HYPERTHERM
A Hypertherm Associates Brand

XPR® Automated Gouging

White paper

Introduction

The adoption of plasma gouging has been rising for years due to a variety of productivity, safety, and environmental drivers. Now more customers are automating the process so that they can get repeatable plasma gouges. For example, customers may automate by putting the torch on a robot, cobot, track-mounted carriage, a stationary manipulator, a tripod, or a custom-made fixture. Customers are also looking for higher metal removal rates, larger gouge profiles, and more reliable arc transfer that are achievable with XPR plasma systems.

To automate correctly, knowledge of the gouge process parameters and a high level of integration skills are necessary. Only then can you get all the equipment to function together to provide the necessary gouge contour.

This document is intended to make the demonstration and adoption of automated gouging with XPR easier and more successful. This document is specific to using an XPR plasma system for automated gouging.

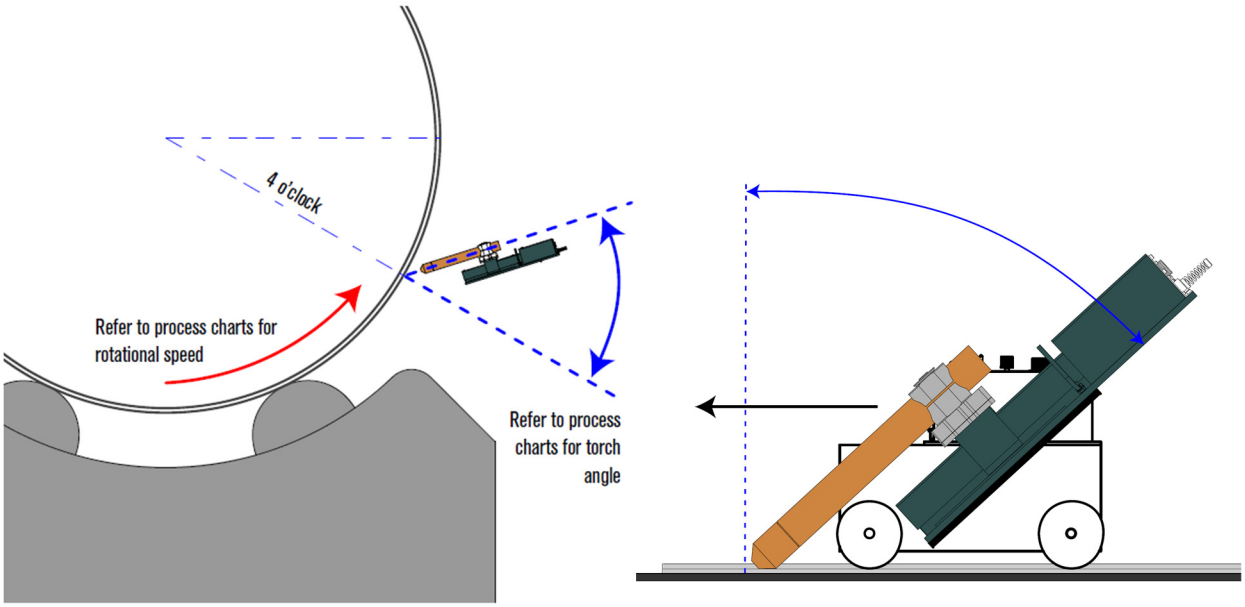
Applications for this type of setup and operation vary greatly, as do the desired gouge contours. Thus, this document focuses on providing information for a common application: producing high-quality single-pass gouges using O_2/Air on mild steel and Mixed Gas/N_2 on stainless steel. The information provided includes the following:

- System Requirements
- Safety
- Definitions of Terms
- How to Change the Gouge Contour and Metal-removal Rate
- Recommended Approach for Gouging Process Development
- Adjusting Amperage and Shield Pressure on XPR Systems
- Automated gouging
- Fume Generation in Plasma Gouging
- Understanding XPR Arc Voltage and 100% Duty Cycle Operation
- Unique Challenge of High-Amperage Plasma Gouging
- Auxiliary Air Can Enhance Plasma Gouging Performance
- 170A O_2/Air Mild Steel Gouge Parameter Chart
- 300A O_2/Air Mild Steel Gouge Parameter Chart
- 460A O_2/Air Mild Steel Gouge Parameter Chart
- 170A Mixed Gas/N_2 Stainless Steel Gouge Parameter Chart
- 300A Mixed Gas/N_2 Stainless Steel Gouge Parameter Chart
- 460A Mixed Gas/N_2 Stainless Steel Gouge Parameter Chart
- N_2/N_2 Stainless Steel Gouge Parameter Chart

System Requirements

- XPR170, XPR300 or XPR460
- XPR firmware package version 1.2 or greater for O_2/Air processes, 1.3 or greater for Mixed Gas/N_2, N_2/N_2 processes
- XPR gouging consumable parts
- Clean, dry compressed or bottled N_2, Air and O_2 for O_2/Air and N_2/N_2 processes and bottled Ar and H_2 for Mixed Gas/N_2 processes
    - Air requirements: 151 slpm (320 scfh), 7.9 bar (115 psi)
    - O_2 requirements: 111 slpm (235 scfh), 7.9 bar (115 psi)
    - Ar requirements: 50 slpm (106 scfh), 7.9 bar (115 psi)
    - H_2 requirements: 50 slpm (106 scfh), 7.9 bar (115 psi)
    - High flow gas regulators are critical. Hypertherm has had success using Control Air Inc. P/N 700-BFNV.
    - Hypertherm recommends an internal diameter of at least 10 mm (0.375 inch) for supply-gas hoses that are 76 m (250 feet) or less.
- Remote pendant or CNC controller to command XPR start / stop.
- Wi-Fi® or Ethernet LAN enabled device, CNC controller or serial communication device to command XPR process.
- Voltage controlled torch height controllers are highly recommended.
- Mechanism for controlling torch motion.
    - For straightforward, single-pass gouging applications, basic manipulators or track-mounted carriages are suitable. Typical gouging speeds range from 10 to 100 inches per minute (IPM).
    - For more complex motion such as weaving, robots, cobots or manipulators with built in oscillation may be required. For optimal performance, systems with higher acceleration capabilities that can accommodate the mass of an XPR torch and its leads offer greater operational flexibility.

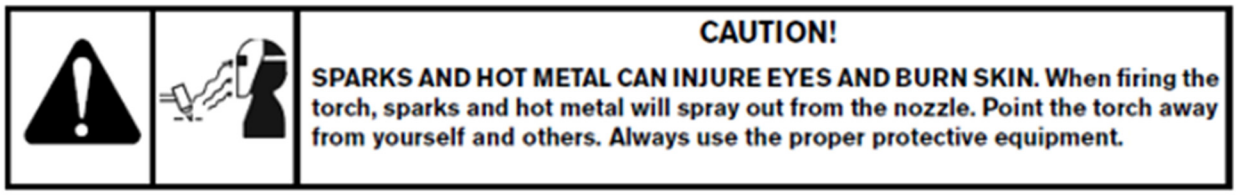
Note: XPR can transfer to the workpiece reliably at all listed standoffs and torch angles.



For additional information related to XPR set up and use, please refer to the XPR Instruction Manual that came with your cutting system:

- XPR170 Plasma Instruction Manual (810060)
- XPR300 Plasma Instruction Manual (809480)
- XPR460 Plasma Instruction Manual (811530)

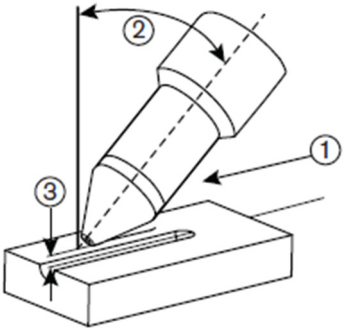
Safety



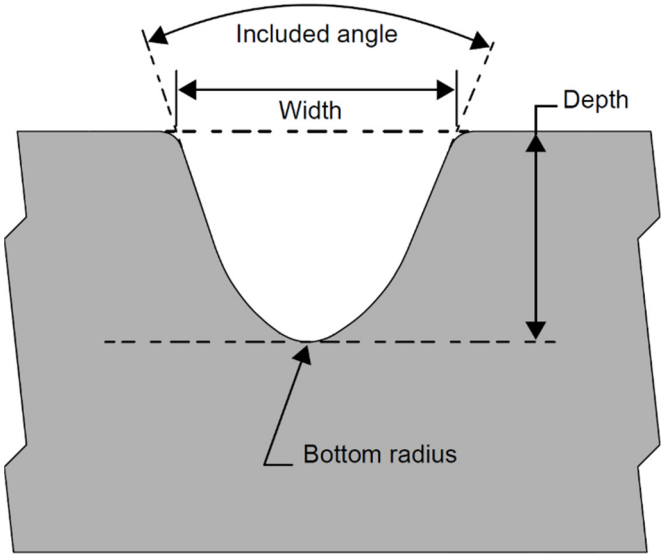
While gouging, always protect yourself and your equipment:

- A welding helmet with at least a #12 glass
- Welding gloves and a welding jacket
- Adequate ventilation
- Be careful of dragging leads over recently gouged parts as the part can be extremely hot and damage leads.
- Torch may become hot under certain gouging conditions.

