Plasma Coating Removal System

PB7000-B series

User Manual

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Summary of Technical Data

PlasmaBlast® PB7000-B-Series

Models:
PB7000-B-24 **PB7000-B-48**

Mechanical Specifications (All Models):

Dimensions:	17.5” x 18” x 8.2”	44 cm x 46 cm x 21 cm
Weight – Controller:	35 lbs	15.8 kg
Weight – Plasma Pen with cable	5.3 lbs	2.4kg
Plasma Cable Length:	20 ft	6.1 meters

Electrical Specifications:

Models:	**All 240V models**	**All 480V models**
Input Power	208-240 VAC, 50-60Hz single-phase	440-480 VAC, 50-60Hz, three-phase
Default Plug Type	NEMA L6-30	NEMA L16-30
Optional Plug Types	NEMA L6-20, NEMA L14-20	NEMA L16-20
Fuse Rating	20A	10A
Degree of Protection	IP 52	

Operating Parameters (All Models):

Operating Temperatures	14°F - 115°F	-10°C - 46°C
Operating Humidity	<95%, non-condensing	
Elevation	<9840 ft	<3000 meters
Operating Sound Level	~90 dBa	
Input Compressed Air Pressure	80 - 100 psi	550kPa - 690kPa, 5 - 7 bar
Burst Pressure	120 psi	827 kPa, 8 bar
Optimal Input Compressed Air Flow	3.5 CFM	99 SLM

1. Introduction

1.1. PlasmaBlast® System - Principle of Operation

The PlasmaBlast® Atmospheric Plasma Coating Removal (APCR) system quickly and efficiently removes coatings and sealants, cleans contaminants, and prepares surfaces for better adhesion, all without damaging the substrate. The system uses a low pressure compressed air source and electricity to produce plasma in air containing chemically active oxygen and nitrogen species that react with organic components found on the surface. The PlasmaBlast® chemical oxidation process converts a large percentage of a coating, adhesive, or organic contaminant into water vapor and carbon dioxide with only the inorganic component left behind which can be safely vacuumed away with a suitable HEPA vacuum. In addition, the PlasmaBlast® system increases the surface energy of the substrate, improving the bond strength for subsequent application of coatings, adhesives, and sealants.

1.2. Overview of PlasmaBlast® PB7000-B Series

Generally, the coating removal system is comprised of a high voltage (HV) plasma controller, a plasma cable, a plasma pen or applicator, and a grounding cable. Inputs to the system are compressed air and electricity, and the system is grounded through its power cord and a ground cable.
There are several different configurations of the PlasmaBlast® B-series system. Each configuration is specialized for a specific use (benchtop or robotics-compatible), the operating voltage range (208-240VAC or 440-480VAC), and location of high voltage connection (front or rear), as outlined in Table 1 below.
This manual describes safety, installation, operation, maintenance, and troubleshooting procedures applicable to systems of all configurations.

System Option	Use	Operating Voltage	HV Connection
Benchtop Option	Can be operated inside buildings/hangars in a semi-stationery setting (on a cart, or a bench). Equipped with handheld plasma pen.	208-240VAC, Single phase	Front
			Rear
		440-480VAC, Three phase	Front
			Rear
Robotic-mountable Option	Can be integrated with robotic systems. Equipped with robotic-compatible plasma pen.	208-240VAC, Single phase	Front
			Rear
		440-480VAC, Three phase	Front
			Rear

Table 1: Models of PlasmaBlast® B- series system.

The manual is divided into the following chapters:

Chapter	Description
1	Introduction: Provides an introduction to the PlasmaBlast® APCR system
2	Safety & Legal: Precautionary measures for safely operating the system and legal statements.
3	System Setup: Describes system connections and facility requirements.
4	System Components and Controls: Describes operational details of the system.
5	System Operation: Describes how to power up and operate the system.
6	Maintenance: Describes maintenance procedures.
7	Troubleshooting: Describes common problems that may occur and methods of their rectification.
8	Support: Provides information on how to obtain technical support

2. Safety and Legal

2.1. Safety Alerts

It is extremely important that you follow the instructions and heed the DANGER and WARNING safety alerts in this Manual. Your safety and the safety of others is very important.

We have provided important safety messages in this Manual and on the PlasmaBlast® B-series unit.

This is the safety alert symbol. This symbol alerts you to potential hazards that can cause death or injury to you or others.

All safety messages will follow the safety alert symbol and either the word “DANGER” or “WARNING”. These words mean:

DANGER	Death or serious injury will occur if you do not follow the instructions in this manual.
WARNING	Death or serious injury may occur if you do not follow the instructions in this manual.
DANGER SHOCK HAZARDS	Death or serious injury may occur if you do not follow the instructions in this manual.

2.2. The PlasmaBlast® System and Diagram

See Section 3.1 for the diagram of the PlasmaBlast® and the names of the PlasmaBlast® System components used in the safety instructions below and throughout this Manual.
Operation of the PlasmaBlast® plasma system may require three pieces of additional equipment (not provided with the system): (1) an air compressor; (2) an electric generator, and (3) a dust collection system.

⚠WARNING

The safety instructions in this manual pertain only to the PlasmaBlast® . Safe operation of the PlasmaBlast® depends on safe operation of the auxiliary equipment. The operator of the PlasmaBlast® must be informed about, and comply with, the safety instructions for any auxiliary equipment, such as an air compressor or power generator. Consult the manufacturers' equipment manuals pertaining to this equipment.

2.3. Safety Instructions

⚠WARNING SAFETY ALERTS AND INSTRUCTIONS

The PlasmaBlast® APCR system produces an atmospheric plasma beam capable of removing organic coatings, cleaning contaminants, and preparing surfaces for better adhesion. A high voltage, high frequency waveform and compressed air are used to internally generate plasma. Depending on the coating or substrate that the plasma is used on the plasma may interact with coatings and surfaces that may result in the release of toxic and other hazardous materials. This portion of the manual provides instructions on how to use PlasmaBlast® in a safe manner.
Read all safety alerts and all instructions. Failure to follow alerts and safety instructions may result in serious injury or death.
It is important to follow all safety procedures defined in this manual to avoid personal injury to yourself and others.

General

- The *PlasmaBlast®* system is an electronic device. Drops may cause irreparable damage. Prevent dropping the unit by always placing it on stable surfaces during operation and storage and securing the unit to reliable structures while in use.
- Follow all local laws, rules, ordinances, statutes and orders.
- Setup and operate the PlasmaBlast® as specified in this Manual.
- Have everything you need to setup and operate the PlasmaBlast® unit™ .
- Make sure the equipment not supplied by APS (electrical generator, air compressor, dust collection system, compressed air line, electrical cord) is in proper and safe operating condition.
- Only certified users as designated in the APS certified user logs should use this equipment.

Work Area Safety

- Use proper lighting, sufficient to see the details of the workspace well. Keep the work area free of obstacles and as clean as possible – the risk of accidents increases when the operator is not able to see and is hindered by obstacles and clutter.
- Ensure the unit is safely secured to avoid drops or falls.
- Keep the cables out of walkways and vehicle /equipment paths.
- Do not allow access to bystanders to an operational system.
- Wear long sleeved shirt, long pants, and closed-toe rubber-sole shoes.
- Remove all loose jewelry, secure long hair.

 RISK OF EXPLOSION AND FIRE

The plasma nozzle of the PlasmaBlast® System will reach temperatures that may exceed 350°F/ 175°C. If the nozzle comes in contact with flammable materials for extended periods of time, there is a possibility of fire. Do not operate the PlasmaBlast® unit in enclosed areas where solvents or other explosive gases are present in the air or where rags and other materials that may have residual solvents exposed to open air. The temperature of the replaceable nozzle of the plasma pen may reach temperatures in excess of 350°F/ 175°C and could ignite these materials; plasma may cause chemical reactions that result in heat; and hot particles ejected from the plasma removal process may create sparks.
Do not operate the PlasmaBlast® in the presence of explosive or flammable liquids, gases.

Electrical Safety

 DANGER SHOCK HAZARDS

- **Proper AC Earth Ground required**

AC line voltages are present in the power cord, and the power supply. The plasma cable contains high voltage and high frequency waveform. Do not operate the plasma controller unless it is securely grounded with a low impedance earth ground connection through the supplied AC power cable.
The plug from the electrical cord to the PlasmaBlast® must match the receptacle. Always use the electrical cord included with the system. Never modify an electrical plug or an electrical receptacle. Always use a plug that includes an earthed (grounded) pin. Do not use any adapters which would defeat or disconnect the connection to earth (ground).
Serious injury or death may occur if the proper safety procedures are not followed or the plasma system is used by untrained users.

- **Never operate with damaged cables**

Make sure that the cord from the electrical source is in good condition. Keep the cord away from heat, oil, water, sharp edges, and moving parts. Do not otherwise compromise the electrical cord. The electrical cord carries electricity at 240VAC or 480VAC depending on the model. If it is compromised severe injury from electrical shock or a fire hazard may result.

- Wear dry, hole-free, OSHA-approved leather gloves to electrically and thermally protect the hands.

- There are no user serviceable parts inside the plasma system. Do not open any covers on the plasma system. Never operate the plasma controller with the cover panels removed or with the interlock bypassed.
- Only use input voltages between the voltage for which the unit is rated and as indicated on the unit (I.e. 208 – 240V or 440-480 V)
- Always assume that the HV output of the plasma controller is active and at high voltage unless the plasma controller has been turned off and unplugged for several minutes.
- The plasma pen can be used in light precipitation conditions, but make sure that the power supply is kept dry at all times.
- Make sure the plasma cable connector that connects to the power controller is seated and the safety lever is locked in place.
- Never use power cable, ground cable, or pen cable as a lift point.
- Make sure that the plasma cable is in good condition prior to use. Do not pull the cable against sharp objects or permit it to be cut or abraded by foreign objects. Do not permit the plasma cable to become

knotted or kinked. Keep the plasma cable away from heat, oil, water, sharp edges, and moving parts. Do not otherwise compromise the plasma cable. It has multiple layers of material protecting the operator but a damaged cable can create the risk of shock, extreme care must be given to the cable and its connection to the plasma controller.

- Do not expose the plasma controller to water, liquids or conductive dusts or powders.
- Do not submerge the plasma system in water or any other liquids.
- Never allow any liquid, such as oil or water, to enter the air lines. Introduction of liquids into the air lines may cause a failure of the plasma system.

Do not open the plasma controller box. *A person who opens the box may be exposed to risk of injury or death from electrocution.*

Operational Safety

⚠ WARNING OPERATIONAL HAZARDS

Operation of the PlasmaBlast® presents hearing, eye and other risks to the operator. Follow all safety instructions to avoid property damage, serious injury or death.

Vision Protection Required

Plasma emits a low output of UV light. Additionally, the interaction of the plasma beam with the surface of a material can produce high velocity airborne particles that may cause permanent eye injury. Protect your eyes with impact resistant clear plastic safety glasses that conform to the current ANSI Z87.1-2015 safety standards.

Hearing Protection Required

The PlasmaBlast® unit operates at noise levels of approximately 85 dB within 5 feet from the plasma pen. Prolonged exposure to the operating noise of the PlasmaBlast® unit without hearing protection may cause hearing loss. Protect your hearing with OSHA approved earplugs or earmuffs with a minimum of 28 dB noise reduction rating (NRR)

Heat Hazard

During prolonged PlasmaBlast® operation certain parts of the system will become hot.

- Pen tip - >350°F/ 175°C
- Pen grip 95°F -165°F / 35°C - 75°C
- Bottom and rear panel of unit - >175°F / 80°C

Wear dry, hole-free, OSHA-approved leather thermally insulating gloves to protect the hands. Welder's leather gloves are recommended.

⚠ WARNING: Compressed Air

A high velocity compressed air stream is emitted from the plasma pen during operation (approximately 80-100 psi / 5.4-7 bar and 3.5 CFM / 100 SLM air flow). Compressed air can penetrate skin and result in air bubbles in the blood stream that can cause heart attack, brain injury, and other serious injury or death. Do not allow the compressed air exiting the pen nozzle to pass in front of bare skin.

- Do not use any gas other than air. Only use clean, dry air.
- Do not change or modify factory air fittings. The use of adaptors is permitted.
- Do not block the air flow from the pen.
- Do not point the plasma pen at any part of the body of the operator or anyone else.

- Do not attempt to replace, tighten, or adjust the replaceable nozzle when air is flowing through the plasma pen or when the plasma pen is connected to compressed air or to electricity.
- Make sure the replaceable nozzle on the plasma pen is securely fastened prior to starting the plasma controller (see Section 6. Maintenance on replacement of the nozzle). If *the replaceable nozzle is not securely fastened it could fly off at a high velocity when operating the PlasmaBlast® unit and cause property damage or serious injury.*

WARNING: Hazardous Debris & Toxic Coatings

The plasma coating removal process can result in flying debris or release other materials that may be toxic and cause personal injury or property damage. The debris may include sand, grit, rust, pigments, paint particles, gases, liquids, and solids resulting from interaction of the plasma with the surface.

- The plasma removal process does not change or mitigate any pre-existing risk in a paint, sealant, or other surface coating. If you remove old paint or coatings, you may release lead or other hazardous dusts.
- Ensure proper air ventilation. Plasma may generate toxic and other hazardous byproducts, including gases and particulates, depending on the coating chemistry. *For example, removal of lead paint will produce lead paint dust and proper PPE and dust collection equipment should be used to contain the lead dust produced.*
- Do not operate the PlasmaBlast® in settings where other people may be injured by toxic and other hazardous debris ejected from the surface being treated. *The plasma plume will dislodge particles in the surface being treated. The debris ejected may strike the operator, other people or physical objects and cause property damage and physical injury.*
- Prior to beginning any treatment, the user must be aware of the potential health risks associated with the coatings being removed. Obtain and review the Safety Data Sheet of any coating being removed. As needed discuss risks with your company's Environmental Health and Safety staff.
- Always wear protective gear, a dust mask, or a respirator. If the exact coating composition is unknown assume that it may be dangerous and take full precautions.
- Always wear protective eye wear and other protective gear as needed for the surface and coating being treated.

WARNING: Gas Buildup

- A small concentration of NO_X is produced as a natural biproduct of the air-plasma generation process. Additionally, small amounts of CO can be produced in coating removal applications.
- In enclosed spaces with limited ventilation, these gases can buildup to nuisance or hazardous levels.
- Always use sufficient ventilation. A full-face mask with supplied air ventilator can be used instead. A full-face mask with an appropriate multi-gas filter can be used only if ventilation can't be brought into the space and a supplied air ventilator is not available.
- Symptoms of CO and NOx exposure include: irritated eyes, nose, chest, or throat; difficulty breathing; coughing; headaches; dizziness; confusion; drowsiness; loss of muscle control; light-headedness; and loss of consciousness.
- Persons exposed to CO and NO_x should seek fresh air immediately and seek emergency medical care for anyone exhibiting the above symptoms.

WARNING: RISK OF INJURY FROM PLASMA BEAM

Plasma, in direct contact with the body, can damage skin and injure other body parts. Improper use of the plasma beam on toxic coatings, such as lead paint, can cause the release of toxic materials. Application of the plasma beam to a glass surface may result in glass breakage or shattering. The plasma beam may etch and otherwise damage physical surfaces.

- Do not point the plasma pen at any part of the body of the operator or anyone else.
- Do not allow the plasma beam to come in contact with bare skin, wear protective gloves and clothing.
- Never use the plasma pen on silicate glass; the glass may shatter producing sharps shards.

WARNING: RISK OF PROPERTY DAMAGE

Do not point the plasma beam at materials or surfaces that are not intended to be altered. *Plasma may cause damage to unintended materials. For example, plasma can etch wood and shatter glass.*
Do not overexpose surfaces that are intended to be altered. *As is the case with other power tools, if a surface is overexposed to the plasma it will be altered in an unintended way and may result in property damage.*

2.4. Maintenance

ATTENTION: THERE ARE NO USER-SERVICEABLE PARTS INSIDE. ANY ATTEMPT TO OPEN THE PLASMA CONTROL MODULE COULD EXPOSE THE USER TO HIGH VOLTAGES AND MAY PERMANENTLY DAMAGE THE EQUIPMENT. OPENING OF THE CONTROLLER BY THE USER WILL VOID WARRANTY.

There are no user-serviceable parts in the PlasmaBlast® System except for the replaceable plasma pen nozzles and electrodes (see Section 6." Maintenance" on replacement of the nozzle or electrode). Do not disassemble any part of the system. Tamper evident seals have been used to detect unauthorized access. Evidence of tampering with or otherwise attempting to open the controller will result in a voided warranty, and for rental systems will void any lease agreement and will require purchase of this non-warrantied system. All repairs and/or modifications should be conducted by qualified APS service personnel.

2.5. Grounding

When using portable generators, follow all grounding instructions included in the operating manual. For facility power, ensure that the power outlet conforms to all local and national electrical codes.
All facility provided outlets must provide a safety ground.
The plasma pen is grounded through the grounding port located on the pen cable about 6 ft from pen body. When working on metal and other conductive substrates, clamp the supplied grounding cable to the substrate. Do not operate the PlasmaBlast® System if the grounding cable is damaged or missing.

2.6. Trained Operator Responsibility

Only operators trained by certified APS trainers should operate the plasma system. The operator of the equipment is responsible for safe operating procedures and proper use of the equipment. APS assumes no responsibility for the operation of the equipment or the safety practices of the end user.
To prevent a possible electrical shock hazard, only replace the nozzles with APS nozzles. Other nozzles may fit the plasma pen but they will not meet the specifications required for safe operation of the plasma pen. There are no third party nozzles suitable for safe operation of the plasma pen.
Do not drop, spill liquids on, damage, or otherwise mishandle the PlasmaBlast®. The system contains breakable parts and parts that will not function when damaged. Do not operate a damaged PlasmaBlast® System.

2.7. Personal Protective Equipment (PPE)

- Always wear impact-resistant, clear plastic safety glasses that conform to the current ANSI Z87.1-2015 safety standards to protect your eyes from dust and flying particles.

- Always wear OSHA-approved hearing protection - foam ear plugs or other approved hearing protection with a minimum 28 dB noise reduction rating (NRR) when operating the plasma pen system.

- Wear OSHA-approved dust mask (N95 or similar)
- If removing a coating with toxic components wear a respirator and any other safety equipment required for the specific toxin encountered.
- If the coating composition is unknown, wear a respirator as a precaution.
- Wear dry, hole-free, OSHA-approved leather gloves to protect the hand electrically and thermally.

