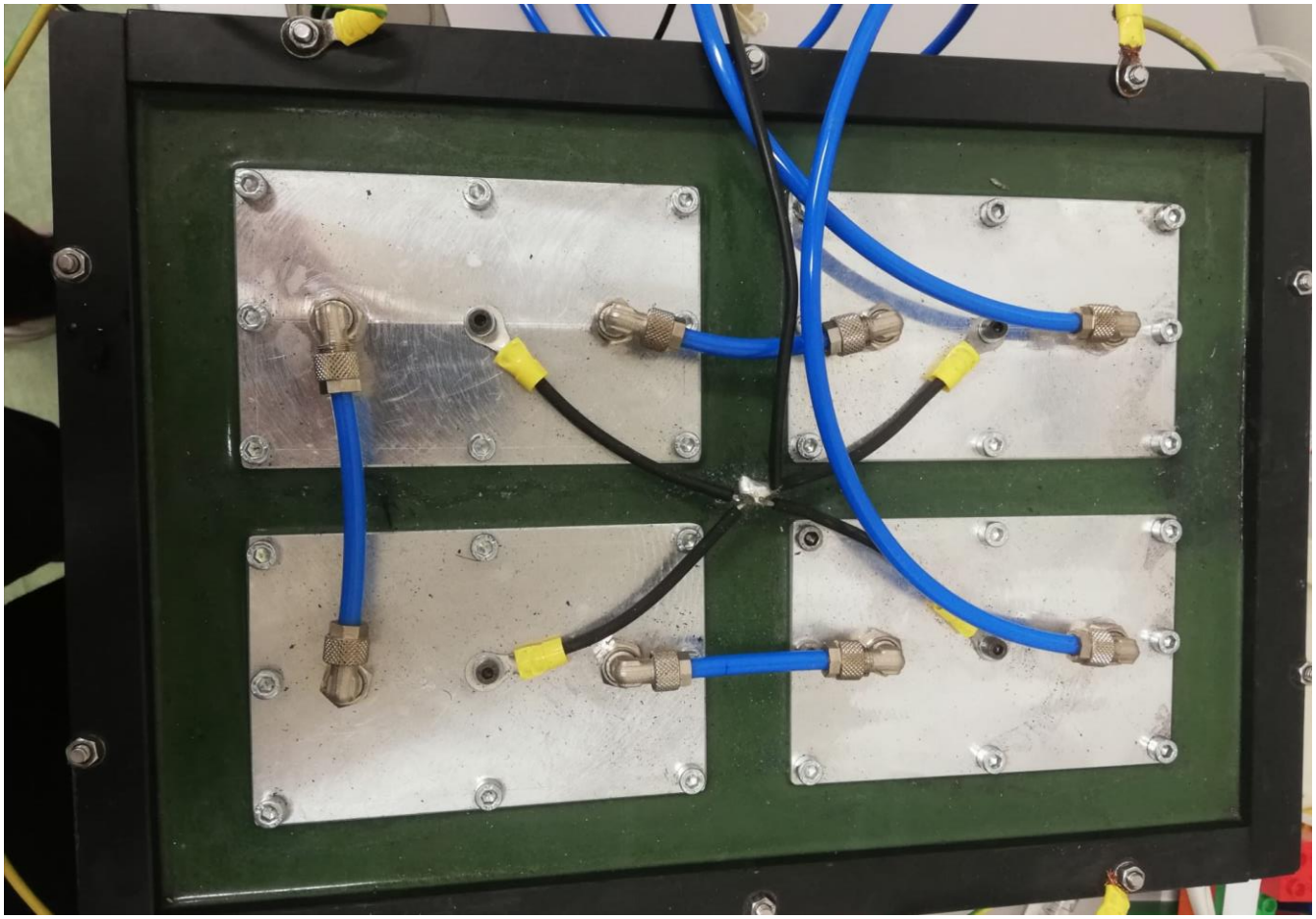
PASS

Plasma Assisted Sanitation System

USER'S GUIDE



AlmaPlasma

SUMMARY

PASS

AlmaPlasma s.r.l.
together in the future!

