|  |
| --- |
| Hazard Control Plan |

Oxygen Gas Plasma Cleaner HCP – [Your Lab Name]

**TEMPLATE INSTRUCTIONS: Some sections will require more or less detail depending on your procedure. Send completed HCPs to ehrslaba@ehrs.upenn.edu for upload to your lab’s document section in BioRAFT. EHRS will review HCPs on your request; however, the supervising faculty member is responsible for ensuring that a thorough hazard assessment has been performed. Replace red text with your text in this template. Delete this message when submitting your HCP.**

# Purpose

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A Hazard Control Plan (HCP) is a standard operating procedure for a specific process performed in your laboratory or department. The HCP describes the hazardous materials or equipment in use and details the controls that will be put in place to minimize risk of exposure, injury, and other incidents. While the HCP may also include experimental procedures, its purpose is primarily to document the hazards and controls for the process. An HCP is typically written for procedures with particularly high hazards or when new hazards are introduced for the first time. A hazard assessment must be repeated, and the HCP amended whenever changes are made to the process.

Hazard Control Plan

Oxygen Gas Plasma Cleaner HCP – [Your Lab Name]

Date HCP Prepared: *[Date]*

HCP Prepared by:

|  |  |
| --- | --- |
| Name | *[Name]* |
| Position/title | *[Position/title]* |
| Email address | *[Email]* |
| Phone number | *[Phone number]* |
| Supervising Faculty Member | *[Faculty member’s name]* |
| Department | *[Department name]* |
| Contributors | *[Names]* |

Location of Process:

|  |  |
| --- | --- |
| Building | *[Building]* |
| Room number | *[Room]* |
| EHRS hood number (if applicable) | *[3-4 digit EHRS ID Hood Numbers]* |
| Other location information | *[Other location info, including storage, if applicable]* |

### References:

*[Insert literature or research notebook references for this procedure here. Specify which procedure in the* *paper is the one you will be following, e.g. “Method 3, page 1427”]*

*[Specify here if there are any parts of the procedure you will be modifying in your experiment, e.g. using a different solvent, a different substitution on a molecule, or different reaction conditions such as temp]*

*[Insert references/links to equipment manuals for any equipment you will be using in the procedure. We recommend uploading equipment manuals to your lab’s Documents section in BioRAFT and linking to that page for easy reference and access by lab members and EHRS.]*

# General Description

The plasma system is used to [clean, prepare, etc.] [substrates, samples, etc.] using oxygen plasma. A vacuum pump is used to reduce pressure in chamber to [number and unit], then O2 gas is introduced at a rate of [number and unit]. Power is then turned on to generate plasma and is run for [number and unit]. The power, vacuum, and O2 are then shut off, and the chamber is returned to atmospheric pressure.

# Scope and Limitations

This Hazard Control Plan applies to the equipment, chemicals, and tasks described herein. Any deviation in materials, pressures, temperatures, or other operational parameters specified in this HCP must be evaluated for new potential hazards and necessary controls before implementation of the changes.

**Describe any limitations in scope that are specific or important to this hazard control plan (if applicable).**

# Hazard Identification

The following chemical and physical hazards have been identified for this process/equipment. [put “x” in box next to hazards]

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Chemical** |  | **Physical/Other** |
|  | Carcinogens |  | Ionizing radiation |
|  | Corrosive Liquids |  | Radioactive materials |
|  | Perchloric Acid |  | Lasers |
|  | Engineered Nano Materials |  | UV light sources |
|  | Flammable Chemicals |  | Inert compressed gases |
| X | Hazardous Gas (Flammable, Oxidizing, Corrosive, Toxic) |  | Electrical Hazards |
|  | Highly Toxic Chemicals |  | Heavy material handling equipment |
|  | Irritants |  | Working at Heights (4 foot or higher) |
|  | Explosive compounds |  | High heat |
|  | Peroxide formers |  | Open Flame |
|  | Pyrophoric chemicals |  | Lithium Batteries |
| X | Strong Oxidizers |  | Noise hazards |
|  | Water Reactive Chemicals |  | Particulates from machines and operations |
|  | Cryogens and Dry Ice | X | Pressure and Vacuum vessels |
|  | Teratogens and/or reproductive hazards |  | Robotic Machinery |
|  | Exothermic reaction/Other chemical reactivity hazards |  | Shop equipment |
|  |  |  | Biological Hazards |
|  |  |  | Exposed blades, needles, etc. |
|  |  |  | Acute/Chronic Aquatic Hazard |
|  |  |  |  |