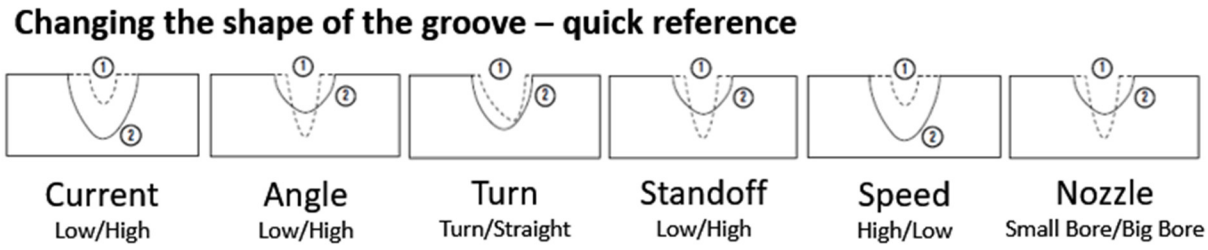
Definition of Terms

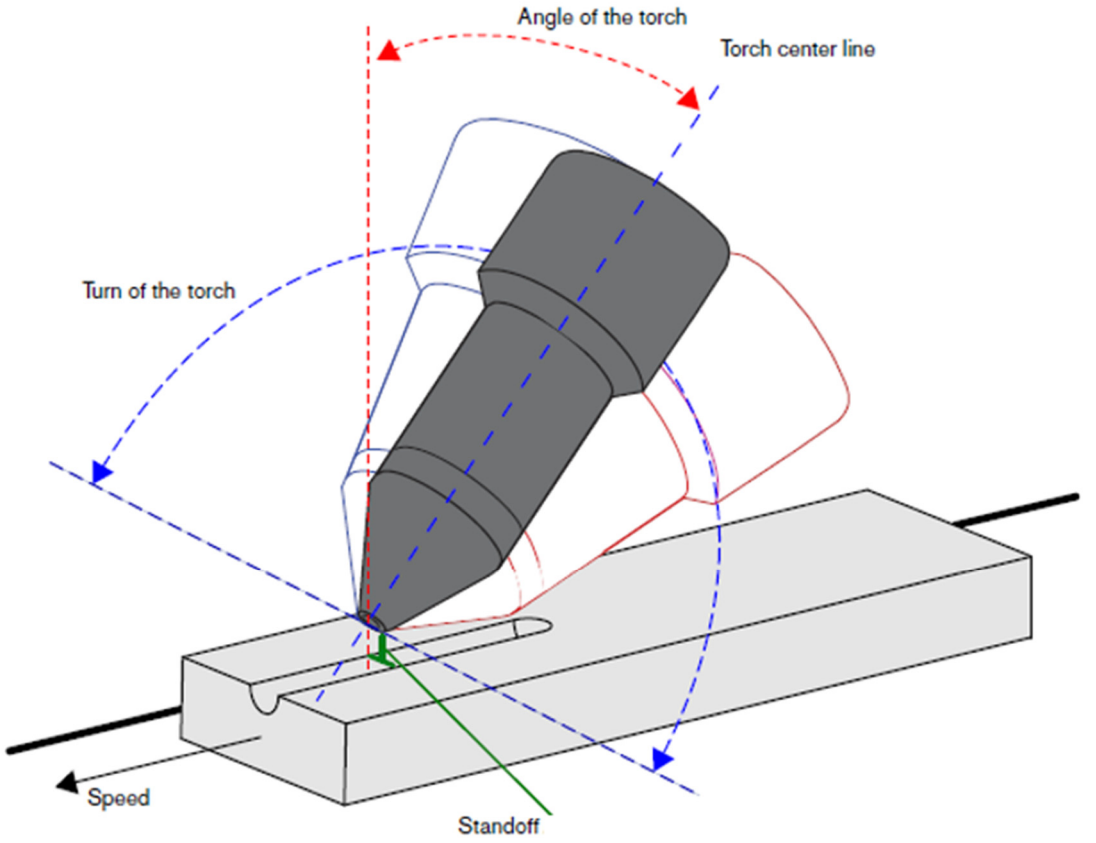


General parameters for gouging		
1	Speed	254 to 2,540 mm/min (10 to 100 in./min)
2	Angle	45 to 62.5 degrees
3	Standoff	2.5 to 24.1mm (0.10 to 0.95 inch)
4	Maximum arc stretch	76+ mm (3+ inches)



How to Change the Gouge Contour and Metal-removal Rate





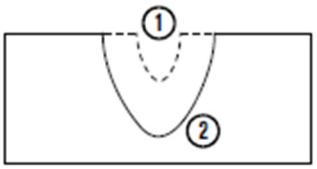
Adjust the following conditions of operation in combination to get the gouge you want:

- Output current (A) of the plasma power supply
- Angle of the torch to the workpiece
- Turn of the torch
- Distance between the torch and workpiece
- Torch speed
- Nozzle bore

Output current (A)

Modify current output using the web interface, EtherCAT, or serial. Decrease the amperage to make the gouge narrower and shallower ①. Increase the amperage to make it wider and deeper ②.

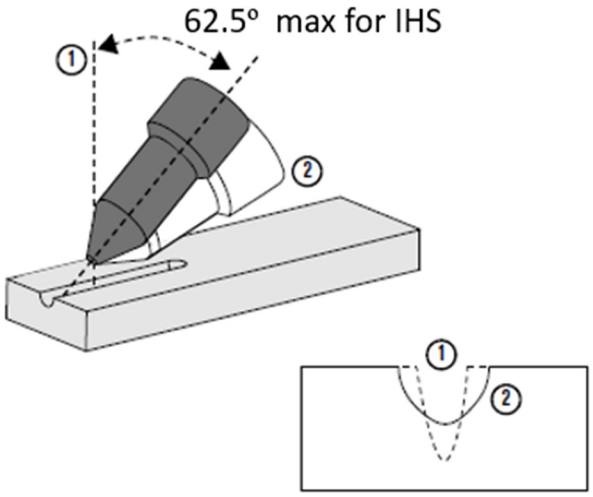
- Reducing the current will allow you to achieve a higher arc voltage (longer arc stretch) while still maintaining 100% duty cycle.



Angle of the torch

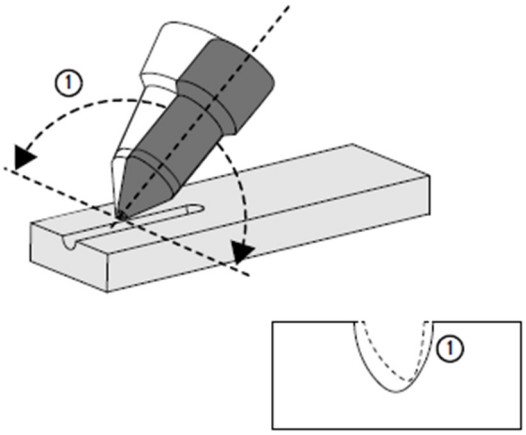
Put the torch in a more vertical position to make the gouge narrower and deeper ①. Tilt down the torch so that it is more horizontal and near the workpiece to make the gouge wider and shallower ②.

- If using Initial Height Sense (IHS) a max angle of 62.5° can be used due to the geometry of the torch.



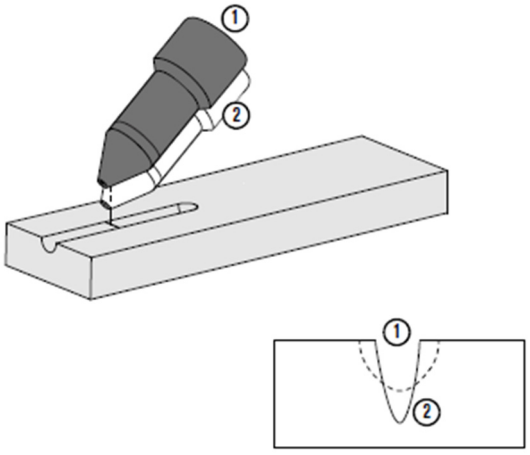
Turn of the torch

Turn the torch in the direction of the torch center line to make the gouge flatter and steeper on one side ①.



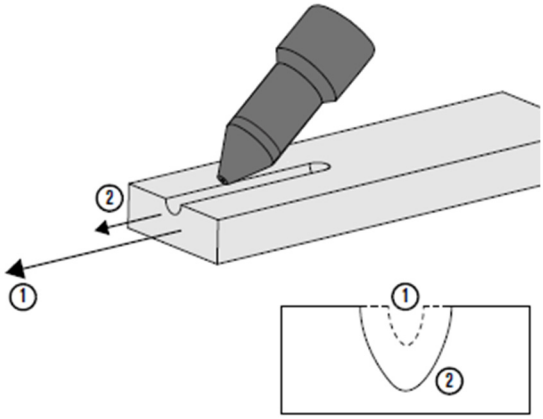
Torch-to-work standoff

Move the torch away from the workpiece to make the gouge wider, shallower, and smoother on the bottom ①. Move the torch near the workpiece to make the gouge narrower and deeper ②.



Speed of the torch

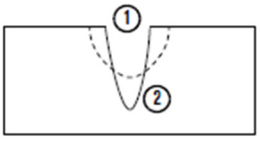
Increase the speed of the torch to make the gouge more narrow and more shallow ①. Decrease the speed of the Torch to make the gouge wider and deeper②.



Nozzle bore diameter

Use a nozzle with a smaller bore to make the gouge more narrow and deeper ①. Use a nozzle with a larger bore to make the gouge wider and shallower ②.

- Smaller nozzle bores will increase metal removal rates, but may require higher torch speeds.



Recommended Approach for Gouging Process Development

1. Determine desired gouge geometry

Start by identifying the key characteristics that matter most for your application:

- Gouge depth
- Gouge width
- Included angle
- Bottom radius
- Gouging speed
- Surface finish

U-shaped gouges:

- Plasma gouging excels at producing smooth, U-shaped profiles in a single pass.
- Refer to the gouge parameter charts to select a profile that closely matches your desired geometry and motion speed. This can also help determine the most suitable power supply.
- For larger U-shaped gouges, **multi-pass** or torch **weaving** may be necessary.

V-shaped gouges:

- Small V-shaped gouges can be achieved in a single pass, typically at **higher speeds** and **lower stand-off distances** (lower arc voltage).
- For larger V-shaped gouges, **multi-pass** or torch **weaving** may be necessary.

Large area metal removal:

- For broad material removal, use the **highest available power** to maximize speed and flexibility.

2. Test on a representative sample

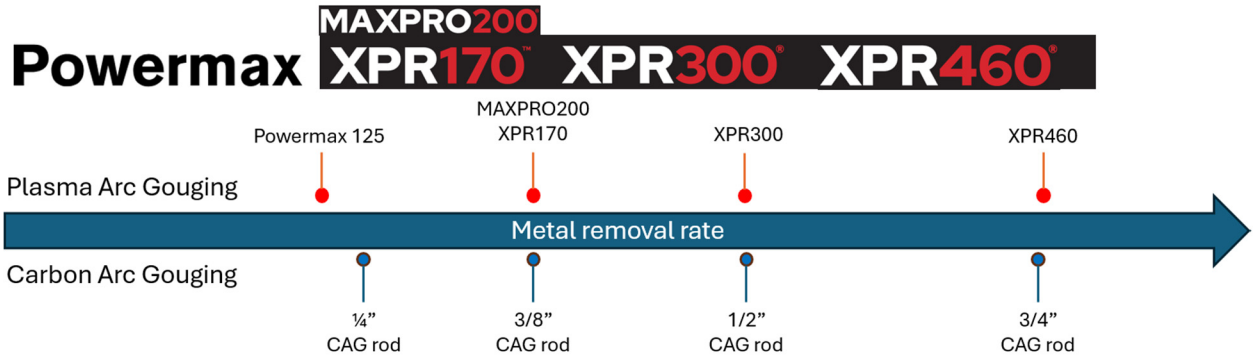
- Test on a sample part that closely resembles your production component in size, material, and thickness. Variability in the chemical makeup of material can have an effect on the gouging outcome, specifically molten material flow and dross adhesion to the workpiece.
- Be cautious with very small samples, as they may heat up more quickly than full-size parts, potentially skewing gouging results.

3. Fine tune process parameters

There are several variables you can adjust to optimize gouging performance:

- **Torch height and travel speed:** These are typically the first parameters to tweak for minor adjustments. Note, faster speeds often yield cleaner gouges.
- **Amperage, torch angle, and nozzle bore:** Consider these for more significant changes in gouge geometry or performance.