3. System Setup

3.1. System Interconnections

The PlasmaBlast® B-series APCR System requires connections to facility electrical power, and facility source of compressed air in order to operate. Operating safety also requires the plasma controller to be grounded. See Figure 1 block diagram of the component parts of the integrated system.

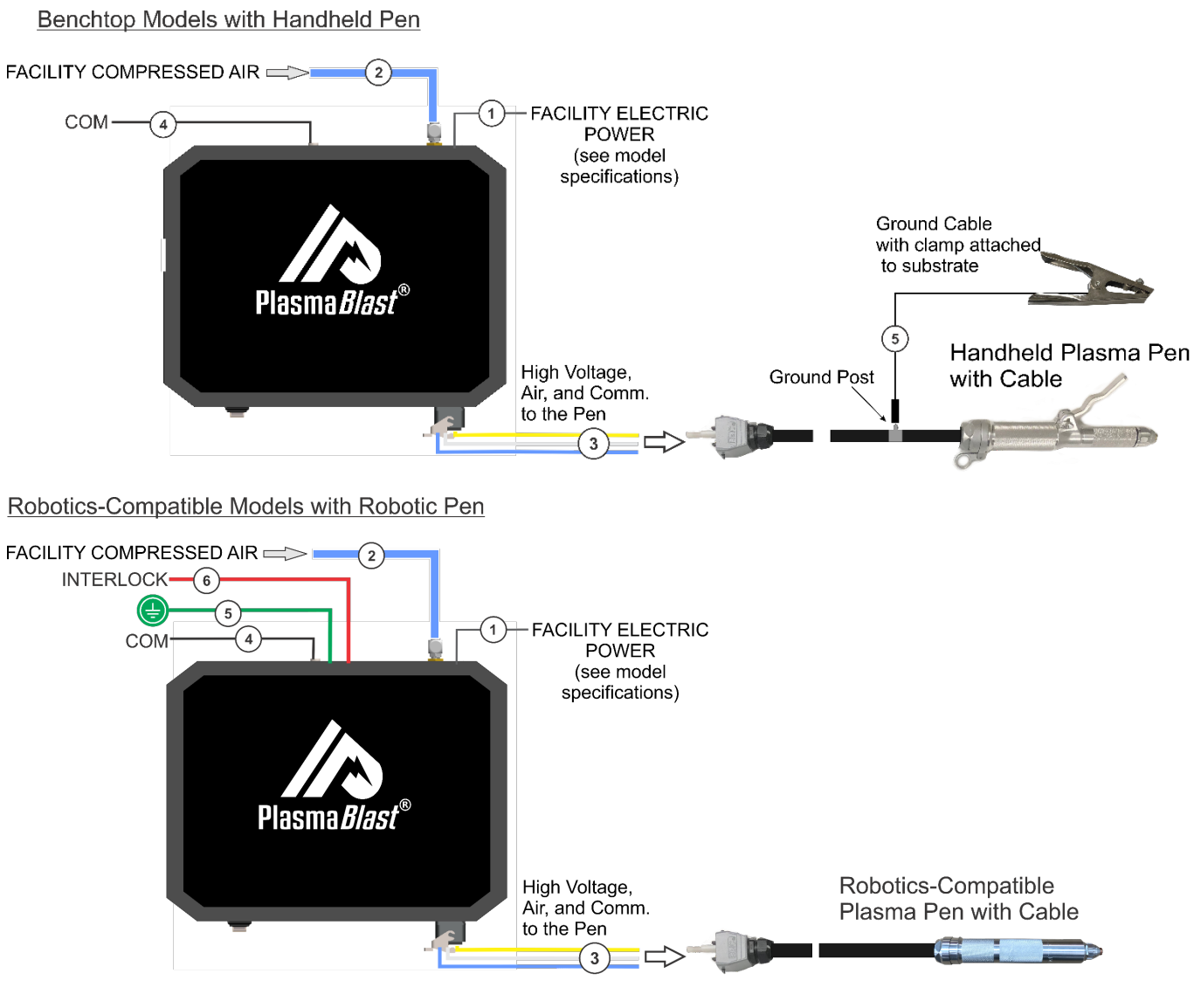


Figure 1: Diagram of the System Interconnections.

System components interconnections are presented in Table 2 below.

Ref. in Diagram	Description		Specification
1	Electrical Power	PlasmaBlast® PB7000-B-24	208-240VAC, single phase, 60 Hz.
		PlasmaBlast® PB7000-B-48	440-480VAC, three phase, 60 Hz.
2	Compressed Air		70-100 psi, 2.5 CFM.
3	Plasma Pen & Umbilical		High voltage connection through custom umbilical cable.
4	Communication (COM)		Data cable with 6-pin circular plug, connects to communication device
5	System ground		**Handheld pen models**: ground through the pen cable to substrate. **Robotics-compatible models**: controller rear panel to the substrate being treated, or a conductive area in direct electrical connection with substrate .
6	Interlock (optional)		Safety interlock connection to an interlocked enclosure or Normally Open switch.

Table 2: System Interconnections

Facility Installation Requirements

Electrical Power

The system requires:

- Model PlasmaBlast® PB7000-B-24 - Single phase electrical service breaker of 20A at 208-240VAC, 60 Hz.
- Model PlasmaBlast® PB7000-B-48 - Three phase electrical service breaker of 10A at 440-480VAC, 60Hz.

Always use the power cord supplied with the system. The system components should be grounded as described in Section 2.5 of this Manual.

By default, the power cords included with the system are equipped with the following plugs:

- for PlasmaBlast® PB7000-B-24 – NEMA L6-30P
- for PlasmaBlast® PB7000-B-48 – NEMA L16-30P

If the User's facility is not equipped with respective receptacles, upon request, the system can be equipped with several other plug types. Please see APPENDIX A for list of acceptable options.

Air Supply

The system requires an air supply capable of delivering up to 3.5 CFM of filtered dry air at 80-100 psi for proper operation. Failure to provide dry, oil-free, particulate-free air may cause irreparable damage to the plasma system. The air source should pass through an air dryer producing air with a pressure dew point of 40°F or less. The compressed air input is located on the rear panel of the system. The default connector is a ¼" diameter standard industrial style connector for a quick disconnect pneumatic coupling (Figure 2). A female quick disconnect adaptor is included with each system to ensure proper functionality with the installed quick-disconnect on the rear panel of the plasma controller. An air line is not provided with the system. It is responsibility of the user to provide necessary air lines and connectors.

Figure 2: Default PlasmaBlast® Air fittings: ¼" standard industrial style.

An optional pressure regulator may be included between the source of compressed air and air input of the plasma controller. An optional air filter passing particles no larger than 30 µm is recommended to be installed inline as close to the air input to the plasma controller input as possible. Please contact APS for more information on purchasing these accessories.

Ventilation and Mounting

The plasma controller is actively air cooled with an internal fan so proper air flow must be ensured by maintaining more than 25mm (1") of free space on the front and back of the plasma controller. Rubber feet on the bottom panel provide ventilation clearance if the plasma controller is operated on a bench top. The ventilating environment should be free of dust, particulates and should be non-condensing.

4. System Components and Controls

The complete PlasmaBlast® System (Figure 3) is comprised of a Plasma Controller (1) equipped with high-density rubber bumpers, an ergonomic handheld or robotics-compatible Plasma Pen (2), Power cable (3), Ground cable (4). A 5-pack of spare plasma nozzles (5) will be provided with each system.
An optional Pressure regulator with filter (6) can be purchased with the system if facility air at the user's site requires additional filtering and input pressure regulation.

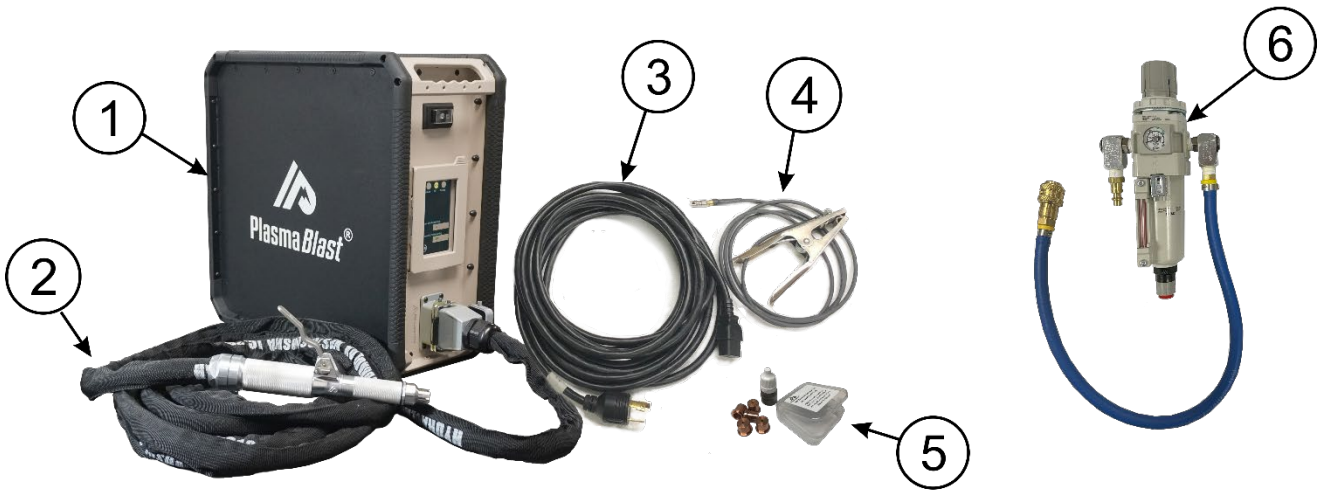


Figure 3: System Components. The device is shown in vertical orientation. Ergonomic Handheld Plasma Pen is shown. Pressure Regulator is optional.

WARNING: The PlasmaBlast® System is an electronic device. Dropping the unit may cause irreparable damages. Prevent dropping of the device by placing it on stable surfaces for operation and storage and securing the unit by fastening it to reliable structures.

4.1. PlasmaBlast® Plasma Controller

The PlasmaBlast® System Plasma Controller converts electrical energy (from a mains outlet or a portable generator) and compressed air into atmospheric plasma. This process begins in the plasma controller, which contains several stages to filter, rectify, and invert the incoming electrical energy, as shown in the figure below, to output a special high-frequency waveform into a custom-designed transformer. The high-voltage output of this transformer is fed through an umbilical to the plasma pen. Simultaneously, compressed air is fed into an air handling subsystem, which regulates the airflow being fed into the plasma pen.

The PlasmaBlast® APCR Plasma Controller can be operated in two orientations horizontal (“landscape”) and vertical ("portrait”) (Figure 4) per the user’s application and/or preference.

The Plasma Controller contains power conditioning and plasma generation electronics. The controller enclosure (1) is equipped with high density rubber bumpers around the perimeter of the device (2) that serve as feet of the device in both orientations. A carrying handle (3) is mounted on the left side (or top, in vertical orientation) on both front and back of the Controller. See APPENDIX A for dimensional drawings of PlasmaBlast® Plasma Controller.

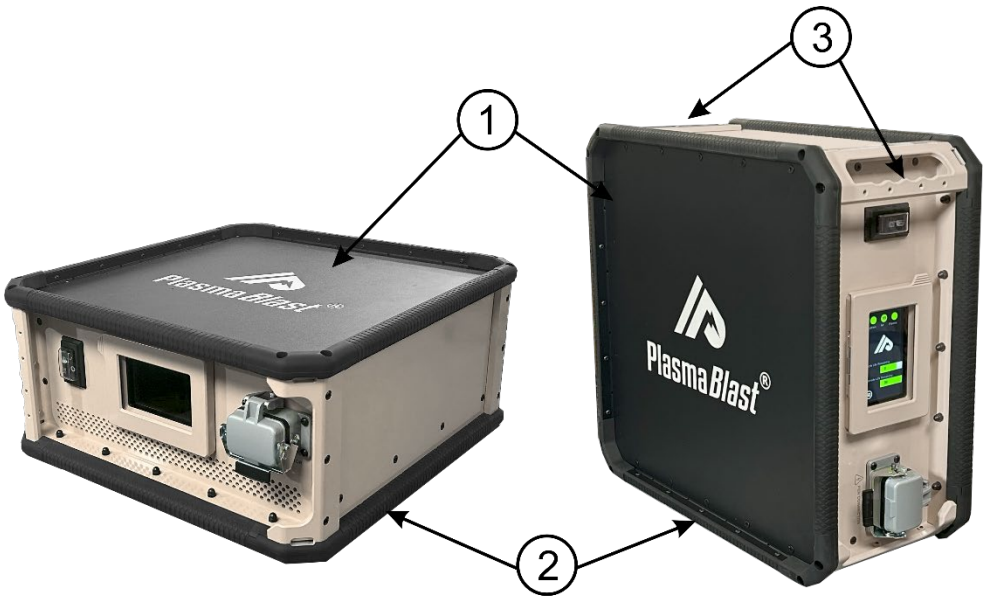


Figure 4: PlasmaBlast® B-series Plasma Controller (shown in both orientations).

PlasmaBlast® Plasma Controller also can be converted into a rack-mounted system (as shown in Figure 5) using rack-mounting brackets. See APPENDIX A for rack-mount conversion instructions.

Various system connections and controls are located on both front and back panels as described in the sections below.

Front Panel Connections and Controls

1. **On/Off Switch:** Turns plasma controller on or off. The ON/OFF switch may be used as an emergency stop to turn the plasma off while there is plasma output. After plasma output has been stopped wait at least 5 seconds before plugging back in or using the front panel ON/OFF switch to turn the system back ON.
2. **Touch-screen System Status Display:** Provides the user with current information on the status of the system and its operating parameters, maintenance information, as well as displays fault codes which are used in diagnostics in the case of equipment malfunction and suggested troubleshooting steps. Please refer to “Section 4.2: System Status Display” for detailed information on the Status Display operation and fault codes. The screen of the Display can be rotated 90 degrees if used in vertical (portrait) orientation (see Section 4.2 – System Menus – System Management Menu – Rotate Button).
3. **Plasma Pen HV Connector:** provides high voltage, compressed air, and communication output to plasma pen.

A – High Voltage output: Supplies high voltage power to the plasma pen. The high voltage push-pull male coaxial plug on the pen cable is plugged into the high voltage output socket on the front panel. Always make sure the high voltage plug is inserted to the full depth and is locked in the receptacle.

Figure 5: PlasmaBlast®-B controller front panel.

B – Air Output connector: Supplies compressed air to the plasma pen. This output is equipped with 1/4” NPT Male Schrader type pneumatic twist-Lock fitting. The plasma pen cable is equipped with a female 1/4 NPT pneumatic twist-lock adapter that connects to this output.

C - Signal connection to plasma pen: Provides signal connection between the system processor and the plasma pen.

In Rear High Voltage connector models (APCR-BHR and APCR-BRR) this connector is located on the back panel of the controller.

4. **Display Protective Cover:** Protects the display from damage by impact and flying debris.

Back Panel Connections and Controls

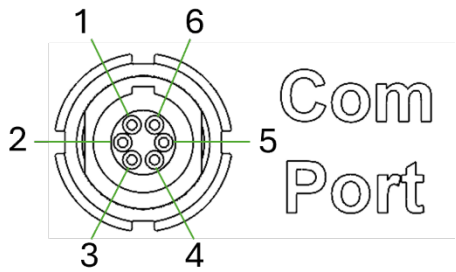
Figure 6: PlasmaBlast® B-series controller back panel.

1. **Power Input:**

In PlasmaBlast®-B-24 (208-240VAC) system the power is plugged into C18 receptacle installed on the back panel of the system. This connector accepts a line cord with an IEC C19 outlet connector.
In PlasmaBlast®-B-48 (440-480VAC) the system power cable is plugged into custom latching receptacle. This receptacle accepts a line cord with 4-pin latching connector rated for 440-480VAC.
The plasma controller should only be operated with a power cord supplied with the system.

2. **Air Input**: ¼" standard industrial style air fitting. An incoming air hose is not included with the system. It is the responsibility of the user to provide all necessary air lines, connectors, and adapters.

3. **Communication Port:** The connector is labeled "Com Port" and is normally used by trained APS personnel for system diagnostics, software updates, and, on robotics-compatible models, for integration with robotics. This connector provides a serial connection for communication between the system processor and a computer or a controller through 6-pin circular connector. The pinout of this connector is as follows:

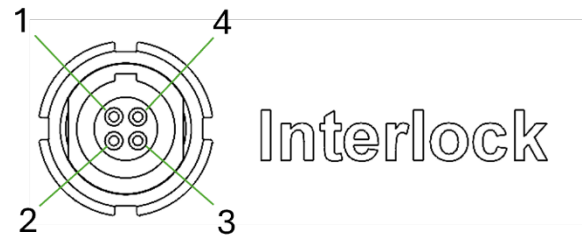


1. GND
2. TX
3. RX
4. No Connect
5. Trigger 1
6. Trigger 2

A serial connection cable with a mating plug can be purchased from APS.

4. **Safety Interlock connector (Optional):** a 4-pin connector labeled "Interlock" (if option was selected) provides a connection to an external user-provided safety interlock such as an interlocked enclosure or a Normally Open (NO) switch. This connection is used in robotic integrated applications and is required to ensure the safety of personnel working near an actively operating PlasmaBlast® System.

   The pinout of this connector is as follows:



1. Safety Interlock 1
2. Safety Interlock 2
3. No connect
4. No connect

   Connect pins 1 and 2 to a normally open interlock system. Connect successive interlock devices such as door contact switches or light curtains in series such that any device in the interlock circuit transitioning to an open state will prevent plasma from firing.
   When using a handheld plasma pen this interlock can be bypassed by installing a bypass plug (interlock jumper plug) which closes (shorts) pins 1 and 2.

5. **Rear Panel Ground:** Dedicated 1/4"-20 stud electrical terminal for system grounding. This terminal must be connected using the supplied grounding cable to any conductive or metallic substrates

being plasma-treated, such as steel, other metals, and carbon fiber, in order to ensure proper equipment operation and personnel safety. The ground cable is terminated with a heavy duty ring terminal which is connected to this stud and secured with the wing nut.