# Training Requirements

*Training beyond the standard EHRS lab safety training is required for hazardous lab processes. Hands-on training by a senior lab member experienced in the use of hazardous gases is required before new lab members can perform experiments with the oxygen plasma cleaner. All researchers conducting this experiment must read and understand the applicable SOPs and Fact Sheets in Penn’s Chemical Hygiene Plan.*

*After completing the training, the new lab member must obtain approval from the PI prior to commencing work. No researcher may work independently with the hazardous material described in this HCP until the Principal Investigator (or their designee) has ensured that the researcher:*

* *Has completed all required EHRS laboratory safety training programs.*
* *Understands the hazards of the materials and risks of the processes involved.*
* *Has read and understands the contents of the related SOP(s) and/or Fact Sheets on the hazard (available on* [*EHRS’s website*](https://ehrs.upenn.edu/policies-resources/chemical-hygiene-plan#paragraph-1016)*) and this task-specific Hazard Control Plan.*
* *Demonstrates the ability to execute their work according to the requirements in the related SOP(s) and/or Fact Sheets on the hazard (available on* [*EHRS’s website*](https://ehrs.upenn.edu/policies-resources/chemical-hygiene-plan#paragraph-1016)*) and this task-specific Hazard Control Plan*

# Tasks, Hazards, and Controls

Describe **each step of the procedure** that involves a hazardous material or procedure. **Replace the use of “should be/do” statements with “must be/do” statements as much as possible**; this reduces the risk of someone misinterpreting “should” statements as optional instructions.

(See Appendix B for an example task description)

***Hazard-Control Table Instructions: (Delete these instructions before submitting your draft)***

(See Appendix B at the end of this document for an example of a completed table)

* *Fill in the Hazard (e.g. Flammable Chemical, or Toxic Gas, etc.) in the top row.*
* *Enter the Risk (e.g. Fire, or Illness/Death due to inhalation).*
* *Enter the Risk Factors (e.g. For Fire: Strong oxidizers, open flames; For Illness/Death from inhalation: Leaks in tubing, inadequate post-reaction purge time).*
* *Define the likelihood and severity of the Risk.*
	+ ***See Appendix A at the end of this document for definitions of Risk likelihood and severity levels (High(H), Medium(M), and Low(L)).***
* *Fill-in any hazard controls that are in place or will be put in place. (You do not need to enter a control for each category.)*
	+ ***See Appendix B at the end of this document for an example of a completed Hazard Control Table.***
* *It is most efficient to group materials that have similar hazard controls in place, and/or quenching procedures. This way, the fewest number of tables must be written. (e.g. most flammable gases have the same controls, so it is best to create a “Flammable Gas” table).*
* *If a material has multiple hazards (e.g. Carbon Monoxide is toxic and flammable) and you have other materials that fit one or both hazards, writing tables for both hazards (e.g. “Toxic Gases” and “Flammable Gases”) is sufficient.*
* *If a material has multiple hazards (e.g. Carbon Monoxide is toxic and flammable) but no other materials fit one of the hazard types (e.g. Carbon Monoxide is your only toxic gas, you have other flammable gases), you may specify extra controls for that material in one hazard table, rather than writing another table (e.g. include “Use a handheld CO detector to detect leaks when working with CO” in your “Flammable Gases” table).*

***Duplicate the table as many times as is necessary for each hazard and risk of each step.***

1. **Setup Steps** (delete/edit what is not applicable)
2. Sign in on the log sheet.
3. Load samples into the instrument and lock the door to the sample chamber.
4. Power on the instrument.
5. Turn on the vacuum pump (and vacuum gauge). Wait for pressure readout to be [desired number and unit].