If transitioning from a carbon arc gouging process, below is a comparison based on metal removal rate to help identify which XPR system may suit your application the best.



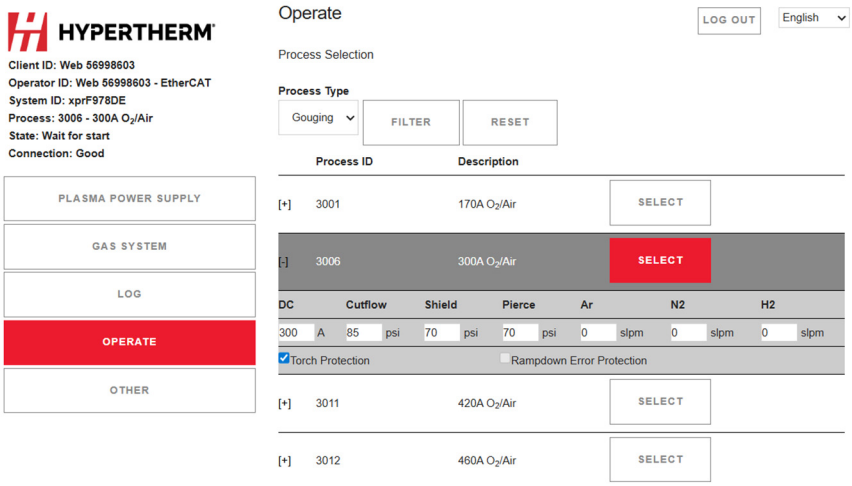
** Mild steel comparisons*

Adjusting Amperage and Shield Pressure on XPR Systems

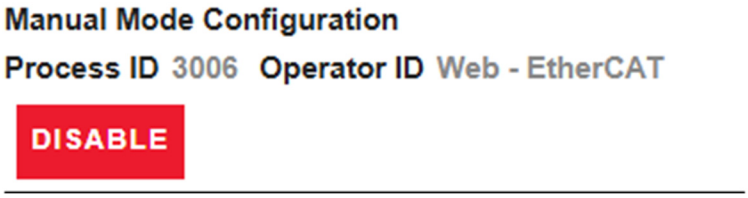
The plasma process can be selected and process settings can be adjusted via EtherCAT, Serial RS-422, or the XPR web interface. If EtherCAT or Serial RS-422 is used, the user interface will differ based on the controller being used. Shown below are examples using the XPR web interface.

Web interface:

- Connect to the web interface via Wi-Fi or Ethernet. On the web interface, select the Operate page, then select the desired process ID, select the plus sign next to the process ID, and adjust any process settings.



- Manual Mode: This will save the current process and any process setting offsets even if the system is powered off. For more information on Manual Mode, refer to the Connect for Communication section in the XPR Instruction Manual that came with your cutting system.



Automated Gouging

Gouging can be automated for repeatable results if the torch is installed on a track-mounted carriage, stationary manipulator, robot, cobot, gantry, or other fixture. The quality of the torch installation and software integration can have an effect on the quality of automated gouging. Experienced installers and integrators who understand gouging can contribute to good results.

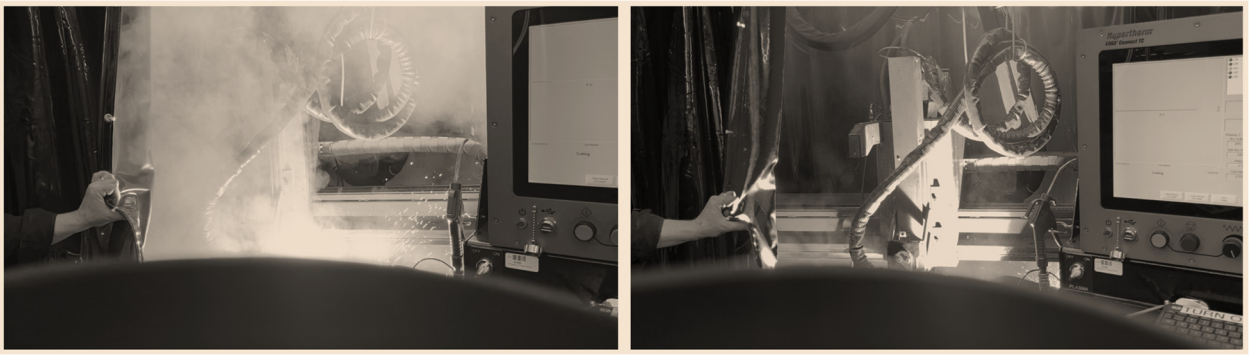
For the best results, Hypertherm recommends a torch height controller that uses the XPR plasma system arc voltage signal to keep the correct torch-to-work distance during automated gouging.

Fume Generation in Plasma Gouging

Plasma gouging inherently produces fumes, and the level of visible emissions varies depending on the process gases used. When gouging mild steel with O_2/Air, visible fume generation is significant—though still marginally lower than what is typically produced during carbon-arc gouging. For applications where fume reduction is a priority, Mixed Gas/N_2 processes generate substantially less visible fumes compared to O_2/Air.

Example: Left photo – 420 A O_2/Air 20 ipm on mild steel without fume extraction

Right photo – 460 A Mixed Gas/N_2 20 ipm on mild steel without fume extraction



Note: fume extraction is recommended for all gouging processes.

Understanding XPR Arc Voltage and 100% Duty Cycle Operation

The XPR plasma cutting system is designed for **100% duty cycle operation**, meaning it can run continuously within its specified parameters without overheating or requiring downtime. The system's power output is determined by the arc voltage and current:

Power Equation:

$$P = V * I$$

Where:

- **P** = Power (Watts)
- **V** = Arc Voltage (Volts)
- **I** = Output current (Amps)

Each XPR model has a maximum power rating at 100% duty cycle up to 40°C ambient temperature:

System	Max Current	Max Arc Voltage @ Max current	Max Stable Arc Voltage	Max Power
XPR170	170 A	210 V	300 V	35,700 W
XPR300	300 A	222 V	300 V	66,600 W
XPR460	460 A	222 V	300 V	102,120 W

Gouging operations often require longer arc lengths. To achieve this, operators may reduce the current, allowing the arc voltage to increase and the arc to stretch further than what is sustainable at maximum current. Note: it is generally advised to maintain arc voltage **below 300 V.**

Example:

Using the XPR460 system for gouging at 375 A allows the arc to stretch to **272 V**, enhancing gouging flexibility.

Unique Challenges of High-Amperage Plasma Gouging

High-amperage gouging presents specific challenges due to the behavior of molten metal:

Molten metal puddles:
At high amperage, slow travel speed, low torch height, smaller nozzle bore, and steeper angle can produce deeper gouges and larger molten puddles. If the plasma arc's gas velocity is insufficient to displace the puddle or evacuate the molten metal from the gouge, gouge quality may degrade.
Poor gouge quality can manifest as:

- Gouge wandering
- Increased surface roughness of the gouge
- Re-solidified material in the gouge

Mitigation strategies:

- Orient the part to use gravity to assist puddle removal
- Use auxiliary air jets to help clear molten metal
- Adjust amperage, travel speed, torch height, nozzle size, or angle
- Use more complex motion such as a weave - this can help break the surface tension of the molten puddle making it easier to manage

Impact of plate temperature on gouging outcomes:
Part temperature affects gouging behavior. As the plate heats up, metal removal becomes more efficient. However, this can lead to inconsistencies when transitioning from small-scale test samples to full-size parts.
Key considerations:

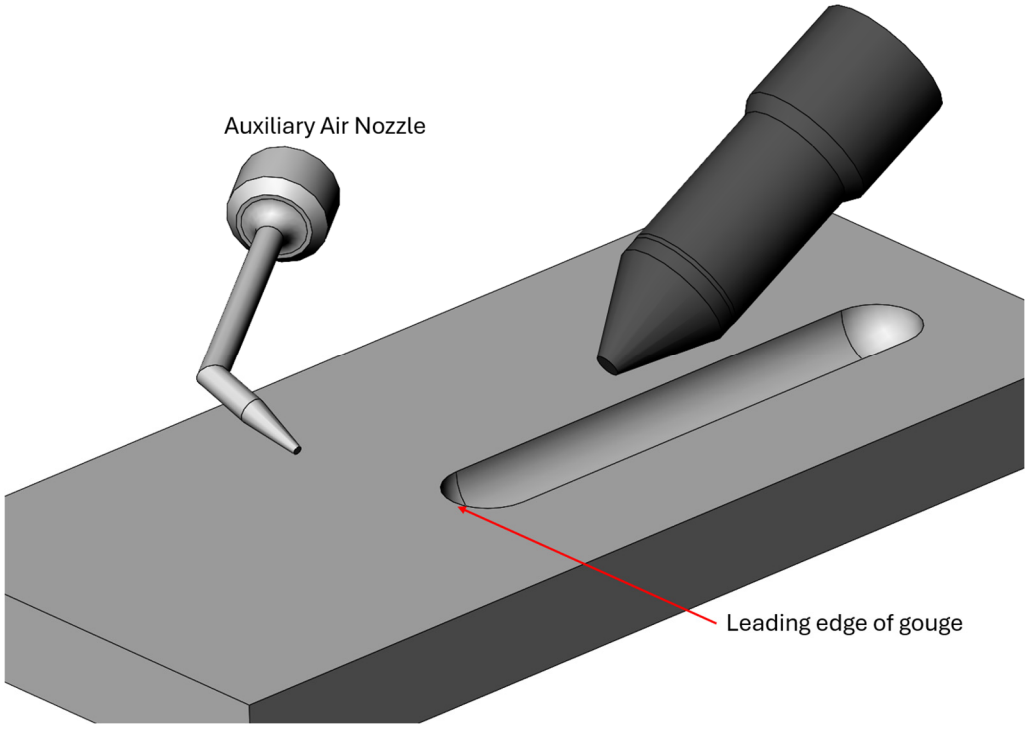
- High-amperage gouging can rapidly increase plate temperature
    - Speed of the gouge directly impacts the heat into the part
- Gouge geometry may take several inches to stabilize due to thermal effects
- Part thickness and part size influence heat buildup and gouging consistency

Auxiliary Air Can Enhance Plasma Gouging Performance

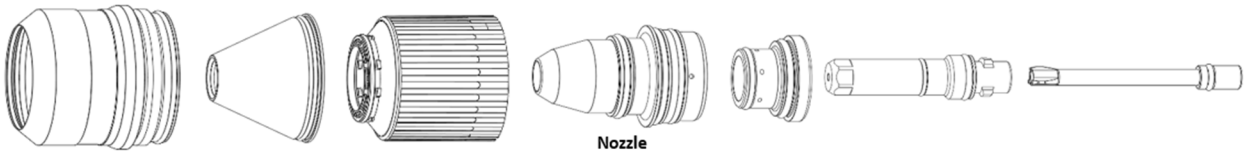
While the XPR system can produce high-quality gouges across a wide range of applications without auxiliary air, incorporating simple air jets can significantly improve gouge consistency in certain conditions. This enhancement is especially noticeable at higher amperages, horizontal work pieces and slower travel speeds. The molten puddle created by plasma gouging presents one of the primary challenges to producing uniform and repeatable gouges. Properly applied auxiliary air helps manage this molten material and maintain a clean, stable gouge profile.