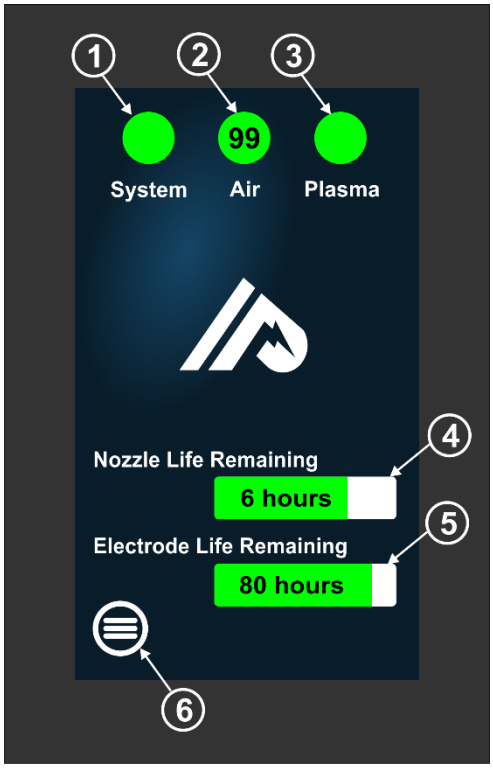
6. **Name plate/Model/Serial label**: Provides information about model and serial number of the system, as well as operating voltage and frequency, and fuse ratings.
7. **Safety warning labels:** provide applicable safety warnings to the user (please also see Section 2. Safety and Legal). The exact location of the labels may vary.

4.2. System Status Display

The System Status Display is located on the front of the Plasma Controller and provides the user with current information on the status of the system and its operating parameters, maintenance information, as well as displays fault codes which are used in diagnostics in the case of equipment malfunction and suggested troubleshooting steps.
As the PlasmaBlast®-B-series system controller can be operated in two orientations - horizontal and vertical - the screen can be rotated to accommodate viewing in both orientations. See more information on how to rotate the screen in the sections below.

System Home screen

The main System Status screen - “Home” screen is loaded by default upon the system power-up.
The Home screen displays certain important operating parameters that are being monitored by the system in real time, as well as system maintenanance information, as follows:

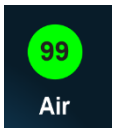


1 – System Status: Indicates current system status, as follows:

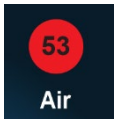
System is initialized and ready to operate, no issues or faults.

System is experiencing a fault or a malfunction. A Fault alarm will be displayed on the Home screen.

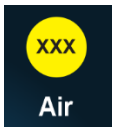
2 - Air Line Status: Displays current input air pressure. This is one of the critical system operating parameters and is monitored by a sensor inside the system. This screen is used to set operating pressure during system setup.



The input airline pressure is in an acceptable range (**85-105 psi**).



The input airline pressure is outside of acceptable pressure range (**too low or too high**).



The system is **unable to read** the input pressure – indicates that the pressure is below ~12 PSI or the system air pressure sensor has failed.

3 – Plasma Status:

The system is initialized and ready to generate plasma. The system is idle (plasma is not being generated at the moment).

Plasma is being generated by the system.

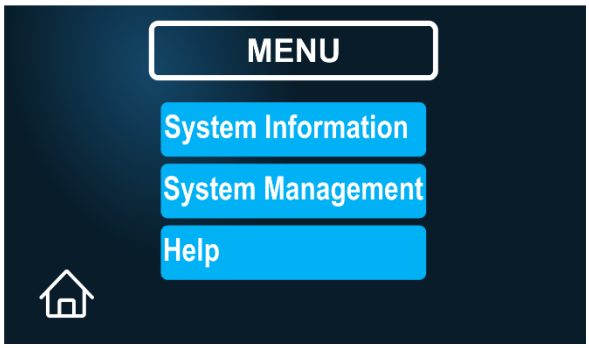
The system is experiencing a fault or a malfunction. Plasma will not be generated until the fault is cleared or the issue is addressed.

4 – Nozzle Life Remaining: A system maintenance indicator - displays Nozzle life remaining until the replacement is necessary. See Section 6. Maintenance for more information.

5 - Electrode Life Remaining: A system maintenance indicator - displays Electrode life remaining until the replacement is necessary. See Section 6. Maintenance for more information.

6 – System Menus button. Pressing this icon will open **System Menu screen** which displays three sub-menus, as outlined in the sections below.

Pressing Home Button will return the user to the Home screen.

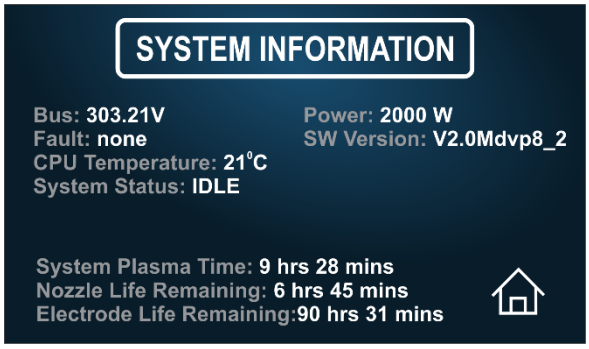


System Menus

SYSTEM INFORMATION Menu

The System Information Menu consists of several sub-menus that contain important information about the system status and operation. The User may be required to access this information and provide it in communications with APS personnel for diagnostics and remote troubleshooting in the case of a system malfunction or a failure.

The information displayed on the System Information screen is as follows:



Bus: Displays current bus voltage. Bus voltage is an internal system parameter related to, but not equal to, line voltage. It is used for diagnostics of line power issues and is to be used by the user in communication with APS in the case of a system malfunction or failure. If the Bus Voltage value is 0 – the unit sustained severe damage and must be sent to APS for repair. Please contact APS immediately.

Fault: If there is no current faults it displays "none", the system is normally in this state. If the system is in a fault state it displays the Fault Code. The System Home screen also will change to display information about the fault the system is experiencing, and troubleshooting assistance related to this fault. See Section 7. Troubleshooting for more information on Fault Codes.

CPU Temperature: Displays current internal temperature. The normal temperature range is below 80°C. If the temperature exceeds this threshold, the system will shut down and a Temperature Fault (038) will be displayed on the Home screen.

System Status: Displays various system states that are used mostly in diagnostics and troubleshooting by a trained technician. The user may be asked to access this screen and provide the current information being displayed to APS personnel. Status "Idle" means the system is ready to operate.

Power: Displays current system power setting. Power setting can be adjusted by a trained technician only.

SW Version: Displays software version currently installed on the system.

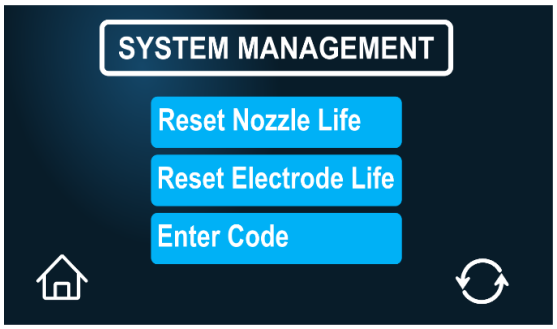
System Plasma Time: Displays cumulative total plasma-on time for the system. This information may be necessary for system performance analysis or in troubleshooting.

Nozzle Life Remaining: Displays Nozzle life remaining until the replacement is necessary.

Electrode Life Remaining: Displays Electrode life remaining until the replacement is necessary.

SYSTEM MANAGEMENT Menu

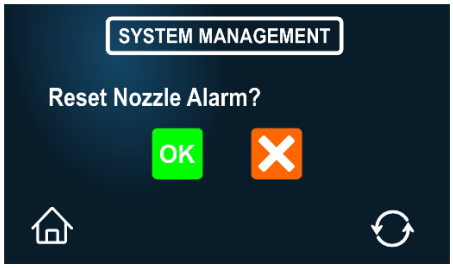
System Management Menu consists of Maintenance sub-menus that allow the user to perform tasks related to maintenance procedures, reset the life of the consumable components (nozzles or electrodes) after replacing them, or enter the code that can be provided to the user by APS to enable certain advanced settings in the system. See **Section 6. Maintenance** for detailed information about maintenance procedures.



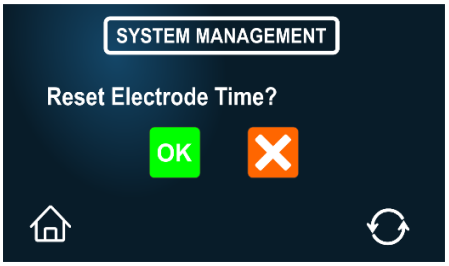
Pressing **Home button** icon will return the user to Home screen.

Rotate button: Pressing this button on System Management screen allows the user to rotate the screen 90 degrees to accommodate the use of the controller in a specific orientation (vertical or horizontal). Press “Save Rotate” to rotate the screen.

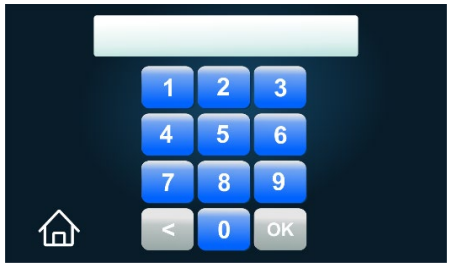
Reset Nozzle Life: Displays a screen that allows the user to reset the life of plasma nozzle after replacement to 8 hours of life. Press OK to reset the life of nozzle after replacement.



Reset Electrode Life: Displays a screen that allows the user to reset the life of electrode after replacement to 100 hours of life. Press OK to reset the life of nozzle after replacement.

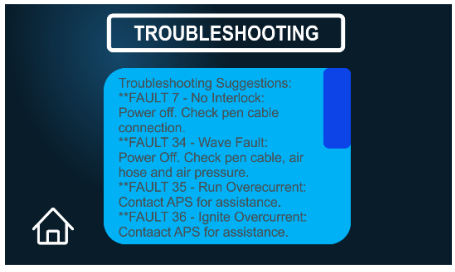


Enter Code: Displays a numeric pad for the user to enter a code provided by APS to enable system operation by a trained user after the completion of mandatory APS User Training or to enable certain advanced system functions.



HELP Menu

Help Menu button displays the **Troubleshooting screen** in which all system faults and suggested troubleshooting steps are listed. The list can be scrolled up and down by pressing and moving the scroll bar on the right side of the window. See Section 7. Troubleshooting for more information.



4.3. Plasma Pen

The PlasmaBlast® plasma controller provides electrical power and low pressure, compressed air to the plasma pen through a single umbilical cord assembly. There are two models of the plasma Pen: handheld and robotic-compatible *(Figure 7)*.

Figure 7: Plasma Pen with umbilical cable assembly.

1. Plasma Pen (see Section 5.4 "Plasma Pen Operation" for details)

H – Handheld Ergonomic Pen (PlasmaBlast® Models APCR-BHF and APCR-BHR, both voltages):

This Plasma Pen model is designed for ergonomic handheld operation, equipped with plasma activation lever and safety mechanism for precise handheld plasma surface preparation. This model of Plasma Pen is included with benchtop system models.

R – Robotic-Compatible Plasma Pen (PlasmaBlast® Models APCR-BRF and APCR-BRR, both voltages):

This Plasma Pen model is designed for use in integration with robotic systems, featuring a cylindrical body with diamond-knurled surface for easy installation into automated systems. This model of Plasma Pen is included with robotic-compatible system models.

2. Umbilical Pen Cable is 20-ft long and consists of high voltage cable, air line and a signal cable bundled together inside a flame-retardant protective sleeve.

- *Take great care when routing the umbilical cable.*
- *Route the high voltage cable to avoid the possibility of it being caught or snagged in moving parts of automated equipment.*
- *Take appropriate precautions to prevent the high voltage cable from becoming kinked, crushed, abraded, or damaged in any way.*
- *Never use the umbilical cable as a lift point.*

DO NOT OPERATE WITH DAMAGED CABLES

- Always check pen cable for damage.
- Immediately contact APS if any damage is discovered

3. High Voltage Connector Plug on the other side of the cable connects to the Pen Connector Receptacle on the Plasma Controller.

- In the course of routine operation, transportation and storage of PlasmaBlast® System the Pen Cable should be connected to Plasma Controller via Pen Connector.
- DO NOT DISCONNECT THE PLASMA CABLE FROM PLASMA CONTROLLER UNLESS NECESSARY FOR SERVICE OR REPLACEMENT. INCORRECT INSTALLATION MAY CAUSE SEVERE DAMAGE TO EQUIPMENT

4. Ground Post (Handheld Pen ONLY) located on the pen cable approximately 6ft from the pen body serves as the attachment point for Ground Cable during system operation when used with Handheld Plasma Pen.
When used with Robotic-compatible Plasma Pen the system grounding is implemented through a ground cable connected to the ground stud on the back panel of the controller. (see Section 5.3 "PlasmaBlast® System Setup" for details).

4.4. Grounding Cable with Clamp (Handheld Pen Only)

To ensure proper grounding the PlasmaBlast® system is equipped with:
Grounding cable (1) with **Ground clamp (2)** on one end and a **Ground connector (3)** on the other end (Figure 9).

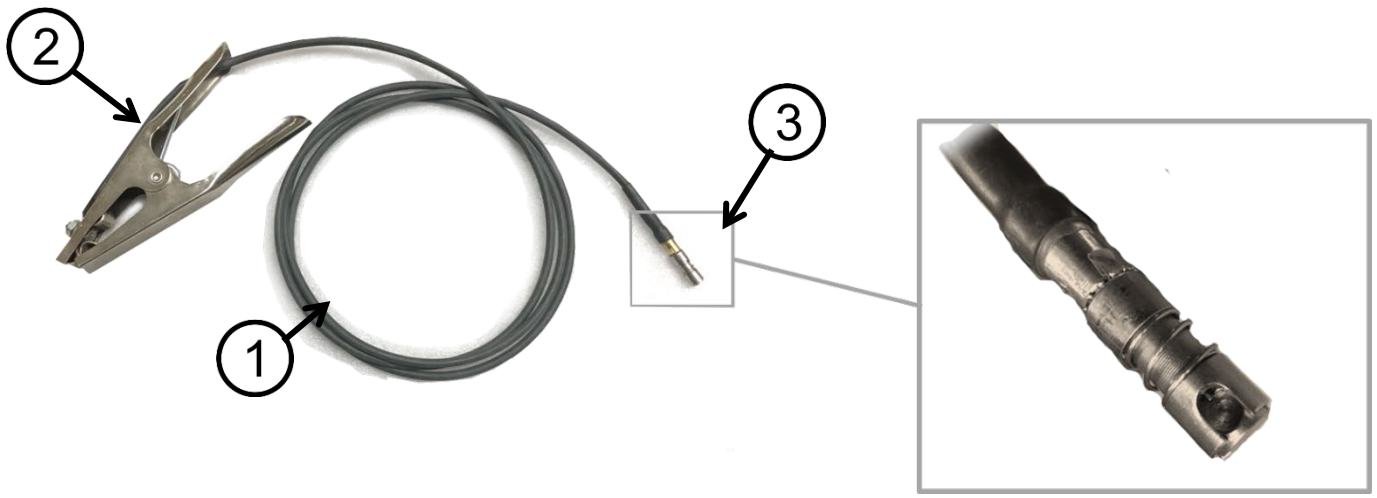


Figure 8: Grounding cable with clamp and connector.

Ground clamp must be reliably connected during operation to the substrate, surface, or item that will be plasma cleaned in order to ensure proper equipment operation and personnel safety.

ATTENTION:

Always place system ground clamp on the substrate of the workpiece. ***If substrate is not grounded properly, electric shock to the user may occur.***

The Ground Connector must be connected to the Ground Post located on the pen cable approximately 6ft from the pen body. Ground Connector is equipped with spring-loaded sleeve which allows for quick connection to the ground post and enables 360^0 rotation of the connector with respect to the post.

4.5. Grounding Cable for Robotic-Integrated system.

A 12AWG grounding cable terminated with heavy duty ¼" ring terminals. This cable must be connected to the designated ¼" ground stud terminal located on the rear panel of the Plasma Controller and secured with the provided wingnut. The other end of this cable must be secured to the conductive surface of the substrate being plasma-treated.

4.6. Electrical Power Cord

Included with the PlasmaBlast® unit is a 20ft power cable, rated appropriately for the specific model operating voltage.

In **PlasmaBlast® APCR-XXX-24 models** (208-240VAC):
This cable has C18 connector that plugs into the C19 receptacle on the front panel of the plasma controller.

The other end of the cable is equipped with the plug appropriate for the operating voltage of the system.
The default plug for these models is NEMA L6-30.

Figure 9: System Power Cord: Top – 240V models. Bottom – 480V models.

In **PlasmaBlast® APCR-XXX-48 models (440-480VAC)**

The other end of the cable is equipped with the plug appropriate for the operating voltage of the system.

The default plug for these models is NEMA L16-30

Upon request, the system can be equipped with several other plug types. Please see APPENDIX A for list of acceptable receptacle options.

4.7. Pressure Regulator with Air Filter (Optional)

A pressure regulator can be included with the system if the user's facility is not equipped with sufficient means to control the air pressure output of their compressed air source, to ensure an appropriate input pressure for proper operation of the system. The device is equipped with an air filter/dryer designed to capture most of the water, oil and dust particles entering the system.
The pressure regulator assembly (Figure 10) consists of:

① **Pressure Regulator Knob**: used to adjust the pressure during system setup (see Section 5.3 "PlasmaBlast® System Setup" for details).
② **Pressure Regulator Dial**: displays pressure setting value during setup and operation of the system.
③ **Inlet Fitting:** compressed air from facility or portable compressor is connected to this fitting.
④ **Output to Plasma Controller:** connects to the "Air In" fitting on Connector Block of the Plasma Controller.
⑤ **Air Filter**: minimizes water, dust, oil and other particles entering the internal airline.
⑥ **Water Trap Drain**: the water captured from the airline is collected at the bottom of the filter and must be drained from time to time using the water trap drain.

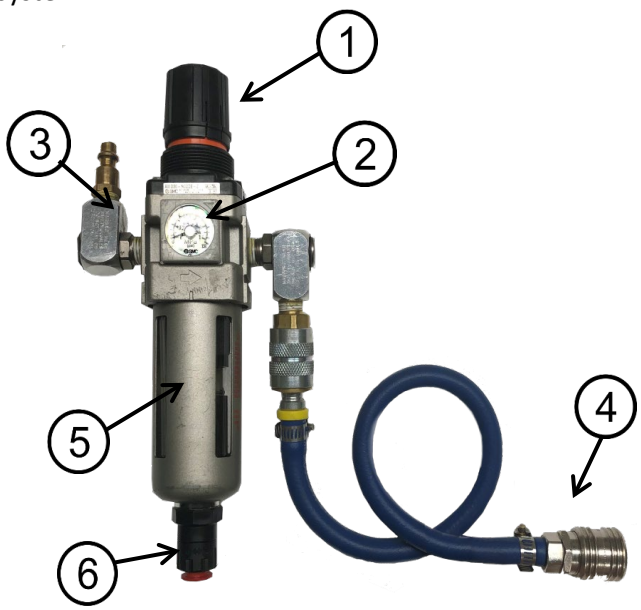


Figure 10: Pressure regulator with filter.

