Jefferson Lab
Thomas Jefferson National Accelerator Facility

Notable Event Worksheet

(See ES&H Manual Chapter 5200 Appendix T1 Event Investigation and Causal Analysis for Instructions)

Click For Word Doc

Title of Event			
Event Title:	Employee Uses Hall B Maglocks and Crashes PSS, Making an Unauthorized Entry into the Hall		
Date and Time of Occurrence:	05/15/2012	**Notable Event Number:**	PHY-12-0515
Event Location:	Hall B Tunnel Entrance	**Date Notable Event Report is Due*:**	06/15/2012

*The Notable Event Report is due to the ESH&Q Reporting Officer with 30 days of the Initial Fact Finding Meeting unless an extension is requested.

Categorization and Reporting
(To be completed by ESH&Q Reporting Officer within two hours – unless essential information is still pending)

ORPS Determination:	**Date:**	05/16/2012	**Time:**	5:23 pm

From Tina Johnson — Reply | Reply All | Forward | Archive | Junk | Delete

Subject **ORPS/NTS determination and notification: PHY-12-0522 - Employee Defeats Hall B Maglocks and Crashes PSS Making Unauthorized Entry into the Hall.** 5/16/2012 5:23 PM

To Steve Neilson

Cc Mary Logue, rossi@jlab.org, Keith Welch, Bob May, Ned Walker, Jennifer Williams, John Kelly, kujawa — Other Actions

Steve,

Good Afternoon! Yesterday, at approximately 7:33 pm, a Hall B employee made an unauthorized entry into Hall B by using the magnetic lock emergency entry switches to defeat the door magnetic locks. The Hall B PSS was in Controlled Access at the time and there were no other personnel in the Hall; the Controlled Access Exchange Master Key was in the Home position, allowing a change of state to Power or Beam Permit if the PSS did not crash on the entry.

The individual did not contact the control room before defeating the locks and entering. On observing the person entering the Hall on the PSS video monitors, the SSG Group Leader immediately made a PA announcement for the person to exit Hall B immediately, and they did.

This event will be investigated using our Notable Event process. The Fact Finding Meeting is scheduled for tomorrow morning and has been placed on your calendar.

Based on the information obtained so far, this event **does not** meet the ORPS/NTS reportable criteria.

If you have any questions or concerns, feel free to contact me.

Thank you,
Tina

--
Tina Johnson
Reporting Officer/
Administrative Assistant
JSA/Jefferson Lab
12050 Jefferson Ave
Suite 602
Newport News, VA 23606
757-269-7611

Categorization and Reporting
(To be completed by ESH&Q Reporting Officer within two hours – unless essential information is still pending)

ORPS Determination:	**Date:**	05/16/2012	**Time:**	5:23 pm

Subject: ORPS Update: PHY-12-0514- Hall B Employee Defeats Hall B Maglocks and Crashes PSS, Makes Unauthorized Entry to Hall.
Date: Tue, 22 May 2012 16:59:21 -0400
From: Tina Johnson <cjohnson@jlab.org>
To: Patty Hunt <phunt@jlab.org>
CC: David Luke <luke@jlab.org>, Mary Logue <logue@Jlab.org>, Steve Neilson <sneilson@jlab.org>, Bob May <May@jlab.org>, Keith Welch <welch@jlab.org>

Patty,

See the following update to the above mentioned event.

The investigation team looking into the event in Hall B has recommended that we report this event to DOE through the Occurrence Reporting & Processing System (ORPS) as a Management Concern (Significance Level 3). Initial indications point to a potential weakness in our safety system that needs a thorough review and repair. It was discovered "no-fault" (no exposure to the employee), but Physics is not treating this lightly.

The investigation team believes that this information is worth sharing with other labs, which is the criteria for reporting under the Management Concern category.

If you have any questions or concerns, feel free to contact me.

Regards,

--
Tina Johnson
Reporting Officer/

10 CFR 851 Screen:	**Date:**	**05/16/2012**	**Time:**	**5:23 pm**

Negative: This event does not meet the NTS voluntary reporting criteria either as a discreet event or as a programmatic weakness.

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Notable Event & Lessons Learned Worksheet

Unless otherwise specified the following is to be completed by the Lead Investigator.

Step 1 Initial Fact-Finding Meeting					
Date:	05/17/2012	**Time:**	9:30am	**Location:**	TED, Room 2559

Required Attendees:	**Optional Attendees:**	**√ if Present**
Lead Investigator:	**Associate Director:**	X
(Print Name): Keith Welch	(Print Name): Patrizia Rossi	
ESH&Q Representative:	**TJSO Observer:**	X
(Print Name): Tina Johnson	(Print Name): Patty Hunt	
Supervisor of involved persons(s):	**Subject Matter Expert(s), Facility/Equipment Owner** as applicable:	
(Print Name): Denny Insley	(Print Name): Todd Kujawa, ESH&Q Electrical SME	X
Involved or impacted person(s):	(Print Name): Chas Hightower, Physics- Safety Professional	X
(Print Name): Employee	(Print Name):	
(Print Name):	(Print Name):	
Witness(es):	(Print Name):	
(Print Name):	(Print Name):	

Agenda *(Ensure the pace of the meeting allows time for accurate note taking.)*	**√ if Complete**
1. Introduction – Provide Event Title, Date and Time of Occurrence, and Location:	X
2. Attendance - Are Required Attendees present.	X
3. Purpose of Initial Fact-Finding meeting.	X
4. Event Reconstruction – Use information to complete Section 3. Summary of Event and/or Injuries below.	X
a. Personnel and organizations involved in the event.	X
b. Conditions and actions preceding the event.	X
c. Chronology (timeline) of the event; and	X
d. Immediate actions taken in response to the event.	X
5. Clarify information – Subject-Matter Expert (SME) confirms work conditions.	X
6. Stop Work or the Tag Out Required? If "Yes" – establish the restart criteria and inform the affected Management chain.	-
7. Compensatory Actions Required? If "Yes" determine responsibility and include confirmation documentation.	-
8. Records or documentation required to confirm, clarify, or complete information (i.e., work plans, work control documents, photos, etc).	X
9. Other Questions or Concerns: Ask attendees if there are any other questions, concerns, or information that they wish to provide.	X
10. Obtain TJSO Observer feedback on conduct of fact finding meeting and potential improvements.	X