Auxiliary Air Set up:

- Place the air nozzle so that the airflow is directed approximately **1 inch ahead of the leading edge** of the gouge path and offset laterally by 2–3 inches. The goal is to push molten material away from the gouge path as early as possible **without disturbing the plasma arc**.
- Aim the air jet at approximately a **90° angle** to the gouge line. Avoid directing air in a way that blows molten material backward or interferes with the direction of travel.
- Mount or install the auxiliary air nozzle so that it moves in unison with the torch.



170 A Mild Steel Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

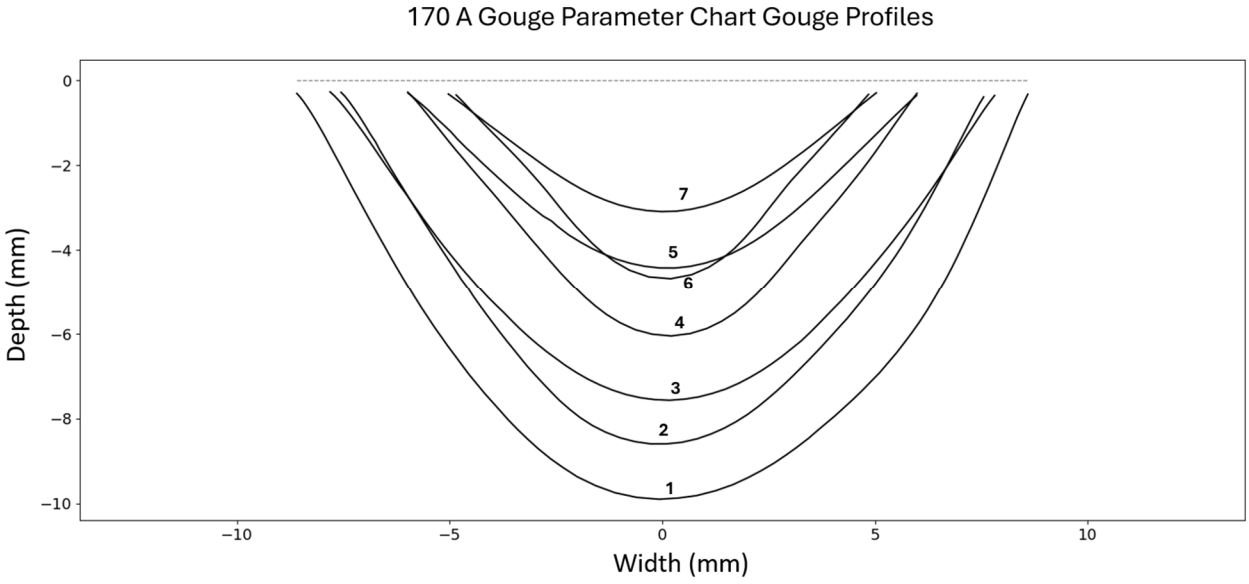
Swirl Ring
420242

Electrode
10086653

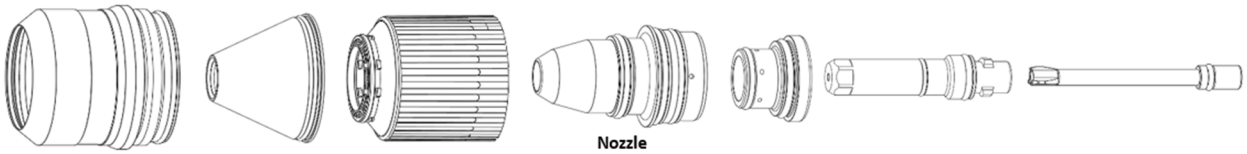
Water tube
420368

Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		0
Cut Flow		111 / 235	99 / 210

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3001	0.140	170	57.5	85	40	210	381	5	3.0	17	10	59	4	21
2	3001	0.140	170	57.5	85	40	190	508	6	1.5	15	9	65	3	20
3	3001	0.140	170	57.5	85	40	210	508	14	1.5	15	8	71	3	18
4	3001	0.140	170	57.5	85	40	180	889	6	0.7	12	6	76	2	18
5	3001	0.140	170	57.5	85	40	210	889	20	0.7	12	4	92	3	15
6	3001	0.140	170	57.5	85	40	170	1270	6	0.4	10	5	83	2	17
7	3001	0.140	170	57.5	85	40	210	1270	23	0.4	10	3	104	3	13



170 A Mild Steel Gouge Parameter Chart English



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10087911 (.250)

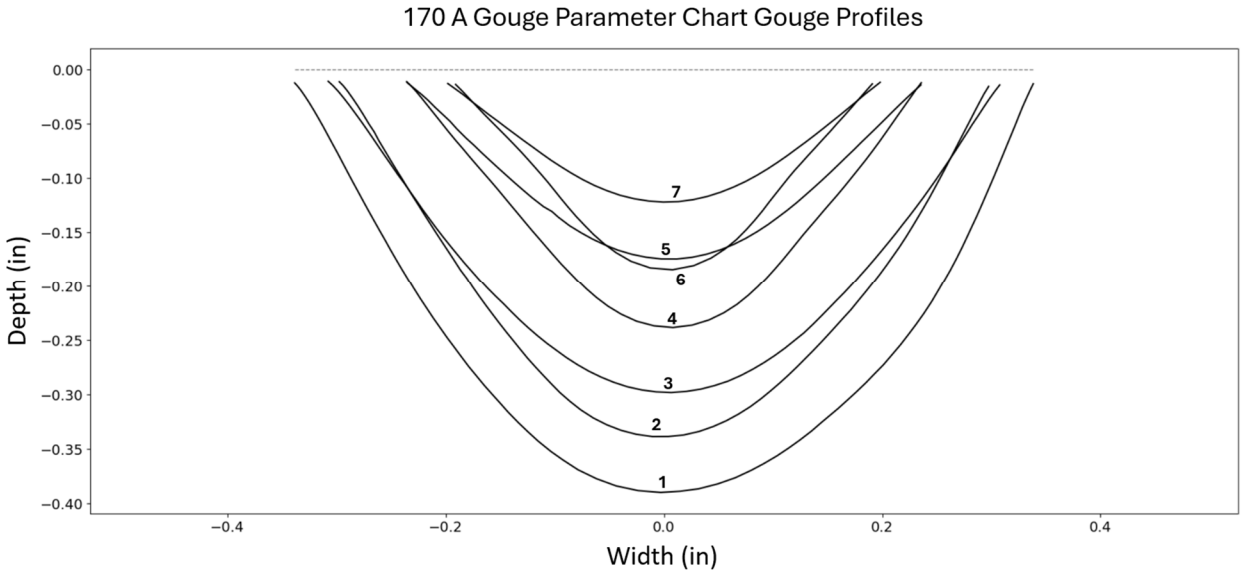
Swirl Ring
420242

Electrode
10086653

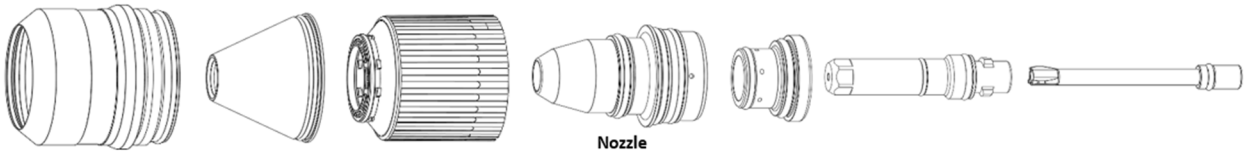
Water tube
420368

Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		0
Cut Flow		111 / 235	99 / 210

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3001	0.140	170	57.5	85	40	210	15	0.20	3.0	0.68	0.39	59	0.16	45
2	3001	0.140	170	57.5	85	40	190	20	0.25	1.5	0.59	0.34	65	0.12	44
3	3001	0.140	170	57.5	85	40	210	20	0.56	1.5	0.61	0.30	71	0.14	40
4	3001	0.140	170	57.5	85	40	180	35	0.24	0.7	0.46	0.24	76	0.09	40
5	3001	0.140	170	57.5	85	40	210	35	0.80	0.7	0.48	0.18	92	0.13	32
6	3001	0.140	170	57.5	85	40	170	50	0.22	0.4	0.38	0.19	83	0.07	37
7	3001	0.140	170	57.5	85	40	210	50	0.91	0.4	0.40	0.12	104	0.13	28



300 A Mild Steel Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

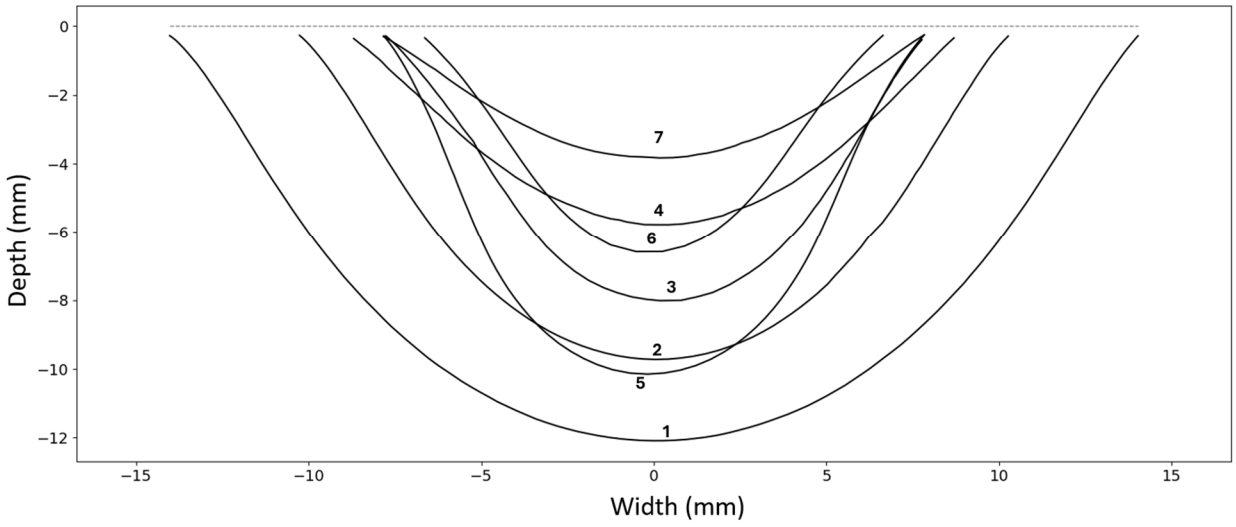
Electrode
10086653

Water tube
420368

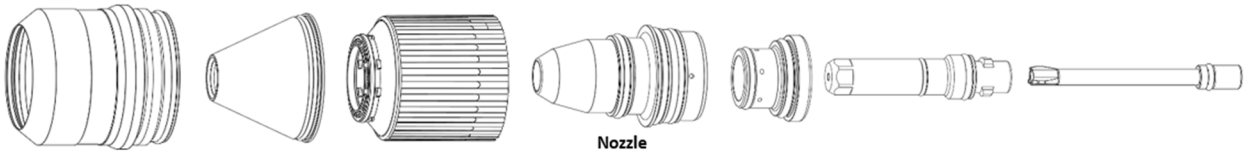
Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		
Cut Flow		111 / 235	151 / 320