THE PRESSURE REGULATOR MUST BE KEPT IN UPRIGHT POSITION TO ALLOW FOR OF THE WATER TRAP PURGING.

To facilitate proper positioning of the pressure regulator, it must be installed onto the back panel of the controller using regulator bracket (provided with the purchase of Regulator) as shown below (Figure 11):

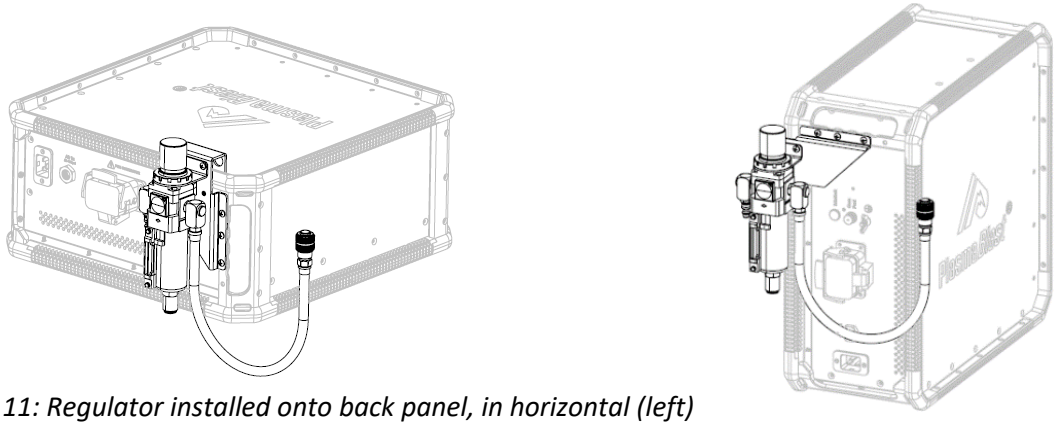


Figure 11: Regulator installed onto back panel, in horizontal (left) and vertical (right) controller orientation.

4.8. Consumable Pen Parts

Nozzles

Over time, plasma wears down the nozzle, opening the aperture, and usually slowing removal, cleaning, and surface treatment speed. Nozzles should be replaced after ~8 hours of plasma-on time (See section 6." Maintenance".)
Use only nozzles supplied by APS. A replacement Nozzle Kit containing 5 nozzles and anti-seize lubricant in a small application tube is normally included with the system. Additional kits are available for purchase at APS.

Electrodes

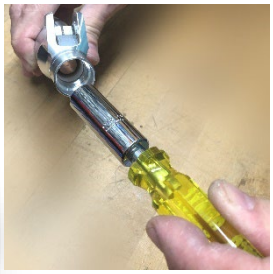
Plasma electrode is located inside the pen body and should be replaced every 100 hours of plasma-on time. Spare electrodes are not supplied with the system, so it is recommended to order spare electrodes from APS ahead of time.

4.9. Toolset

To facilitate nozzle or electrode replacement, the system includes a set of tools:

- 1" Hex tool: used in both nozzle and electrode replacement procedures. It precisely fits the hex feature in the front of the pen and is used to hold the hex feature in place to prevent the rotation of the internal part while loosening the nozzle nut or to loosen/tighten the internal threads during electrode replacement.

- Deep well ½" 6-point socket with handle: used in the electrode replacement procedure to remove and replace the electrode inside the pen body.



- A small (#1) Philips style screwdriver for use in electrode replacement.

5. System Operation

5.1. Safety Check

- ENSURE PROPER GROUNDING OF ALL COMPONENTS!
- WEAR THERMALLY AND ELECTRICALLY INSULATING GLOVES!
- Ensure that a momentary safety interlock switch is installed and functioning properly.
- Wear safety glasses, gloves and hearing protection at all times when operating.
- Ensure adequate exhaust of gases and particulate debris emanating from the plasma pen at all times.
- Only properly trained personnel may operate the plasma system.
- Please read, understand and follow all of the safety instructions in the complete manual before operating!

5.2. Recommended Operating Conditions

The PlasmaBlast® plasma controller is designed specifically to create a stable plasma discharge using dry compressed air when used as directed. Operation outside of the recommended parameters may cause damage to the applicator or the plasma controller. Please contact APS for information regarding the use of alternative configurations such as alternate gas mixtures or plasma controller settings.

Keep the power supply dry at all times. Failure to keep power supply dry may result in electrocution.

.

The PlasmaBlast® System is rated for a maximum input pressure of 120 psi. The acceptable range of air pressure is from 80 to 100 psi at up to 3.5 CFM with **99 psi** being optimal operating air pressure. The incoming air pressure is measured by the system and is displayed on the Status Display on the front panel of the plasma controller.

5.3. PlasmaBlast® B- Series Operating Procedure

1. Inspect the High Voltage Cable for damage, if damage is found do not operate the system and call APS for repair.

2. Connect facility air-source line to the ¼" standard industrial air fitting on the back panel by pushing the adapter onto the fitting until locked.

   ***To disconnect**: pull the adapter sleeve back to release the lock.*

3. Connect the pen cable to the Pen HV Connector on the front panel (in front HV connector models) or the rear panel (in rear HV connector models) of the controller by plugging the HV plug on the pen cable into HV receptacle on the controller. Make sure that the plug slides into the receptacle straight; inserting the plug may require mild force. The plug must lock into the receptacle with an audible click.

4. Make sure the latch of the high voltage connector is engaged fully.

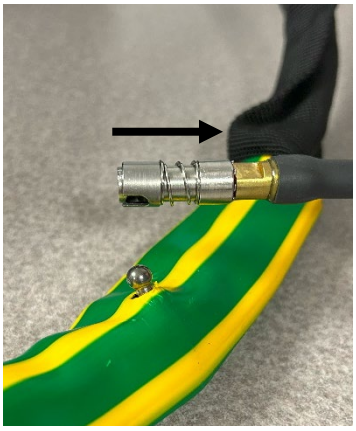
FAILURE TO DO SO MAY CAUSE ELECTRIC SHOCK TO THE USER DURING OPERATION

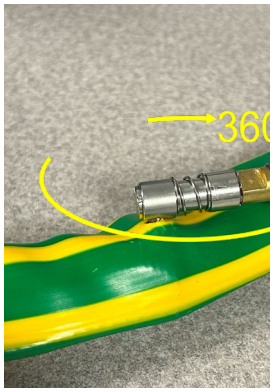
If using with handheld plasma pen:

5. Locate the Ground Port with the ground post, which is located approximately 6 feet from the pen body on the handheld ergonomic pen cable.

6. Locate the connector with a spring-loaded sleeve on the ground cable, and pull the spring-loaded sleeve back.

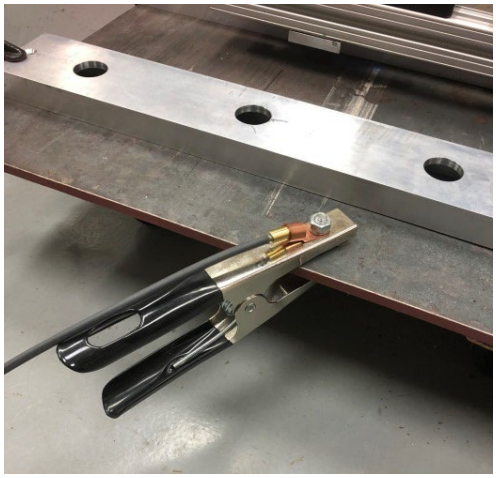
7. Place the opening over the ground post. Then let go of the spring. The ground cable will be able to rotate 360 degrees with respect to the post.





8. **Ground the Substrate**: Attach the clamp to the workpiece where coating removalwill occur. Ensure that the clamp is attached to an area that is in direct electrical connection with the metal that is undergoing plasma treatment.

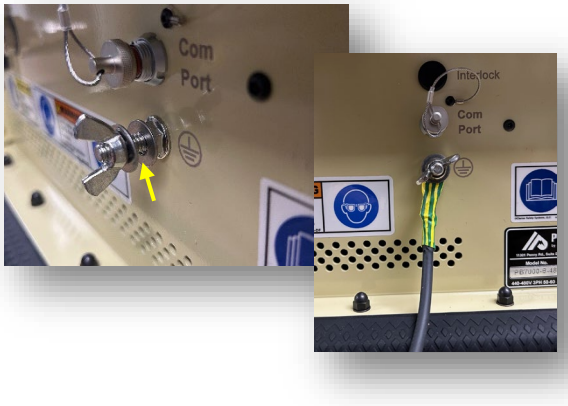
Failure to ground the substrate may result in electric shock to the operator.



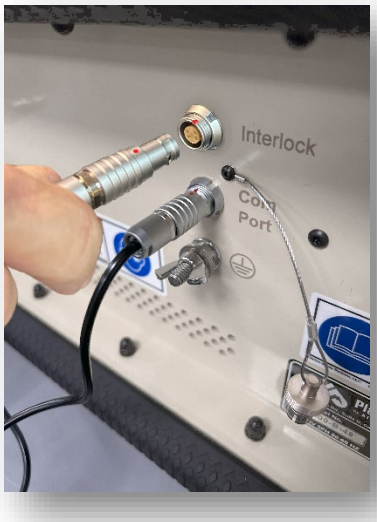
If using with robotics-compatible plasma pen:

9. Connect the ground cable to the ground stud on the rear panel of the controller using the ring terminal on the ground cable. Place the terminal between the two flat washers and secure with wingnut.

   Connect the other end of the ground cable to a conductive area of the workpiece that is in direct electrical connection with the metal that is undergoing plasma treatment.

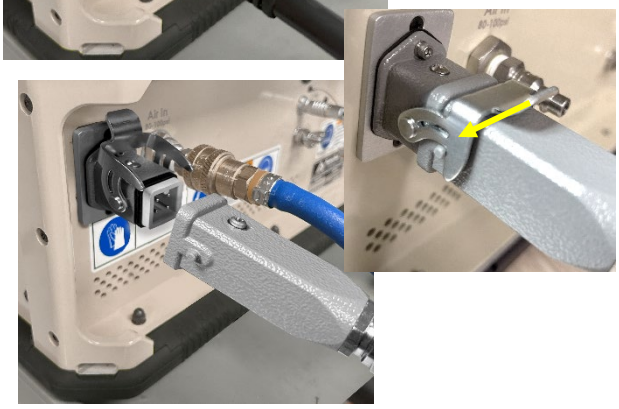


10. **If Safety Interlock option was purchased**: Connect safety interlock cable (either user provided or purchased from APS) to Interlock port on the rear panel of the controller. The other end of the interlock cable should be connected to a normally open (NO) interlock system.



11. **240V models**: Plug the power cord into the C19 receptacle on the back panel. Make sure the On/Off switch is in "OFF" position

480V models: Plug the custom connector on the power cord into custom 480V power input receptacle on the rear panel of the controller. Make sure that the power connector is fully latched and the On/Off switch on the Front panel is in "OFF" position



12. Plug the power cable into the facility power outlet or generator power outlet. The plug may vary from the one pictured in this manual.

13. **Ensure that you are wearing appropriate PPE at this point (gloves, safety glasses, dust mask, hearing protection).**

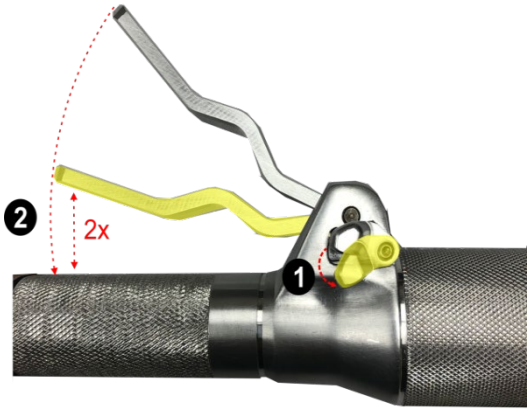
    With the pen nozzle facing away from you and other people, and the pen lever in the off position, turn on the AC power switch on the front panel. Wait for the plasma controller to initialize.

WARNING: The system will briefly purge air through the plasma nozzle while starting up.

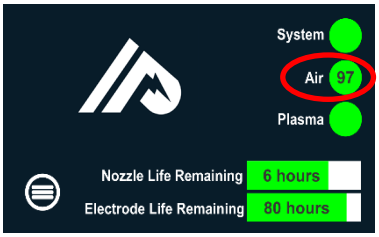
Setting Operating Air Pressure

This procedure is required to be completed every time the system is plugged into a compressed air source.

14. With the pen nozzle facing away from you and other people, push the safety lever down and quickly depress and release the lever twice, double click, but do not hold down. If this is done properly, there should be a steady flow of air only out of the nozzle with the lever released.



15. On the Status Display located on the front panel of the system, identify the indicator labeled “Air”. This indicator displays the current incoming air pressure as measured by the system.

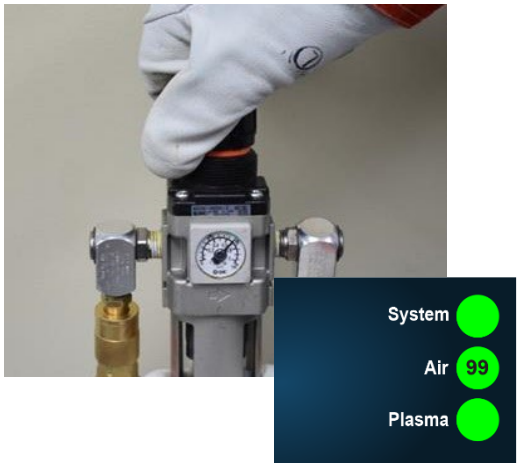


16. While in the air purging state, adjust the air pressure on the external regulator connected to the system (either provided with PlasmaBlast® system or customer-provided) so the indicator on the Display screen shows the pressure around **99 psi.**

    Do not use any external read-outs for this adjustment.

    *The acceptable range of air pressure is 85 to 105 psi with **99 psi** being optimal operating air pressure.*

    If using an optional regulator provided by APS adjust pressure by rotating the regulator knob.



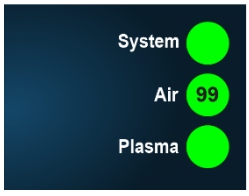
17. Stop air flow by pushing the safety lever down then pushing the trigger lever forward once and finally releasing back to the safe locked position (see Section 5.4 Handheld Plasma Pen Operation.)

Testing Portable Air Compressor

Continue to this step if using a portable compressor for the first time with PlasmaBlast®

18. Purge air through the pen as described in Step 12.

19. Adjust the incoming air pressure to 99 psi as described in steps 13-14 above.



20. Continue to purge air through the pen for 10-15 minutes while watching the Display screen. Take a note of pressure displayed every minute.

21. Pay special attention to note if the pressure displayed at any point is below **80 PSI.**
If the pressure is at any point below 80 PSI, then this compressor is not safe to operate with PlasmaBlast®.

22. Stop air flow by pushing the safety lever down and push the trigger lever forward once then pull back to the safe locked position (see Section 5.4 Handheld Plasma Pen Operation.)

System setup is now complete.

5.4. Handheld Plasma Pen Operation

Parts of Plasma Pen

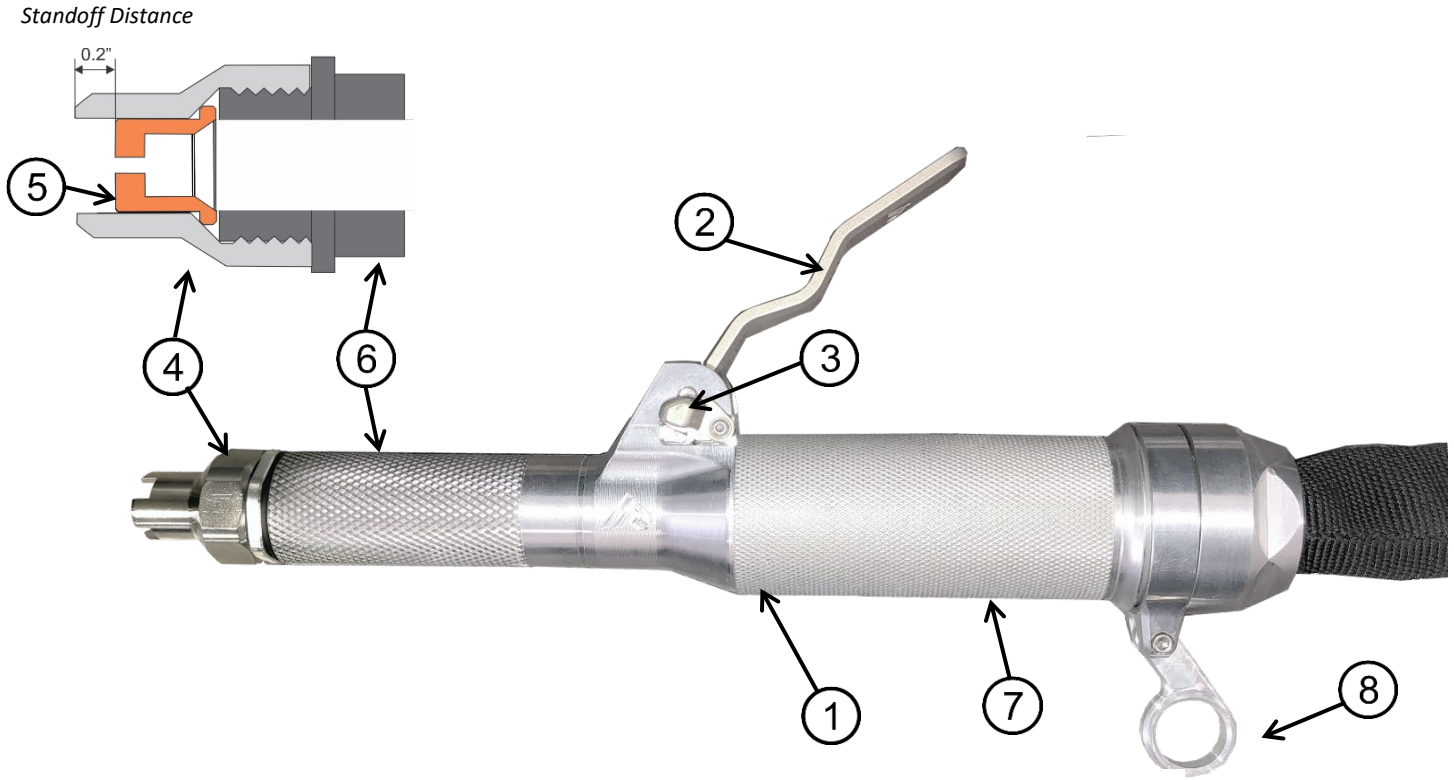


Figure 12: Parts of Plasma Pen

1 - Pen Body
2 - Plasma Trigger Lever
3 - Safety Lever (both sides)
4 - Nozzle Nut with 0.2” standoff attachment
5 – Nozzle (inside Nozzle nut)
6 - Front Grip
7 - Rear Grip
8 - Attachment Loop

WARNING: DO NOT ATTEMPT TO DISASSEMBLE THE PEN BODY EXCEPT AS DIRECTED FOR REPLACEMENT OF CONSUMABLE PARTS. THERE ARE NO USER-SERVICEABLE PARTS INSIDE. ANY ATTEMPT TO OPEN THE PEN BODY COULD EXPOSE THE USER TO HIGH VOLTAGES AND MAY PERMANENTLY DAMAGE THE PEN AND/OR THE POWER SUPPLY.