[Include Photos as applicable]

|  |
| --- |
| **Hazard: Low pressure (Vacuum Pump operation, maintenance), Potential for Combustibles** |
| **Risk** | **Likelihood** | **Severity** | **Risk Factors** |
| -Rapid release of vacuum-Incompatible mix of oxygen gas and combustible pump oil | L | M | -Reducing pressure too greatly for line/equipment.-Connectors/clamps on tubing becoming loose.-Puncturing the tubing.-Not using non-combustible vacuum pump-oil.[Enter any additional risk factors here – conditions or actions that would increase risk] |
| **Controls** |
| **Administrative [work practices]** | -Use of a log sheet to track how long the pump has been active.-The tightness and integrity of the connectors/hose clamps are evaluated using leak detecting solution every [frequency].-Routine maintenance of vacuum pumps per the schedule recommended by the pump manufacturer to ensure standard operation and adherence with Penn guidance on the use of vacuum pumps (see link below). -Detailed records of all pump maintenance including routine maintenance, pump-oil changes, and vendor-provided services will be kept in [indicate location(s)].-Vacuum pump-oil must be changed every [frequency].\*[Indicate any additional work practices taken to increase safety during this process.] |
| **Engineering** | -Tubing suitable for the low-pressure processed is used. -Non-combustible tubing is used to transport oxygen gas within the system.-Only oxygen-compatible pump oil is used; this is typically a perfluoropolyether oil.**-OR-**-An oil-free vacuum pump is used, negating the possibility of a fire borne of concentrated oxygen gas and combustible oil.[Indicate any additional engineering controls in place to increase safety during this process.] |
| **Personal Protective Equipment** | -Standard Lab PPE (gloves, safety glasses, 100% cotton lab coat)-Standard lab attire (long pants, close-toed shoes, etc.)[Indicate any additional PPE used to increase safety during this process.] |
| **Other mitigating factors****(inherent risk reduction)** |  |

**Link to Penn Chemical Hygiene Plan Fact Sheet for this hazard:**

[SOP: Hazardous and Highly Toxic Gases | https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/standard-operating-procedures/sop-hazardous-and](https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/standard-operating-procedures/sop-hazardous-and)

1. **Running the Chamber, Stopping the Experiment** (delete/edit what is not applicable)
2. Open the O2 tank valve, adjust and open the regulator valve, adjust and open mass flow controller (MFC) as necessary. Maintain an O2 flow rate of [number and unit].
3. Activate plasma generation; maintain power for / set operation to run for [number and unit].
	1. [Insert more specific steps on how to do this using your instrumentation].
4. Deactivate plasma generation/wait for automatic deactivation.
5. Close the O2 tank valve, the regulator valve, and the mass flow controller (MFC) as necessary.
6. Turn off the vacuum pump (and vacuum gauge).
7. Open the door to the sample chamber and retrieve your sample.
8. Sign out on the log sheet.

[Include Photos as applicable]