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3006 (offset)	0.180	275 (offset)	57.5	85	70	240	254	19	4.0	29	12	70	10	28
2	3006	0.180	300	57.5	85	70	220	508	17	1.5	22	9	69	7	30
3	3006	0.180	300	57.5	85	70	185	889	11	0.5	16	8	69	4	35
4	3006	0.180	300	57.5	85	70	215	889	20	0.6	18	6	93	6	28
5	3006	0.140	300	57.5	85	70	220	1143	8	0.5	16	10	48	4	55
6	3006	0.180	300	57.5	85	70	175	1270	10	0.3	15	6	79	3	35
7	3006	0.180	300	57.5	85	70	220	1270	24	0.4	16	4	112	7	24

300 A Gouge Parameter Chart Gouge Profiles



300 A Mild Steel Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

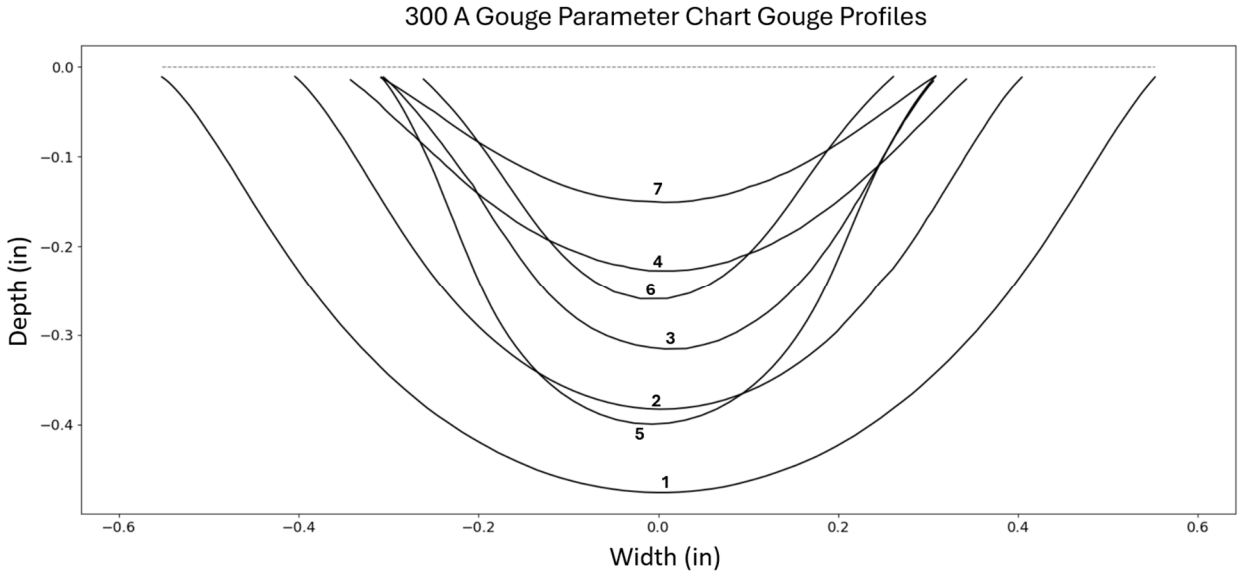
Swirl Ring
420242

Electrode
10086653

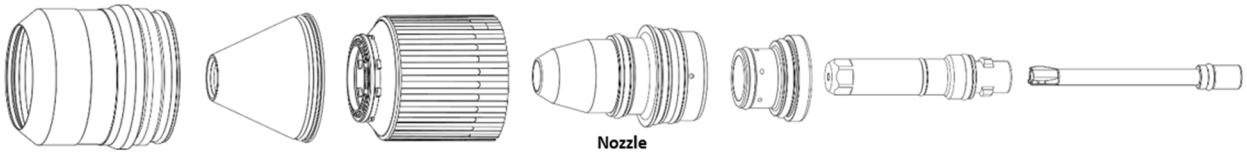
Water tube
420368

Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		
Cut Flow		111 / 235	151 / 320

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3006 (offset)	0.180	275 (offset)	57.5	85	70	240	10	0.76	4.0	1.14	0.48	70	0.39	62
2	3006	0.180	300	57.5	85	70	220	20	0.68	1.5	0.85	0.35	69	0.28	67
3	3006	0.180	300	57.5	85	70	185	35	0.42	0.5	0.63	0.32	69	0.15	76
4	3006	0.180	300	57.5	85	70	215	35	0.79	0.6	0.69	0.23	93	0.23	61
5	3006	0.140	300	57.5	85	70	220	45	0.33	0.5	0.61	0.39	48	0.16	121
6	3006	0.180	300	57.5	85	70	175	50	0.39	0.3	0.57	0.25	79	0.13	76
7	3006	0.180	300	57.5	85	70	220	50	0.93	0.4	0.61	0.15	112	0.29	52



460 A Mild Steel Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

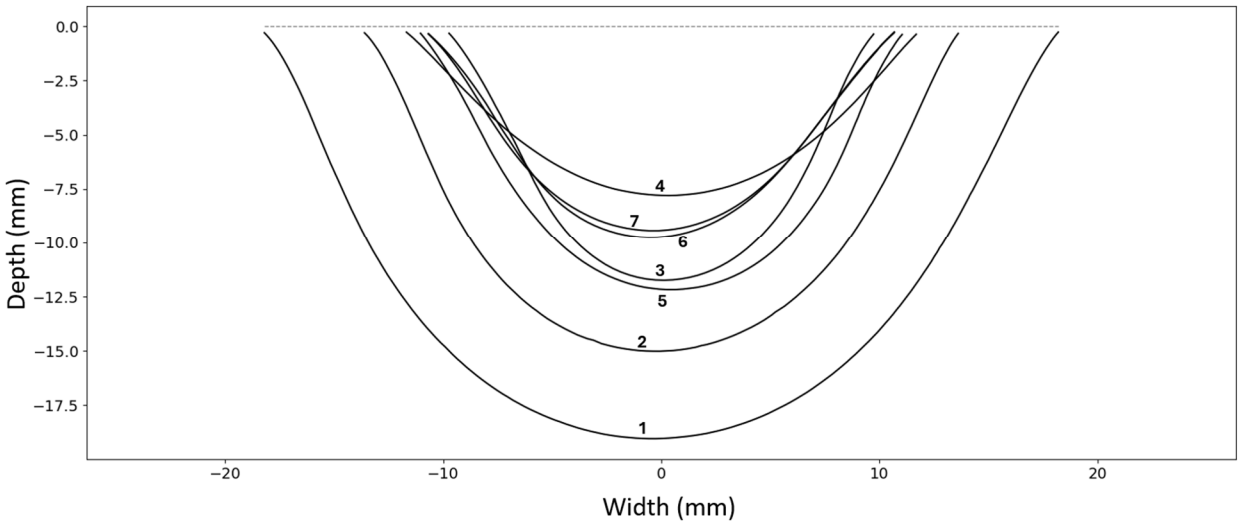
Electrode
10086653

Water tube
420368

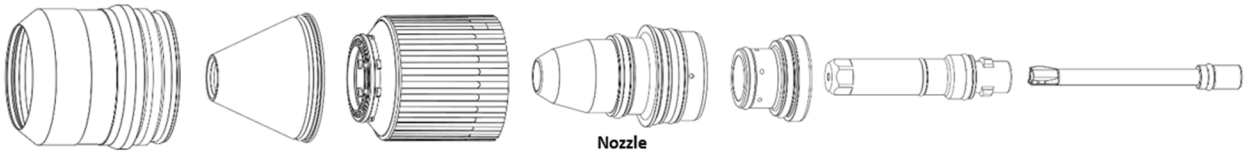
Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		
Cut Flow		111 / 235	151 / 320

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3011 (offset)	0.195	380 (offset)	57.5	85	70	265	254	25	5.0	33	19	65	12	56
2	3011	0.195	420	62.5	85	70	240	508	20	3	28	14	59	9	66
3	3011	0.195	420	62.5	85	70	200	889	11	1	22	10	70	7	63
4	3011	0.195	420	62.5	85	70	240	889	23	1.5	24	7	94	10	48
5	3012	0.195	460	62.5	85	70	220	889	15	1	24	11	66	8	74
6	3012	0.195	460	62.5	85	70	205	1270	14	0.5	21	9	72	6	75
7	3012	0.195	460	57.5	85	70	215	1270	24	0.5	21	9	72	7	74

