Person: Suleiman, Riad (suleiman@jlab.org)
Org: ACCCIS

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Jefferson Lab
Thomas Jefferson National Accelerator Facility

Operational Safety Procedure Review and Approval Form # 107399
(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 Click for LTT-Individual Information Click for LTT-Group Information	
Serial Number:	***ACC-20-107399-OSP***		
Issue Date:	***10/6/2020***		
Expiration Date:	***9/6/2023***		
Title:	***Magnetized Beam Cathode Solenoid***		
Location: (where work is being performed) Building Floor Plans	***18 - Low Energy Recirculator Facility (LERF) - 217***	Location Detail: (specifics about where in the selected location(s) the work is being performed)	
Risk Classification: (See ES&H Manual Chapter 3210 Appendix T3 Risk Code Assignment)	Without mitigation measures (3 or 4): With mitigation measures in place (N, 1, or 2):	***3*** ***1***	
Reason:	This document is written to mitigate hazard issues that are : ***Determined to have an unmitigated Risk code of 3 or 4***		
Owning Organization:	***ACCCIS***		
Document Owner(s):	***Suleiman, Riad (suleiman@jlab.org)*** Primary		

Supplemental Technical Validations

Lock, Tag, Try (Phillip Stanley, Tim Fitzgerald)
Static Magnetic Fields >5G: Fringe, High, & Quench Effect (Imani Burton, Jennifer Williams)

Document History

Revision	Reason for revision or update	Serial number of superseded document
1	***PPE was updated.***	***ACC-19-94484-OSP***

Lessons Learned	Lessons Learned relating to the hazard issues noted above have been reviewed.
Comments for reviewers/approvers:	***Fixed staff personnel name in section 5.3.***

Attachments

Procedure: ***GTS_Solenoid_MLDGT01_OSP.pdf***

THA: ***GTS_Solenoid_MLDGT01_THA.pdf***

Additional Files:

Review Signatures

Subject Matter Expert : Lock-> Tag-> Try	**Signed** on 10/5/2020 9:57:06 AM by Tim Fitzgerald (tfitzger@jlab.org)
Subject Matter Expert : Static Magnetic Fields >5G: Fringe-> High-> & Quench Effect	**Signed** on 10/5/2020 9:16:26 AM by Jennifer Williams (jennifer@jlab.org)

Approval Signatures

Division Safety Officer : ACCCIS	**Signed** on 10/5/2020 10:02:40 AM by Harry Fanning (fanning@jlab.org)
Org Manager : ACCCIS	**Signed** on 10/6/2020 9:30:46 AM by Matthew Poelker (poelker@jlab.org)
Person : Lock, Tag, Try Coordinator	**Signed** on 10/5/2020 9:59:05 AM by Riad Suleiman (suleiman@jlab.org)
Safety Warden : Low Energy Recirculator Facility (LERF) - 217	**Signed** on 10/5/2020 12:07:44 PM by Joe Gubeli (gubeli@jlab.org)

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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 For Word Doc

Title:	Magnetized Beam Cathode Solenoid		
Location:	LERF Gun Test Stand (GTS)	**Type:**	☒ **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
		Highest Risk Code after Mitigation (N, 1, or 2):	1
Owning Organization:	Accelerator Center for Injectors and Sources	**Date:**	October 1, 2020
Document Owner(s):	Riad Suleiman		

DEFINE THE SCOPE OF WORK

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

This OSP is to be used to power the magnetized beam cathode solenoid. This magnet has a maximum operational current of 400 Amps.

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

This OSP identifies and specifies mitigation measures for all aspects of significant hazards associated with the cathode solenoid magnet operation.

This OSP does not cover maintenance or internal adjustment of the power supply or access to LCW and electrical leads on top of the magnet in GTS enclosure.

3. Description of the Facility – include building, floor plans and layout of the experiment or operation.

The Gun Test Stand is located on the west side of the LERF (Building 18) and consists of a control room (Bldg. 18, room 217) and an enclosure (Bldg. 18, room 109A) with concrete shield walls that is under room 217 and is adjacent to the LERF vault.

