Person: Kumar, Onish (okumar@jlab.org)
Org: EESDCP

Status: PROCESSED
Saved: 11/6/2018 2:18:59 PM
Submitted: 11/6/2018 2:18:59 PM

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Operational Safety Procedure Review and Approval Form # 78689
(See ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure for Instructions)

Type:	***OSP*** Click for OSP/TOSP Procedure Form Click for LOSP Procedure Form		
Serial Number:	***ENG-19-78689-OSP***		
Issue Date:	***1/9/2019***		
Expiration Date:	***11/9/2021***		
Title:	***Testing and Adjusting Power supplies while Energized***		
Location: (where work is being performed) Building Floor Plans	***55 - Technology & Engineering Development - 1521*** ***55 - Technology & Engineering Development - 1522*** ***36 - General Purpose Building - 101***	Location Detail: (specifics about where in the selected location(s) the work is being performed)	***All locations where power supplies operated by EES DC Power are installed. DC Power Labs and Test Stands***

Risk Classification: (See ES&H Manual Chapter 3210 Appendix T3 Risk Code Assignment)	Without mitigation measures (3 or 4):	***4***
	With mitigation measures in place (N, 1, or 2):	***2***

Reason:	This document is written to mitigate hazard issues that are : ***Determined to have an unmitigated Risk code of 3 or 4***
Owning Organization:	***EESDCP***
Document Owner(s):	***Kumar, Onish (okumar@jlab.org)*** Primary ***Coleman, James (colemanj@jlab.org)***

Supplemental Technical Validations

Lock, Tag, Try (Paul Powers, Todd Kujawa)

Other Hazards:
Electrical Safety (Todd Kujawa)
Shock Hazards (Rick Nelson)
High Power Electronics (Andrew Kimber)

Document History

Revision	Reason for revision or update	Serial number of superseded document
3	***Document owner names were updated***	***ENG-16-62550-OSP***

Lessons Learned	Lessons Learned relating to the hazard issues noted above have been reviewed.
Comments for reviewers/approvers:	***Changed the Rev from 3.1 to 3.1a, In REV 3.1 accidentally uploaded the wrong file, the issue has been correct in this current revision.***

Attachments

Procedure: ***3310T1Form OSP DC Power Rev3.1a.pdf***

THA: ***THA form OSP for DC Power Rev1.pdf***

Additional Files:

Review Signatures

Person : Subject Matter Expert : Electrical Safety	**Signed** on 11/13/2018 9:13:30 AM by Todd Kujawa (kujawa@jlab.org)
Person : Subject Matter Expert : High Power Electronics	**Signed** on 11/21/2018 2:33:41 PM by Andrew Kimber (kimber@jlab.org)
Person : Subject Matter Expert : Shock Hazards	**Signed** on 11/14/2018 5:31:49 PM by Rick Nelson (nelson@jlab.org)
Subject Matter Expert : Lock-> Tag-> Try	**Signed** on 11/13/2018 9:13:37 AM by Todd Kujawa (kujawa@jlab.org)

Approval Signatures

Division Safety Officer : EESDCP	**Signed** on 12/18/2018 4:14:33 PM by Will Oren (oren@jlab.org)
Org Manager : EESDCP	**Signed** on 11/26/2018 2:54:37 PM by Sarin Philip (philip@jlab.org)
Safety Warden : General Purpose Building - 101	**Signed** on 1/9/2019 1:48:53 PM by Jason Delk (delk@jlab.org)
Safety Warden : Technology & Engineering Development - 1521	**Signed** on 11/26/2018 6:50:50 AM by Barry Shinault (shinault@jlab.org)
Safety Warden : Technology & Engineering Development - 1522	**Signed** on 11/26/2018 6:50:51 AM by Barry Shinault (shinault@jlab.org)

fa

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Operational Safety Procedure Form

(See ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure for instructions.)

Click

DEFINE THE SCOPE OF WORK

Title:	**Testing and Adjusting Power Supplies while Energized**		
Location:	All Locations where Power Supplies operated by EES DC power group are installed, EESDC Power Work Labs and Test Stands	**Type:**	[x] **OSP** [ ] **TOSP**
Risk Classification (per Task Hazard Analysis attached) (See *ESH&Q Manual Chapter 3210 Appendix T3 Risk Code Assignment*.)		**Highest Risk Code Before Mitigation (3 or 4):**	4
		Highest Risk Code after Mitigation (N, 1, or 2):	2
Document Owner(s):	Onish Kumar, Jim Coleman	**Date:**	November 2nd, 2018

Document History (Optional)

Revision:	Reason for revision or update:	Serial number of superseded document
3	Adding 2015 NFPA70E Standards	

ANALYZE THE HAZARDS

1. Purpose of the Procedure – Describe in detail the reason for the procedure (what is being done and why).

To provide guidelines for operating and testing Power Supplies while energized. Guidelines include recognizing hazards, implementing mitigations, choosing proper PPE and following safe work standards.