460 A Gouge Parameter Chart Gouge Profiles



460 A Mild Steel Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

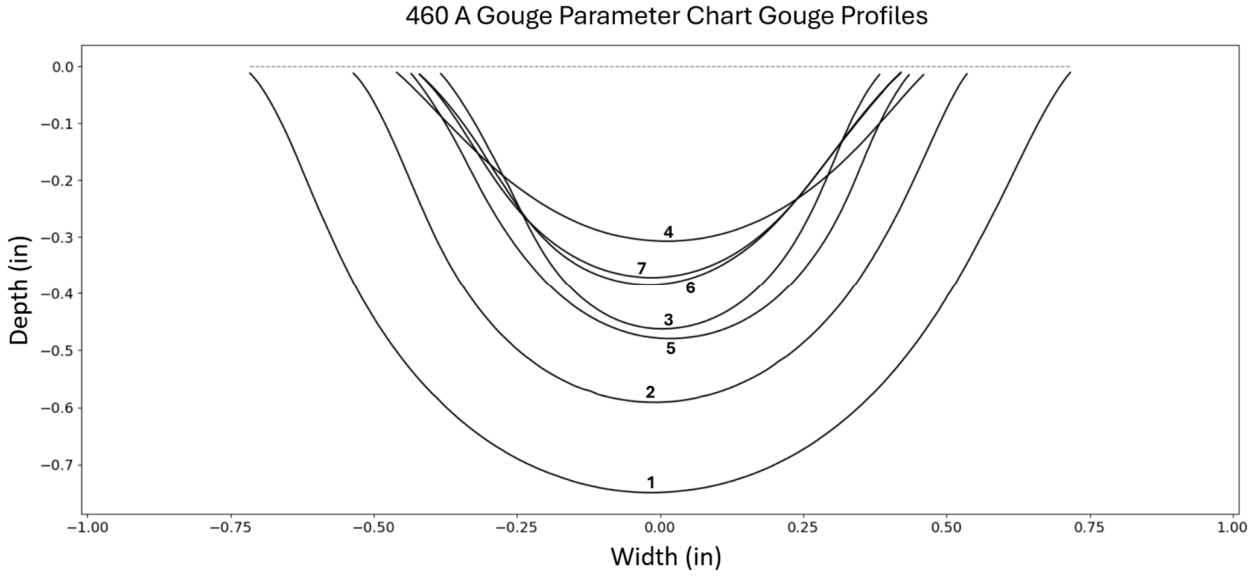
Swirl Ring
420242

Electrode
10086653

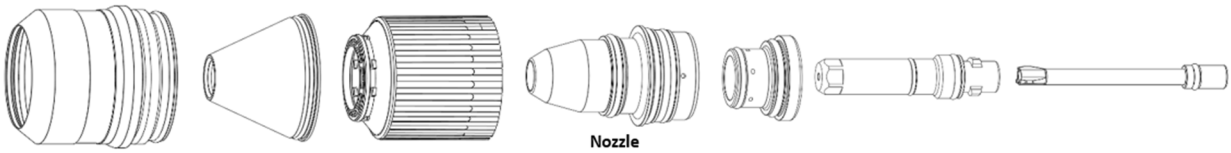
Water tube
420368

Flow Rate (lpm/scfh)			
	N_2	O_2	Air
Pre flow	15 / 32		
Cut Flow		111 / 235	151 / 320

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3011 (offset)	0.195	380 (offset)	57.5	85	70	265	10	0.97	5.0	1.31	0.75	65	0.47	124
2	3011	0.195	420	62.5	85	70	240	20	0.79	3	1.12	0.56	59	0.36	144
3	3011	0.195	420	62.5	85	70	200	35	0.43	1	0.88	0.41	70	0.26	139
4	3011	0.195	420	62.5	85	70	240	35	0.91	1.5	0.93	0.29	94	0.40	106
5	3012	0.195	460	62.5	85	70	220	35	0.60	1	0.94	0.44	66	0.31	163
6	3012	0.195	460	62.5	85	70	205	50	0.54	0.5	0.82	0.37	72	0.24	166
7	3012	0.195	460	57.5	85	70	215	50	0.95	0.5	0.82	0.35	72	0.26	163



170 A Stainless Steel Mixed Gas Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

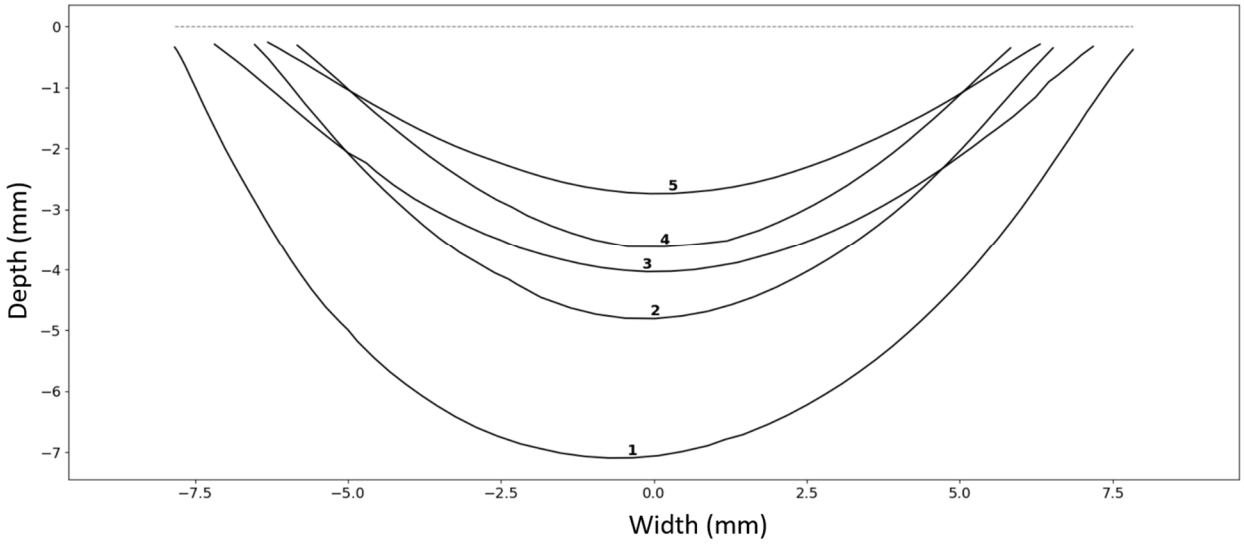
Electrode
10086650

Water tube
420368

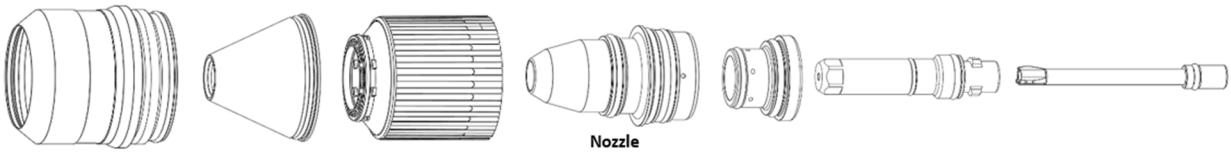
Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	40/85	40/85	92/195

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3016	0.165	170	57.5	40	40	0	40	210	508	5.98	1.0	15.63	6.82	74	5.24	18
2	3016	0.165	170	57.5	40	40	0	40	180	889	1.21	0.5	12.94	4.94	84	3.84	18
3	3016	0.165	170	57.5	40	40	0	40	210	889	8.55	0.5	14.41	4.03	103	6.54	17
4	3016	0.165	170	57.5	40	40	0	40	175	1270	2.14	0.3	11.65	3.64	99	4.37	17
5	3016	0.165	170	57.5	40	40	0	40	210	1270	9.88	0.3	12.50	2.71	121	8.01	14

170 A Stainless Steel Mixed Gas Gouge Parameter Chart Gouge Profiles



170 A Stainless Steel Mixed Gas Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

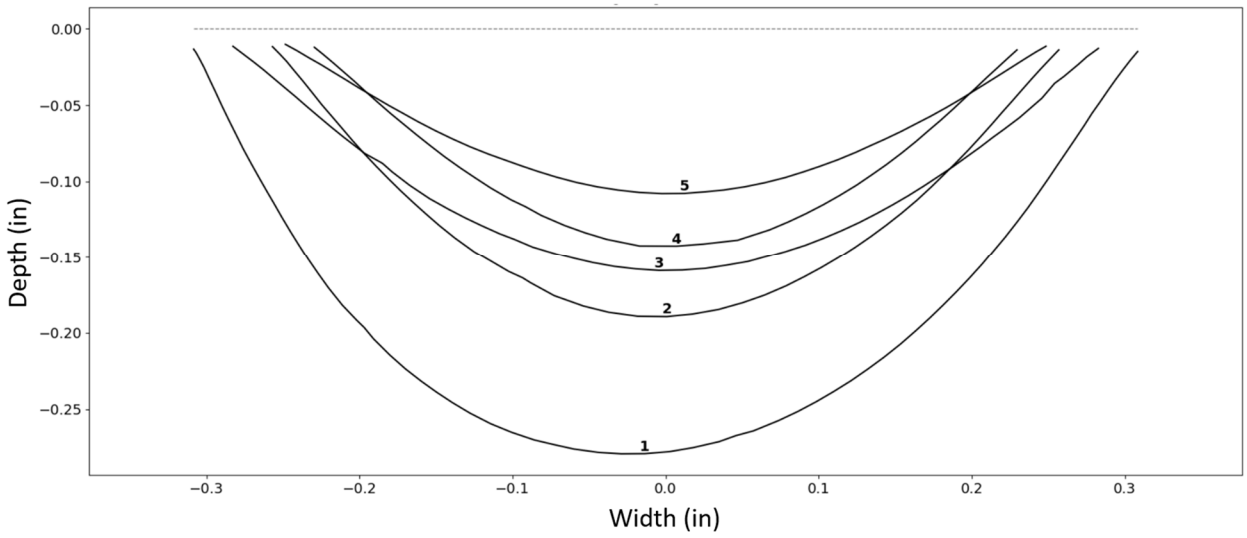
Electrode
10086650

Water tube
420368

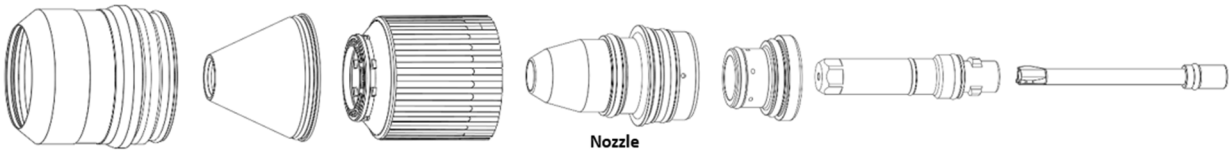
Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	40/85	40/85	92/195

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3016	0.165	170	57.5	40	40	0	40	210	20	0.24	1.0	0.62	0.27	74	0.21	39
2	3016	0.165	170	57.5	40	40	0	40	180	35	0.05	0.5	0.51	0.19	84	0.15	40
3	3016	0.165	170	57.5	40	40	0	40	210	35	0.34	0.5	0.57	0.16	103	0.26	36
4	3016	0.165	170	57.5	40	40	0	40	175	50	0.08	0.3	0.46	0.14	99	0.17	38
5	3016	0.165	170	57.5	40	40	0	40	210	50	0.39	0.3	0.49	0.11	121	0.32	31