ANALYZE THE HAZARDS and IMPLEMENT CONTROLS

4. Hazards identified on written Task Hazard Analysis

The solenoid magnet is located in the GTS enclosure. When powered up to 400 A, the solenoid can generate about 3200 Gauss field inside the bore and medical boundary of 5 Gauss is 7 feet from the solenoid. The hazards related to solenoid operation include the following:

1. Electrical hazard
2. Magnetic field
3. Magnet Heating

5. Authority and Responsibility:

5.1 Who has authority to implement/terminate

Matt Poelker and Riad Suleiman

5.2 Who is responsible for key tasks

Riad Suleiman

5.3 Who analyzes the special or unusual hazards including elevated work, chemicals, gases, fire or sparks (See ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure)

Jim Coleman and Jennifer Williams

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

SAF603 Electrical Hazard Awareness
SAF104 Lock, Tag and Try
This OSP

6. Personal and Environmental Hazard Controls Including:

6.1 Shielding

N/A

6.2 Barriers (magnetic, hearing, elevated or crane work, etc.)

Concrete door and flashing red beacons.

6.3 Interlocks

To be able to turn on the magnet power supply, these interlocks must be green:

1. Magnet LCW Flow (>4.00 GPM)
2. Magnet temperature (<65°C)
3. Power Supply LCW Flow (>1.25 GPM) – nominal flow is 2.2 GPM
4. Concrete Door Interlock – unless bypassed by key. Riad Suleiman is in possession of this key.
5. Power Supply Voltage (<79 V)

6.4 Monitoring systems

6.5 Ventilation

N/A

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

7. List of Safety Equipment:

7.1 List of Safety Equipment:

7.2 Special Tools:

8. Associated Administrative Controls

DEVELOP THE PROCEDURE

9. Operating Guidelines

The cathode solenoid provides a magnetic field of about 1400 Gauss at the photocathode with a maximum operational current of 400 A and operational voltage of 77 V. The magnet and leads resistance was measured to be 0.183 Ohms, the cable adds an additional 0.01 Ohms. With 73 V of applied voltage across the magnet, the power is about 30 kW. The magnet is bare copper coil (no steel around it) and is made of 8 double pancakes (16 layers) by 20 turns with an ID of 12 inches, OD of 28 inches and a thickness of 6 inches. The magnet weighs about 560 pounds and sits in a cradle (weighs 150 pounds) with a hand-driven mechanical motion to move magnet on its stand – see Figure 1.

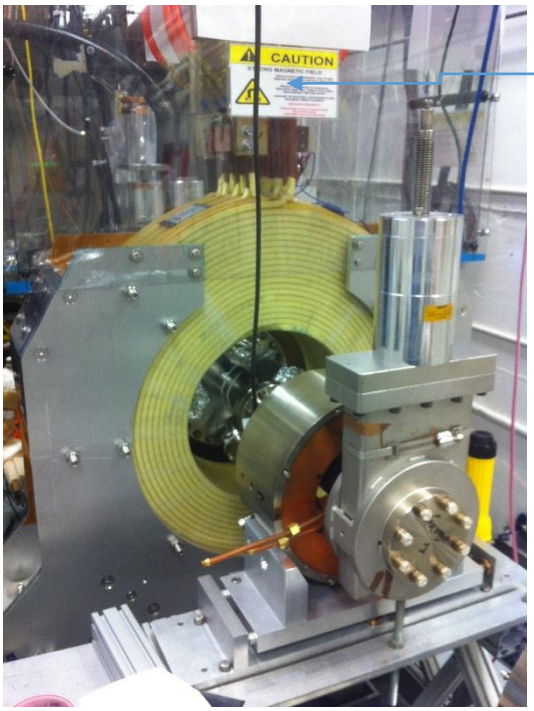

Figure 1: Cathode solenoid magnet positioned in front of the gun chamber.

Hazards

The hazards related to solenoid operation include the following:

1. Electrical hazard
2. Magnetic field
3. Magnet Heating

Mitigation

Electrical Hazard

The solenoid magnet power supply (shown in Figure 2) operates with input voltage of 480 VAC. The wall feed is located on the wall close to the entrance door to the GTS control room and labeled "magnetized power supply" and "FED FROM MDP–25". The power supply output over voltage trip level is set to 79 V. Maintenance and servicing of the power supply can only be conducted by "Qualified Electrical Workers". The supply is located at the GTS mezzanine and is cooled with LCW. The LCW flow is interlocked to the power supply.

During normal operation, connections at the power supply are made inside the cabinet that has interlocked doors. Insulated cables carrying current to the magnet are routed with cable tray to the magnet with all exposed leads covered by nonconductive 0.125" thick Lexan enclosure – shown in Figure 1.