Step 2 Investigation Team:	**Date Convened:** (Within 24 hours of Fact Finding Meeting.)	5/21/2012	
Role	**Name**	**Department/Group**	**Phone**
Lead Investigator	Keith Welch	ESH&Q/RadCon	7212
Co-lead	Tina Johnson	ESH&Q/Reporting	7611
SME- Electrical	Todd Kujawa	ESH&Q	7006
SME- PSS	Kelly Mahoney	ENG	7024
SME- Accelerator Ops	Randy Michaud	ACC	7416
SME -FM&L	Michael Sprouse	FM&L	7574
Hall B Work Coordinator	Doug Tilles	PHY	7566

Step 3 Summary of Event and / or Injuries, including Initial Fact Finding Meeting information: determine the chain of events and timeline. Use attachment as necessary.

Context: Newport News was experiencing an intense electrical storm with extremely heavy rain. The events of this incident were triggered by the effects of the storm. Rainwater overwhelmed several areas of the accelerator enclosure, causing flooding in experimental halls A, B and C. The involved employee lives in Gloucester where it was not raining at the time. The employee was the technician-on-call for Hall B.

The employee received a page at 6:26 pm stating that there was a coolant leak associated with the tagger magnet power supply. Employee called the Counting House and was requested with some urgency to report to work. The employee received another page while on his way to work (at 6:57 pm) stating that there was 2 feet of water in the hall (this was exaggerated; water levels in the hall proper approached 4 – 6 inches, water at the exterior of the truck ramp approached 2 feet in depth, water backed up against the inner truck ramp door to about 18 inches). Photo 2 shows conditions outside truck ramp shortly after the storm.

Employee reached the Counting House at about 7:25 pm and made his way to the lower level. There was 2-3 inches of water on the floor at the base of the stairs (Photo 1). He briefly discussed the situation with two Hall B personnel who were at the bottom of the stairwell (one of these persons was the Run Coordinator for Hall B at the time, the other a Hall B liaison for the experiment). During this discussion, the employee noted that these personnel had wet feet and clothing. During this brief encounter, the employee made a number of assessments and assumptions about the scenario, including (a) that these and other persons had already made access to the hall, (b) that the hall was in Restricted Access, and (c) it was reasonably safe to enter and make a quick assessment of conditions. The hall was in fact in Controlled Access. No Hall B personnel had been inside the hall since flooding began. Two Facilities personnel and a Hall B person had attempted to enter the hall about an hour earlier, but stopped when they reached the inner door to the hall due to the amount of water that had backed up against the door and was rushing out when the door was opened.

After the brief interaction with the Hall personnel, the employee immediately proceeded to the entrance to the hall. No discussion of the PSS access status took place. The employee did not call the MCC. He attempted entry by repeatedly swiping his ID badge at the CANS access reader while attempting to open the door. He did not look at the PSS access panel. When the door would not open, he assumed the CANS system was malfunctioning due to the electrical storm, so he pressed the maglock emergency release switch(es) to gain access to the hall (see Photo 3 for configuration of access area). He entered the hall and immediately checked the water levels at the truck ramp door. Observing that water had backed up to significant depth at the truck ramp door (at least one foot), he determined that there was nothing he could do to mitigate the situation and immediately exited the hall. Upon exiting the hall, both entry vestibule doors were open simultaneously, which caused the PSS to trip to Restricted Access status. The change in PSS state drew the attention of the MCC staff, who began checking PSS status and video screens at the Safety System console.

The employee returned to the stairwell, at which point the Hall B liaison inquired about the condition of the Tagger Dump, which could be flooded by about 5 inches of water in the Hall. The employee immediately reacted by entering the Hall again to check the tagger dump. At that time the Safety Systems Group Leader, who was assisting the Operations crew, observed the employee entering the hall on the Hall B video monitor. The SSG Leader made a PA announcement directing the employee to exit the hall immediately and report to the MCC. The employee heard the announcement, aborted his mission to observe the Tagger dump, and exited. As he exited the hall, the employee reset the maglock over-ride switches, allowing the SSO to re-apply the maglocks, preventing further access. The employee reported to the MCC as requested.

Step 3 Summary of Event and / or Injuries, including Initial Fact Finding Meeting information: determine the chain of events and timeline. Use attachment as necessary.

TIMELINE of BASIC EVENTS – Shading indicates approximate time, others are known within 1 minute.

Time	Location	Action/Event	Comments
16:30	C. H. sump room	Sump pumped	Pumps left in off position as normal
17:15	SL	Lightening causes PSS drop	PSS fault in South Linac
17:20	HB	To Controlled Access	(opportunistic access) 4 people in/out
17:22		SSG Mngr. paged	SL PSS error
17:22	HB	Entry by HallB staff	Opportunistic access to hall B
17:28	HB	HB staff exit	No water on floor at this point
18:05		Sump pit high alarm page to FM	Page came in between 18:00 - 18:10
18:15	C.H. sump room	FM to sump room	Water was coming out of Hall B, sump not to floor level, but high
18:17		Radcon called about pumps	C. Jones requesting Radcon permission to turn on sump pumps
18:19		Call RCD Coord to Env. Eng. abouot pumps	RCD coordinator contacted RCD Env.Eng for concurrence on pump operation
18:20		Call RCD Coord. To FM	Reported back to FM&L okay to start pumps
18:20	C.H. sump room	Sump pumps started	
18:26	HB	FML attempt entry to HB	Opened door, did not enter hall proper. B. Eng also entered at that time, also turned around.
18:26	HB	Page to TOC	"Tagger Magnet down. Coolant leak" (possible auto-page)
18:29	HB	FML exit	
18:57	HB	Page to TOC	"We have flouding, 2 feet in hall. Please call to the coutning hous"
19:25	CH	TOC arrives counting house	Time is approximate
19:31	HB	First entry to hall by TOC	Bypass buttons pushed. Went to truck ramp door briefly, then exited
19:33	HB	TOC exits hall	
19:33	HB	PSS dropped to restricted	Both doors open at same time, PSS crashed
19:33	C.H. basement	TOC/HB Liason discuss tagger dump	HB Liason concerned about rad. significance of dump flooding
19:34	HB	Second entry to hall by TOC	Re-entered to check on tagger dump flooding
19:34	MCC	PA announcement to hall B	Directed person in Hall B to leave immediately
19:35	HB	TOC exits hall	Did not make visual assessment of dump, exited when announcement made on PA