170 A Stainless Steel Mixed Gas Gouge Parameter Chart Gouge Profiles



300 A Stainless Steel Mixed Gas Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

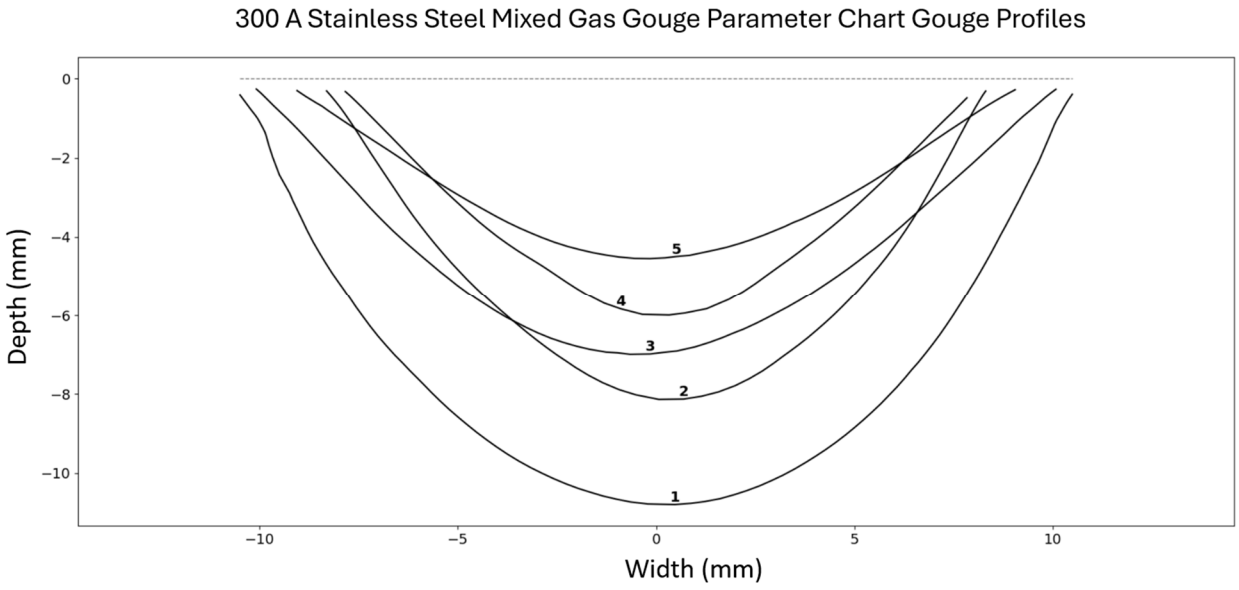
Swirl Ring
420242

Electrode
10086650

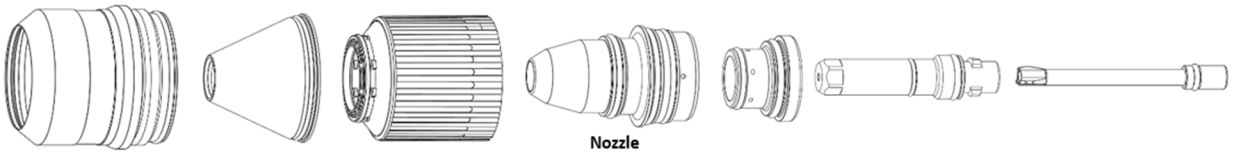
Water tube
420368

Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	50/106	50/106	99/210

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3021	0.210	300	57.5	50	50	0	45	220	508	9.98	1.5	21.49	10.44	67	6.22	38
2	3021	0.210	300	57.5	50	50	0	45	185	889	3.00	1	16.98	8.00	72	3.65	38
3	3021	0.210	300	57.5	50	50	0	45	220	889	14.76	1	20.20	6.73	93	6.85	38
4	3021	0.210	300	57.5	50	50	0	45	167	1270	2.41	0.5	15.82	5.91	90	3.57	36
5	3021	0.210	300	57.5	50	50	0	45	220	1270	16.43	0.5	18.22	4.53	113	7.54	32



300 A Stainless Steel Mixed Gas Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

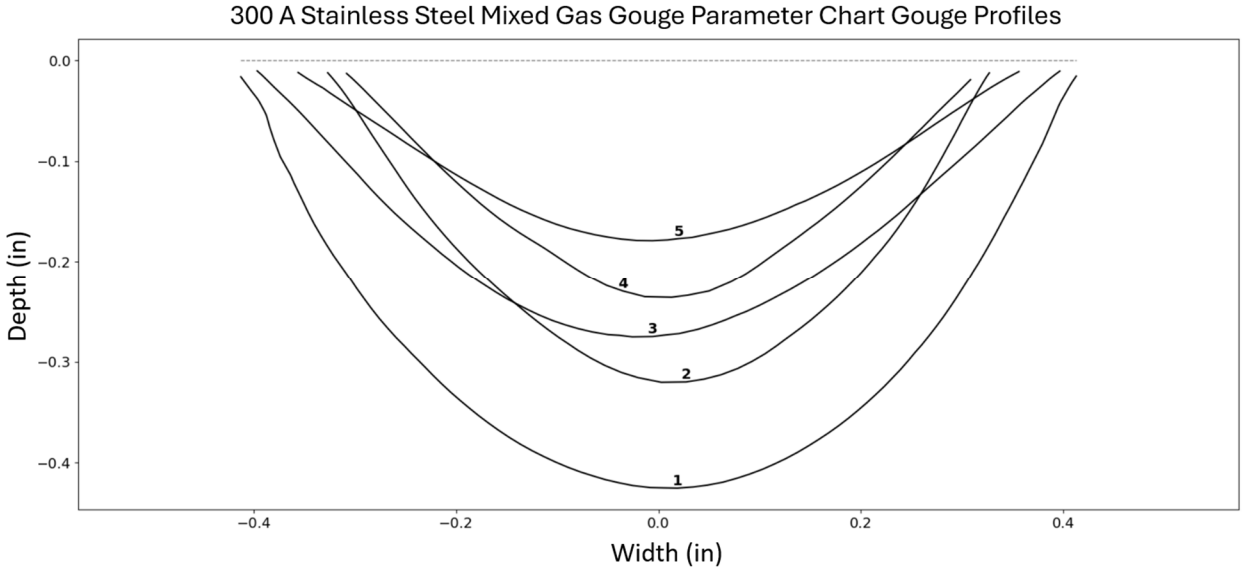
Swirl Ring
420242

Electrode
10086650

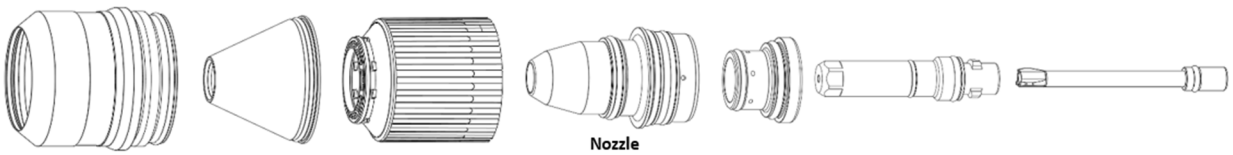
Water tube
420368

Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	50/106	50/106	99/210

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3021	0.210	300	57.5	50	50	0	45	220	20	0.39	1.5	0.85	0.41	67	0.24	83
2	3021	0.210	300	57.5	50	50	0	45	185	35	0.12	1	0.67	0.31	72	0.14	84
3	3021	0.210	300	57.5	50	50	0	45	220	35	0.58	1	0.80	0.27	93	0.27	83
4	3021	0.210	300	57.5	50	50	0	45	167	50	0.10	0.5	0.62	0.23	90	0.14	79
5	3021	0.210	300	57.5	50	50	0	45	220	50	0.65	0.5	0.72	0.18	113	0.30	71



460 A Stainless Steel Mixed Gas Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

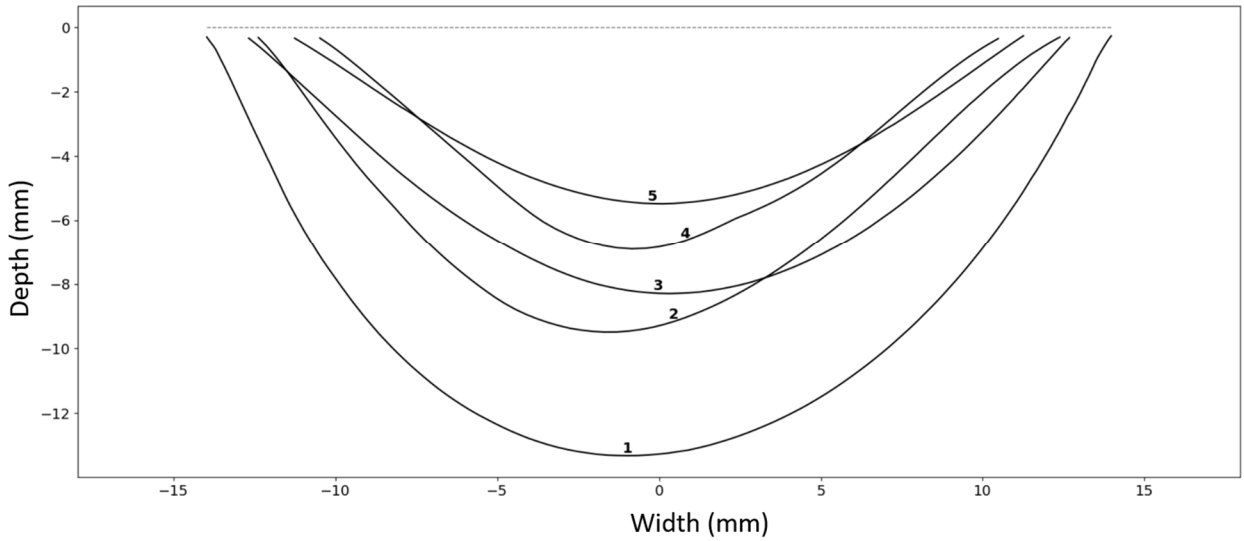
Electrode
10086650

Water tube
420368

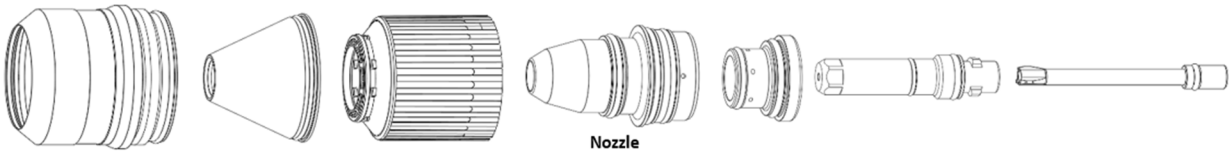
Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	50/106	50/106	137/290

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3026	0.250	460	57.5	50	50	0	65	220	508	8.39	2.5	27.44	13.63	66	9.23	64
2	3026	0.250	460	57.5	50	50	0	65	190	889	3.95	1	23.92	9.47	83	6.51	61
3	3026	0.250	460	57.5	50	50	0	65	220	889	12.64	1	25.05	8.45	91	8.56	60
4	3026	0.250	460	57.5	50	50	0	65	183	1270	3.00	0.5	21.08	7.06	98	5.29	55
5	3026	0.250	460	57.5	50	50	0	65	220	1270	14.58	0.5	22.82	5.77	111	9.45	52