Handheld Ergonomic Plasma Pen Operating Principles

Plasma Pen Grip Positions

The Plasma Trigger Lever can be used in two grip positions: flipped forward and flipped backward.

Flipped Forward

Plasma On

Plasma Off

Flipped Backward

Plasma On

Plasma Off

Plasma Trigger Lever Operational Positions

The Plasma Pen is equipped with a Plasma Trigger Lever that has to be depressed before plasma is delivered to the pen nozzle. There are three operational positions for the Plasma Trigger Lever (Figure 14):

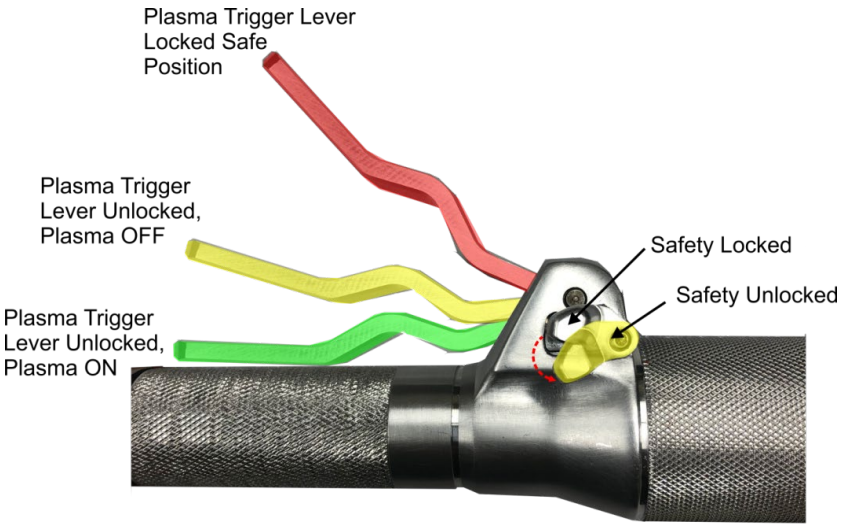


Figure 13: Plasma Trigger Lever Operational Positions

1. Locked Safe Position: Plasma Trigger Lever cannot be depressed; Safety Lever is in Locked position.

2. Unlocked, Plasma OFF: the Lever is released from safety and partially depressed; it is being held down lightly; when released it will snap back into safety mechanism.

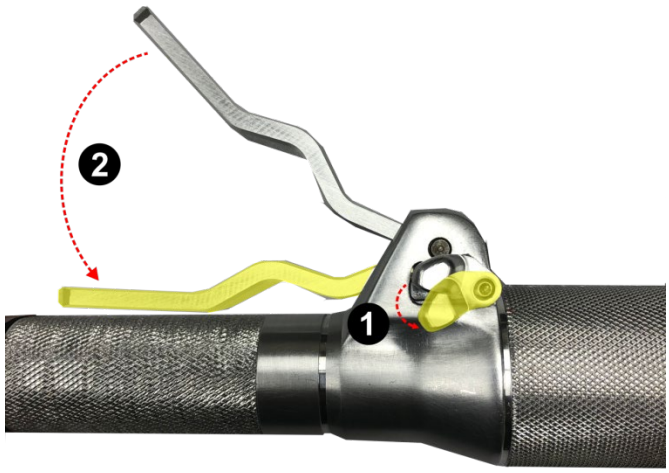
3. Plasma ON: the lever is fully depressed, and being held down while the Plasma Pen is generating plasma.

Release of Plasma Trigger from Safety Mechanism

If not in operation, the Plasma Trigger Lever is locked by the Safety Mechanism in a safe position to prevent it from being depressed accidentally. In order to generate plasma, the trigger lever must be released from safety.

1. Depress Safety Lever on either side of the pen and hold down.

2. Depress Plasma Trigger Lever to the front or to the back, then release the safety lever.



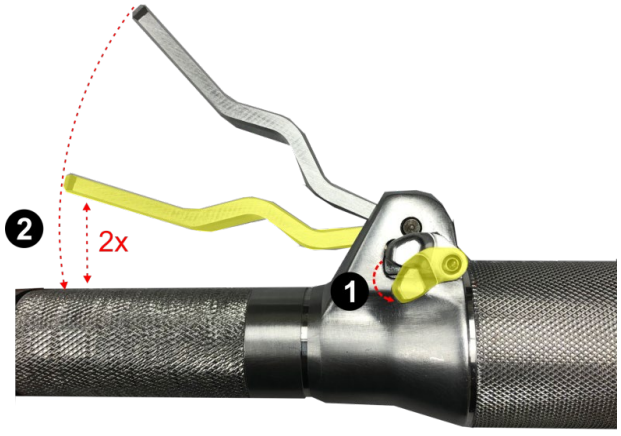
Purging Air through the Pen

As a part of operating procedures (such as setting up the appropriate pressure on the Pressure Regulator), or under various other circumstances (e.g. to cool the Plasma Pen down), the operator is able to purge air through the Plasma Pen without generating plasma. To accomplish this, perform the following steps:

1. With the pen nozzle facing away from you and other people, push the safety lever down.

2. Quickly depress and release the lever twice (double click), but do not hold down. The release of the lever into Plasma OFF position should result in a steady flow of **air only** out of the nozzle.

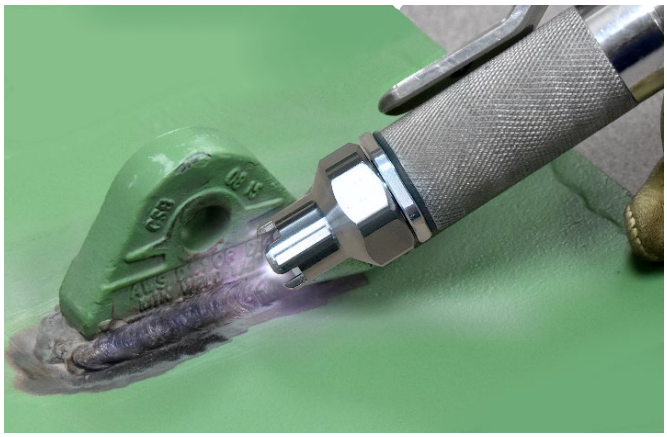
To stop air flow, push the safety lever down and push the trigger lever forward once then pull back to the safe locked position.



Handheld Plasma Surface Preparation

While handheld plasma coating removal requires some skill that is best developed through practice, there are a few basic principles of plasma surface preparation.

- Hold the Pen facing the surface to be treated, normally at an angle, with the tip of the nozzle at approximately 1/8” from the surface.
- Move the tip in a continuous side-to-side or circular (**small circles)** motion over the removal area.
- Never dwell the plasma beam over one spot, this may cause overtreatment and potential damage to the substrate.
- Minimize touching the bare substrate with nozzle tip, as this may result in arcing; If equipped with the 0.2” standoff attachment, the nozzle tip is unable to touch the substrate.
- Use the angle of the pen and its distance from the surface to control power of removal.



5.5. Robotic-Compatible Plasma Pen Operation

The robotic-compatible model of the plasma pen is designed to be mounted onto a robotic device and IS NOT suitable for handheld operation. An attempt to operate a robotics-compatible plasma pen by hand may result in serious injury or damage to the equipment.

The Plasma Pen comprises the Pen Body, the Nozzle Nut, and the Nozzle (Figure 15).The Pen Body is connected to the umbilical cable on one end and consists of the Main Body and Front Sleeve. The Front Sleeve contains an insert with external threads and a 1” Hex Feature. The Nozzle Nut is holding the Nozzle and is screwed onto the external thread of the insert of the Front Sleeve. The Nozzle Nut and the Nozzle can be removed for inspection, cleaning, and replacement of the Nozzle. The Front Sleeve with insert can be removed for electrode replacement. See Section 6- Maintenance, for detailed instructions.

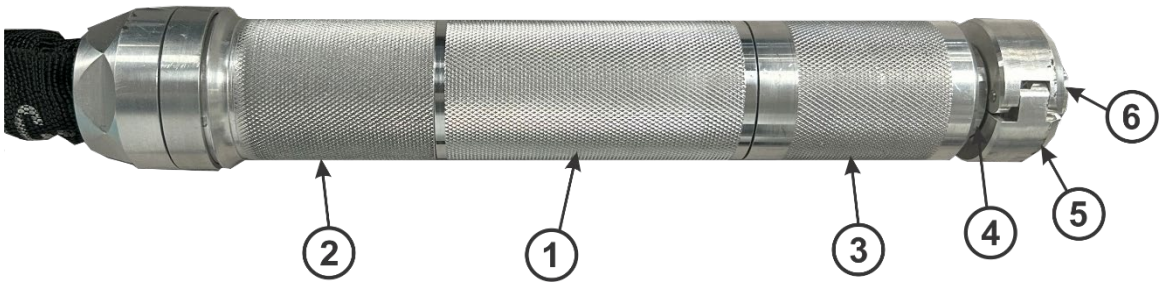


Figure 14: Plasma Pen: 1 - Main Body, 2 – Back Cover, 3 – Front Sleeve, 4 – 1” Hex, 5- Nozzle Nut Retainer Collar, 6 – Nozzle Nut (with nozzle inside).

WARNING: DO NOT ATTEMPT TO DISASSEMBLE THE PEN BODY EXCEPT AS DIRECTED FOR NOZZLE OR ELECTRODE REPLACEMENT.

Mounting Plasma Pen onto a Robotic Device

When mounting the Plasma Pen onto a robotic device using a clamp, only use the Main Body or Front Sleeve of the pen to apply the clamp (as shown in Figure 16).DO NOT use the Back cover of the pen for clamping: this part is not designed to withstand clamping pressure.

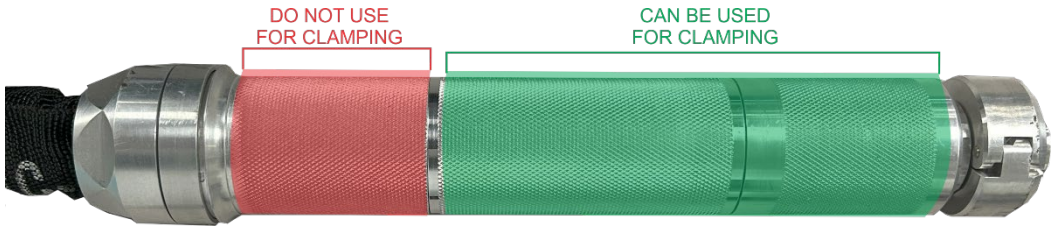


Figure 15: Clamp/No Clamp Areas of the Plasma Pen.

Take great care when moving the plasma pen and routing the high voltage cable. Route the high voltage cable to avoid the possibility of it being caught or snagged in moving parts of automated equipment. Take appropriate precautions to prevent the high voltage cable from becoming kinked, crushed, abraded, or damaged in any way. NEVER use the system with a damaged umbilical cable.

Operating Robotic-Compatible plasma pen

Robotic-compatible plasma pen can be operated only through serial communication with external computer/controller connected via Com Port on the rear panel of the controller. Please see Appendix B for detailed information on serial communication and control of robotic-compatible PlasmaBlast® unit.

6. Maintenance

WARNING: Disconnect power and allow time for the plasma pen to cool down, if applicable, before any maintenance operation.

6.1. Maintenance of PlasmaBlast® Plasma Controller

General Cleaning (as needed)

The outside surface of the plasma controller may require periodic cleaning if operated in a dusty or dirty environment. If necessary, the outside of the plasma controller can be wiped with clean, dry static free cloth. Aqueous cleaners or solvents are not recommended to clean the plasma controller.

Do not attempt to open the enclosure; there are no user-serviceable parts inside the Controller. Evidence of tampering with or otherwise attempting to open the controller will result in a voided warranty, and for rental systems requires purchase of this non-warrantied system.

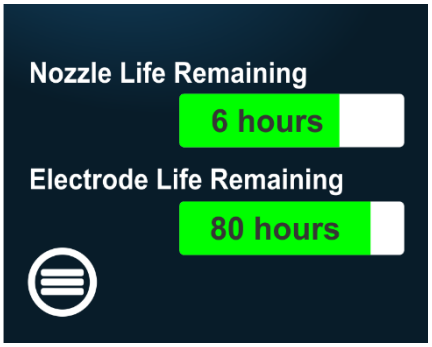
6.2. Maintenance of Plasma Pen

The Plasma Pen contains consumable parts – nozzles and electrodes – that wear off with use and require regular maintenance. This includes regular nozzle cleaning and inspection to determine the level of wear, and regular replacement of nozzles and electrodes.
The time between replacements is defined as “life” of a consumable part and is expressed in hours of “plasma-on” time.
The recommended replacement schedule is:

Nozzle – replace every **8 hours** of plasma-on time.
Electrode – replace every **100 hours** of plasma-on time.

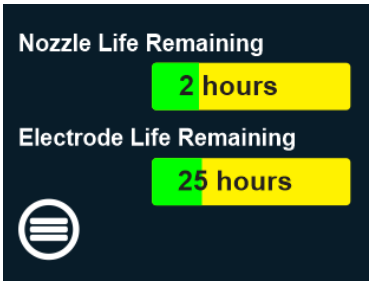
Nozzle and Electrode Maintenance Alarms

To assist the user in keeping up with the maintenance schedule, the PlasmaBlast® APCR system keeps track of plasma-on time and the “life” of currently installed nozzle and electrode remaining after the last replacement. The time remaining for the life of each item can be accessed from Maintenance Menu (see Section 4.2 - System Status Display– System Management Menu)



The life status of a consumable part - nozzle or electrode – is indicated on a status bar for the respective consumable part on the Home screen of the PlasmaBlast® System.
When the consumable is within 75% of its life the status bar is green and the life remaining is displayed in hours.
No action is necessary at this point.

When the consumable is beyond 75% of its life the system enters Maintenance Alarm state:



- When the consumable part reaches 75% of its life the status bar changes to **yellow**, and the remaining life is displayed in hours.

  Action: Prepare for replacement. Make sure the replacement part is on hand; order if necessary.

- When the consumable part reaches 100% of its life, the status bar becomes **red** and life remaining is displayed as 0.

  Action: Replace immediately. From this point the replacement becomes overdue.

Maintenance alarms do not prevent the PlasmaBlast® unit from operating and generating plasma. However, operating the unit with nozzles or electrodes that have exceeded their life can cause damage to both the PlasmaBlast® unit and the substrate being treated.

WARNING: APS is not responsible for any damage caused by operating the system with consumable parts that are exceeded their life.

Once a maintenance item is replaced, the tracked life of the part needs to be **RESET** by navigating to Menu-> System Management Menu-> Select respective Item to reset (Reset Nozzle or Reset Electrode) and confirming the reset by pressing the "OK" button on the respective screen (see Section 4.2 - System Menu – System Management Menu).

Plasma Pen Nozzle Inspection

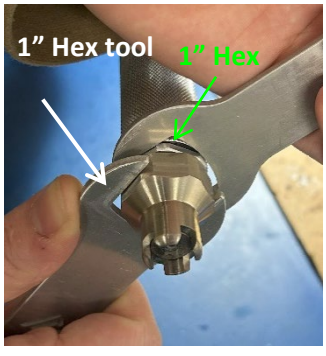
Inspect the plasma pen nozzle prior to each use and as needed if any irregularities, such as assymetric shape of the plasma plume, are noticed. To inspect the nozzle:

1. Unscrew the nozzle nut:

On Handheld Pen:

- First try to unscrew it using only fingers.
- If you experience difficulty doing this, loosen the nozzle nut first:

Holding onto the hex feature behind the nozzle nut with the included 1" hex tool, turn the tool counterclockwise. Do not use the pen body to hold onto while turning, this may cause internal threaded connections to come loose.



Do not use conventional tools.

Once loosened, finish unscrewing the nozzle nut with your fingers.

On Robotics-Compatible Pen:

- Unscrew the the socket cup screw holding the nozzle nut retainer clamp together using a 9/64” allen wrench provided with the pen.
- Open and remove the clamp

2. Remove the nozzle nut and the nozzle for inspection and cleaning.

3. Note all damage and wear to the nozzle and nozzle opening, such as:

- Irregular shape of the nozzle opening.
- Debris or pieces of material on the outside and the inside surfaces of the nozzle.
- Debris inside the nozzle opening.

Handheld Pen

Robotic Pen

Plasma Pen Nozzle Cleaning

- If debris is found during the inspection, clean the nozzle by blowing compressed air through the nozzle or using a toothpick, if necessary.

- Make sure the tip of the nozzle is relatively clean of paint or coating residue. Periodic cleaning of the outside surface of the nozzle with a green 3M Scotch-Brite™ pad or similar mild abrasive pad is recommended.

- After cleaning, replace the nozzle nut using procedures described in the Nozzle Replacement section below.

Plasma Pen Nozzle Replacement

Generally, a plasma nozzle should be replaced approximately every 8 hours of plasma-on time. The wear consistent with this level of use can be identified through visual inspection (see Figure 17).