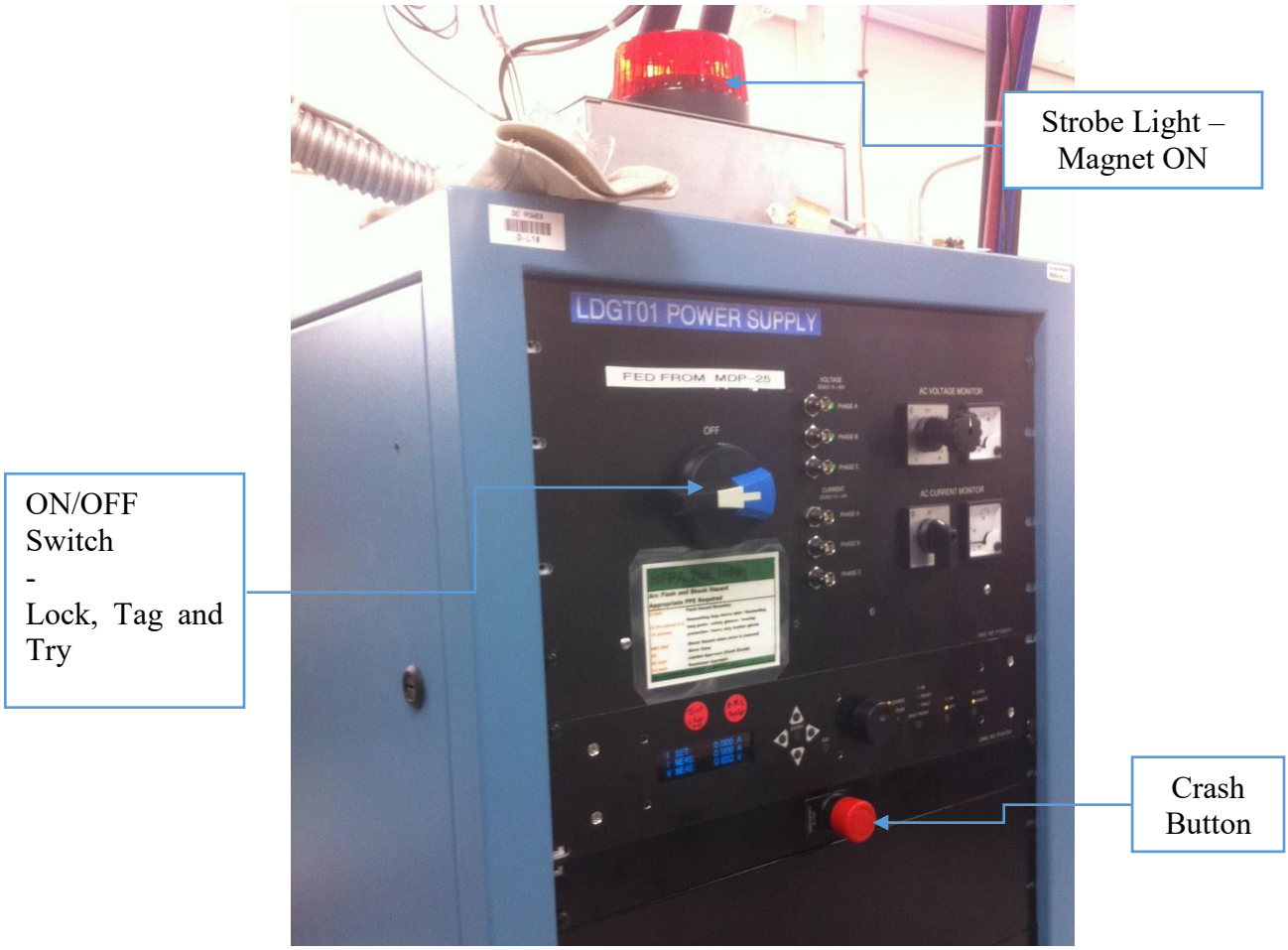

Figure 2: Magnet power supply at the GTS mezzanine. There is a crash button on the front panel.

Magnetic Field

When powered up to 400 A, the solenoid can generate about 3200 Gauss field inside the bore. The 5 Gauss boundary restricting access by personnel with surgical implants and bioelectric devices and the 600 Gauss whole body boundary were surveyed by Industrial Hygiene. When the solenoid is at 400 A, the medical boundary of 5 Gauss is 7 feet from the solenoid. The highest measurement of 2000 Gauss was taken within 6" of the solenoid. A 5 Gauss boundary sign is posted at the GTS enclosure door and a 600

Gauss boundary is posted near the solenoid.
Strong magnetic field will attract loose ferromagnetic objects, possibly injuring body parts or striking fragile components. Prior to energizing the magnet, a sweep of cordoned area will be performed for any loose magnetic objects. All personnel entering the 600 Gauss area will be also trained to remove ferromagnetic objects from themselves including wallet.
A Concrete Door Interlock will prevent access to the magnet when it is energized. However, there will be a Concrete Door Interlock Bypass Key to be able to enter GTS with magnet ON – see Figure 3. When door interlock is bypassed, to prevent personnel with surgical implants and bioelectric devices from entering the 5 Gauss boundary, strobe light indicators are installed on the top of power supply and at the access door down stairs to show solenoid is energized as well as flashing red beacons are installed at the actual 5 Gauss contour.