2. Scope – include all operations, people, and/or areas that the procedure will affect.

Testing and measurement of DC power supplies including Mode 1 and Mode 2 work on Class 2 or Class 3 equipment. Safety guidelines to follow while operating and testing power supplies

3. Description of the Facility – include floor plans and layout of a typical experiment or operation.

Typical operation will be power supplies in designated operational or Test areas with properly assigned clearance areas. Typical areas for testing by type as follows:

1. Box Power Supplies: Service Buildings, Box supply Test Area
2. 10 Amp Trim Cards: Bench Testing in DC Power Lab, Trim Racks in DC Power Lab
3. 20 Amp Trim Supplies: Bench Testing or Test Rack in DC Power Labs.
4. Bulk Supplies: Test Stand in Lab, Test Rack in DC Power Lab
5. Shunt Module: Test stand in Lab, YA style test stand, Shunt communication setup
6. Hi-pot Test Station

4. Authority and Responsibility:

4.1 Who has authority to implement/terminate

Head of DC Power Group or Electrical Engineering System (EES) Group Leader

4.2 Who is responsible for key tasks

Senior Test Personnel for the system as determined by the Head of the DC Power Group and Electrical Engineering Group Leader

4.3 Who analyzes the special or unusual hazards (See ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure)

Senior Test Persons leading the tests are responsible for analyzing the hazards

4.4 What are the Training Requirements (See http://www.jlab.org/div_dept/train/poc.pdf)

1. SAF 104 LT&T training
2. Equipment specific LT&T training
3. Equipment specific training and qualification
4. SAF 603A Electrical Worker qualification
5. SAF105 CPR & AED training
6. SAF603N - NFPA70E training.

5. Personal and Environmental Hazard Controls Including:

5.1 Shielding

Barriers and covers to prevent inadvertent contact with live electrical equipment. Barriers and covers to protect against SHOCK & ARC flash hazards.

5.2 Interlocks

Door Interlocks, Temperature Interlocks, Load Interlocks, Water Flow Interlocks, Ground Fault Interlocks have to be working during tests. PSS/MPS interlocks will be maintained on power supplies being tested while connected to the accelerator components.

5.3 Monitoring systems

Fire protection systems are installed in most test areas

5.4 Ventilation

High power testing must be conducted in spaces with adequate air conditioning for operating power supplies. High power loads must be located in ventilated areas to allow for proper air/water cooling.

5.5 Other (Electrical, ODH, Trip, Ladder) (Attach related Temporary Work Permits or Safety Reviews as appropriate.)

6 List Of Safety Equipment

Personal Protective Equipment

1. Long Sleeve shirt and pants.
2. Heavy duty leather gloves (see Table 2 Note 2).
3. Safety glasses or safety goggles (Shock rated).
4. ARC Flash rated protective clothing minimum of 8 cal/cm^2; pants and shirt/ or coverall (see Table 2).
5. ARC Flash rated face shield, minimum 8 Cal/cm^2, and arc rated balaclava or arc flash suit/hood (see Table 2)
6. Hearing Protection (ear canal insets).
7. Safety Shoes

Special Tools

1. Voltage rated meters and probes
2. Insulated Tools
3. High Voltage probes
4. High Voltage or High Current transducers

DEVELOP THE PROCEDURE

1. Associated Administrative Controls

1. SAF 104, General Lock, Tag, and Try (LT&T) training
2. Equipment specific LT&T training, equipment specific operations and manuals (e.g.; SAS and BAS LT&T training)
3. EH&S Manual electrical safety Chapter 6200
4. Task Hazard Analysis form 331T0T1
5. SAF603A, Electrical safety Awareness
6. SAF603N - NFPA70E training

2. Operating Guidelines

Mode 1 and Mode 2 work on Class 2 or Class 3 equipment as defined in the EH&S Manual Chapter 6230.

3. Notification of Affected Personnel (who, how, and when)

1. PSS: Safety System Group Leader and Deputy via email and phone
2. Operations Staff: Crew Chief and ATLIS
3. Other Groups: ATLIS and E-mail

4. List the Steps Required to Execute the Procedure: from start to finish.

1. Test Plan put together by person leading the test. The test plan must use this OSP as part of the guidelines.
2. Proper PPE and Work Tools gathered
3. ATLIS submitted and approved if working on machine components. Task Hazard Analysis performed by Senior Test Person/qualified test personnel and approved by Engineering if working in DC power test areas or on non-machine related components
4. Test Plan approved by DC Power group leader or Senior Test Personnel if in test stands
5. Testing/Adjustment under general guidance of this OSP
6. Restoration of circuits and equipment. Follow ABIL requirements if necessary
7. Inspection of test data and approval for restoring operation from Senior Test Personnel

5. Back Out Procedure(s) i.e. steps necessary to restore the equipment/area to a safe level.

1. LT&T equipment according to equipment specific procedures
2. Remove all test equipment
3. Restore all circuits to their proper operational condition
4. Re-test interlocks
5. Get approval from Engineering/Operations if restoring power to the Accelerator
4. Restore operation of power supply

6. Special environmental control requirements:

6.1 Environmental impacts (See EMP-04 Project/Activity/Experiment Environmental Review)

None

6.2 Abatement steps (secondary containment or special packaging requirements)

None

7. Unusual/Emergency Procedures (e.g., loss of power, spills, fire, etc.)

1. Personnel trained to use CPR and proper contact release protocols for SHOCK victims.

8. Instrument Calibration Requirements (e.g., safety system/device recertification, RF probe calibration)

1. Testing and verifying proper operation of multi-meters and test probes
2. Calibration of Current and voltage transducers and readouts
3. PSS device re-certifications when equipment is installed in machine and required
4. Interlocks re-certification if equipment is installed in the machine

9. Inspection Schedules

SAD maintenance periods

10. References/Associated Documentation

2015 Edition NFPA70E Electrical Safety

11. List of Records Generated (Include Location / Review and Approved procedure)

1. Interlock Test Checklist where necessary
2. ATLIS updates/Elog Entries
3. ABIL tag and Log Entry if necessary

Click
To Submit OSP
for Electronic Review

Distribution: Copies to: affected area, authors, Division Safety Officer
Expiration: Forward to ESH&Q Document Control

