Operational Safety Procedure
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Author(s): Marcy Stutzman		
Risk classification (See EH&S Manual Chapter 3210.)	**Without mitigation measures:**	4
	With specified measures implemented:	1

	Supplemental Technical Validations:	
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Electrical: ion pumps power supplies, NEG activation, tack welder	Todd Kujawa	2/24/2010
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Copies to: affected area, authors, Division EH&S Officer, EH&S Reporting Manager
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TABLE OF CONTENTS

1. Purpose

This document is designed to cover routine operations of the experimental equipment in room 118, EEL building. Work in the room involves vacuum and photocathode research, and this document is intended to address hazards and mitigations not specifically addressed in equipment SOPs for the room.

2. Scope

This SOP covers the hazards common to many of the systems used in the room, including the nitrogen gas plumbed into the room, low powered class 3a lasers used for photocathode characterization, current supplies used for activating non-evaporable getter (NEG) pumps, and proper handling of ion pump high voltage supplies. Other equipment used in the room may involve additional SOPs and training for that specific equipment.

3. References

1. JLab EH&S Manual Chapter 6110, Lock Tag and Try Policy
2. JLab EH&S Manual Chapter 6230, Electronic Equipment Safe Work Policy
3. JLab EH&S Manual Chapter 3510, Emergency Management
4. ODH Assessment Tech Note: JLAB-TN-07-080

4. Overview

4.1. Facility/System Description

Room 118 EEL is a multipurpose room used by the members of Jefferson Lab's Center for Injectors and Sources and guests working with the group for research, development and assembly of vacuum equipment, photocathode handling and characterization. The room has several vacuum chambers pumped with a combination of NEG and ion pumps, and low powered lasers are routinely used to study photoemission from photocathodes. Several systems in the room have individual SOPs, including but not limited to the micro-Mott retarding field polarimeter and the NEG pump sputtering stand.

4.2. Configuration Management

New equipment being used in the room will be assessed by the room safety warden in consultation with the principle investigators using the new equipment to discuss hazards and determine if additional task hazard analyses, procedures or SOPs are required.

5. Staffing

5.1. Responsibility and Authority

The group leader for the Center for Injectors and Sources is responsible for authorizing users of the laboratory facilities in EEL 118. Each user of the room is responsible for following safety protocols and understanding safe operation of the equipment before beginning work.

5.2. Training and Qualifications

All workers in EEL 118 need training on this SOP and training for ODH hazards (SAF 103), Lock Tag and Try (SAF 104) and Electrical Safety (SAF603A) or trained escort. Workers using lasers need Laser Safety training (SAF114). Operation of equipment in EEL 118 that is covered by other SOPs requires the user to be trained on that equipment SOP.

6. Safety Systems and Equipment

EEL 118 has an eyewash station just outside the door which is inspected weekly by the safety warden and should be used in the event of an emergency involving chemical eye exposure.

First aid supplies are located either in the machine shop or in the high bay area at the door nearest CEBAF center.

An automated external defibrillator (AED) is located in the high-bay area just through the double doors.

EEL 118 has safety lighting, tested weekly and documented monthly by the room safety warden.

A fire extinguisher is located just inside the lab door and is inspected monthly by the safety warden.

Pressurized nitrogen from the liquid nitrogen dewar outside the test lab is supplied through copper tubing. A solenoid interlock (installed October 2009) is designed to shut off nitrogen supply to the room when ventilation to the room is lost, thus preventing the possibility of the room becoming oxygen deficient. The solenoid valve is located in the Test Lab (Bldg 58) high bay outside Room 117. ODH evaluation of room 118 EEL is detailed in JLAB-TN-07-080.

7. Procedures

7.1. Operating Procedures

7.1.1. Ion pump power supply handling

Ion pumps are energized with power supplies that use up to 7 kV or currents up to 100 mA.

