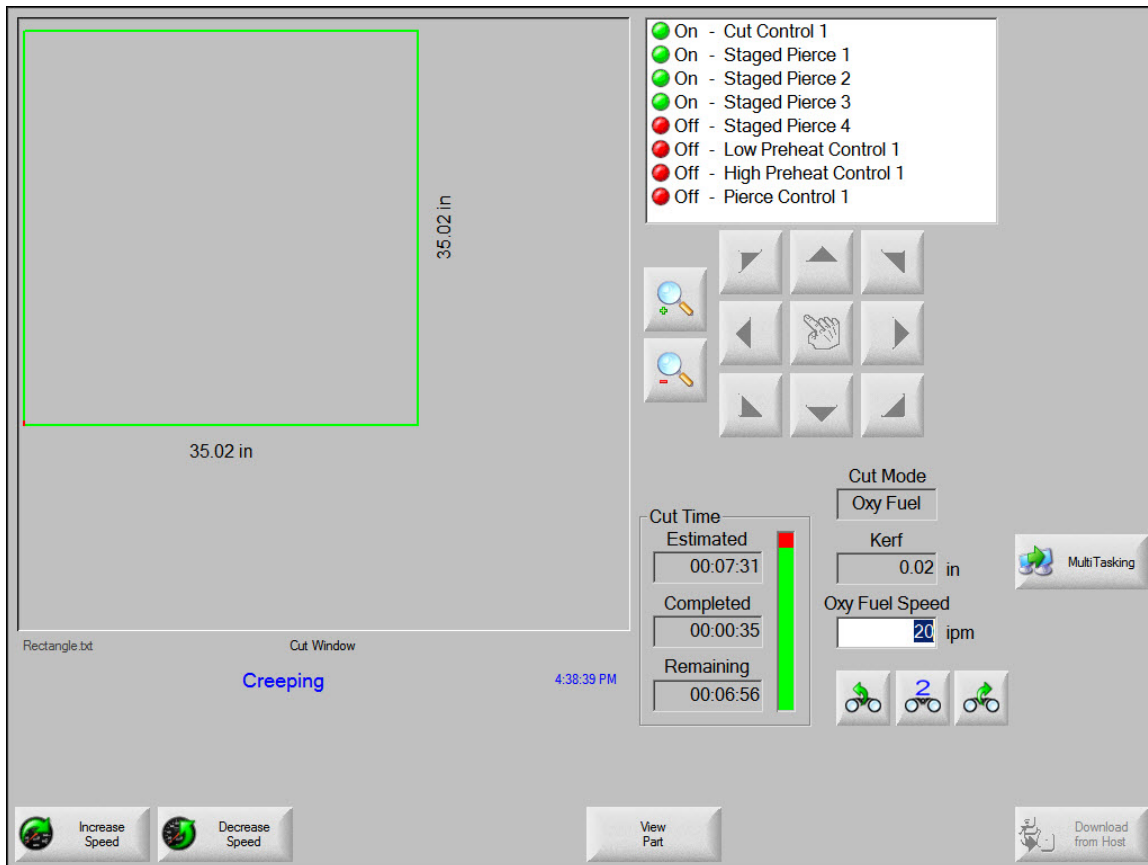
Apply Cancel OK

Staged pierce for oxyfuel cutting

Staged pierce increases the oxygen pressure while piercing and helps the torch penetrate the material more quickly. It is also a moving pierce that replaces the stationary pierce. During the staged pierce, the CNC begins moving at the creep speed as it performs the pierce.

Staged pierce requires four outputs called Staged Pierce 1 – 4. The outputs can control four separate oxygen regulators or one proportional regulator. On the oxyfuel process screen, you can select one of three modes for the staged pierce. Each mode activates the staged pierce outputs in a different order. You can enter the duration for each output to be activated.

- Staged Pierce Time 1 controls Staged Pierce 1 output.
- Staged Pierce Time 2 controls Staged Pierce 2 output.
- Staged Pierce Time 3 controls Staged Pierce 3 output.
- Staged Pierce 4 activates after Staged Pierce Time 3 elapses.



The following table illustrates the output activation for the three modes. When you run the part, the Creeping message displays as the status when the I/O that are associated with these parameters activate.

	Mode 1	Mode 2	Mode 3
	Staged Pierce Output (number) = (state)	Staged Pierce Output (number) = (state)	Staged Pierce Output (number) = (state)
Torch reaches creep speed	1 = On 2 = Off 3 = Off 4 = Off	1 = On 2 = Off 3 = Off 4 = Off	1 = On 2 = Off 3 = Off 4 = Off
Staged Pierce Time 1 expires	1 = On 2 = On 3 = Off 4 = Off	1 = On 2 = On 3 = Off 4 = Off	1 = Off 2 = On 3 = Off 4 = Off
Staged Pierce Time 2 expires	1 = On 2 = On 3 = On 4 = Off	1 = On 2 = On 3 = On 4 = Off	1 = Off 2 = Off 3 = On 4 = Off
Staged Pierce Time 3 expires	1 = On 2 = On 3 = On 4 = On Torch accelerates to cut speed	1 = Off 2 = Off 3 = Off 4 = On Torch accelerates to cut speed	1 = Off 2 = Off 3 = Off 4 = On Torch accelerates to cut speed
At end of Staged Pierce	All Staged Pierce outputs remain on until the end of the cut (M08)	Staged Pierce output 4 remains on until the end of the cut (M08)	Staged Pierce output 4 remains on until the end of the cut (M08)