|  |
| --- |
| **Hazard: Oxygen Gas** |
| **Risk** | **Likelihood** | **Severity** | **Risk Factors** |
| -Incompatible mix of oxygen gas and combustible pump oil.-Fire intensified/started by leaking oxygen gas mixing with combustibles outside of the system. | L | M | -Opening the O2 valve without running the vacuum pump.-Leaving the O2 valve open after finishing the operation.[Enter risk factors here – conditions or actions that would increase risk] |
| **Controls** |
| **Administrative [work practices]** | -Any gas cylinders not in active use must be capped and closed at all times.-Training required from a senior lab member is required for all people using the equipment-O2 flow only introduced after vacuum pump is engaged and is shut off before vacuum pump is turned off-Store cylinders of oxygen gas at least 20 ft. away from combustible materials, including flammable gases.-The tightness and integrity of the connectors/hose clamps are evaluated using leak detecting solution every [frequency].-Other safety checks concerning the vacuum pump are performed (See above table).[Indicate any additional work practices taken to increase safety during this process.] |
| **Engineering** | -Flow of O2 into the plasma cleaner is restricted by the mass flow controller [set to allow up to # SCFH]. (remove if not applicable)-Use a regulator to dispense compressed gas; do not dispense directly from the gas cylinder.-Non-combustible tubing is used to transport oxygen gas within the system.-Gas cylinders of O2 must be secured to the wall or lab bench using chains/straps ~2/3 up the length of the cylinder. Use at least one chain per row of cylinders.-Only oxygen-compatible pump oil is used, negating the possibility of a fire borne of concentrated oxygen gas and combustible oil; this is typically a perfluoropolyether oil.**-OR-**-An oil-free vacuum pump is used, negating the possibility of a fire borne of concentrated oxygen gas and combustible oil.[Indicate any additional engineering controls in place to increase safety during this process.] |
| **Personal Protective Equipment** | -Standard Lab PPE (gloves, safety glasses, 100% cotton lab coat)-Standard lab attire (long pants, close-toed shoes, etc.)[Indicate any additional PPE used to increase safety during this process.] |
| **Other mitigating factors****(inherent risk reduction)** |  |

**Link to Penn Chemical Hygiene Plan SOP for this hazard:**

[SOP: Hazardous and Highly Toxic Gases | https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/standard-operating-procedures/sop-hazardous-and](https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/standard-operating-procedures/sop-hazardous-and)

**Other Considerations**

**(Not specified elsewhere in this HCP)**

**Equipment Manual Safety Warnings**

*[Equipment manuals often come with a “Safety” or “Safety Messages” section that summarizes the “to-dos” and “not-to-dos” regarding the equipment. If a safety manual is available for a piece of equipment used in the procedure specified in this HCP, locate the “Safety” or “Safety Messages” section and copy the contents to here.]*

**[Storage and Transport](https://ehrs.upenn.edu/policies-resources/chemical-hygiene-plan%22%20%5Cl%20%22paragraph-945)**

*O2 gas tanks are* *secured to the wall in [Room ###] using straps and a wall support.* *Only transport gas cylinders with a cylinder cart/dolly. Oxidizing gases must be stored at least 20ft away from any flammable materials or be separated from the flammable materials by a noncombustible wall, not less than five feet high, having a fire resistance rating of one hour.*

*[Identify specifically where and how any other hazardous materials will be stored and transported in your lab.]*

**[Waste Disposal](https://ehrs.upenn.edu/health-safety/regulated-waste/chemical-waste)**

*Gas cylinders can be returned to the vendor for disposal. If gas cylinders are/become non-returnable, they can be submitted for disposal by EHRS. [Include the following if pump oil is used:] Pump oil is collected in a primary waste container with a completed yellow waste tag attached and placed in a satellite accumulation area. It and other chemical waste can be submitted to EHRS’s EHS Technicians using the online form* [*here*](https://apps.ehrs.upenn.edu/secure/fm/COLLECTIONS/index.php)*.If you are concerned that a reagent bottle will deflagrate/detonate/etc. if moved for waste pickup, contact* *chem\_waste@lists.upenn.edu* *for advice.*

*[Indicate any other waste disposal practices for the waste generally produced by this process.]*

[**Building/Lab Specific Emergency Procedures**](https://ehrs.upenn.edu/emergency-info)

*[Indicate where the* ***nearest eyewash and safety shower*** *are located. Refresh the lab group on the* ***emergency phone numbers*** *and* ***evacuation procedures****. Include any special* ***emergency response or spill clean-up instructions*** *for this particular process.]*

*[****Consider “what-if” scenarios*** *- is there something external that could fail, such as loss of running water, loss of fume hood exhaust, etc. impact the safety of your operation? How would you respond if you were mid reaction, or could not easily get to your reaction to stop it? Provide a brief overview of some relevant scenario(s).]*

*During a fire emergency, the University of Pennsylvania’s Division of Public Safety – Fire and Emergency Services (FES) emphasizes safe evacuation as top priority. While evacuating, shut the fume hood sash (if applicable) and close doors behind you. Notify emergency services of the fire and its location by either of the following methods:*