ELECTRICAL SAFETY NOTES

- The power supplies, operated only with all covers in place and no exposed live conductors, are connected to the pumps using cables terminated in 10kV rated SHV connectors.

- The SHV (safe high voltage) connector used on these ion pumps is a 10kV rated SHV connector. The connector uses a bayonet mount similar to those of the BNC, but with a long insulator that maintains contact with ground after the high voltage connection is disconnected.

- This insulation geometry makes SHV connectors safe for handling high voltage by preventing accidental contact with the live conductor in an unmated connector or plug. The connector is also designed such that when it is being disconnected from a plug, the high voltage contact is broken before the ground contact, to prevent accidental shocks.

- The capacitive charge that can be stored in a cable that is disconnected from a power supply while energized is less than 10 Joules. Equipment with a stored charge of less than 10 Joules is categorized as Class 1, which can cause a shock if the person is able to access the conductor deep within the SHV connector or inside the Kings connector, but is not a threat for respiratory paralysis or heart fibrillation as the stored charge is quite small. (A 50ft cable on a pump at 7kV would then give us .012 Joules using $E=1/2*V^2*C$. At this level the hazard is primarily from reaction to shock (falling off a ladder, etc.))

The cable termination at the pump is either the same style 10 kV SHV connector where the conductor as the supply connection where cannot be accessed or an older style “Kings” connector. The conductor in the large diameter Kings connector is preferable from a vacuum and bake standpoint. Its conductor is recessed approximately 1 inch deep in a ~0.5 inch diameter insulator, making it unlikely that the conductor would be inadvertently touched while handling the cable.

- The ion pump power supplies do not exceed voltages of 7 kV, thus no x-ray radiation hazards are presented by routine operation of the ion pumps.
- Hazards are mitigated through administrative controls: Training on this SOP and the following LT&T procedure:

PROCEDURE for connecting and disconnection ion pumps from power supplies:

To avoid the possibility of exposed live conductors, the cable must always be disconnected at the power supply before disconnecting at the pump, particularly on the cables with the older “Kings” connectors.

To disconnect an ion pump from a power supply,

1. Disconnect the cable at the 10 kV connector from the back of the ion pump supply. This can be done with the power supply on or off.
2. With the disconnected cable in the worker’s control (Lock Tag and Try compliant), the cable can be disconnected from the pump as needed.

To connect an ion pump to a power supply

1. Connect the cable at the pump end of the cable, with the other end of the cable in your control to ensure that the cable is not energized.
2. Connect the cable to the ion pump power supply with the 10 kV SHV connector.

If you need to repair a cable and must make contact with the conductor, make sure to short the conductor to ground using an insulated tool before touching the conductor with your hands.

Qualifications for this task:

- Lock, Tag and Try (SAF 104)
- Electrical Safety (SAF603A)
- Equipment specific LT&T through this SOP

7.1.2. NEG pump activation

NEG pumps are activated by resistive heating, with transformer supplies used to achieve currents up to 40A. The voltage provided by the transformer is 24V, making this a class 1 system. Work is done only in mode 1, with power disconnected before manipulating current leads, so a qualified worker may work on the system alone.

PROCEDURE for using the source group red toolbox transformer boxes to activate NEG pumps.

1. With the transformer box unplugged (and in control of the qualified worker), connect the current lead securely to the NEG activation vacuum feedthrough and shield the lead (typically slide a shrink-wrap insulating cover over the assembly)
2. Connect the ground lead securely to the appropriate location: the second terminal of a cartridge pump, or securely to the chamber when NEG modules use the chamber wall as the ground connection.
3. Attach the clamp-on current meter to one current lead.
4. Plug in the current supply.
5. Turn up current, monitoring vacuum during the process. Current requirements for various NEG are detailed at http://www.jlab.org/accel/inj_group/vacuum/vacuum.html Take care to avoid any surfaces that become hot during NEG activation.
6. When finished, turn down the current to zero and unplug the unit.
7. Monitor that current drops to zero on the current meter
8. Disconnect current leads, once hot surfaces are cool enough to handle.