Form Revision Summary

Revision 1.2 – 09/15/12 – Update form to conform to electronic review.
Revision 1.1 – 04/03/12 – Risk Code 0 switched to N to be consistent with 3210 T3 Risk Code Assignment.
Revision 1 – 12/01/11 - Added reasoning for OSP to aid in appropriate review determination.
Revision 0 - 10/05/09 – Updated to reflect current laboratory operations

ISSUING AUTHORITY	FORM TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	REVIEW REQUIRED DATE	REV.
ESH&Q Division	Harry Fanning	12/01/11	12/01/14	1.2

This document is controlled as an on line file. It may be printed but the print copy is not a controlled document. It is the user's responsibility to ensure that the document is the same revision as the current on line file. This copy was printed on 11/2/2018.

OPERATIONAL SAFETY PROCEDURE (OSP)
FOR
TESTING OR ADJUSTING POWER SUPPLIES WHILE ENERGIZED

OWNERSHIP: This document is created under the direction of the EES group leader. Changes may be made to this document only with the consent of the EES group leader.

PURPOSE:

The purpose of this OSP is to supplement and reinforce the requirements of the JLab EH&S Manual, Chapter 6230, Electronic Equipment Safety and the NFPA 70E as they apply to Mode 2 testing of Class 2 and 3 power supplies for the EES DC Power Group.

Definitions of Classes and Modes

The Jefferson Lab ES&H Manual Chapter 6230 defines the Classes and Modes as shown below:

Class 1 – Hazard

a. $\leq$ 50 Vac or 60Vdc, $\leq$ 50 Amps
b. > 50 Vac or 60Vdc, $\leq$ 5 mAmps

Class 2 – Medium Hazard

a. $\leq$ 50 Vac or 60Vdc, > 50 Amps – Low voltage, high current
b. 50 Vac or 60Vdc < V $\leq$ 250 Vac or 250Vdc, > 5 mAmps – Medium to high voltage, medium current
c. > 250 Vac or 250Vdc, I $\leq$ 500 VA/Volt – Medium to high voltage, medium current
d. > 50 Vac or 60Vdc, >10 Joules Stored Energy – Medium to high stored energy

Class 3 – High Hazard

a. > 250 Vac or 250Vdc, I > 500 VA/Volt – High voltage, high energy

Mode 1: Equipment fully de-energized using LT&T procedures or unplugging power source with plug in control of test person

Mode 2: Equipment energized with interlocks bypassed or covers removed while performing **Non-Manipulative** Diagnostics and measurements

Mode 3: Manipulative Operations while equipment is energized

Definitions:

LT&T: Lock Tag and Try.

Flash Protection Boundary: When an arc flash hazard exists, an approach limit at a distance from a prospective ARC source within which a person could receive a second degree burn if an Electrical Arc Flash were to occur.

Limited Approach Boundary: An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exits.

Restricted Approach Boundary: An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to energized electrical conductor or circuit part.

Qualified Person: One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved.

Authorized Person: A person who has been permitted to work on equipment by their supervisor.

SCOPE:

This OSP applies to all Mode 2, Class 2 and 3 power supply testing or measurements within or near exposed high power portions of the power supply, with power supply doors opened, covers removed, or interlocks bypassed. It sets up the guidelines and procedures for use of dummy loads or magnet loads that are not inside interlocked enclosures when testing power supplies. This OSP also covers bench and in situ testing and repair of Shunts, Bulk Supplies and other rack mount equipment. In the event of a conflict, the requirements of the EH&S Manual shall prevail.

For more information on Mode and Class definitions, Work Matrix for this OSP, refer to Appendix A

****

*Mode 3 work on Class 2 or Class 3 equipment is **NOT** permitted under this SOP. All Mode 3 work on Class 2 or Class 3 equipment **REQUIRES** an electrical work permit and Director's approval and clearance. (Class 1, Mode 3 as defined in the EH&S Manual, chapter 6230 is also permitted under this OSP per the guidelines of the EH&S manual.)*

All work shall be performed at the lowest possible Class/Mode required to do the measurement and testing. At no time shall safety be compromised for ease of measurement or to expedite work.

This OSP does **NOT** apply for the following conditions.

a. Where manipulative work needs to be done while in the energized state.
b. Where measurement equipment is connected to the high power circuitry while the supply is de-energized, using LT&T rules and the supply is then re-energized with all interlocks restored and operational.
c. Where measurements are confined to low voltage compartments containing only Class 1 hazards

TEST AREAS:

The operations may take place in Accelerator service buildings, the LERF gallery, Experimental Halls, the Engineering Department work/repair Labs, in the Test Lab or any other area where supplies are installed and operational procedures may be followed safely.

APPROVAL/ AUTHORIZATION:

Testing under this OSP shall always be led by individuals identified as Senior Test Personnel by the head of the DC Power Systems or the DC Power Deputy, and confirmed by the EES Group Leader. A list of Senior Test Personnel is included in Appendix A, which will be updated as necessary.

Electrical workers participating in the testing of power supplies shall be certified by the head of DC Power as possessing the necessary knowledge and skills for working with the circuitry and equipment involved in these procedures. A list of Electrical workers qualified to work on specific equipment is included in Appendix A.