Notable Event Report

Emergency Notifications Made (Subsequent to the Event):	Date	Time
Fire, Rescue & Emergency Medical: (9-911)	-	-
Guard Post: x4444; 269-5822		
Occupational Medicine 269-7539	-	-
ESH&Q Reporting Officer: 876-1750	05/16/2012	10:49 am
Crew Chief 630-7050		
Industrial Hygiene: 269-7863:	-	-
Other:		

Witness Accounts: (Use attachments as necessary. Box will expand as necessary)

Statement from Andy Sandorfi
05/21/2012

Someone from Hall C came into the Hall B Counting Room and stated that we, *Hall B*, were flooding Hall C and that there was a foot of water in Hall B.

I asked the Shift Leader to page *Engineering On Call* and Calvin Mealer responded. Meanwhile, we went downstairs to investigate.

Calvin called the Counting House and responded that he was on his way in to work.
Calvin met me and Bill Briscoe, the Run Coordinator at the time, at the bottom of the stairs where we exchanged a brief conversation about the amount of water that was flowing in the Halls. Calvin waded through the water down the hallway to the Hall B vestibule entrance but did not go in – I think – he was out of direct sight.

Calvin returned and we had another conversation in the stair well. I expressed my concerns that the water may be flooding the Tagger dump. Calvin responded that there had been a protective lip around the tagger dump but he thought it had been removed during the previous experiment. I expressed the concern that this could create what is at least technically a radiological hazard. Calvin responded by saying he would take a look into the Hall. I stated to Calvin that he should not to go into the Hall because of the potential for electrical outlets under the water. Calvin headed towards the PSS vestibule. At that point he was again out of direct sight. I assumed that Calvin would call the MCC once he entered the PSS vestibule, to get permission to enter under "controlled access." I did not see Calvin hit the maglock release buttons.

At some point in all this I went upstairs to phone Rad Con of the potential problem of pumping water that had contacted the tagger dump out into the public sewers. This was at best a frustrating experience and as a result took some time.

I returned downstairs and Calvin had returned. I can't remember if I heard any PA announcements

Witness Accounts: (Use attachments as necessary. Box will expand as necessary)

Follow-up to interview with Crew Chief.

Keith,

Sorry I did not get back to you sooner!

-Did you communicate this [the decision to restrict entry to the halls due to presence of water] to the halls by phone or other means? If you did, do you recall who you spoke to and what you told them?

I spoke with the hall staff, in the Counting House, and told them my intention to limit the access into the Halls. Ed Folts called and asked for access into Hall A. He wanted to go down to divert the water, I had already gotten reports (Carroll Jones) that Hall A was the better of the three. At this point I called Arne Freyberger to ask his opinion on access to the Halls. He instructed to allow limited access to the halls and let staff make judgments about the hazards. So, we allowed Jack Segal and Ed Folts to enter the hall.

-Did you by any chance consider this to be, in effect, a "stop work" order?
I really did not know how this event should be classified. I was concerned.

-When David Hamlette and I arrived on site (about an hour after this), we were allowed access to the halls. Did you consider this to be part of the emergency response and therefore not affected by the "no entry" restriction?

I had already spoke to Arne about allowing limited access to the halls. I also knew that you two were here to assess the radiological hazards. So yes, I thought of you as part of the emergency response effort.

-Did you and your operators have the sense that you were engaged in an "emergency", and that the default emergency conditions and assumptions should apply - such as the default central point of contact during this event is the Crew Chief? Did you look at (or consider looking at) your emergency flow charts and procedures to see if there was any guidance there for such a condition? do you think some written guidance for such an event would be helpful, or even feasible? Could some generic guidance for any "off-normal" condition be helpful?

Yes, we thought of this as an emergency. No we did not consider invoking any previously determined protocol.

I know that Tina Menefee is also doing the safety investigation. We had a meeting last week, that I requested you be invited to, this may have fallen through the cracks. I asked in that meeting to have some clarification on what our protocol should be in an event such as this. I did have a feeling of being a little unprepared for an event like this. I know that it is difficult to plan/ proceduralize every potential emergency, but it would be nice to get some clarification on the potential electrical hazards of that much standing water.

I hope this helps, and and again I apologize for my delayed response.

-Brian Freeman

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Notable Event & Lessons Learned Worksheet

Environmental Aspects	
Type of Material Released:	**Quantity:**
Source:	**Time Flow was Halted or Controlled:**

For Investigation Team (√ All That Apply):

☐ **Reportable Quantity** ☐ **Impact Ground/Soil** ☐ **Storm Water Channel/Drain** ☐ **Sanitary Sewer**

Records, Documents, Pictures, and Other References: (Copy and paste, use attachments or document links as necessary)

Photo 1, Conditions in Counting House Basement during Event

Records, Documents, Pictures, and Other References: (Copy and paste, use attachments or document links as necessary)