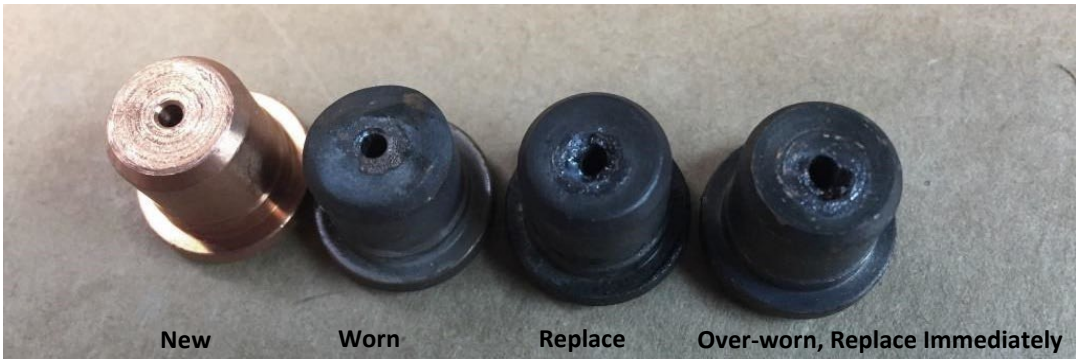


Figure 16: Levels of nozzle wear.

If excessive wear (highly irregular shape of the nozzle opening, pitting around the opening, or material buildup that cannot be removed) is detected on the nozzle during daily inspection, replace the nozzle:

1. Remove nozzle nut as described in Plasma Nozzle Inspection procedure, using the built–in tool in the frame.
2. Remove worn nozzle.
3. Wipe the old grease off the threads with a clean cotton cloth, then finish cleaning with a small bronze wire brush to completely remove grease residue from previous nozzle replacement.

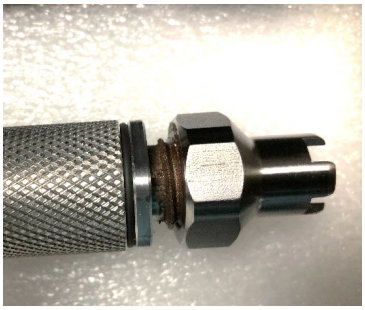
FAILURE TO FOLLOW THIS STEP REGULARLY MAY CAUSE GREASE RESIDUE BUILDUP AND MAY RESULT IN ELECTRIC SHOCK TO THE OPERATOR

4. Drop the new nozzle into the nozzle nut as shown.

For Handheld Pen

5. Add copper-based anti-seize compound provided with nozzle kit (Henkel LB 8008/C5-A anti-seize) to the threads and re-attach the nozzle nut. DO NOT SUBSTITUTE THE SPECIFIED ANTI-SEIZE WITHOUT AUTHORIZATION FROM APS.

6. Thread the nozzle nut on, then un-thread to spread out the anti-seize compound.



7. Tighten the nozzle nut by hand, using only 2 fingers. It must not be over-tightened

DO NOT USE 1” Hex Tool OR ANY OTHER TOOL FOR TIGHTENING!

For Robotics-Compatible Pen

8. Insert the nozzle nut with nozzle inside into the opening of the plasma pen. No anti-seize is needed.

9. Re-install the nozzle nut retainer collar and tighten the screw that holds the collar together.

10. Once the nozzle is replaced, the tracked life of the nozzle needs to be RESET by navigating to Menu -> System Management - > Reset Nozzle Life- > OK

Plasma Electrode Replacement

- *The Plasma Electrode replacement procedure is the same for Handheld Pen and Robotics-Compatible Pen. The procedure is illustrated using Handheld Pen.*
- *The internal Plasma Electrode should be replaced every 100 hours of plasma-on time.*

Before replacing the Plasma Electrode, disconnect the PlasmaBlast® unit ***from AC power. Failure to do so may result in serious injury or death.***

If the pen was operated immediately before the electrode replacement, make sure that it is sufficiently cooled down before starting the procedure.

- This procedure must be performed in a clean and dry area.
- You will need the following tools:
    - Deep well 1/2” 6 -point socket with handle (provided)
    - 1” hex tool (provided)
    - 3/8” drive ratchet (not provided)
    - 3/8” drive torque wrench (10-50 inch-pound range), not provided
    - Anti-Seize compound included with consumable nozzles kit

To replace Plasma Electrode:

1. Remove the nozzle nut and nozzle following procedures described in the Nozzle Inspection section.

2. Remove the small flathead screw located on the underside of the pen using a small #1 phillips screwdriver (provided). Turn counter-clockwise to remove.

3. Remove the front of the pen body using the 1” hex feature in the front of the pen. Use a 1” hex tool if necessary.

4. Identify the electrode inside the pen body.

5. Use a 1/2” deep well, 12-point socket to loosen the electrode. Once loose, it can be turned by hand.

6. Remove the electrode from the socket. It may need to be pushed out using a small screwdriver through the drive opening of the socket.

Worn Electrode

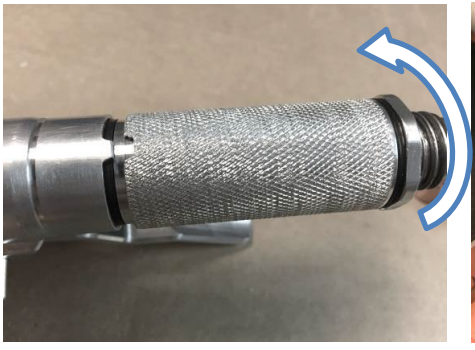
7. Insert a new electrode into the 1/2” deep well, 12-point socket. Turn clockwise to thread in. Thread in carefully by hand. There should be very little resistance.

New Electrode

Use the 3/8” drive torque wrench to tighten to a maximum torque of 20 inch-pounds or 3.95 Newton/meters. Do not over-tighten as this will strip the threads.

8. Re-install the front pen assembly into the pen body.
Make sure the O-ring and threads are clean and do not have debris attached. There is a small amount of anti-seize in this location. If there is some that is visible, then it will not be necessary to apply more.

9. Turn front body assembly clockwise by hand. *Make sure, as you thread it on, that the notch in the grip goes into the feature on the pen body.* Tighten by hand, then use a 1” hex tool on the hex to tighten further.



10. Re-install the panhead screw.

It is important to tighten the front pen assembly to the point where the threaded hole for the panhead Phillips screw in the front pen assembly aligns with the hole in the locking feature the as shown. Otherwise, it will be difficult to install the screw or possible to cross-thread.

11. Re-attach the nozzle nut with the nozzle using the procedure described in Nozzle Inspection section. Use a new nozzle if necessary.

12. Once the electrode is replaced, the tracked life of the electrode needs to be RESET by navigating to navigating to Menu -> System Management - > Reset Electrode Life- > OK

Plasma Pen Cable Maintenance

Check Pen Cable for kinks or knots; straighten kinks and remove knots as soon as they are noticed. Check for damage on the cable sleeving. Contact APS immediately if any damage is found.

Pressure Regulator Maintenance

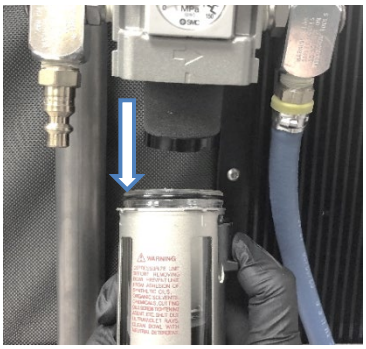
- Check the filter bowl for the presence of water, oil, or other contaminants at least two times a day during normal operation, by visual inspection.
- Be alert to any automatic purging of water/other contaminants from the auto-purge valve at the base of the filter bowl. Collection of significant amounts of water/debris and automatic purging is an indication that there is an excess of moisture/contamination in the air flowing through the system. Do not operate the system in this condition. Install supplemental air dryer and/or filtration system at your compressed air source.
- If water/debris are observed in the filter bowl, clean the regulator filter following the below procedure:

1. Disconnect compressed air source line from the regulator input.

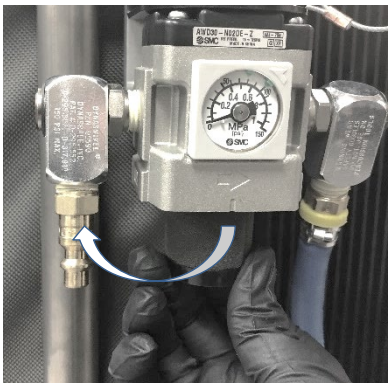
2. Slide the black filter bowl locking mechanism downward to unlock the filter bowl.

3. While maintaining pressure on the locking mechanism, rotate the filter bowl in a counterclockwise direction (as shown).

4. Remove the filter bowl by pulling it down.



5. Unscrew the filter (as shown) and remove it from the regulator.



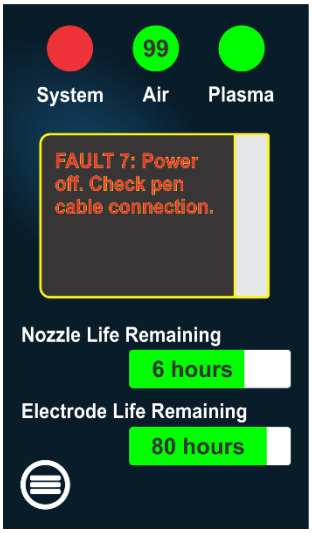
6. Use clean water to rinse the filter. If oil contamination is present, use mild detergent.

7. Re-install the filter and the filter bowl.
   If the foam on the filter appears heavily contaminated or damaged, please contact APS to purchase a replacement filter.

7. Troubleshooting

7.1. PlasmaBlast® System Troubleshooting

PlasmaBlast® is equipped with a digital device safety system that is programmed to detect various abnormalities in system operation and communicate this information to the user through fault codes. In certain instances, the safety system will shut the device down to prevent damage to the system electronics; in some other instances, it will display the fault code as a warning, but will continue operation.



If the system encounters an active fault event, the **fault code** associated with this type of event will be displayed on the main Plasma System Status screen. (e.g FAULT 7) along with required troubleshooting steps. It will also be indicated by the system's status indicator turning **red.** The fault code associated with this fault will be displayed in the respective section of the System Information screen.

Once the fault screen is cleared by pressing any button or navigating away from this screen, the troubleshooting information for this fault or any other fault can still be accessed through the **Help** Menu.

Fault Codes

Each fault code is associated with a certain type of abnormal system operation. The System Status Display allows the user to view the definitions of the fault codes and the troubleshooting tips for each fault code. The table below presents the fault codes used by the PlasmaBlast® System, as well as extended descriptions/recommendations for each of the faults.

Fault Code	Probable Cause	Solutions
0	No faults, normal operation	
7	Interlock open 1. Pen cable interlock not fastened.	1. Remove and then re-connect pen cable to unit. May try this several times as oxidation on the connectors may be the problem.
34	Plasma Waveform Fault 1. Low or high air pressure. 2. No air pressure. 3. Very hot pen. 4. Shorted cable.	1. Increase or decrease air pressure to within recommended range. (80-105 psi) 2. Connect air. 3. Perform nozzle maintenance. Let pen cool. 4. Inspect and replace cable if necessary.
35	Switching Current Too High While Plasma is Operating. 1. Internal overheating. 2. Failure in Power Control Loop.	1. Let the unit cool. Could be caused by unit being in the direct sunlight. In this case, run external fan directed toward unit. 2. Hardware problem in power control loop. Must be returned for service.

36	Switching Current Too High During Ignition State. 1. Internal overheating. 2. Cable capacitance is too high. 3. Electrode damaged.	1. Let the unit cool. Could be caused by unit being in the direct sunlight. 2. Inspect Cable for open or other damage. 3. Inspect nozzle. Replace if necessary.
37	No Cable 1. Cable is missing or not connected. 2. Cable interlock is not fastened.	1. Connect cable securely to unit. 2. Remove then re-connect pen cable to unit. May try this several times as oxidation on the connectors may be the problem.
38	CPU Temperature Too High 1. Unit is too hot.	1. Let unit cool. Could be caused by unit being in the direct sunlight. 2. Run external fan directed toward unit.
39	Line Voltage Out of Range 1. Generator or Line Voltage is too low or too high.	1. Check line voltage. 2. Check generator voltage.
41	High Ripple Power. 1. Mains line frequency too low or too high. 2. Noisy power line. 3. Lost a fuse in a 3-phase system. 4. Lost a filter capacitor.	1. Check generator frequency. (50/60 Hz) 2. Try a different outlet or correct power Line noise. 3. Must be returned for service. 4. Must be returned for service.
42*	Check Air Pressure. 1. Air pressure is too high or too low. 2. Air is not connected.	1. Set air pressure to 85-105 PSI 2. Verify that air is connected to unit.

*If you operate PlasmaBlast® APCR system with a portable air compressor and receive a Fault 42 that persists and/or wouldn't clear - test the compressor for air pressure/flow stability using test procedure described in Section 5.3 PlasmaBlast® System Setup – Testing Portable Air compressor.

8. Support

For technical support, please call APS at 919-341-8325 or enter a technical service request via our “Contact Us” Form at www.apsplasmablast.com

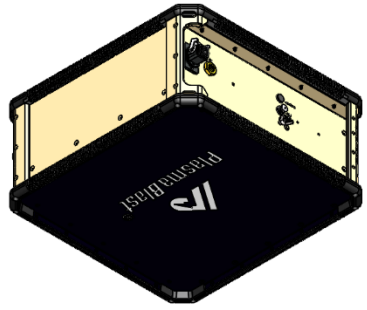
Support Hours:
Regular hours: 9am – 5pm Monday-Friday, Eastern time
Emergency hours: 24/7 via email with APS on-call personnel (service@APCRlasma.com)

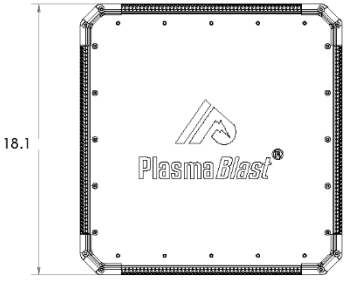
Appendix A

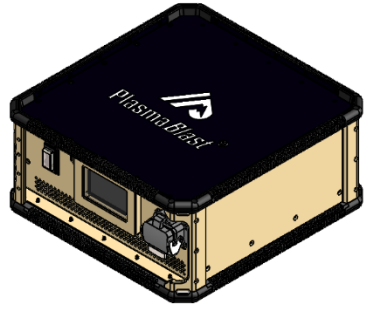
PlasmaBlast® B-series Plasma Controller Dimensional Drawings and Rack-Mount Conversion Instructions.

PB7000-B

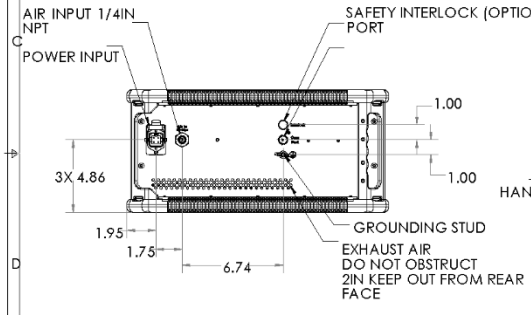
FRONT FACING PEN

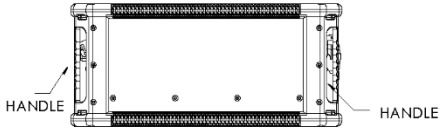


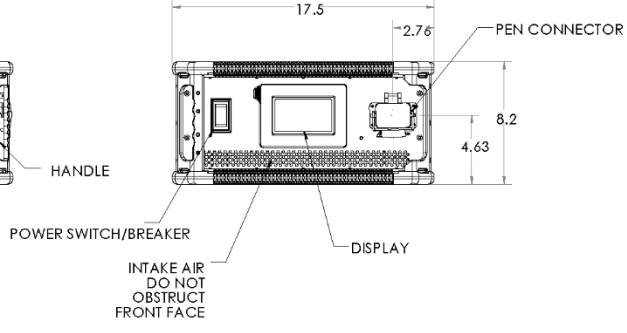


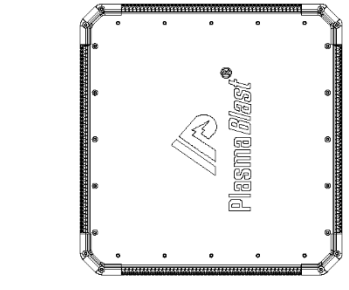


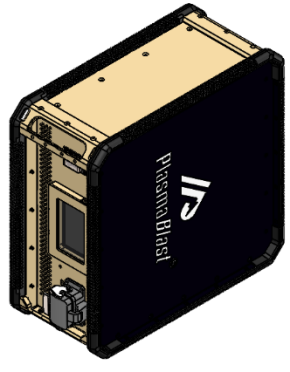
LANDSCAPE ORIENTATION











PORTRAIT ORIENTATION

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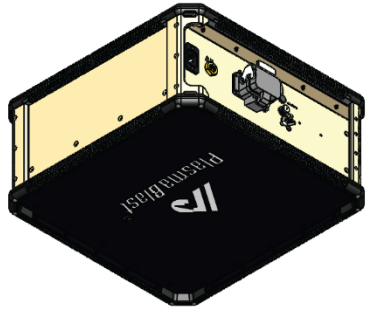
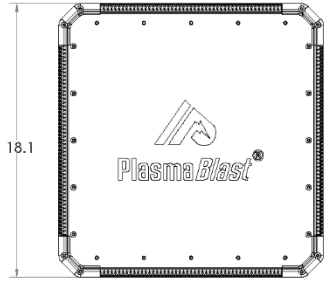
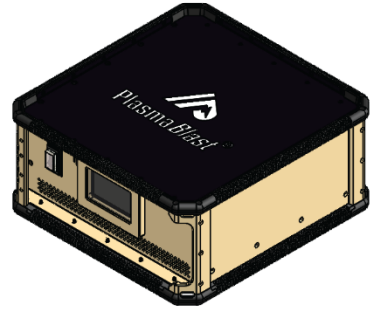
PB70000-B