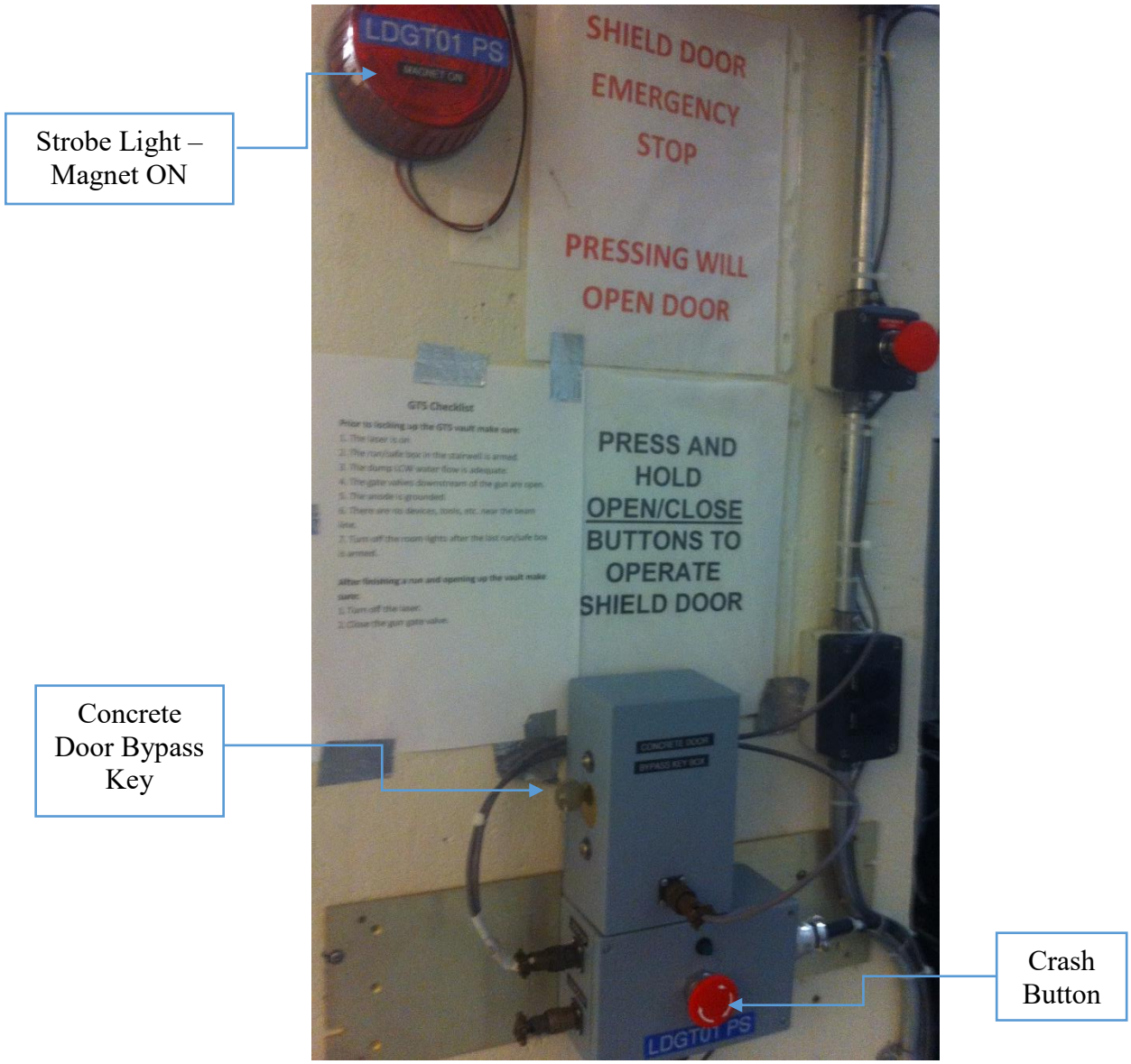

Figure 3: Magnetic field strobe light indicator at the access door. Also shown, the magnet power supply crash button.