* ***Pulling the nearest fire alarm manual pull station*** *while you evacuate the building, or*
* *If on the* ***Philadelphia campus,****calling* ***215-573-3333, or 511****from a campus phone.*
* *If at* ***New Bolton Center or Morris Arboretum & Gardens calling 911****.*

*Incipient fires with a* ***mundane*** *fuel source (e.g. pure flammable solvents, nonhazardous lab trash) may be fought to assist oneself or another to evacuate, or to control a small fire.* *In case of a small, incipient fire of this nature, a [specify class] fire extinguisher can be found in [location].* *Only fight such a fire if:*

* *You have received hands-on training at Penn on how to use a portable fire extinguisher.*
* *It is safe to do so, and the fire is not located between you and your exit.*
* *The fire is still contained to the original fuel source and has not begun to spread.*
* *You are not alone.*
* *The appropriate type of extinguisher is available.*

*Do not feel compelled to fight a fire if you are not comfortable doing so. Evacuation is always an acceptable option.*

*After notifying emergency services of a fire, please notify EHRS of the fire at* ***215-898-4453****.*

*In case of an incident which causes life-threatening or otherwise severe injury in need of immediate medical care call 215-573-3333 or 511 from a Penn campus phone. For injuries that are not immediately life-threatening, or are otherwise minor, rinse any contaminated areas in safety shower for at least 15 minutes, then seek treatment at one of the following locations:*

***Faculty and Staff:***

***Go to Occupational Medicine:*** *HUP RAVDIN 2nd floor, 34th & Spruce Streets*

*Hours: 8:30am - 3:30 pm
Phone: 215-662-2354*

*An appointment is not required for a new injury or exposure.*

***Go to Emergency Service at HUP or Penn Presbyterian after hours:***

*HUP:  Pavilion (1 Convention Avenue)*

*Penn Presbyterian: Myrin Building (51 N 39th St.)*

***Students:***

***Go to Student Wellness during hours:*** *3535 Market Street, Suite 100
215-746-3535*

***Go to Emergency Service at HUP or Penn Presbyterian after hours:***

*HUP:  Pavilion (1 Convention Avenue)*

*Penn Presbyterian: Myrin Building (51 N 39th St.)*

***Do not hesitate to call EHRS for assistance with compressed gas leaks, spills, or exposure concerns. 24-hour EHRS on-call phone number: 215-898-4453***

***Contact Penn Police (511 from a Penn campus phone or 215-573-3333) if there is a fire, imminent risk of fire, an injury requiring an ambulance, or if there is a hazard that may affect others in the building.***

Optional attachments:

* Safety Data Sheets
* Operation Manuals for Equipment
* Experimental Procedure
* List of Individuals Trained and Authorized on this Procedure

**Appendix A: Definitions of Risk Likelihood and Severity Level**

**Likelihood**

**-------------------------------------------------------------------------**

**Low:**

To the best of your knowledge, this has not happened in the past with the same or similar equipment/material/location.

*And*

This would not be expected to occur under normal operating conditions.

*And*

This would only be expected to occur in the event of a rare upset condition.

**-------------------------------------------------------------------------**

**Medium:**

To the best of your knowledge, this has not happened in the past with the same or similar equipment/material/location.

*And*

This would not be expected to occur under normal operating conditions.

*And*

This would be expected to occur under reasonably anticipated upset conditions.

**-------------------------------------------------------------------------**

**High:**

This is known to have happened in the past with the same or similar equipment/material/location.

*And/or*

This could occur under normal operating conditions.

*And/or*

This could occur under reasonably anticipated upset conditions.

**-------------------------------------------------------------------------**

**Severity**

**-------------------------------------------------------------------------**

**Low:**

This would not cause an injury or exposure that would require medical evaluation or treatment.

*And*

No permanent damage to equipment or facility would result.

*And*

Damage would not result in downtime of more than a few hours.