All testing personnel must have the following ***Qualifications and Training***:

- Electrical Safety Awareness (SAF 603A)
- Lock, Tag and Try Training (SAF 104)
- CPR & AED (SAF 105)
- SAF603N- NFPA70E
- Demonstration of satisfactory understanding of the following
  - Proper use of precautionary techniques
  - Proper use of PPE
  - Proper use of insulated tools and equipment
  - Skills and techniques necessary to distinguish exposed energized parts from other parts of the circuit
  - Decision making process necessary to determine the degree and extent of the hazard and the PPE and job planning necessary to perform the task safely

HAZARD IDENTIFICATION:

Electrical:

During testing, personnel will have to provide mitigation to safely work on live electrical circuitry with the following characteristics:

a. High DC Voltages: up to 2300VDC, conductor-to-conductor or conductor to ground.
b. Medium to High AC Voltages: up to 600 VAC with bolted fault currents up to 5kAmp or more.
c. High Current: Power source capable of currents to 4kA DC, with potential for higher fault currents
d. Multiple power sources: The low level control circuitry within supplies can be configured to be powered from secondary 120VAC. In these cases, follow equipment specific LT&T procedures to de-energize all sources before repair or active manipulation of components. Additionally, magnet loads may contain auxiliary windings powered from different power supplies (examples: SRCC coils in ARC7, trim compensation coils in Hall Compton dipoles, clamshell magnets).
e. Stored energy in active components, capacitors and inductors

This is a Class 2 or Class 3, Mode 2 electrical hazard, Risk Code 4.

POTENTIAL EXPLOSIVE ARC HAZARD DUE TO HIGH ELECTRICAL CURRENTS AVAILABLE:

Although equipped with fault protection, power supplies are capable of internal currents as high as 4000 amperes (or higher under fault conditions). If a small gauge wire, test lead, or a metallic tool were to momentarily contact between the circuitry being tested and Earth ground (such as the nearby equipment frame), currents of up to several thousand amperes could momentarily flow through the short, causing explosive sparking, arcing, and showering of hot metal before the supply would shut down and the current flow through the loads drain off.

Mechanical:
During Testing, personnel need to be aware of the following mechanical hazards and include it in their work plans:

a. Heavy components, copper buss or cables.
b. Tightly spaced components within power supply enclosures
c. Inadequate cooling which can cause overheating of components
d. LCW water pressurized up to 150 psig
e. Sharp edges inside power supply enclosures
f. Stored energy in springs, hydraulic equipment, compressed air

Other:

There may be other environmental or physical hazards that will be identified during the pre-job task hazard analysis using Task Hazard analysis worksheet. Some examples are:
a. Magnetic Fields
b. Radiation boundaries
c. Dust
d. Work being conducted by other groups

HAZARD BOUNDARIES (ELECTRICAL):

SHOCK HAZARD ANALYSIS:

Class 2 or Class 3 shock hazards from 120VAC, 208VAC, 480VAC, and DC voltage >50 Volts, exists within the power supplies.

SHOCK PROTECTION BOUNDARY:

***Approach Boundaries*:** The Hazard Identification label on the power supply may contain information about the approach boundaries for that particular power supply. For definitions of the boundaries consult the "Definitions" section on page 6 of 17.
If a power supply is unlabeled, the default values from NFPA70E may be used as shown in Table 1. The Limited Approach boundaries in Table 1a & 1b refer to the case where the live conductor is a fixed, unmovable part of the power supply.

Nominal Voltage, Phase to Phase (volts)	Limited Approach Boundary, Fixed Conductor	Restricted Approach Boundary
Less than 50V	Not specified	Not specified
50V to 150V	3 feet 6 inches	Avoid contact
151V to 750V	3 feet 6 inches	1 foot
751 to 15kV	5 feet	2 feet 2 inches

Table 1a. Approach boundaries to LIVE parts for Shock Protection on AC systems

Nominal DC Voltage (volts)	Limited Approach Boundary, Fixed Conductor	Restricted Approach Boundary
Less than 100V	Not specified	Not specified
100V to 300V	3 feet 6 inches	Avoid contact
301V to 1kV	3 feet 6 inches	1 foot
1.1kV to 5kV	5 feet	1 feet 5 inches

Table 1b. Approach boundaries to LIVE parts for Shock Protection on DC systems

FLASH HAZARD ANALYSIS:

Class 2 and 3 power supplies are usually powered by 480VAC feeders and may have incident energies ranging from 0.5 to 8 cal/cm^2. The Hazard Identification label on the power supply contains information on the energies available. If the power supply is unlabeled, the value will be determined by arc flash hazard analysis on the piece of equipment being tested.

FLASH PROTECTION BOUNDARY:

The default distance where a flash hazard exists is within 5 feet of the energized conductor for voltages up to 600Vac. For higher voltages and currents, a separate Flash Hazard analysis will be conducted.

PERSONAL PROTECTIVE EQUIPMENT (PPE):

To decide the correct PPE requirement for your equipment testing, troubleshooting or probing please refer to the equipment **Arc Flash and Shock Hazard** sticker. In the sticker look for equipment "Incident Energy" rating (See **Figure 1** for reference). Once you have figured out the equipment "Incident Energy" then please check Table 2 for the correct PPE. If equipment Arc Flash and Shock Hazard Sticker was not found on the equipment of use then please contact engineering or the equipment system owner.