Magnet Heating

At 400 A, the total power deposited in the magnet is about 30 kW. LCW is used to cool the magnet with flow rate of about 4.7 GPM. Before connecting the magnet, the LCW flow was measured to be about 6.8 GPM. The flow to the magnet is interlocked to the power supply with a trip level of 4.00 GPM – see Figure 4. The temperature of the magnet is interlocked to the power supply using 8 Asahi US-602S Thermal Switches (65°C) mounted on each of the 8 return conductors (one for each of the double pancakes). These switches are normally closed and open when temperature exceeds 65°C and automatically reset when temperature drops below 49°C. With magnet at 400 A, the hottest temperature measured is about 58°C (136 F) with the 4.7 GPM LCW flow rate.

Figure 4: Cathode magnet LCW flow rate monitor chassis at the GTS mezzanine in Rack GL01B05. The status of this interlock is displayed in the control screen under "Solenoid LCW".

There are three power supply crash buttons located at:

1. Power supply front panel
2. GTS enclosure access door
3. Power Supply Interlock chassis in GTS Control Room

Figure 5: Cathode magnet power supply interlock box in the GTS Control Room (Rack GL01B15)

The PSS Interlock chassis (shown in Figure 5) displays the status of the power supply interlocks. All interlocks must be green to be able to turn the supply ON. Figure 6 shows the power supply control

screen.

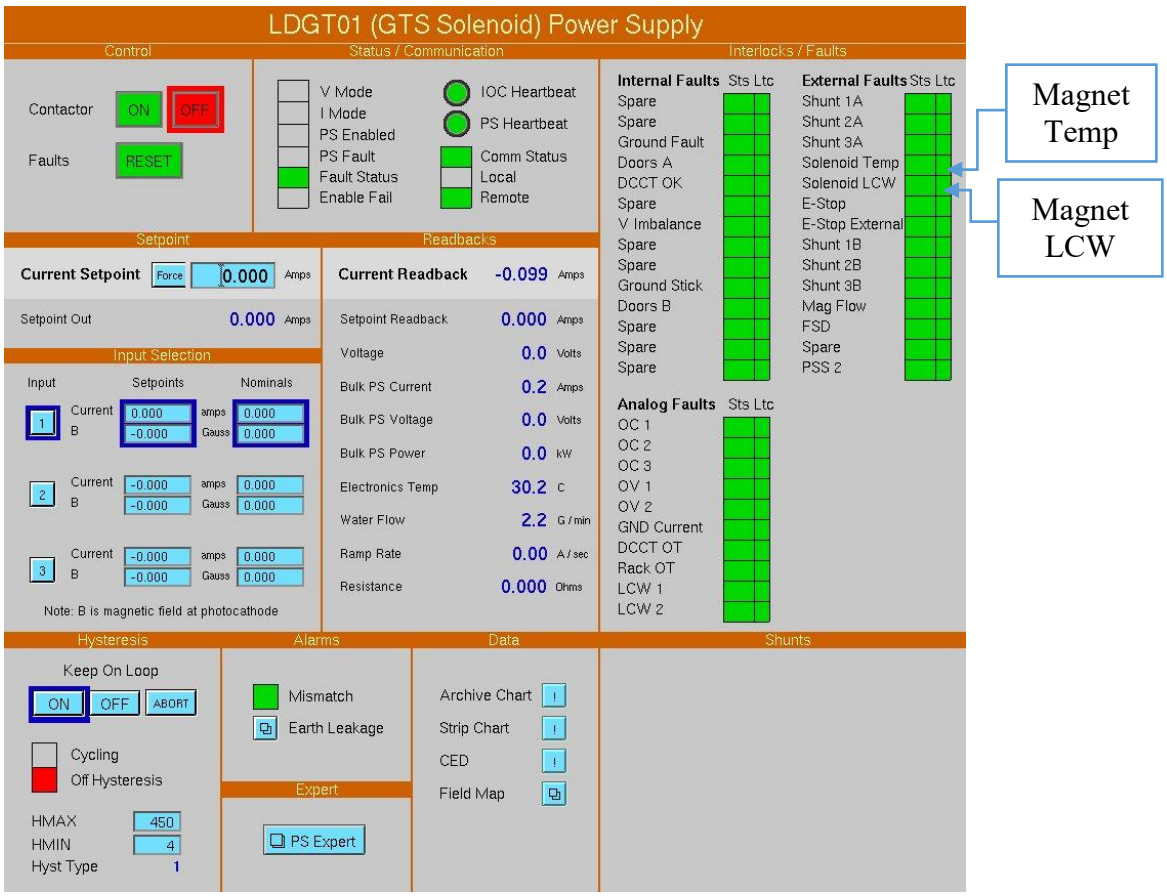

*Figure 6: Cathode Solenoid power supply control screen. The firmware is under **iocfel12** in Rack GL01B02.*