 **-------------------------------------------------------------------------**

**Medium:**

Injuries or exposures would not exceed first-aid level treatment and would not result in any lost work days due to injury.

*And/or*

Minor equipment or facility damage would result.

*And/or*

Damage would result in downtime of a few hours or more.

*And/or*

A hazardous material spill clean-up would need to be done by the lab.

 **-------------------------------------------------------------------------**

**High:**

Injuries or exposures would require medical treatment beyond first-aid and/or would result in lost work days due to injury.

*And/or*

Serious equipment or facility damage would result.

*And/or*

Damage to the facility would be beyond the lab/room of origin.

*And/or*

Damage would result in more than one day of downtime.

*And/or*

External hazmat team required for hazardous material spill clean-up.

**----------------------------------------------------------------------------**

# Appendix B: EXAMPLE TASK/HAZARDS/RISKS/CONTROLS

1. **Diluting hydrofluoric acid**

Hydrofluoric acid (49%) is poured from a 500-mL bottle through a plastic funnel into a 25-mL plastic graduated cylinder to the 11-mL mark. Any excess acid that was dispensed is poured from the graduated cylinder back into the bottle. The 11-mL of hydrofluoric acid are then poured into a 250-mL plastic beaker containing 50 mL of D.I. water.

Photo of Equipment/Process if available

(See Example Hazard-Control Table on Next Page)

 EXAMPLE HAZARD-CONTROL TABLE

|  |
| --- |
| **Hazard: Highly toxic and corrosive chemical (Hydrofluoric acid)** |
| **Risk** | **Likelihood** | **Severity** | **Risk Factors** |
| Serious burns to eyes or skin from hydrofluoric acid exposure | M | H | Chemical spill/splashPoor housekeeping practices/contaminated surfacesUsing funnels/vessels made of material incompatible with HF. |
| **Controls** |
| **Administrative [work practices]** | -Label the area where HF is stored and used; a warning sign labelled “Hydrofluoric Acid Use in This Area” must be hung on the work space to alert other group members.-Do not work with HF when alone in lab. Notify lab mates before working with HF.-Use an appropriately sized funnel for the size of the graduated cylinder.-Close HF bottle immediately after pouring chemical. Do not leave the bottle open.-Wipe the outside of the bottle with a damp paper towel after use.  -Clean up all spills immediately. Ensure that no puddles or droplets are on the work surface when done.-Immediately remove gloves if they become contaminated. -As soon as possible after completing task, remove gloves and wash your hands.-Thoroughly rinse all labware immediately after use.-Do not perform any other procedures in the fume hood until all HF work is complete, the waste has been collected, and equipment and materials have been cleaned, properly discarded, or removed from the area. |
| **Engineering** | -Conduct this task only inside of a designated, functioning chemical fume hood (####).-Use the chemical fume hood sash as a barrier to shield your face and as much of your body as possible while performing this task.-Use a metal clamp to secure the graduated cylinder from tipping during pour. |
| **Personal Protective Equipment** | -Standard lab attire (long pants, fully-enclosed shoes) and:* Single 8-mil-thickness nitrile gloves, 100% cotton lab coat, an HF-resistant lab apron, and safety goggles must be worn properly **at minimum** when conducting the reaction.
* EHRS also strongly recommends working with a face shield, HF-resistant gloves, and HF-resistant arm sleeves (if not already a part of the glove) for all work with HF.
* Neoprene is a common HF-resistant material for PPE, but always check with the manufacturer for HF resistance before purchasing.
 |
| **Other mitigating factors****(inherent risk reduction)** | -An HF exposure kit with non-expired calcium gluconate gel is available in the lab near fume hood #### where HF is stored and used. -Training is provided to all lab workers on the location and use of the kit.-The lab will routinely check the expiration date of the calcium gluconate in the exposure kit and will replace the tube as needed. |

**Link to Penn Chemical Hygiene Plan SOP for this hazard:**

[Fact Sheet: Hydrofluoric Acid|https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/fact-sheets/fact-sheet-hydrofluoric-acid](https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/fact-sheets/fact-sheet-hydrofluoric-acid)