SAFETY PRECAUTIONS

To prevent injury to the user or other people and property damage, this manual must be read completely and the following instructions must be followed closely before operating the *PASS* plasma source.

Meanings of symbols used in this manual are shown below:

- WARNING: this symbol indicates the possibility of death or serious injury
- CAUTION: this symbol indicates the possibility of injury or damage to property

- : STRICTLY PROHIBITED
- : BE SURE TO FOLLOW THE INSTRUCTIONS

WARNING

- Connect the power supply properly. Otherwise, it may cause electric shock or fire.
- Disconnect power supply in presence of strange smell and smoke. Otherwise, it may cause electric shock or fire.
- Do not use the system with wet hands. Otherwise, it may cause electric shock.
- Forbid the contact between liquid water and electrical parts. Otherwise, it may cause system damage or electric shock.
- Forbid the contact between the plasma source and heat sources. Otherwise, it may cause electric shock or fire.
- Do not damage the plasma source or use it inappropriately. Otherwise, it may cause electric shock or fire.
- Do not touch the plasma source while the high voltage generator is running. Otherwise, it may cause electric shock.
- Do not use flammable materials like gasoline, benzene, thinner, etc… near the plasma source except as differently described in this manual. Otherwise, it may cause fire or explosions.
- Do not modify the plasma source. Otherwise, it may cause system damage or electric shock.

CAUTION

- Before handling and operating the source, read the manual carefully.
- Use the plasma source in a ventilated environment. Make sure the ventilation system has already been turned on before operating. If the system is installed in a hermetic chamber, after operating the plasma source make sure that the chamber has been vented before opening it.
- Make sure that gas connections have been correctly fastened to avoid possible losses.
- Make sure to prevent condensation on the components of the plasma sources.
- Make sure that the plasma source has been placed firmly on holders.
- Make sure all electrical cables are correctly connected.
- Turn off the high voltage generator after use.
- Handle the plasma source carefully in order to avoid damaging it.
- Do not touch the plasma source when the high voltage generator is turned on.
- Do not use the plasma source in environmental conditions that are not allowed in this User's Guide.
- Do not use other operating conditions that are not specified in this User's Guide.
- Do not use the plasma source for other purposes that are not specified in the User's Guide.
- Do not use the plasma source if not correctly connected to an external compressed air system. Otherwise it may cause system damage.

INSTRUCTIONS GUIDE

✔ COMPONENTS

The *Large Area*-Surface Barrier Discharge (*PASS PLASMA SOURCE*) plasma system presents the following components:

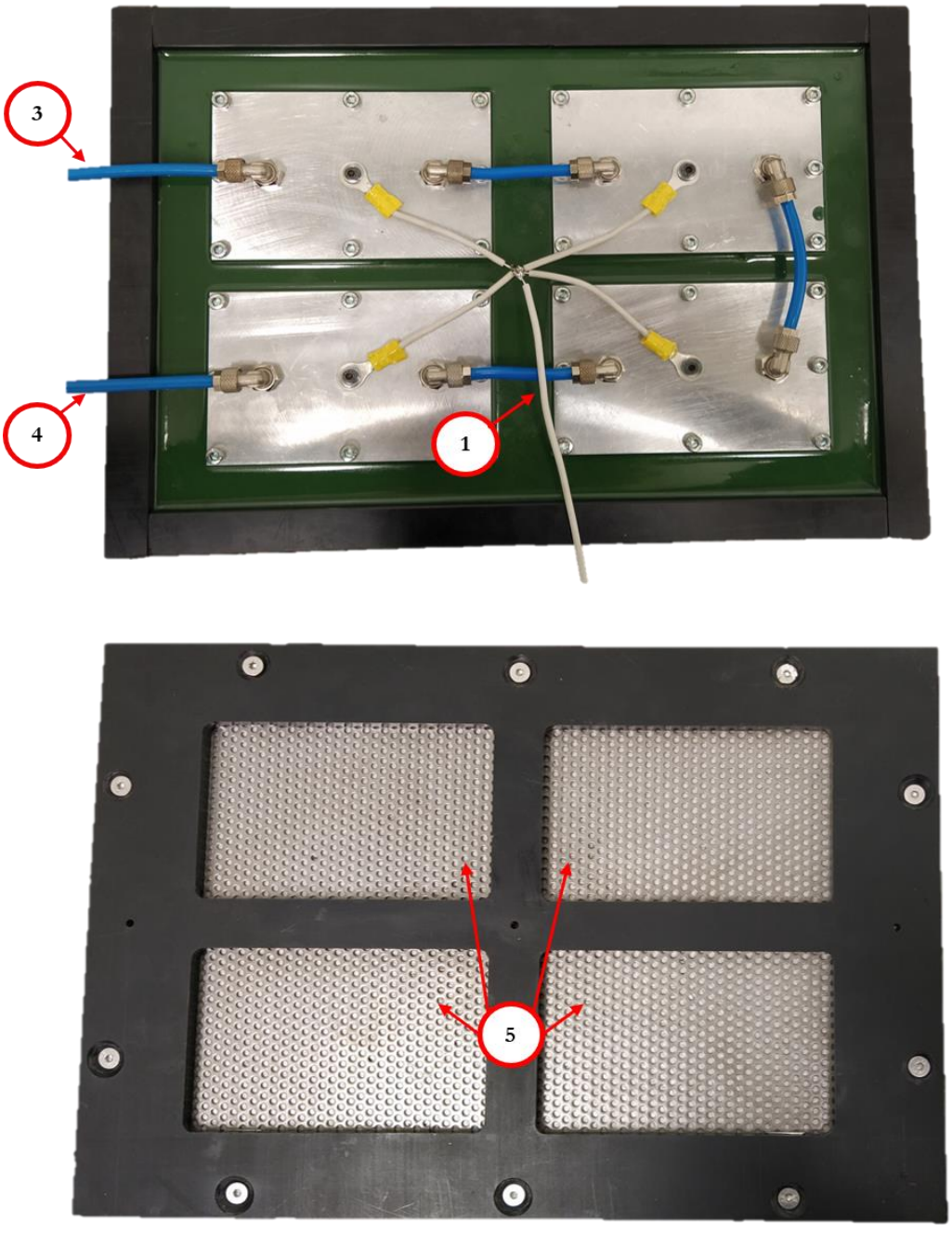


Figure 1: Views of the *PASS* plasma source

1. High voltage connections and high voltage cables;
2. Ground connections and ground cables;
3. Cooling liquid inlet;
4. Cooling liquid outlet;
5. Ground electrodes (metal meshes, x4) and dielectric barrier;

Plasma is generated on the surface of the ground electrodes. The source can be operated only using the Alma*PULSE* generator (by AlmaPlasma srl) and following the instructions here reported.

The *PASS PLASMA SOURCE* is expressly designed to produce reactive species at atmospheric pressure, in the temperature and relative humidity ranges of 5÷40°C and 0÷90 %, respectively. At high values of relative humidity, the operator must carefully prevent the insurgence of condensation on any component of the plasma source, since this may cause system damage or electrical shock.

The *PASS PLASMA SOURCE* has to be connected to the Alma*PULSE* generator through electrical connections provided by AlmaPlasma s.r.l. and to an external cooling system. The wiring has to be performed by AlmaPlasma s.r.l. during the *PASS PLASMA SOURCE*'s installation

✔ LIQUID-COOLING SYSTEM

The cooling system integrated in the *PASS plasma source* provides a flow of a liquid coolant through the HV electrodes. It can be turned on/off moving the switch on its back.

Fig. 2: Views of the cooling system and zoom on the on/off switch.

✔ OPERATION OF THE SOURCE

- CAUTION

- Before operating the *PASS plasma source* for the first time it is necessary to attend the initial training course provided by AlmaPlasma s.r.l.;
- Before operating the *PASS plasma source*, make sure that the electrical connection is correctly assembled;
- Before operating the *PASS plasma source*, make sure that the plasma source is correctly connected to an external cooling system.