460 A Stainless Steel Mixed Gas Gouge Parameter Chart Gouge Profiles



460 A Stainless Steel Mixed Gas Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

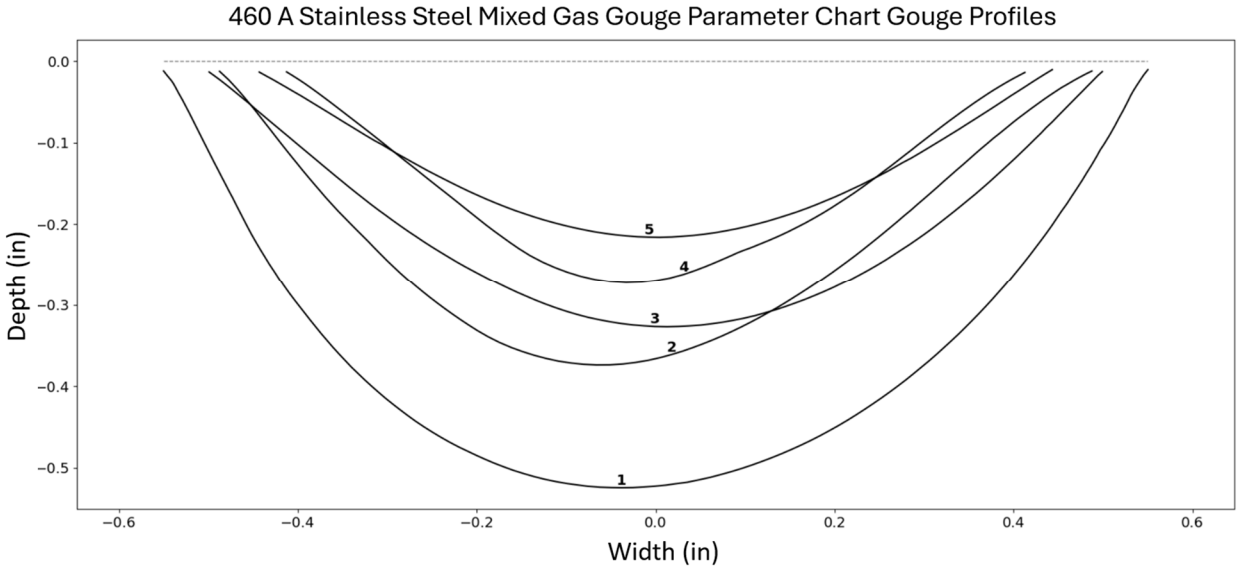
Swirl Ring
420242

Electrode
10086650

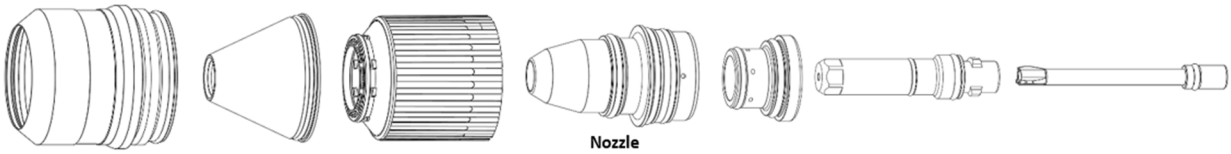
Water tube
420368

Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	50/106	50/106	137/290

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	H_2 Flow	Ar Flow	N_2 Flow	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	lpm	lpm	lpm	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3026	0.250	460	57.5	50	50	0	65	220	20	0.33	2.5	1.08	0.54	66	0.36	141
2	3026	0.250	460	57.5	50	50	0	65	190	35	0.16	1	0.94	0.37	83	0.26	135
3	3026	0.250	460	57.5	50	50	0	65	220	35	0.50	1	0.99	0.33	91	0.34	131
4	3026	0.250	460	57.5	50	50	0	65	183	50	0.12	0.5	0.83	0.28	98	0.21	122
5	3026	0.250	460	57.5	50	50	0	65	220	50	0.57	0.5	0.90	0.23	111	0.37	114



All Stainless Steel N_2/N_2 Gouge Parameter Chart Metric



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

Swirl Ring
420242

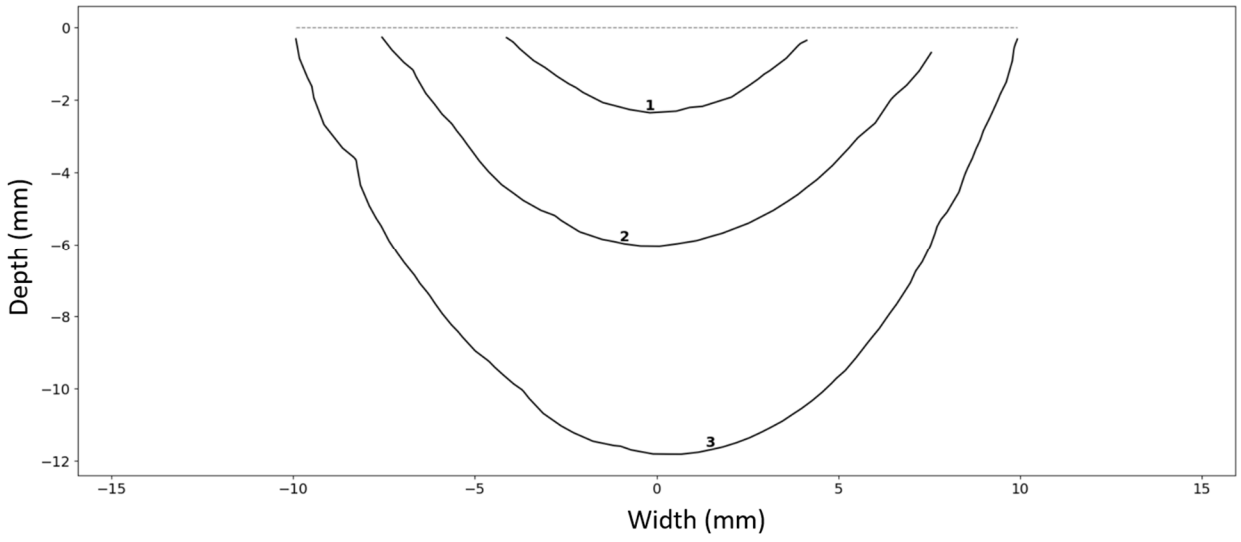
Electrode
10086650

Water tube
420368

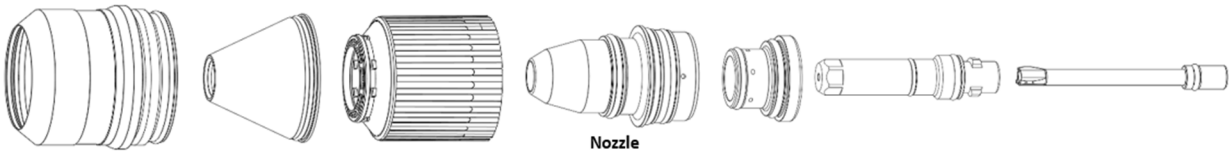
Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	-	-	236/500

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	mm/min	mm	seconds	mm	mm	degrees	mm	kg/hr
1	3031	0.165	170	57.5	75	55	210	508	8.97	1.0	8.23	2.33	107	1.82	3
2	3032	0.180	300	57.5	75	55	220	508	7.61	1.5	15.46	6.79	76	4.60	18
3	3033	0.210	460	57.5	75	55	220	508	10.67	2.5	19.83	11.67	62	5.75	40

All Stainless Steel N_2/N_2 Gouge Parameter Chart Gouge Profiles



All Stainless Steel N_2/N_2 Gouge Parameter Chart English



Shield retaining cap
420200

Shield
10086659

Nozzle retaining cap
420365

Nozzle
10087904 (.140)
10087907 (.165)
10086655 (.180)
10086657 (.195)
10087909 (.210)
10087911 (.250)

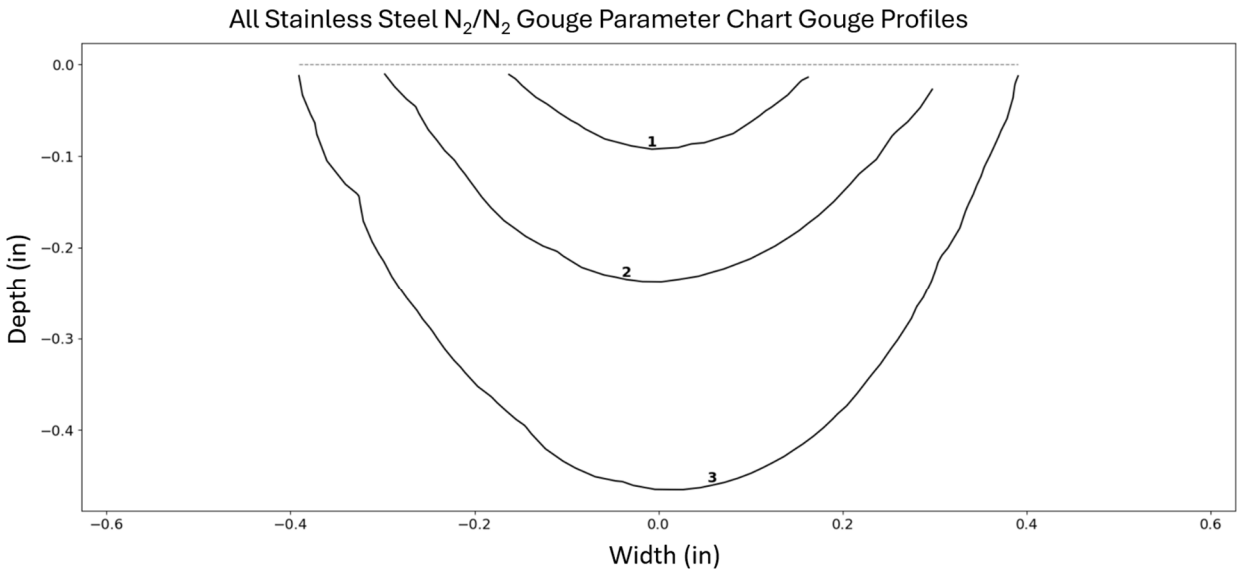
Swirl Ring
420242

Electrode
10086650

Water tube
420368

Flow Rate (lpm/scfh)			
	H_2	Ar	N_2
Pre flow	-	-	15/32
Cut Flow	-	-	236/500

Ref	XPR Process ID	Nozzle Bore	Amperage	Torch Angle	Plasma Pressure	Shield Pressure	Arc Voltage	Speed	Standoff	Motion Delay	Width	Depth	Included Angle	Bottom Radius	Metal-Removal Rate
		inches	amps	degrees	psi	psi	volts	in/min	in	seconds	in	in	degrees	in	lb/hr
1	3031	0.165	170	57.5	75	55	210	20	0.35	1.0	0.32	0.09	107	0.07	7
2	3032	0.180	300	57.5	75	55	220	20	0.30	1.5	0.61	0.27	76	0.18	39
3	3033	0.210	460	57.5	75	55	220	20	0.42	2.5	0.78	0.46	62	0.23	89



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