Photo 2, Conditions at Hall B Truck Ramp Shortly After Storm

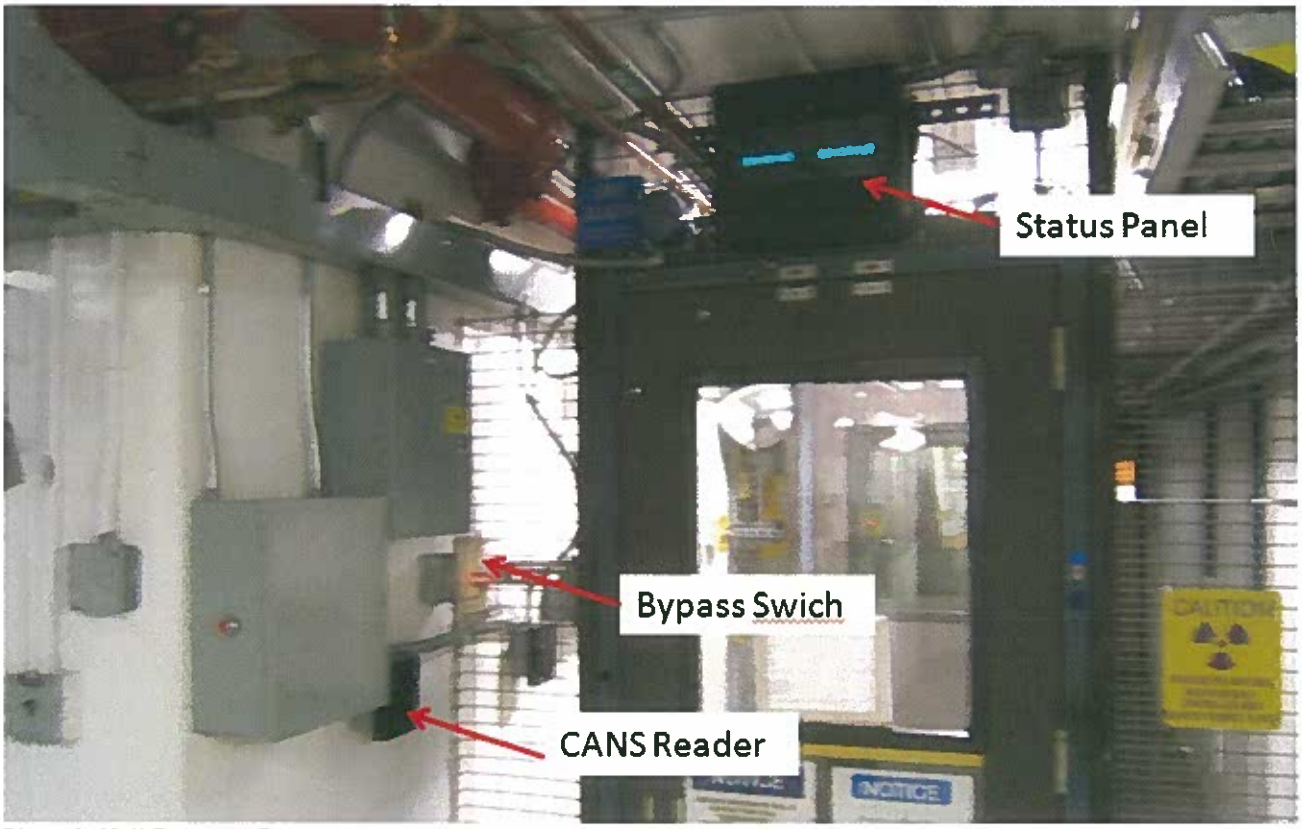

Photo 3, Hall B Access Door

Causal Analysis: (Use attachment as necessary)

See attached causal analysis tree and detailed analysis description.

Direct Cause:	The direct (immediate) cause of the event was that the Hall B technician on-call (TOC) failed to follow the appropriate access procedure for a Controlled Access by using the mag-lock emergency bypass switch to gain access to the hall while the hall was in Controlled Access.
Root Cause:	There are two root causes for the event. Both human error and engineered system error caused the event to occur. Using the coding in the causal analysis tree contained in DOE O 232.2, the causes were: (1) *"Human Performance Less Than Adequate; Signs to stop were ignored and step performed incorrectly"* (A3B2C02), and (2) *"Design/Engineering Problem; Design output scope less than adequate"* (A1B2C01).
Contributing Causes: (List as many as apply.)	a) Planning for weather (and other) emergencies b) Training/awareness c) Communications
Non-causal Issues that Should be Addressed	a) Floor drain sump pump configuration and level monitoring

Extent of Condition Check	Responsible Person(s)	JLab CATS Number	Target Date
N/A.			

Corrective Action(s)	JLab CATS Number	Target Date
See attached investigation report	NE-2012-16	9/2013

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Notable Event & Lessons Learned Worksheet

Lessons Learned (Confer with Division/Department Lessons-Learned Coordinator) (Use attachment as necessary)	JLab COE Number
Decision making during stressful situations can be difficult. Procedures and practices for responding to abnormal situations should factor in expected degradation of human performance during such events.	-

Investigation Team Confirmation:
The below signees, confirm to the best of their knowledge, that the information presented in this document is accurate and complete.

Role	Print	Signature	Date
Lead Investigator	Keith Welch		6/26/12
Co- Lead	Tina Johnson		6/26/12
EHS&Q	Todd Kujawa		6/26/12
Physics/Hall B	Doug Tilles		6/26/12
FM&L	Michael Sprouse		6/27/12
Engineering	Kelly Mahoney		7/2/12
Accelerator	Randy Michaud		6/28/12

Upon confirmation submit document to the ES&H Reporting Officer for completion and distribution.

Documentation of Findings: (To be Completed by ESH&Q Reporting Officer)

Notable Event Number:	PHY-12-0515
CATS Number:	NE-2012-16
JLab COE Number:	-
ORPS Number:	N/A
NTS Number:	N/A
CAIRS Entry:	N/A
DOE Cause Code:	Human Performance was LTA (A3B2C02) Design/Engineering Problem; Design Output LTA. (A1B2C01)
ISM Code:	Perform Work Within Controls.