Training requirements:
Lock, tag and try (SAF104)
Electrical safety (SAF603A)

7.1.3. Tweezer welding

The tweezer welder used in EEL 118 is an Aidlin DC80-C commercial tweezer welder with TW-110A Pliers, which can provide 250 Watt.sec. stored energy/3kVA (high current, very low voltage) to make spot welds in metal foils for vacuum connections. This device operates on 110V line power, with a three prong plug to ensure proper case grounding.

PPE required

- Safety glasses
- lint-free cotton glove for hand holding tweezer weld grip (cotton gloves won't burn with these small sparks, and avoid possibility of melted plastic gloves)

Welding area requirements

- Place welder on lab bench in clear area with no flammable materials (kim-wipes, solvents, etc.) within two feet of work area
- Make sure surface for welder is dry

PROCEDURE for tweezer-welding

- Place welder on bench with all flammables within 2 feet removed
- Put on safety glasses and a lint-free cotton glove to squeeze the tweezer welder
- Plug in unit, and turn on
- DO NOT PUT FINGERS IN TWEEZER GRIP
- Using vacuum compatible vinyl glove to handle vacuum parts, arrange materials to be welded and grip with tweezer (cotton glove on that hand) and move hand away
- Squeeze tweezer welder to weld, readjust and move tweezers to several adjancent spots if a more secure weld is required, moving hand away from part each time
- Part may be slightly warm – use care to make sure it is cool before touching
- Turn off welder, unplug and store under bench

7.1.4. Chamber backfilling with dry nitrogen

Vacuum chambers are routinely back-filled with nitrogen gas which has evaporated from the liquid nitrogen tank outside the test lab. To avoid over-pressurizing the chambers, systems are only to be backfilled with a pressure-relief valve in the system.

Vent systems using one of the following:

1. The rough pump cart, with a pressure-relief valve at the nitrogen inlet
2. One of the dedicated vent-valves with pressure relief (Quick-flange with vent valve on a tee at the nitrogen inlet)
3. Directly with a nitrogen line from one of the spigots in the EEL lab equipped with a green pressure-relief valve at the wall.

All of these systems have a maximum of 1 psi, mitigating the possibility of pressurizing the chambers to dangerous pressures.

7.1.5. Parts cleaning

Small parts are routinely cleaned for use in ultra-high vacuum systems in the EEL lab.

- Safety glasses must be used for small quantities of solvents in squirt bottles
- Safety goggles with closed sides must be used when pouring solvents from 4L bottles.

Typical cleaning procedure:

1. Degrease first in mixture of “Micro-clean” and DI water
    - Ultrasonic cleaner can be used for agitation

- DO NOT USE Micro-clean on Aluminum – it will etch surface. See Phil Adderley for aluminum cleaning procedure.

2. Rinse several times with DI water, using ultrasonic cleaner
3. Rinse with acetone (stored in flammables cabinet)
    - DO NOT USE ultrasonic cleaner with solvents
    - Only latex or neoprene gloves compatible with acetone work
    - Pour used acetone into the "used acetone" container and return to flammables cabinet
4. Rinse with methanol (stored in flammables cabinet)
    - DO NOT USE ultrasonic cleaner with solvents
    - Only nitrile, neoprene or latex gloves compatible with methanol work
    - Used methanol poured into "used methanol" container and return to flammables cabinet
5. Finish with a DI water rinse and blow dry with nitrogen if desired.

Note: if chemically acceptable gloves are not sufficiently clean for a process, clean gloves may be worn over the appropriate chemically resistant gloves. Vinyl cleanroom gloves may be worn over gloves resistant to methanol and isopropyl alcohol, and poly or nitrile gloves can be worn over acetone resistant gloves to avoid contamination of UHV parts while wearing latex or neoprene gloves.