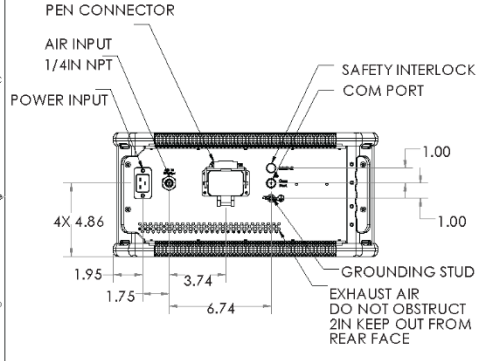
REAR FACING PEN

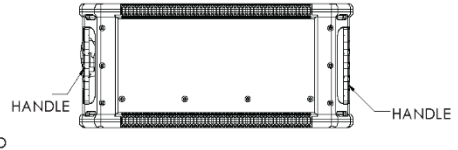


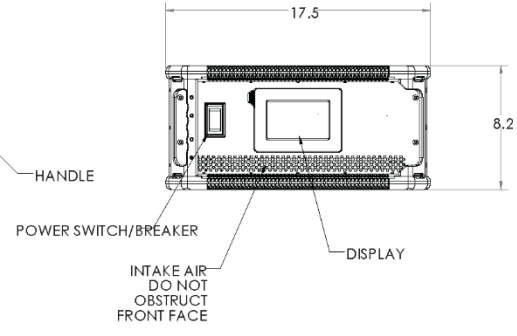


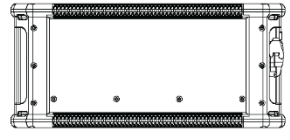


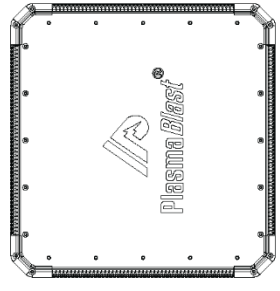
LANDSCAPE ORIENTATION

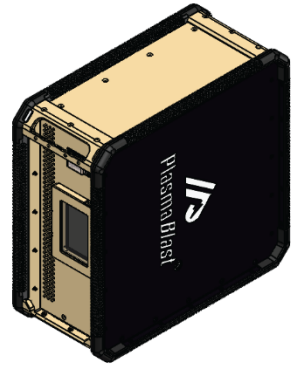












PORTRAIT ORIENTATION

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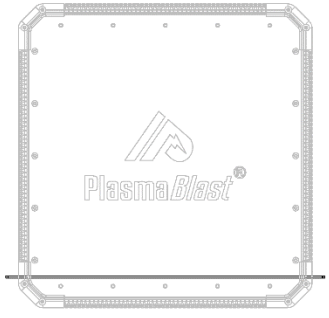
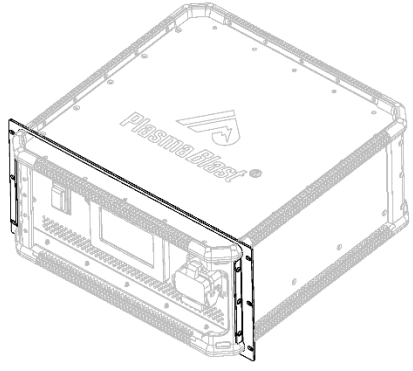
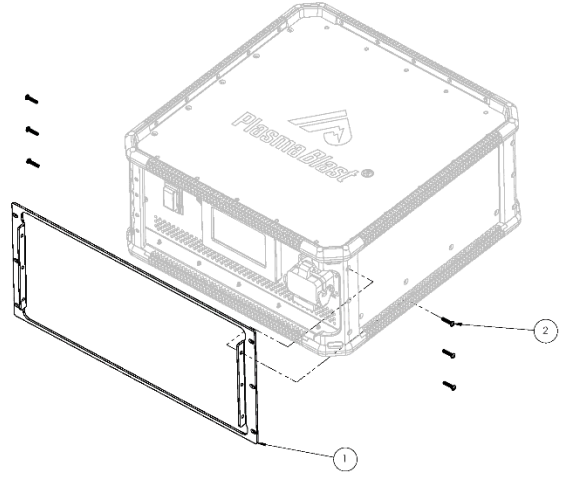
PROPRIETARY AND CONFIDENTIAL INFORMATION

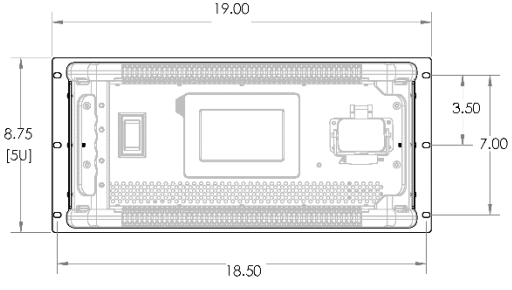
PB7000-B Rack Mount Conversion

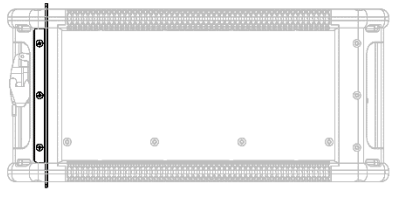
FRONT PEN CONNECTOR
MODEL SHOWN

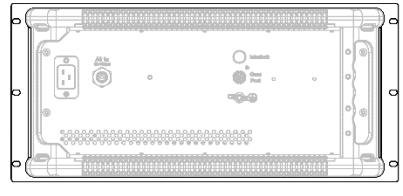


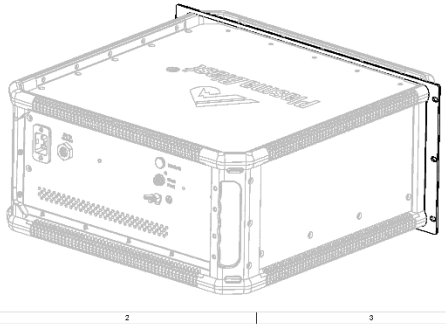












ITEM NO.	Part Number	DESCRIPTION	QTY.
1	3410492	BRACKET, 1-PIECE, RACK MOUNT, MILITARY BENCHTOP	1
2	3410385	Black-Oxide 18-8 Stainless Steel Pan Head Phillips Screws 8-32 Thread, 3/4" Long	6

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PROPRIETARY AND CONFIDENTIAL INFORMATION

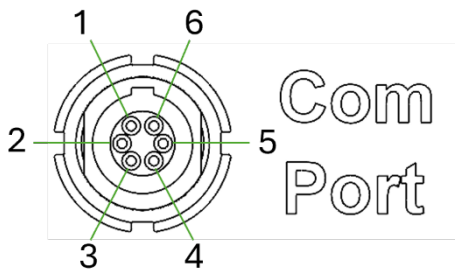
Appendix B

Serial Communication and Control of the PlasmaBlast® Unit

ATTENTION: Applies only to models with RS232 communication enabled.

Interface Overview

Serial communication and control of the PlasmaBlast® Systems are handled through a 6-pin serial port on the rear panel of the plasma controller, through use of the corresponding mating plug. The serial port uses a full-duplex 8N1 configuration with a 57600 Baud rate and can support a cable capacitance up to 1200pF wire to ground. It uses a standard RS-232 protocol with no auxiliary pins or on/off protocol. The system transmits a +/- 5V signal and accepts either a +/- 5V or +/- 12 V signal. A serial terminal program such as RealTerm may be used to handle the serial communications or other RS-232 compliant interfaces.
The pin-out of the Communication Port is as follows:



7. GND
8. TX
9. RX
10. No Connect
11. Trigger 1
12. Trigger 2

Serial Communication Code

Commands are formed as an ASCII text string beginning with the '$' character and are terminated with the appropriate CRC-32 calculation value.

Output messages are automatically printed in User Mode during PlasamBlast® operation. The ASCII character strings printed through the serial port typically begin with the '$' character and are also terminated with a CRC-32 value.

A VT-100 style serial terminal is required to interact with the PlasmaBlast® through the RS232 serial port. (See Section 4.1 – "Back Panel Connections and Controls".)

System Initialization

The screen shot below shows the typical output of the PlasmaBlast® during power-on initialization of the system. The system is always in User Mode after initialization is completed.

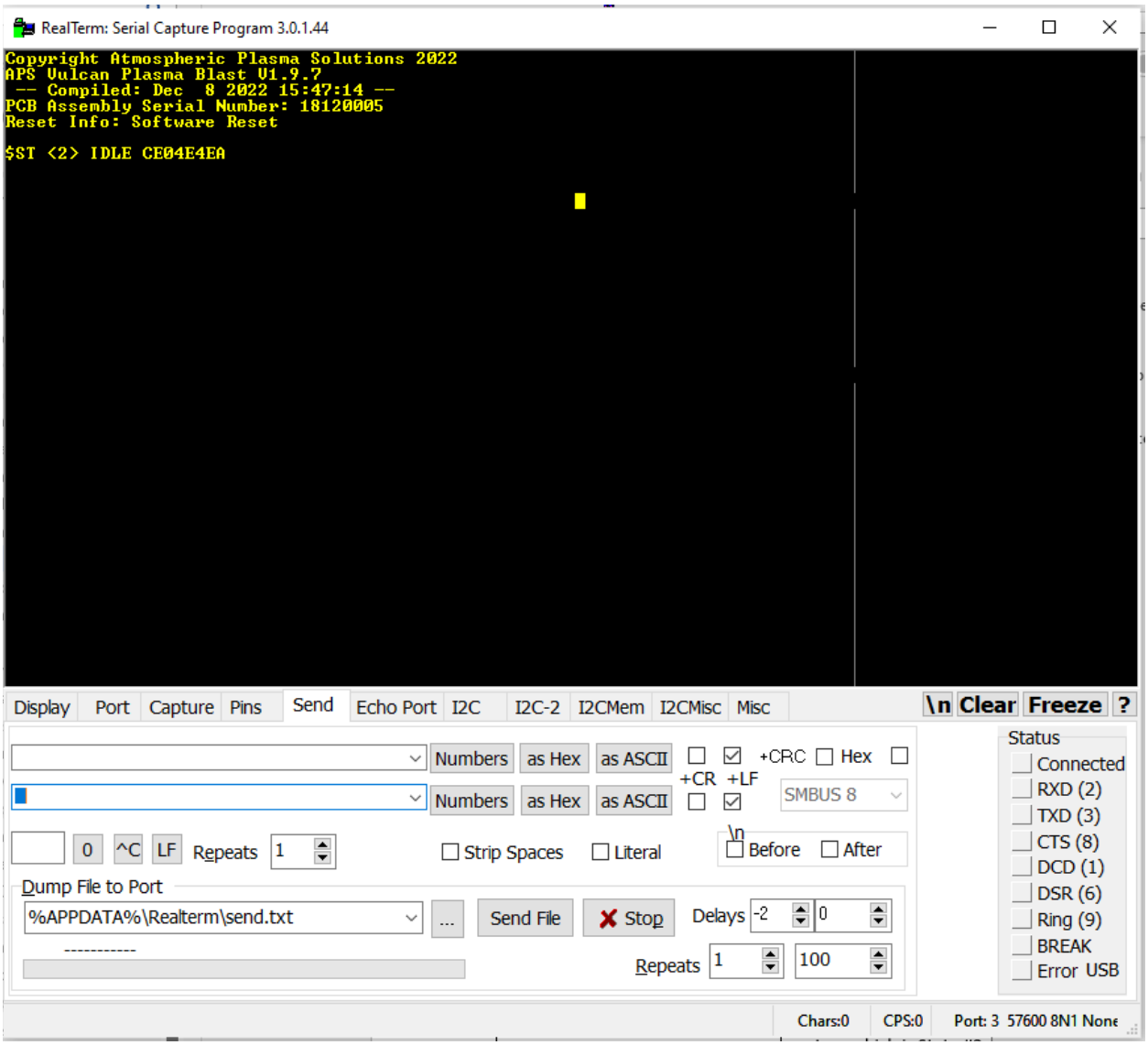


Figure 1: PlasmaBlast® Initialization Output

If a terminal is configured properly and connected to the serial port when the system is powered on, PlasmaBlast® software information and the controller PCB serial number are printed in the terminal window. The status of the plasma control state machine is displayed on the last line of this output.

A system status output line always begins with a $ST and indicates the current status of the system. In Figure 1, the status output reflects the IDLE state and indicates that the unit is ready to attempt to fire plasma.

If there is a fault condition detected by the system, the related fault information message is printed. The fault information message displays only the fault number, $IM FT###.

Possible status messages and their formats are defined in Table 2: System Output Messages.

User Mode Interface Definition

User Mode is the default serial port mode at power on. This mode allows control of the plasma system through commands entered at the serial port, and it prints changes in controller status, fault conditions, and requested system data.

Commands

Command strings are case-sensitive and require a valid CRC-32 calculation at the end of the string for the command to be accepted by the unit. The terminal must be configured to send a linefeed (LF) or a carriage return-line feed (CRLF) after the command.

The system prints a response to any user input:

- $ER CBA6B740 indicates an invalid command. See Table 2: System Output Messages for more information.
- $OK 5D319B8E is the response to a valid command.

Command	Description
$PO 0x2E27BAC7	Plasma Off
$PS 0xC850E79A	Plasma On
$SA 0xB2E22910	System Status Report
$RE 0xD74C8623	Reset Unit. This is a warm restart.
$RE_NOZZLE 0x0BE9DDF3	Reset plasma time on nozzle. Maintenance command to issue after the nozzle is replaced with a new one. Needs to be reset to clear the maintenance alarm associated with 0 time remaining on the nozzle. Note: the electrode has its own reset. See $RE_ELECTRODE.
$RE_ELECTRODE 0xACC05A13	Reset plasma time on electrode. Maintenance command to issue after the electrode is replaced with a new one. Needs to be reset to clear the maintenance alarm associated with 0 time remaining on the electrode. Note: the nozzle has its own reset. See $RE_NOZZLE.
$AIR 0x1D63E8D0	Read the air pressure

Table 1: User Mode Commands

Serial Port Output

The User Mode display shows everything output by the system line by line. Every message is followed by a CRLF. Most output strings are followed by the CRC-32 value of the string that is sent to the display. System information and messages are printed in order, one line after another. The CRC values are blue in the table below.

Output	Description
$OK 5D319B8E	System response to a valid command
$ER CBA6B740	System response to an invalid command or a command that is not enabled on this system.
$ST <2> IDLE CE04E4EA	Status message: This output typically occurs when the controller state changes. Some examples are: IDLE – System Ready FAULT_WAIT – Fault transition state AIR_FLOW_ON PLASMA_ON PLASMA_OFF_WAIT
$IM <information text> CRC-32	Information Message, General For example, $IM <Air=Sensor Failure> 0x1E6973F $IM <Air=96_PSI> 0x2D3DC98A
$IM FT### CRC-32	Information Message, Fault For example, $IM FT037 C3D533CE In this case the fault is Fault 37, which is raised if the Plasma Pen cable is not installed properly on the system. See Table 3: Fault Troubleshooting Chart for a comprehensive list of faults and troubleshooting steps.
$SA <State=2> <Power= 0.0_Watts> <Microcontroller_Temperature=27ø_Celsius> <Fault=0> <Plasma_ON_Time= 0.000_s> <Plasma_ON_Time_Total=0:00:00> 0x3784CAE9 $SA_MAINTENANCE <Nozzle_State=0> <Nozzle_Plasma_Time_Remains=8:00:00> <Nozzle_Plasma_Time=0:00:00> <Electrode_State=0>	Status All Command Response The information printed in response to this command is: $SA, General Current State Plasma Power Internal temperature Most recent fault that occurred on the system Plasma ON time since this power on Total Plasma ON time for the system $SA_MAINTENANCE Nozzle Maintenance Alarm State*

<Electrode_Plasma_Time_Remains=100:00:00 ><Electrode_Plasma_Time=0:00:00> 0xA728433E	Nozzle plasma time remaining before maintenance is required Plasma ON time for this nozzle Electrode Maintenance Alarm State* Nozzle plasma time remaining before maintenance is required Plasma ON time for this electrode *0 = OK, 1=Maintenance WARNING, 2= Maintenance DUE, 3=Maintenance OVERDUE
Vulcan Plasma Blast P2.0.7 -- Compiled: Dec 8 2022 15:47:14 – PCB Assembly Serial Number Reset Info:	System Initialization Output: Software Version and creation date Internal PCB module serial number Reason for current microcontroller restart.

Table 2: System Output Messages

Examples of User Mode Output

Here are various terminal window captures of messages output by the system during operatio

Figure 3 shows the system output sent to the RealTerm terminal in response to issuing the following commands: Plasma on ($PS), Plasma off ($PO), then Status All ($SA).

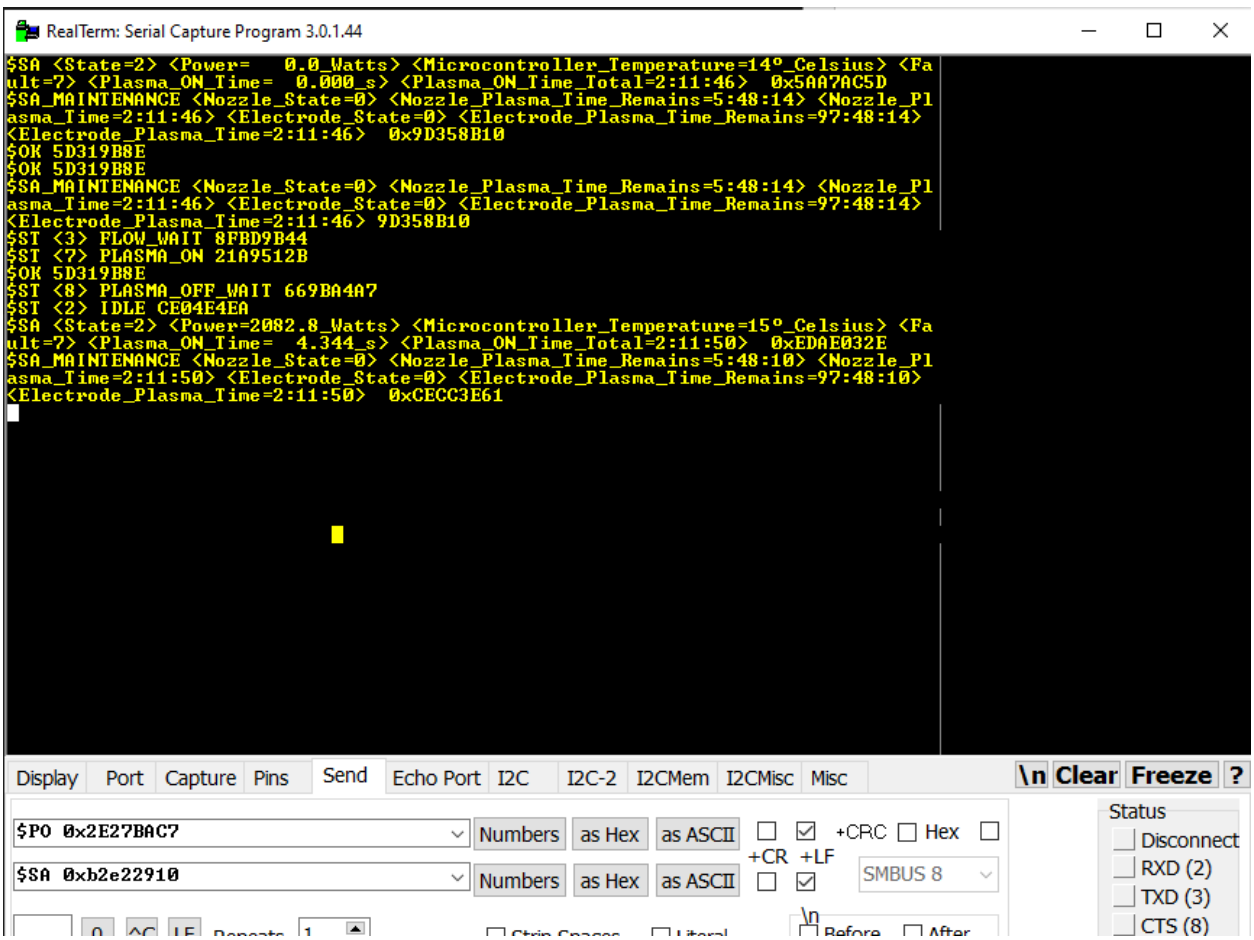


Figure 3: Plasma ON, Plasma OFF

Figure 4 shows output while running plasma by issuing the Plasma On ($PS) command. Notice that the Maintenance Status data is printed after receiving the command and before starting air. An air pressure fault (Fault 42) occurs while plasma is ON. Plasma halts and the system automatically returns to IDLE state after this fault occurs.