Acceptance/Acknowledgement of Facts

	Print	Signature	Date:
Associate Director/ Department Manger	R. Ent		07/02/12

Distribution:

ES&H Reporting Officer (Original)
Associate Director/Department Manager
Division Safety Officer
Investigation Team Members

Form Revision Summary

Revision 1.3 – 01/31/12 – Updated ESH&Q Reporting Officer assignment from SSmith to CJohnson per MLogue
Edited to clarify process steps.
Revision 1.2 – 10/20/11 – Updated ESH&Q Reporting Officer assignment from JKelly to SSmith per MLogue.
Revision 1.1 – 05/24/11 - Edited to clarify process steps.
Revision 1 – 11/23/10 – Updated to reflect current laboratory operations.

ISSUING AUTHORITY	FORM TECHNICAL POINT-OF-CONTACT	APPROVAL DATE	EXPIRATION DATE	REV.
ESH&Q Division	Tina Johnson	10/19/09	10/09/12	1.3

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Introduction

On May 15, 2012, an employee gained unauthorized access to Hall B while the hall was in Controlled Access. A summary of the event and timeline are contained in Section 3 of the Notable Event Report (NER). The information in this report is the result of an in-depth evaluation of the causal and contributing factors leading to the event. This analysis was performed by an investigation team ("the Team") consisting of: Keith Welch (ESH&Q, Team lead), Tina Johnson (ESH&Q, Team co-lead), Kelly Mahoney (Engineering), Randy Michaud (Operations), Mike Sprouse (Facilities), Doug Tilles (Physics) and Todd Kujawa (ESH&Q). The Team used an analysis approach based on the TapRoot root-cause analysis process and made use of guidance and requirements from DOE STD 1197-2011 and DOE O232.2.

Summary

The Team considers this event to be very serious, involving high-level institutional conditions that warrant the attention of JLab management at the highest levels. This event involved both human error and the failure of engineered controls to operate as desired. Several error precursors have been identified that contributed to the human performance error. Importantly, the event also revealed a number of other conditions that either contributed to the event or failed to prevent it. These issues fall mainly under the category of "Contributing Factors/Latent Weaknesses" in our analysis (they did not cause the event, but had they not been present, might have prevented it). They include issues such as; clearly identifying conditions that require the initiation of crisis/event management protocols, establishing clear roles and responsibilities for dealing with off-normal events, developing protocols intended to manage crisis conditions while intentionally preventing serious human error during such conditions, and the training of staff on expected actions during such events. The Team believes that the individuals involved in this event responded predictably, given the context and scenario, and that no disciplinary actions are warranted as corrective actions.

Personnel interviewed

Name	Division/group	Position/role
Calvin Mealer	Physics/Hall B	Technician On-Call (TOC) 5/15/12
Brian Freeman	Accelerator/Operations	Crew Chief on duty 5/15/12
Andrew Sandorfi	Physics/Hall B	HDIce liaison, present in Hall B counting house 5/15/12
Anna Shabalina	Accelerator/Operations	ARM on duty 5/15/12
Mike Sprouse	FM&L	Responded to flood conditions, present in counting house basement area
Carroll Jones	FM&L	Responded to flood conditions, present in counting house basement area
Kelly Mahoney	Eng/ Safety Systems	SSG Manager, responded to storm conditions, present in MCC during event
Tina Menefee	ESH&Q	Emergency Manager
Dave Kausch	FM&L	Fire Protection

Documents reviewed

- Hall B Worker Safety Training (SAF-111)
- Hall B Conduct of Operations for g14 experiment
- ESAD for CLAS g14 run

- Hall Work Governance (SAF-110kd)
- JLab Emergency Management Plan
- JLab Technical Basis Document for Emergency Planning
- CEBAF Weather Emergency Response Procedure (MCC-PR-16=007)
- Accelerator Operations Directives
- Tunnel worker safety pre-brief (SAF-132A)
- Task group report, "Plans for Improving Notifications to Hall and Facilities Staff Regarding Flood Events at Jefferson Lab"
- EH&S Manual Chapter 3510 (and appendices), Emergency Response Activities

Findings

Event – the specific event being evaluated is the unauthorized entry to Hall B when the hall was in Controlled Access. Authorized access in this state requires the coordinated actions of the Safety System Operator (SSO) and entrants to the hall. The unauthorized entry was made possible by the inappropriate use of a mag-lock emergency bypass switch at the entrance to the hall coupled with a logic error in the Personnel Safety System (PSS). The PSS failed to fault to a safe state when an entry that did not adhere to authorized access steps was made. This condition represents a failure in both human performance and engineered system performance. In addition, the event illuminated a number of other latent organizational weaknesses that we have considered as contributing factors in this report.

1. Direct Cause
   The direct (immediate) cause of the event was that the Hall B technician on-call (TOC) failed to follow the appropriate access procedure for a Controlled Access by using the mag-lock emergency bypass switch to gain access to the hall while the hall was in Controlled Access.

2. Root Cause
   The Team finds that there are two root causes for the event. Both human error and engineered system error caused the event to occur. Using the coding in the causal analysis tree contained in DOE O 232.2, the causes were: (1) *"Human Performance Less Than Adequate; Signs to stop were ignored and step performed incorrectly"* (A3B2C02), and (2) *"Design/Engineering Problem; Design output scope less than adequate"* (A1B2C01).

3. Contributing Factors/Latent Weaknesses
   The causal analysis identified several important contributing factors. The contributing causes consist mainly of gaps in management systems (latent organizational weaknesses). Many of these issues are interrelated, highlighting the need for an integrated approach to implementing steps taken to improve the conditions. See the analysis below for details.

   This report deals mainly with the human performance error and contributing factors. The PSS error is being evaluated through the Unreviewed Safety Issues (USI) process managed by the Safety Configuration Management Board (SCMB). In addition to the PSS programming error itself, we consider the presence and configuration of the emergency access switches to be a contributing factor.

Analysis of Root Causes

Discussion: Root Cause (1), *"Human Performance Less Than Adequate; Signs to stop were ignored and step performed incorrectly"* (A3B2C02)

It should be noted that *all* the other C-level "nodes" under B2 (Rule-based errors) were factors in this error (as well as some C-level nodes in B3 (Knowledge-based error)). For instance, B2C03, *"Too much activity was occurring and error made in problem solving"* was a factor due to the context of the situation (flooding of the experimental hall). The Team believes the selected root cause most closely describes the performance error. Most of the factors leading to the performance failure are directly associated with readily identifiable *error precursors*. These error precursors are noted on the causal analysis chart.