For safely operating the plasma source, the following instructions have to be respected and operating conditions selected according to the chapter "Operating Conditions":

1. Place the source *PASS PLASMA SOURCE*on the box;
2. Make sure that the source is properly connected;
3. Turn on the liquid flow that supplies the liquid-cooling circuit integrated in the *PASS PLASMA SOURCE;*
4. Set on the Alma*PULSE* generator the operating conditions (within the allowed ranges);
5. Make sure nobody is in proximity of the *PASS PLASMA SOURCE*, the HV connection or the HV cable during operations;
6. Release the "emergency" button and press the "start" button on the Alma*PULSE* generator;
7. Make sure the plasma generation ended controlling the User Control Interface of the Alma*PULSE* generator;
8. Push the emergency button;
9. Leave the liquid flow to the integrated liquid-cooling circuit on for at least 3 minutes before starting the following test.

✔ CLEANING OF THE SOURCE

- CAUTION

- Protective clothes have to be used during this operation;
- Before starting the cleaning procedure of the *PASS PLASMA SOURCE*, make sure that the high voltage generator Alma*PULSE* is turned off;
- Don't use cleaning solutions different from the ones described below;
- Be sure to remove any trace of cleaning solution before the next use of the *PASS PLASMA SOURCE.*

For a safe cleaning of the source the following instructions have to be respect:

1. Use only the following solvents: pure ethanol, pure distilled water or a mixture of 30% water and 70% ethanol;
2. Clean the external surfaces of the *PASS PLASMA SOURCE* using the chosen solvent and a piece of paper or cloth, paying particular attention to not leave fragments on the stainless-steel mesh;
3. Use a compressed air gun (operating pressure 3 bar or less) to remove the residues of the solvent solution from the *PASS PLASMA SOURCE* within few minutes from the previous phase. Use compressed air and/or tweezers to remove any paper/cloth fragment that could have been left during the previous phase.

ALLOWED OPERATING CONDITIONS

- CAUTION

- If the *PASS PLASMA SOURCE* is used selecting different operating conditions with respect to the ones reported in this chapter, the *PASS PLASMA SOURCE* could incur into damages and could be dangerous for the other components of the setup and for the operators;
- If you want to use different operating conditions with respect to the ones reported in this chapter first you have to contact AlmaPlasma s.r.l. for a case by case evaluation; permission may not be granted, in the best interest for the safety of the operators and the equipment;
- After each treatment it is necessary to let the plasma source cool down; to do so, leave the air-cooling system turned on for at least 3 minutes.

The allowed operating conditions, tested in ambient air, are reported in the following table:

Voltage [kV]	Frequency [kHz]	Duty Cycle *	Treatment time [min]
15÷20	5	≤ 100 %	≤ 15
18÷20	10÷20	≤ 25 %	≤ 15
18÷20	10÷20	≤ 40 %	≤ 5
18÷20	20	≤ 60 %	≤ 1

Legenda:

* = The Alma*PULSE* generator can work either in continuous or discontinuous mode. In continuous mode, the generator is emitting the high voltage signal during the entire duration of the treatment; in the discontinuous mode, the generator is emitting the high voltage signal intermittently, alternating between emitting periods (T_{ON}) and shut off periods (T_{OFF}). These two parameters can be defined when setting the operating conditions (the magnitude of the values is ms). The Duty Cicle is defined as the ratio (percentage) between T_{ON} and the sum $T_{ON}+T_{OFF}$. When operating in continuous mode, the Duty Cycle is 100%, as T_{OFF} is set to 0. Lower Duty Cycles can be set in order to produce a less intense plasma discharge, limiting the power density during the treatment, without any risk of damage to the source. For certain values of Duty Cycle (too short T_{ON} times with respect to T_{OFF}) the plasma could possibly not ignite.

A set of possible operating conditions tested in ambient air and resulting in different power densities [W/cm^2] are reported in the following table:

Voltage [kV]	Frequency [kHz]	T_{ON} [ms]	T_{OFF} [ms]	Power density [W/cm^2]
18	5	/	/	0.07
20	20	2	6	0.09
20	20	2	3	0.14
20	20	3	2	0.23

These operating conditions were tested in ambient air (22°C, U.R. 50%). If different atmospheres or environmental conditions have to be employed these values could result different and they should be measured with the assistance of AlmaPlasma s.r.l.

If you want to test different values of power densities [W/cm^2] you have to contact AlmaPlasma s.r.l. for a case by case evaluation; permission may not be granted in the best interest for the safety of the operators and the equipment.