7.1.6. Photocathode activation

Photocathodes are activated using a combination of Cs (or other alkali metals) dispensed through SAES dispenser strips resistively heated, and application of an oxidant (O_2, NF_3,or possibly NO) through a leak valve into the vacuum system.

The alkali metals are resistively heated by passing currents from 4-7A through the source using a commercial power supply depending on the specifications of the alkali metal. Commercial current supplies, typically with maximum output of 15V/7A or 30V/4A, are used to resistively heat the alkali metal dispenser. This is a class 1 system, and all manipulation of electrical leads is done in mode 1.

- First, connect leads to the vacuum feedthroughs to the alkali metal dispenser and insulate exposed electrodes (either screws on barrel connectors or securely fitting slide on connectors).
- With power supply turned off, connect the current leads to the power supply.
- Turn the power supply to zero current, and energize the supply.
- Turn the current up to operating value, making sure to raise the voltage knob enough to supply the required current.
- Before disconnecting current leads, turn the supply off.

Store used strips in labeled bag and when needed, give to the ESH&Q department for disposal: alkali metals and their alloys are quite reactive and should not be disposed in a way that might contaminate groundwater according to the manufacturer's MSDS sheet.

The oxidants are loaded behind the leak valve to pressures ~5 psi.

- Attach the rough pump to the leak valve and gas bottle using appropriately configured flex lines and fittings.
- Pump and backfill the rough pump line with nitrogen gas three times.
- Pump and backfill the oxidant reservoir behind the leak valve three times with nitrogen.
- Pressurize regulator with oxidant then close main valve of the oxidant gas tank.
- Fill smallest possible segment of tubing with oxidant to a pressure, typically 3 psi, close regulator valve, and pump out reservoir and gas lines.
- Fill same small segment of tubing to desired fill pressure, typically 3-5 psi, close reservoir valve, close regulator valve, and pump away remaining oxidant.

When using NF_3, the typical quantity of gas released into the room is equivalent to approximately 2×10^{-5} ppm. OSHA TWA limits for 8 hour exposure are 10 ppm. We are three orders of magnitude below this limit.

7.1.7. Laser usage

Class 3a lasers at wavelength from 760-860 nm are used in EEL 118 for photocathode research.

To use these lasers:

- Laser safety training (SAF114) is required.
- You must understand procedures for operating these lasers safely.
  - Do not combine beams.
  - Do not look directly into beam.
  - Do not view with optically-aided devices (telescopes, magnifiers).
  - Control reflections.
- Beams can be viewed using an IR viewer or IR sensitive cards as needed during alignment.
- Lasers at higher powers than the class 3a limit of 5 mW in this wavelength range or at different wavelengths require additional safety controls and are not covered under this SOP.

7.2. Emergency procedures

In the event of spill, fire, or injury, all responders should follow the emergency response procedures found in EH&S Manual or on the "Yellow Cards" attached to the telephone.

In the event of the release of an unusually large volume of NF_3 into the air (for example the whole bottle vents into the room), have everyone in the room leave for fresh air, and contact ESH&Q department to determine when the room is safe to resume work.

In the event of power outage, secure equipment and leave the room: temporary emergency lighting is sufficient to assist in leaving the area. The solenoid will shut off the nitrogen gas supply. Consider shutting down computers and making sure any pumps that have vented are in appropriate states before leaving.

7.3. Maintenance Procedures

EEL 118 safety warden is responsible for maintaining the safety systems in EEL 118 and keeping a log of maintenance activities. No routine maintenance is required for the equipment in the room.

Table 8.1 Maintenance Schedule

Category	Task	Frequency
nitrogen gas interlock check	Trigger test on interlock, verify GN_2 shutoff	annually
Eyewash maintenance	Verify eyewash flow and note on inspection card	weekly
Emergency lighting check	Check the emergency lighting Record inspection	weekly monthly
Fire Extinguisher	Check and note on inspection card	Monthly

Appendix A. Hazard Analysis and Controls

Hazards associated with EEL 118 include:
These hazards, their causes, and mitigation are discussed in the following tables.