- Since this error is a human performance issue, evaluation of this root cause must take into account the context in which the event occurred. Factors affecting the context include the following. The Hall B TOC was responding to a call-in situation caused by flooding of the hall from extreme rainfall in the local area (he was paged at about 6:30 pm while at home). The first page indicated only that there was a leak detected in a power supply in the hall. The TOC received a second page while en route that there was "two feet" of water in the hall (inaccurate, exaggerated report). When the TOC arrived, he went immediately to the lower level of the counting house, where he encountered flood conditions (about two inches of water throughout the lower level (see photo 1 in NER)). This is where he met with the Run Coordinator and a Hall B experiment Liaison. The situation created significant stress and anxiety for the TOC. This stress contributed significantly to errors in judgment and incorrect decisions, and represents the first error precursor.
- The TOC stated that he perceived it as his duty upon call-in as the TOC to make an access to the hall to evaluate conditions and status of equipment. This perception grows from a sense of responsibility and ownership for the activities occurring in a given accelerator/experimental area. This responsibility includes the upkeep of sensitive and costly experimental equipment that is critical to the success of an experiment. While this sense of responsibility is appropriate, extenuating circumstances in this case should have triggered a cautious re-evaluation of the status of the hall, and the possible safety issues at hand. Instead, the stress of the moment intensified this sense of responsibility to the point that the TOC seemed to regard his duties to evaluate the hall as being *essential* at almost "any cost", leading him to give more importance to the hall status than to his own safety. This led to his having "blinders" to basic safety steps (failure to call the Crew Chief, observe the PSS status, or invoke prudence regarding potential electrical safety issues). Several error precursors are at work here; a *"can-do" attitude for a crucial task*, which can lead to placing the job before safety, *time pressure* to evaluate the hall immediately, and *habit patterns* and *biases* which all conspire to make for decision error.
- Many of the above error precursors and faulty decisions occurred or manifested themselves when the TOC met and briefly discussed the situation in the hall with two Hall B staff. This event (the discussion) could have acted to prevent the performance failure had certain policies and controls been in place as part of a larger emergency response protocol. This is considered an important contributing factor, and is discussed further in that section of the report. From a human performance perspective, the event represents poor communications practice, since it was not

used to brief the TOC on important status conditions, such as the Crew Chief's prohibition on hall access. This contributed to a precursor of the TOC having an *inaccurate risk perception*.

- The TOC made several significant *assumptions*. He observed that the staff he spoke with (and others) had wet shoes and pant legs, indicating they had spent time wading through the several inches of water on the floor of the counting house. Given that his commute to the lab took about an hour, he assumed that under the prevailing conditions, the accelerator had been placed in Restricted Access, and staff had already made entries to all the experimental areas.
- Due to the above mental state, assumptions, biases, attitudes and perceptions, the TOC went directly to the hall entrance and swiped his badge without observing the status panel above the door, expecting the door to open (see Photo 3 in the NER).
- When the door did not unlock, the TOC again operated on an assumption that this was due to failure of the CANS access system. Several factors affected this assumption. First, it is common knowledge that the CANS system fails secure – errors cause the locks to fail to a locked state. The TOC had experience with this and stated that he had been present on at least one occasion when the bypass switch was used to exit the hall when CANS failed. The investigation Team received reports from staff that the bypass switches have been used on numerous occasions to exit experimental halls, and on one or more occasions to make access to Hall B (during Restricted Access). This condition of allowing a "work around" to become routine is significant, and causes precursors of *bias* and *mindset*.
- Contributing to these precursors are factors associated with the training and indoctrination of workers concerning the bypass switches, and the labeling of the switches. Hall B is unique in that it is the only location having a bypass switch that can allow emergency access *into* the hall. The need to review the rationale for this condition is discussed further in the Contributing Factors section. However, given the presence of the bypass, worker training concerning when it is appropriate to use it, and what the consequences of use might be, is important. Hall B area familiarization training mentions use of the bypass (parenthetically) as a means of *emergency exit* from the counting house basement in the event of emergencies in which the stairwell may be inaccessible. It is unknown at what level this may be covered during training (the three halls and accelerator conduct their awareness training using differing methods). No other mention is given in the training as to use of the bypass. Given the treatment of the bypass switch in the training materials, it is clear that the writers assumed any use of the bypass would cause the PSS to fault to a safe state, if that was not already the case. The Team was unable to locate evacuation maps of the basement to determine if Hall B is denoted as an escape route. Safety walkthrough information from the other halls does not contain reference to this.
- The use of the bypass as an *emergency exit only* should be reinforced by other human factors inputs such as identification and layout of the switches. Other than a plastic cover over the outer door switch, the layout of the emergency access switches is essentially the same as the emergency exit switches (see photos below). Contrary to reinforcing special conditions for use, this layout reinforces the notion that there is fundamentally no difference in the entry/exit switches.

Emergency Entry Switch Emergency Exit Switch

Summary:

The "signs to stop" referred to in this root cause included (a) status panel indicating Controlled Access, (b) the failure of the door to unlock upon scanning of ID badge and (c) the potential hazards associated with significant standing water on the floor. One of these signs was ignored entirely (due to assumptions mentioned) and two of them were used to form incorrect conclusions about how to proceed (again due to assumptions and the stressed mental state of the TOC). Because of the context of the situation, several other causal factors were at least partially involved. From O 232.2, these include:

A1B2C01 Strong rule incorrectly chosen over other rules
A1B2C03 Too much activity was occurring and error made in problem solving
A1B2C04 Previous success in use of rule reinforced continued use of rule
A1B2C05 Situation incorrectly identified or represented resulting in wrong rule used
A1B3C01 Attention was given to wrong issues
A3B3C05 Incorrect assumption that a correlation existed between two or more facts

Recommended Corrective Actions:

1. If emergency entry bypass switches for Hall B are retained (see subsequent sections), modify the switch configuration to reinforce the uniqueness of the configuration and restrictions on its use. Add an alarm function (in MCC) to warn operators of use (include "alarm will sound" on local signage).
2. Review the combined use of CANS/PSS for access points to the accelerator. Given the expectation that CANS may periodically fail, investigate alternatives to bypass switches (i.e. use crash bars on exit doors as in most other locations).
3. Conduct a broad review of safety familiarization training of all beam enclosure areas, focusing on actions expected of workers under emergency conditions. Ensure harmonization (all areas should identify common evacuation routes). Use consistent, effective means for training delivery. Self-guided tours are discouraged.