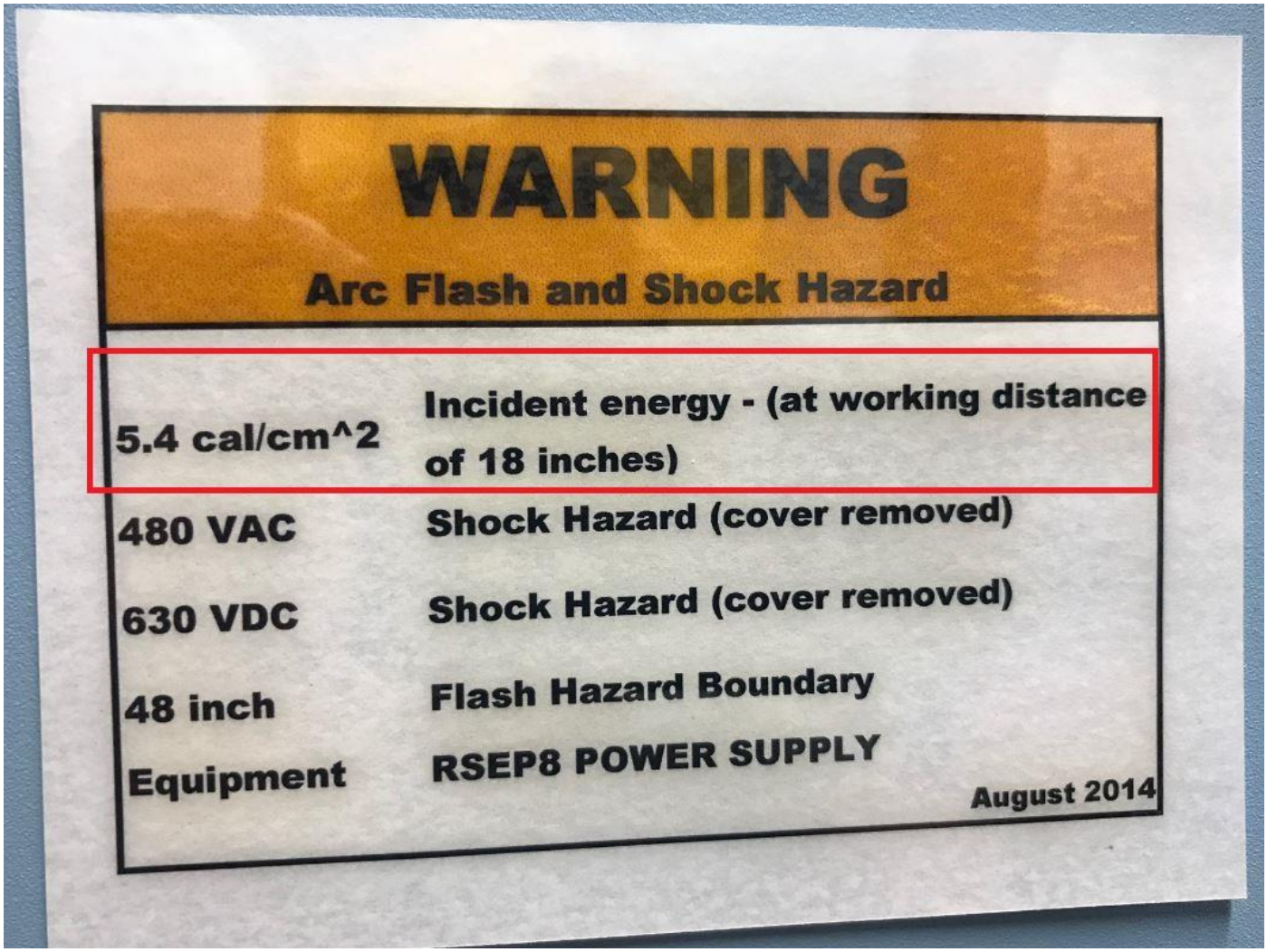

Figure 1: Arc Flash and Shock Hazard Sticker

PPE Category	Personal Protective equipment (PPE)	Typical Equipment (Not all equipment included)

(**Minimum** ARC rating of **8 cal/cm^2**)	Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield (see Note 1) and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat line (AN) **Protective Equipment** Hard hat, Safety glasses or safety goggles (SR), Hearing protection (ear canal insets), Heavy duty leather gloves (See Note 2), Leather footwear (AN)	• Box Power Supplies • Bulk supplies: Test Stands in DCP Lab, and in trim racks in the field. • 20A Trim Supplies: Bench Testing in DCP Lab • Hi-Pot Test Station

Table 2. PPE for Class 2 and 3 Power Supplies

Note 1: Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or alternatively, an arc-rated arc flash suit hood is required to be worn.
Note 2: If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirements.
***Note:** All personnel working on energized DC power equipment are required to wear safety glasses for Class 1, Class 2 or Class 3 equipment.