PPE Requirement to Turn Power Supply Switch ON/OFF

PPE required for Equipment specific Lockout Tagout of CS-80-500 model power supply. LO/TO training is required to turn the power supply switch ON/OFF.

Responsible Personnel

The individuals responsible for the operation of the solenoid will be trained and listed here.

Mark Augustine	augustin@jlab.org	7103
James Coleman	colemanj@jlab.org	7312
Kevin Banks	banks@jlab.org	7418
Riad Suleiman	suleiman@jlab.org	7159
Carlos Hernandez-Garcia	chgarcia@jlab.org	6862
Md Abdullah Mamun	mamun@jlab.org	
Mark Stefani	mstefani@jlab.org	

10. Notification of Affected Personnel (who, how, and when include building manager, safety warden, and area coordinator)

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

Power Supply Operation
To be able to turn on the magnet power supply, these interlocks must be green. Use the control screen (shown in Figure 6) turn the magnet on/off and to set the magnet current.

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

Set the magnet current to zero and turn off the power supply.

13. Special environmental control requirements:

13.1 List materials, chemicals, gasses that could impact the environment (ensure these are considered when choosing Subject Mater Experts) and explore EMP-04 Project/Activity/Experiment Environmental Review below

None

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

None

13.3 Abatement steps (secondary containment or special packaging requirements)

None

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

N/A

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

N/A

16. Inspection Schedules

17. References/Associated/Relevant Documentation

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

Click
To Submit OSP
for Electronic Signatures

Distribution: Copies to Affected Area, Authors, Division Safety Officer
Expiration: Forward to ESH&Q Document Control

Form Revision Summary

Revision 1.4 – 06/20/16 – Repositioned "Scope of Work" to clarify processes
Qualifying Periodic Review – 02/19/14 – No substantive changes required
Revision 1.3 – 11/27/13 – Added "Owning Organization" to more accurately reflect laboratory operations.
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 1.0 – 12/01/11 – Added reasoning for OSP to aid in appropriate review determination.

Revision 0.0 – 10/05/09 – Updated to reflect current laboratory operations

ISSUING AUTHORITY	FORM TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	REVIEW DATE	REV.
ESH&Q Division	Harry Fanning	06/20/16	06/20/19	1.4

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Task Hazard Analysis (THA) Worksheet

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

Click For Word

Author:	Riad Suleiman	**Date:**	October 1, 2020	**Task #:** If applicable	

Complete all information. Use as many sheets as necessary

Task Title:	Magnetized Beam Cathode Solenoid			**Task Location:**	LERF Gun Test Stand (GTS)
Division:	Accelerator	**Department:**	Center for Injectors and Sources	**Frequency of use:**	Daily
Lead Worker:	Riad Suleiman				
Mitigation already in place: Standard Protecting Measures Work Control Documents	See OSP, "Magnetized Beam Cathode Solenoid".				

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	Electrical Hazard	M	M	3	All electrical leads covered	Read and Adhere to this OSP **Training:** • SAF603 Electrical Hazard Awareness • SAF104 Lock, Tag and Try	1
2	Magnetic Field Hazard	L	H	3	Interlocked concrete door Postings: Signs, Strobe lights, flashing red beacons 5 Gauss barrier markings	Read and Adhere to • This OSP • ESH Manual Chapter 6420	1
3	Magnet Heating	L	M	2	LCW cooling Thermal switch Interlocks Postings: Signs	Read and Adhere to this OSP	1

Highest Risk Code before Mitigation:	3	**Highest Risk Code after Mitigation:**	1

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Task Hazard Analysis (THA) Worksheet

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

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.)

Task Hazard Analysis (THA) Worksheet

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

Form Revision Summary

Periodic Review – 08/13/15 – No changes per TPOC
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	TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	REVIEW DATE	REV.
ESH&Q Division	Harry Fanning	08/13/15	08/13/18	0.1

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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: ACC-20-107399-OSP

Title: Magnetized Beam Cathode Solenoid

Name	Signature	Date