4. Hold briefings with all Hall staff (A, B and C) concerning the configuration and purpose of the Hall B emergency access switches to reinforce the restrictions on use of this bypass (emergency exit of counting house basement only).
5. See corrective actions related to emergency response issues.

Discussion: Root Cause (2), *"Design/Engineering Problem; Design output scope less than adequate"* (A1B2C01)

The PSS system failed to produce a safe state when the unauthorized access occurred. This occurred due to omission of logic that causes a fault state if the inner access door is opened during Controlled Access when no key exchange has occurred. Current logic prevents operation of the inner door mag-lock from the PSS control panel under this condition, but the addition of the mag-lock bypass switch overrides this control, creating a condition in which access can occur without a key exchange, and which does not create a fault. This allows for a condition in which the only safeguards against a beam-on exposure to persons inside the hall are administrative (PA announcements, claxon warning alarm).

A complete analysis of the safety system failure is beyond the scope of this review. The mechanism for conducting this review is the Unreviewed Safety Issue (USI) process administered by the Safety Configuration Management Board (SCMB). However, the broader issue of the need for the access bypass, its justification, documentation supporting the justification, and the configuration of the system (interaction with PSS, alarms, signage, etc.) needs review. There does not appear to be any documentation to support the basis for the access bypass.

Recommended Corrective Actions:

1. SCMB conduct a USI investigation concerning the PSS error.
2. Conduct a multidisciplinary review of the access bypass feature to determine need for (consideration of future configuration of Hall B should be included) and configuration of such a feature. The Emergency Management Team, SCMB and other stakeholders should either review the evaluation or participate in it, to validate underlying assumptions used to arrive at conclusions.

Analysis of Contributing Factors/Latent Weaknesses

Discussion:

As with many undesirable events, underlying conditions are often among the most important, pervasive, and difficult to address. We have used the event causal analysis chart to identify what the Team believes are the most important issues. These conditions, left unaddressed, represent potential error precursors for future events.

Important Contributing Factors

1. Planning for weather (and other) emergencies
2. Training
3. Communications

1. Planning for weather (and other) emergencies

Discussion: Several issues exist with regard to this factor.

a) The formal plans and procedures that exist at the lab for dealing with weather emergencies do not address response to flooding. The Technical Basis Document (TBD) for the Emergency Management Plan lists flooding from an extreme rain event as "likely" in the threat matrix, with the impact of such an event being assigned a rating of "limited". The TBD is designed to evaluate and document the likelihood of triggering the declaration of an Operational Emergency as defined in DOE O 151.1C, which defines the scope of the emergency management program. The risk matrix does not appear to have been fully exploited to prioritize development of formal response plans for likely emergency scenarios. Even though the impact of local flooding is unlikely to be severe enough to warrant declaring an Operational Emergency, the likelihood of occurrence should drive the development of formalized response plans. Since no specific plan for flood response exists, specific hazards unique to flooding (i.e. electrical) have not received adequate treatment in response planning. This may be the case for other scenarios in the threat matrix as well.

b) National Weather Service warnings were available to the Lab through the iNWS system, but the Lab has not integrated these communications into our weather emergency systems. The iNWS system broadcasted a flash flood warning for Jefferson Lab approximately an hour before the flooding event. If these warnings had been received – and importantly – if the Lab had had an integrated plan for responding to such warnings, it is likely that protective measures (flood gates, sump pump configurations, etc.) could have been implemented, and the effects of the storm significantly reduced.

c) The emergency management plan does not direct specific actions except in the event of the declaration of an Operational Emergency (OE). Since an OE requires immediate notification of DOE Headquarters, declaring such an event will only be done under "worst case" conditions in which the Lab has insufficient resources to manage the event on its own. Since the lab has a "Base Program", it does not use a categorization system (no events warranting an "Alert" status or higher are credible). In addition, the lab has not devised local categorization for emergencies that have a severity less than an OE. This leaves a very large spectrum of conditions and events that fall below the threshold of OE for which the Lab has no formalized management process to use in designating an event condition or response activities (an exception to this is hurricane preparedness condition classifications). Therefore, managing an unusual or off-normal event is made more difficult due to a lack of clear guidance. The existing Operations Department weather emergency procedure is not applicable to immediate events such as flood or tornado, and the existing tornado response procedure (EH&S Manual Ch 3510-T3) provides only immediate actions for general workers on how and where to seek shelter. These procedures do not appear to be linked to any coordinated system that defines criteria for declaring an event or managing the response (although the Operations procedure does define its own set of event classes, and could be used as a model or starting point for a more general protocol).