OPERATIONAL PROCEDURES:

1) Personnel leading the test effort are **REQUIRED** to perform an on-site hazard evaluation before start of work. The Hazard analysis shall consist of the following steps:
   - ✓ Identify and locate voltages that could be encountered during testing. Analyze the Class of voltages needed for testing and if power supply needs to be energized in order to obtain this voltage.
   - ✓ Where applicable, establish boundaries for shock and flash protection based on analysis of labels attached to the power supply, circuit breakers feeding the power supply and NFPA70E.
   - ✓ Ensure that there are proper clearance areas in the front, the back and sides of the power supply under test. The minimum clearance is 4 feet from the front and 4 feet from the rear for Box power supplies. Trim and Shunt Racks require a minimum clearance of 3 feet from the front and rear for access during troubleshooting.
   - ✓ Ensure there are adequate entry ways and easy egress around equipment under test. Equipment used for testing must not inhibit personnel from moving around freely.
   - ✓ Determine if testing can be safely carried out in Mode 2 or if other mitigating methods need to be used. Operational restrictions outlined in this document must be used as a guide to determine if testing can be carried out safely
   - ✓ Determine the PPE to be used and the necessary equipment needed to carry out test procedures based on NFPA 70E Table 130.7(C)(15)(A)(b), Table 130.7(C)(15)(B) and Table 130.7(C)(16) or labels attached to equipment

2) A Pre-job briefing of the planned work should precede any testing on power supplies. The briefing should consist of at least the following information:
   - ✓ Results of the on-site hazard analysis
   - ✓ PPE and equipment that is needed to carry out the test. Removal of jewelry, wrist watches and other personal effects.
   - ✓ Location of cutoff switches, breakers or emergency shutdowns, contact release of shock victims.
   - ✓ Procedures that will be carried out for the test

- ✓ Make sure that testing area is clean, dry and prepared for testing
- ✓ Discuss using other mitigating factors in order to reduce Class rating of the equipment being worked on. (*Example: Using an external source at a lower voltage to power low level controls circuitry during troubleshooting, allowing high voltages to be off. Shielding high power compartment from lower power compartments using suitable insulation*)

3) Cordon off the testing area to prevent personnel not involved in testing from entering the Flash or Shock protection boundary, whichever is greater. Barricades and/or signs should be used to warn other persons that high powered testing is underway.

4) When temporary cabling is installed, it must be protected from inadvertent contact by testing personnel or others in the test vicinity by use and placement of barricades and signs.

5) Follow LT&T rules to safe out the power supply and to de-energize the equipment before removing covers or bypassing interlocks. The two-man rule applies for LT&T on Class2 or Class 3 power supplies.

6) At all times, when a power supply is unlocked, its doors open or covers off with interlocks defeated, and is capable of having its output energized there shall be a minimum of two qualified persons present at the immediate site where testing is being performed. One person shall act as a safety watch and will be positioned outside the Flash Protection Boundary, unless PPE is used. The safety watch shall remain in continuous sight and sound communication with the test person(s). The safety watch shall activate the emergency shutdown switch and/or AC disconnect switch located at the power supply control panel at the first indication of a potential electrical safety problem. *(Example: for a box supply the Flash Protection Boundary may be 5 feet from an open back door.)*

7) Once the power supply has been energized for testing, personnel may not cross the Restricted Approach Boundary with any part of the body which is not properly insulated. *(Example: For a box supply, the Limited Approach Boundary may be 3 feet 6 inches (42 inches) from an open back door, and the Restricted Boundary will be within 1 foot of the enclosure of the power supply)*

8) Wearing the appropriate PPE, and using proper tools, personnel may perform required test and measurement procedures inside the power supply as planned during the pre-job briefing. Any unplanned testing or measurement will require on-site re-evaluation before being carried out. *(Example: Typically, measurements are conducted using rated DVM's, oscilloscopes, clamp on meters, hand held ammeters)*

9) At the end of the testing procedure, all components and interlock devices and circuitry shall be re-installed and restored to their normal, safe operating condition and their proper operation verified.

**OPERATIONAL PRECAUTIONS AND RESTRICTIONS

- All measurements on energized 480VAC circuits must be made by returning the power supply to a Mode 1 state prior to attaching probes, unless appropriate PPE is used as described in the NFPA70E manual Table130.7(C)(16). Power can then be restored to take the measurements while equipment is attached in a hands-free configuration.

- No measurements may be made on a moveable live conductor within a power supply while the power supply is energized
- Testing, which involves energizing the power supply output, shall only be performed under the following conditions:
  - ✓ When the area in which the magnet loads are located is secure and the Personnel Safety System (PSS) has issued a POWER PERMIT signal to the power supply; or
  - ✓ The load in use is a fully enclosed dummy load; or
  - ✓ The load has terminations fully covered and protected or otherwise interlocked. Access to leads or any electrical or magnetic hazard must be controlled at all times by the testing personnel either by interlock, barricades or continuous safety watches outside the Flash Hazard Boundary.
- In NO case shall active PSS interlocks be defeated for purposes of testing under this OSP. Defeat of active PSS interlocks must be authorized and conducted by PSS personnel.
- If using the high power dummy loads, verify that the fan and rotating beacon are operational. Inspect cable, interlocks and terminations to verify integrity. When routing cables to dummy load, install protective measures to prevent access or damage to cables.
- At no time shall a line powered piece of test equipment be isolated from ground to make a measurement. This type of operation requires a separate hazard analysis and a TOSP.
- Changes requiring barehanded adjustment or contact with the circuitry or to attach test clips to the circuitry should NOT be performed while the power supply is energized. When working in tight spaces that restrict a range of motion, do not blindly reach into areas of the enclosure.
- All equipment, tools and instruments shall have insulation, test leads and input ratings appropriate to the class of voltage encountered during measurements or adjustments. Wherever possible, all test equipment will remain ground referenced and differential voltage probes shall be used
- The second person (in a two-man rule situation) should meet the criteria as described under Qualifications and Training of this document. Line supervisors shall ensure that the second person has equipment specific lock and tag training and on-the-job-training (OJT) clearance. If the second person is undergoing on-the-job training, Senior test personnel shall monitor and supervise all activity within the Limited Approach Boundary