Table A-1

Cause	Hazard	Administrative and PPE Controls	Engineering Controls	Unmitigated Risk Code	Mitigated Risk Code
Ion pump power supplies have voltage up to 7 kV and currents typically microamps but supply capable of over 30 mA	Electric Shock	Conductors at high voltage are not exposed at any time during typical ion pump operation, including connecting and disconnecting pumps from power supply while energized. Relevant Lock, Tag and Try protocol qualified worker will disconnect ion pump power cable from supply and have control of cable end (either visual or locked out with a danger tag) before disconnecting the cable from the pump.	10 kV (SHV) connectors are used at the ion pump supply. These connectors maintain contact with ground after the HV connection is broken, avoiding any possible exposure of the high voltage conductor, and thus can be unplugged during operation without hazard	3	1
Residual charge in ion pump cables after disconnection	Electric shock	Do not touch conductor on HV cables, even if disconnected (design of connectors makes incidental contact unlikely). Qualified electronics technicians must discharge any residual charge in cable before working on cables.	10 kV SHV connectors and older large diameter ceramic connectors have conductors deeply recessed.	1	0

Table A-2

Cause	Hazard	Administrative and PPE Controls	Engineering Controls	Unmitigated Risk Code	Mitigated Risk Code
Class 3a laser beam: direct or specular reflection into eyes.	Eye injury from misuse	• Laser safety training (SAF114) is required. • Do not combine beams. • Do not look directly into beam. • Do not view with optically-aided devices (telescopes, magnifiers). • Control reflections. • Beams can be viewed using an IR viewer or IR	None	2	1

		sensitive cards as needed during alignment.			

Table A-3

Cause	Hazard	Administrative and PPE Controls	Engineering Controls	Unmitigated Risk Code	Mitigated Risk Code
Inadequate ventilation during N_2 purge or supply line leak.	Oxygen deficiency hazard * Refer to ODH Assessment: Tech Note JLAB-TN-07-080	Annual test of interlock function.	Orifice in the supply line limits the available N_2 flow rate. Solenoid interlocked to air handling unit will shut off nitrogen gas supply to the room when the air handler is not functioning	4	1

Table A-4

Cause	Hazard	Administrative and PPE Controls	Engineering Controls	Unmitigated Risk Code	Mitigated Risk Code
Solvents used to clean parts	Exposure to solvents are skin, eye, inhalant irritants	Avoid eye exposure through using safety glasses for squirt bottle quantities, goggles when using 4L bottles. Eye wash available outside room. Use gloves appropriate to the particular solvent. Methanol and isopropyl: latex, nitrile, neoprene; Acetone: latex or neoprene only.		2	1
	Explosion hazard from solvent fumes in the ultrasonic cleaner	Ultrasonic cleaner is to be used only with non-volatile cleaners, such as Micro detergent and deionized water. Do not use ultrasonic cleaner when solvents are being used on the same lab bench.		2	1

Table A-5

Cause	Hazard	Administrative and PPE Controls	Engineering Controls	Unmitigated Risk Code	Mitigated Risk Code
SAES alkali dispenser strips chemical composition	Environmental hazard (potential water	Do not throw used SAES alkali dispenser strips in the trash can – turn in to		2	1

	contamination) from improper disposal	EHS&Q division for proper chemical waste disposal			

All workers in EEL 118 shall sign below to indicate that they have read, understand, and agree to perform work according to the SOP.

Acknowledgement of Understanding of SOP

I acknowledge that I have read, understand, and agree to comply with the requirements of the current SOP for EEL 118.

Note
Your review and signature will be required again whenever revisions to the document are published. Please fill in the SOP number, and if applicable, revision level from the cover of the SOP that you have reviewed.

SOP No. and Rev.	**Printed Name**	**Signature**	**Date**