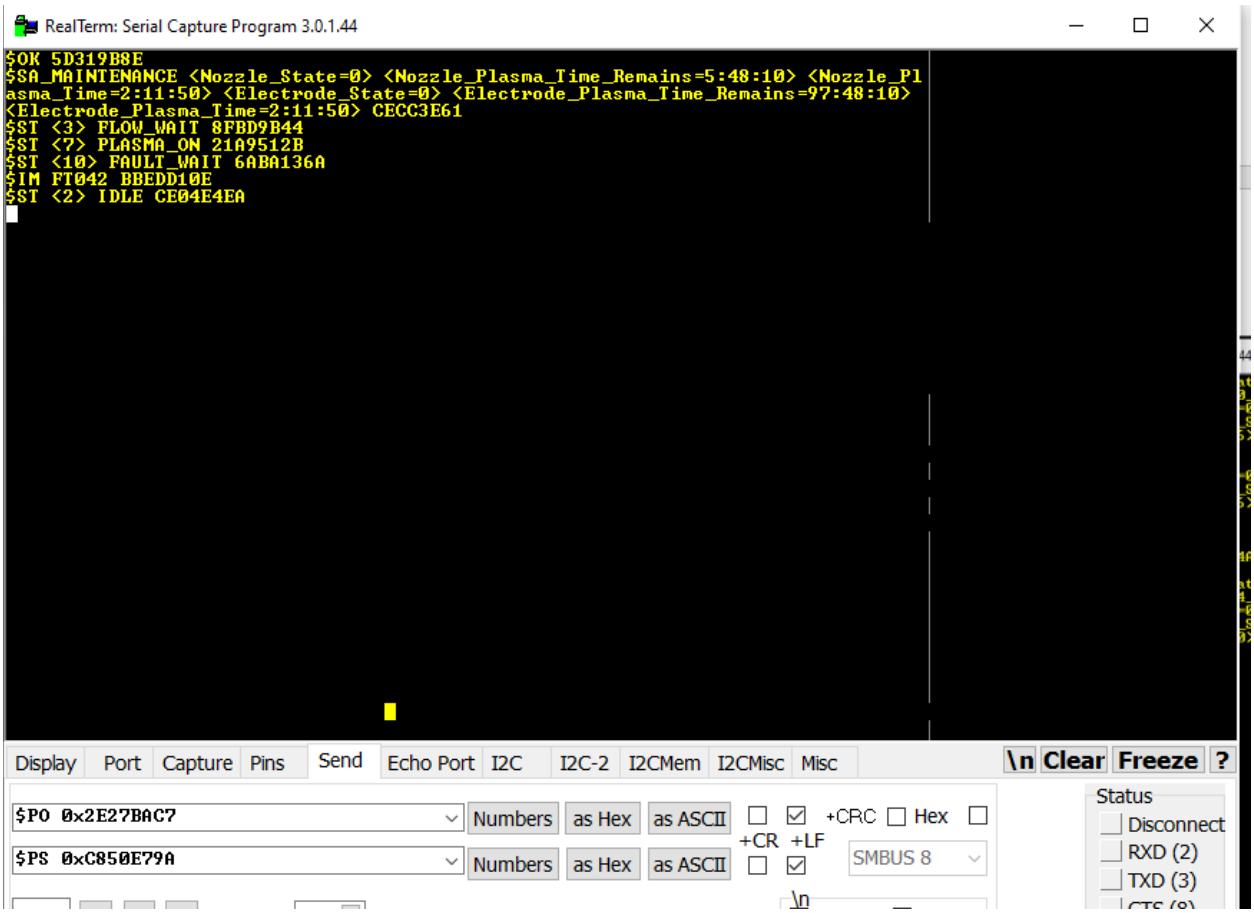


Figure 4: Plasma ON with Fault Output

The User Mode output in Figure 5 is a result of issuing a Plasma On ($PS) and running plasma for approximately 3 minutes. After the system returns to IDLE state (as indicated by the $ST message), the Status All command ($SA) was issued followed by the command to read the air pressure.

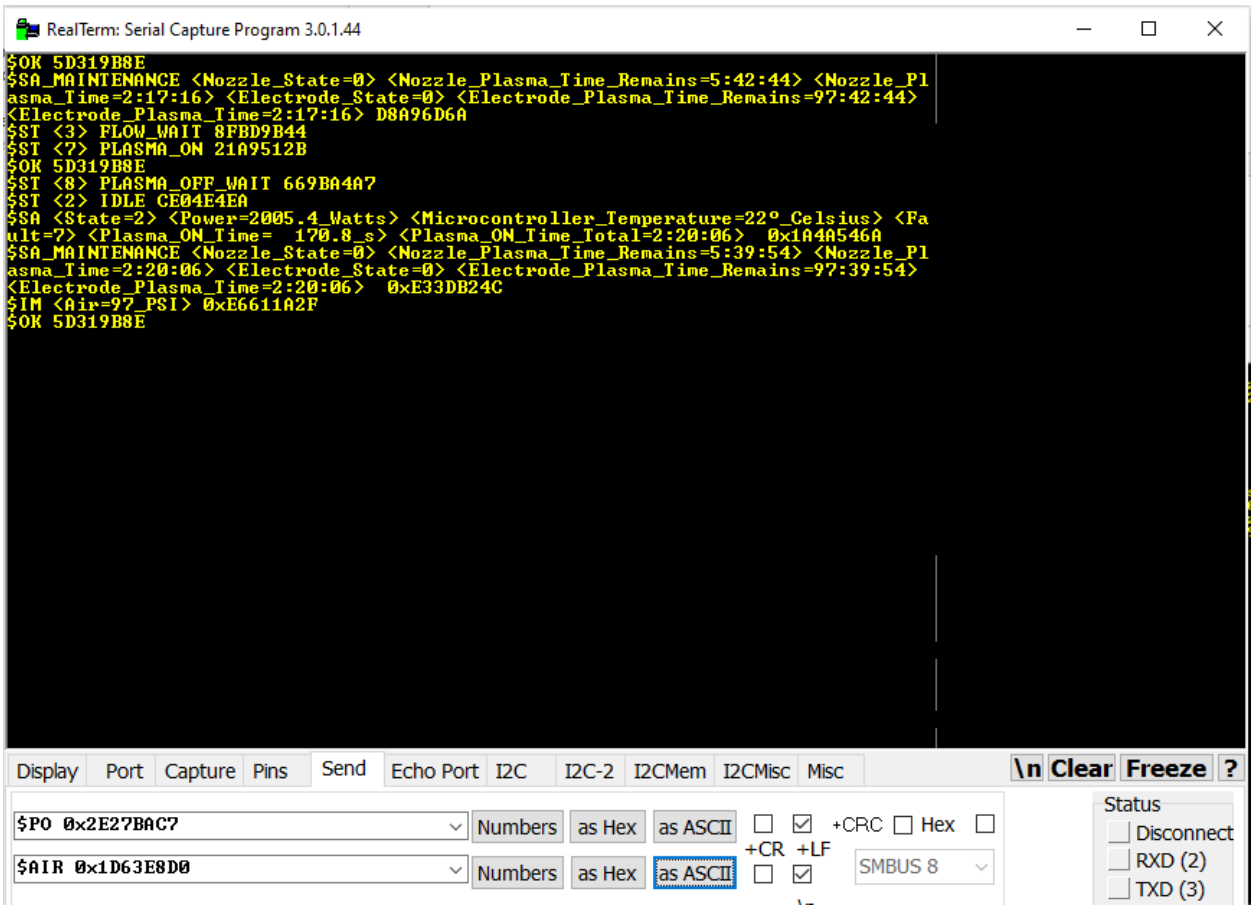


Figure 5: Plasma ON, Request for Air Pressure

Figure 6 shows output on a RealTerm window for a system that begins in the IDLE state and receives the valid plasma on command ($PS). Since the air pressure sensor is failing, there is an information message ($IM) printed indicating the failures and 3 repeated attempts to sense the air pressure. Since these consecutive attempts fail, the sensor is disabled and the state machine transitions from IDLE to AIR ON while the cable detection state is entered. Notice that the air pressure sensor failure is not a fault condition. Next, the cable detection fails, as indicated by the Information Fault message, $IM FT037, and the control state machine remains in AIR_FLOW_ON state.

The command validation ($OK) is printed after each valid command. For this particular fault, Fault 37, the plasma on command ($PS) must be issued to clear this fault and allow the system to return to the IDLE state. Not all faults require entry of a command to allow the system to return to IDLE state. The system is shown to return to IDLE state with the last $ST <2> IDLE message.

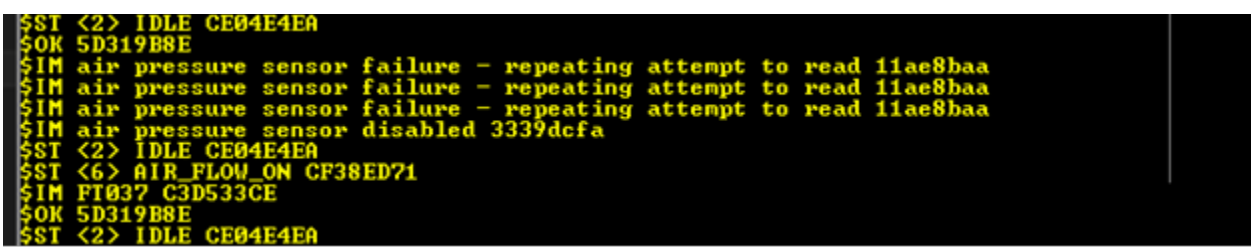


Figure 6: User Mode Output with Pressure Sensor Failure and No Cable Fault

Figure 7 shows system output for a system that begins in IDLE state and receives a valid Plasma On command ($PS). The output indicates that there was an attempt to re-initialize the sensor 3 times, but these attempts have failed to produce a valid reading. In this case, the sensor has been disabled, but plasma ignition proceeds.

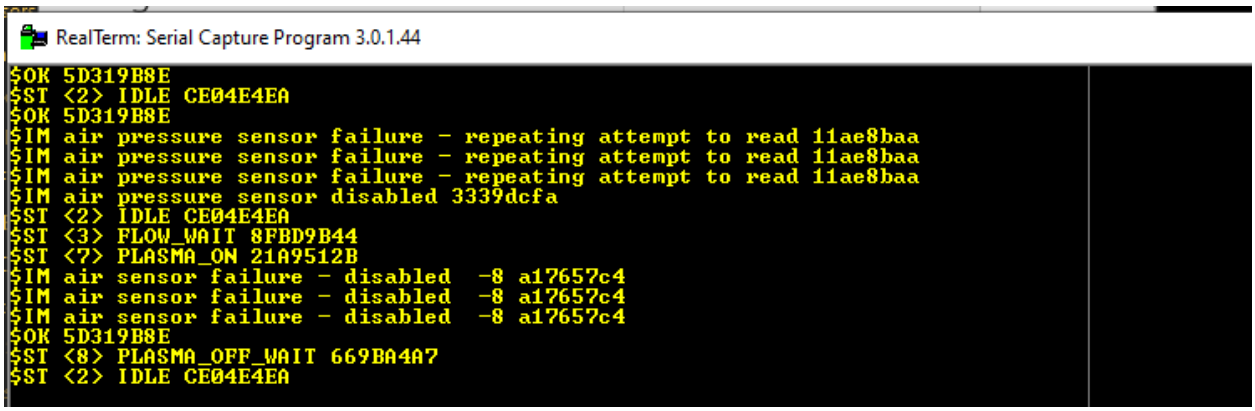


Figure 7: User Mode Output with Pressure Sensor Disabled

Troubleshooting Help

Table 3: Fault Troubleshooting Chart lists possible system faults and suggested troubleshooting steps.

Fault Number	Causes	Troubleshooting Steps
Fault 7	Interlock Open	Verify that the Pen Cable is securely fastened to the unit.
Fault 34	Plasma Wave Fault This could mean shorted cable, no air, very low air pressure (less than 60 PSI) or a very hot pen/torch where the plasma is so hot that it is approaching a short instead of standard resistive load.	Verify Air hose connection. Verify Air pressure is within range. Check for damaged pen cable. Check for overheated pen. Cool pen. May cool pen by flowing air through pen with no plasma.
Fault 35	IGBT RUN OVERCURRENT	It is always necessary to contact APS if this fault persists. Contact APS: info@APCRlasma.com
Fault 36	IGBT IGNITE OVER CURRENT	It is always necessary to contact APS if this fault persists. Contact APS: info@APCRlasma.com
Fault 37	No plasma cable detect	Verify pen cable is securely attached. Inspect the pen cable for damage.

Fault 38	Temperature Fault - CPU Hot	Let the unit cool. Use a fan to blow air on the heat sink. Move unit out of the sun. If fault persists, contact APS. Contact APS: info@APCRlasma.com
Fault 39	Improper Bus Voltage	Check input power voltage level.
Fault 41	High Ripple – may be a blown fuse. Detected for 3-phase units only.	Check input power voltage level and frequency. If fault persists, contact APS. Contact APS: info@APCRlasma.com
Fault 42	Air Pressure Out of Range	Verify the air pressure is within acceptable range.

Table 3: Fault Troubleshooting Chart

Serial Terminal Settings

A serial terminal is connected to the RS232 interface on the PlasmaBlast® using the PlasmaBlast® serial cable provided by APS.

Communication Port Configuration

Configure the VT100 style serial terminal (such as Realterm or PuTTy) as follows:

- 57600 baud
- 8 data bits, 1 start bit, 1 stop bit, no parity
- No hardware flow control
- New line mode (PlasmaBlast® does not send LF or CRLF with strings)
- Send a LF or CRLF with each command3

Appendix C

Acceptable Receptacles Options:

PlasmaBlast® -B-24 : 208 to 240 Volt: Single or 3-phase

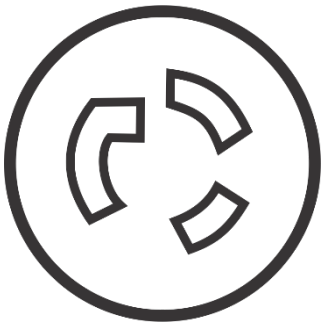
- NEMA L6-20
- NEMA L6-30
- NEMA L14-20
- NEMA L14-30
- NEMA L15-30, 3 phase

PlasmaBlast® -B-48:440 to 480 Volt: 3-phase

- NEMA L16-20
- NEMA L16-30

Table 4: Default and optional receptacles acceptable for PlasmaBlast®

PlasmaBlast® 208 to 240 Volt System Receptacles

Receptacle Type	Receptacle	Receptacle Diagram	System sub-model
NEMA L6-20			PlasmaBlast® -208 to 240 Volt System

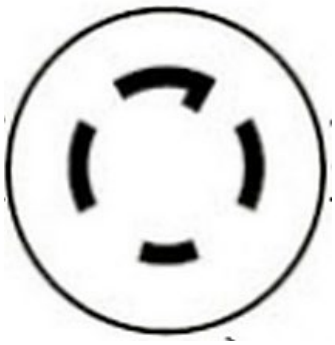
NEMA L6-30 (default)

PlasmaBlast®
-208 to 240
Volt System

NEMA L14-20

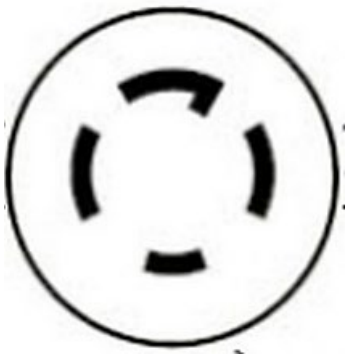
PlasmaBlast®
-208 to 240
Volt System

NEMA L14-30



PlasmaBlast®
-208 to 240
Volt System

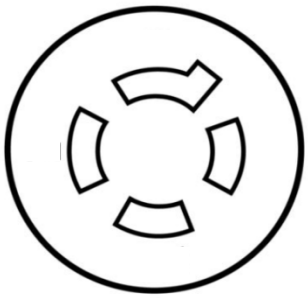
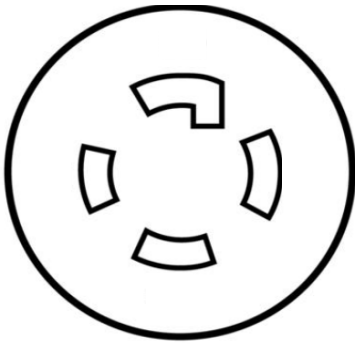
NEMA L15-30 3 phase



PlasmaBlast®
-208 to 240
Volt System

Figure 17: Most commonly used plugs for PlasmaBlast® 208 to 240

PlasmaBlast® -440 to 480 Volt System Receptacles

Receptacle Type	Receptacle	Receptacle Diagram	System sub-model
NEMA L-16-20			PlasmaBlast® -440 to 480 Volt System
NEMA L-16-30			PlasmaBlast® -440 to 480 Volt System

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