Some Application Examples:

1. A Power module needs to be tested on the bench:
   a. Communicate with Senior Test Person, for that system that power module is to be tested
   b. Along with Senior Test Person, determine the highest voltage or current that is available on the module when it is powered on. Identify all exposed conductors with voltage/current greater than Class 2 if applicable.
   c. If necessary, determine the shock hazard boundary, flash hazard boundary and place warning signs around test area as shown in Tables above.
   d. Create properly rated covers, as needed, to securely seal all exposed voltages and currents above Class 1.
   e. Determine what tests and measurements can be conducted **without** Class 2 and Class 3 voltage or current.
   f. If needed for diagnostics, attach measurement points while module is verified to be in electrically safe work condition (LT&T) and all energy sources locked out/dis-connected and stored energy has been discharged.

g. Perform **hands-off** measurements for diagnostics signals using proper rated equipment and PPE. Two-person rule applies here while module is energized.
h. Turn off all power sources by dis-connecting or locking out, and verify that power is removed. Discharge any stored energy.
i. Perform any repairs or adjustments while in a verified, electrically safe work condition (LT&T) Mode 1 state.
j. Remove all test equipment. Contact Senior Test person to inspect module before final implementation.

2. Performing diagnostic measurements on a card cage assembly within a rack
   a. Communicate with Senior Test Person, for that system, that a test will take place
   b. Along with Senior Test Person, determine the highest voltage or current that is available on the module when it is powered on. Identify all exposed conductors with voltage/current greater than Class 2 if applicable.
   c. If necessary, determine the shock hazard boundary, flash hazard boundary and place warning signs around test area as shown in Tables above.
   d. Create properly rated covers, as needed, to securely seal all exposed voltages and currents above Class 1.
   e. Determine what tests and measurements can be conducted **without** Class 2 and Class 3 voltage or current.
   f. If needed for diagnostics, attach measurement points while module is verified to be in electrically safe work condition (LT&T) and all energy sources locked out/dis-connected and stored energy has been discharged.
   g. Perform **hands-off** measurements for diagnostics signals using proper rated equipment and PPE as determined by Tables given above. Two-person rule applies here while module is energized.
   h. Turn off all power sources by dis-connecting or locking out, and verify that power is removed. Discharge any stored energy.
   i. Perform any repairs or adjustments while in a verified, electrically safe work condition (LT&T) Mode 1 state.
   j. Remove all test equipment. Contact Senior Test person to inspect if any changes are made

3. A box supply needs to be turned on for diagnostics with covers removed:
   a. Communicate with Senior Test Person, for that system, that a test will take place
   b. Along with Senior Test Person, perform Task hazard analysis and determine the highest voltage or current that is available when the unit powered on. Identify all exposed conductors with voltage/current greater than Class 2 if applicable.
   c. Determine the shock hazard boundary, flash hazard boundary and place warning signs around test area as shown in Tables above.
   d. Create properly rated covers, as needed, to securely seal all exposed voltages and currents above Class 1. If doors are open, then place a portable see-through plexi-glass shield in front of the open door.
   e. Determine what tests and measurements can be conducted **without** Class 2 and Class 3 voltage or current. Determine if diagnostics can be accomplished using only “Control Power”.
   f. If needed for diagnostics, attach measurement points while module is verified to be in electrically safe work condition (LT&T) and all energy sources locked out/dis-connected and stored energy has been discharged.

g. Perform **hands-off** measurements for diagnostics signals using proper rated equipment and PPE as determined by Tables given above. Two-person rule applies here while module is energized.
h. Turn off all power sources by dis-connecting or locking out, and verify that power is removed. Discharge any stored energy.
i. Perform any repairs or adjustments while in a verified, electrically safe work condition (LT&T) Mode 1 state.
j. Remove all test equipment. Contact Senior Test person to inspect if any changes are made

4. A magnet needs to be tested along with a power supply:
   a. Communicate with Senior Test Person, for that system, that a test will take place
   b. Along with Senior Test Person, perform Task hazard analysis and determine the highest voltage or current that is available when the unit powered on. Identify all exposed conductors with voltage/current greater than Class 2 if applicable.
   c. Determine the shock hazard boundary, flash hazard boundary and place warning signs around test area as shown in Tables above.
   d. Create properly rated covers, as needed, to secure all exposed voltages and currents above Class 1.
   e. For diagnostics, attach measurement points while power is verified to be in electrically safe work condition (LT&T) and all energy sources locked out/dis-connected and stored energy has been discharged.
   f. Perform **hands-off** measurements for diagnostics signals using proper rated equipment and PPE as determined by Tables given above. Two-person rule applies here while module is energized.
   g. Turn off all power sources by dis-connecting or locking out, and verify that power is removed. Discharge any stored energy.
   h. Remove all test equipment. Contact Senior Test person to inspect if any changes are made

Appendix A:

Work Matrix under This OSP

Mode	Equipment Class	Hazard/Risk Category	Work Permission Guidelines	Work Requirements
Mode 1	1	0	OK Always Permissible in fully de-energized state	Qualified person may work alone once LT&T applied to High power. Hazard and PPE Evaluation
	2	0	OK Always permissible in fully de-energized state	Qualified person may work alone once LT&T applied to High power. Hazard and PPE Evaluation
	3	0	OK Always permissible in fully de-energized state	Qualified person may work alone once LT&T applied to High Power. Hazard and PPE Evaluation
Mode 2	1	0	OK	Qualified person may work alone once LT&T applied to High Power. Hazard and PPE evaluation required
	2	1	OK	Two Qualified people (Senior Test Person and Safety Watch) Required. Hazard and PPE Evaluation Required
	3	2	OK	Two Qualified people (Senior Test Person and Safety Watch) Required. Hazard and PPE Evaluation Required
Mode 3	1	0	As Defined in EH&S Manual Chapter 6230	Qualified Person must be in the presence of another individual who can provide or summon assistance. Hazard Analysis, PPE Evaluation
	2	2	NOT PERMITTED	NOT ALLOWED
	3	4	NOT PERMITTED	NOT ALLOWED

List of Test Personnel found in link below:

M:\ees\DC\MANAGEMENT
Filename: Authorized Test Personnel DC Power July 2018.xlsx

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

Click

Author:	Onish Kumar, Jim Coleman	**Date:**	October 25th 2018	**Task #:** If applicable	N/A

Complete all information. Use as many sheets as necessary

Task Title:	Testing and Adjusting DC Power Supplies while fully Powered			**Task Location:**	Accelerator Service Building and DC Power Workshops
Division:	Engineering	**Department:**	EES	**Frequency of use:**	Regular use during testing or troubleshooting DC Power Supplies
Lead Worker:	M.Augustine, J. Coleman, S. Phillip or as assigned				
Mitigation already in place: Standard Protecting Measures Work Control Documents	SAF 104 –LT&T SAF603A –Basic Electrical Safety SAF603N – NFPA70E SAF105 – CPR/AED Equipment Specific LT&T Procedure for Box Power Supplies				

Sequence of Task Steps	Task Steps/Potential Hazards	Consequence Level	Probability Level	Risk Code (before mitigation)	Proposed Mitigation (Required for Risk Code >2)	Safety Procedures/ Practices/Controls/Training	Risk Code (after mitigation
1	Lock and Tag of PS: Arc Flash Hazards, Exposure to Class 3 Voltages up to 2300VDC and 480VAC if not using VVU. High Current AC and DC buss	Medium	Medium	4/3	LT&T, using VVU to verify voltage is removed, use ground stick to remove stored energy. Barriers installed as required	Equipment Specific LT&T procedure and training, PPE usage, ground stick usage, Flash and Limited Approach Boundaries observed. Only Authorized people may perform work, 2-man rule (both qualified)	1
2	Energized testing of PS with Doors Open and interlocks bypassed, with barriers – Observation only: same as hazards as #1 above	Medium	Medium	4/3	Area around PS is restricted for access to trained personnel, PPE as defined in document, No crossing of the restricted approach boundaries allowed. Barriers/shields installed as required.	Hands off observation of indicator lights inside PS only, PPE required to be inside ARC Flash and Limited Approach Boundaries. Only Authorized people may perform work, 2-man rule (both qualified)	1

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure)

Sequence of Task Steps	Task Steps/Potential Hazards	Consequence Level	Probability Level	Risk Code (before mitigation)	Proposed Mitigation (Required for Risk Code >2)	Safety Procedures/ Practices/Controls/Training	Risk Code (after mitigation
3	Energized Testing of the PS with doors open and interlocks bypassed with test equipment installed while power supply is Locked out and de-energized. Use of Hands-Off techniques. Class 3 shock hazard, Arc Flash hazard	Medium	Medium	4/3	Perform measurement equipment connection with PS de-energized and LT&T where necessary. Re-energize supply to make measurements. L&T the PS to remove or reposition test equipment. Barriers/shields installed as required.	Hands Off observation of instruments connected to PS only, PPE required to be inside Arc Flash and Limited Approach Boundaries. Only Authorized people may perform work under supervision of senior personnel, 2-man rule, safety watch requirements	1
4	Energized Testing of the PS with doors open and interlocks bypassed, with test equipment, performed using Hands-On probing. Class 3 shock hazard, Arc Flash Hazard	Medium	Medium	4/3	Hands-on probing to make measurements on safe measurement points using appropriately rated equipment and PPE. Barriers/Shields installed as required to prevent inadvertent contact with nearby circuitry.	Procedures and techniques described in the document. PPE required, authorized personnel only under direct supervision of senior personnel, 2-man rule, safety watch requirements, voltage rated test equipment or isolated test equipment used	2

Highest Risk Code before Mitigation:	4	Highest Risk Code after Mitigation:	2

When completed, if the analysis indicates that the Risk Code before mitigation for any steps is "medium" or higher (RC≥3), then a formal Work Control Document (WCD) is developed for the task. Attach this completed Task Hazard Analysis Worksheet. Have the package reviewed and approved prior to beginning work. (See ES&H Manual Chapter 3310 Operational Safety Procedure Program.)

Form Revision Summary

Revision 0.1 – 06/19/12 - Triennial Review. Update to format.

Revision 0.0 – 10/05/09 – Written to document current laboratory operational procedure.

ISSUING AUTHORITY	FORM TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	EXPIRATION DATE	REV.
ESH&Q Division	Harry Fanning	06/19/12	06/19/15	0.1

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Task Hazard Analysis (THA) Worksheet

(See ES&H Manual Chapter 3210 Appendix T1
Work Planning, Control, and Authorization Procedure)

By signing this page, you testify that you have read, understand, and agree to abide by the procedure specified in the above referenced work control document:

Serial Number: ENG-19-78689-OSP

Title: Testing and Adjusting Power supplies while Energized

Name	**Signature**	**Date**