d) Roles and responsibilities during off-normal events need to specific and clear. Because of the conditions noted above, when an event occurs for which a coordinated response would improve the outcome, such a response is difficult to mount because it is not clear who is in charge of what. There is no general process for establishing "incident command", and no general guidance for

those in charge. Most events have to be managed on a case basis, with few pre-defined or general protocols for first response. There are a few exceptions to this (e.g. fire response and hurricane preparedness) but otherwise, the people "on the ground" have to rely primarily on "on-the-fly" decision-making (sometimes local, sometimes from management via telephone). Responses to fires are a notable exception, since these events always result in the establishment of incident command and control if offsite fire response is called (in the time between discovery and arrival by offsite emergency responders, procedures define a designated individual as the Point of Contact for the event). However, there is no similar, formalized approach to deal with other events. The Operations procedure for weather emergencies (referenced above) is aimed at weather situations that allow time for preparation. However, it uses a hierarchical model that could be emulated in devising protocols for emergent/crisis conditions. As noted above, having a systematic protocol for handling emergencies is important for purposes of preventing errors and mishaps that are likely under such conditions. The lack of such a system leaves roles and responsibilities unclear. Even those who are in positions of some authority are unsure of the proper steps to follow (see Crew Chief comments in the Witness Accounts section of NER). In this particular event, use of an event response protocol could have created the additional control needed to prevent the unauthorized access (assuming such a protocol invokes more rigorous work authorization and communication requirements, and is incorporated into routine training and conduct of operations documentation for potentially affected areas).

e) Off-normal response protocols need to be devised to intentionally restrict personnel actions in light of human factors. This event highlights the effect of stress on human behavior (other cases of human error during off-normal events have occurred recently). This stress should be anticipated and its effects controlled to the extent possible by the implementation of specific protocols to be used in unusual events. Procedures and processes should be intentionally designed to prevent poor decisions (including "heroic actions") made in the heat of the moment. In an emergency situation, the tendency for people to take matters into their own hands and to do things without thinking them through should be assumed to predominate. Again, protocols for responding to crisis or unusual scenarios should be developed with this in mind, with steps designed to help employees stop, think and review (and perhaps obtain permission or authorization) prior to commencing with a response activity.

Significance to Event:

The conditions described above contributed to an un-coordinated response to the flooding event and allowed missed opportunities to mitigate impact of the flooding. Clear plans and protocols reduce uncertainty and help limit human error.

Recommended Corrective Actions:

1. Conduct gap analysis of the EMP-TBD threat matrix to identify likely or significant event scenarios. Address all scenarios in a consolidated emergency management manual or guide that clearly delineates responsibilities during specific events.
2. Devise a system of emergency event designations and create specific guidance with directions on how to declare and manage each type of event, including initial actions (i.e. restricting access to site, requiring check-in and pre-job briefs, etc.).

3. The protocols above should provide specific directives as to roles of authority in each situation (should consider location (accelerator site), staff available, etc.) – create communication requirements to ensure all affected people are aware of the event conditions, and establish basic first-response requirements to ensure protection of life and health until triage can occur – e.g. for flooding in hall or tunnel, establish "keep out" requirement until a first entry protocol is approved. Create flowcharts, protocols/checklists as necessary to address each scenario.
4. Integrate iNWS notifications into emergency response process – establish specific actions to be conducted for a given warning (e.g. flash flood = install flood gates at halls).
5. Train affected staff. Ensure flow-down of basic awareness. Conduct drills to reinforce expected actions.

2. Training and awareness

Discussion: Training needs enhancement (in addition to training items noted above).

a) The EMP describes emergency training required for various groups and individuals at the lab. But most of this training is broadbased and not specifically focused on emergency response. An assumption of the emergency response program (because it is a Base Program) is that training received by most staff on their regular job assignments is adequate for the level of emergencies that might be expected. However, staff who are responsible for complex technical systems and areas, such as an experimental hall, and might be expected to get off-hours calls to respond to unusual situations are candidates for additional emergency response training, which should include drills and practice for likely off-normal situations.

b) Implementation of an event response protocol, such as discussed in the sections above, would naturally create the need for enhanced emergency response training.

c) Included in the topic of training is the broader aspect of education of staff in topics such as systems operation and configuration and the interrelationship of systems from a given work area with other systems. One of the conditions identified in this analysis is that both the TOC and the experiment Liaison for Hall B had an inaccurate conceptual understanding of the operation of the floor drain sump system in the halls. In addition, the Liaison believed that compromising the Tagger dump with flood water could lead to a significant radiological event, in terms of negative public response to loss of containment of radioactivity from the dump (through the pathway of the floor drain sump), even though the radioactivity levels might be very small. The second entry of the TOC to the hall was made because of this concern. The actual impact of such an event would likely be insignificant, and the radioactivity release would be accounted for in existing waste water permits. Understanding these specific system interactions requires area/system familiarization and training. In this case, the specifics of how these systems might interact has not been formally documented or communicated to staff that might benefit from the knowledge. The impact of flooding on the dump itself is has not been considered a significant aspect of a flooding event, since the dump resides in the groundwater under the hall. However, documentation of this and other details of the dump configuration were not readily available during this review.

Significance to Event:

Staff members with responsibilities to respond to this event had not been trained on or conducted practice exercises for such an event. Especially for human performance issues, practice is an important way to reinforce "forcing functions" which are designed to ensure consistent, appropriate response.

Recommended Corrective Actions:

1. Assess the adequacy of emergency training needed for staff and users who might be expected to respond during off-normal conditions. (This may be done through task/needs analysis focusing on emergency response job functions, looking for gaps between needed knowledge, skills and abilities (KSAs) and existing training objectives).
2. Identify appropriate persons to receive enhanced training, establish retraining requirements as appropriate.
3. Obtain tagger dump design documents, evaluate and document impact of hall flooding on dump, train key Hall B, Radcon, FM and Accelerator staff (others?) on interrelation of tagger dump with sumps and impact of flooding]

3. Communications

Discussion: Verbal and written communications need improvement.

a) The team noted several instances of unclear verbal and other communications during the event. Important specific items related to communications included the exaggerated information in the text page sent to the TOC regarding the depth of water in the hall. This condition (water depth in the hall) was significantly miss-communicated even much later in the event (when RadCon personnel arrived, they received a report that large volumes of water were flowing *out of the Tagger dump pit* into the hall). Another important interchange occurred when the TOC arrived and discussed the situation with the Run Coordinator and Hall Liaison. This conversation is noteworthy for what it did not include – it apparently lacked discussion of the Crew Chief's prohibition on access, the current status of the machine and PSS and potential hazards in the hall. These communications errors point to the need for more formalized protocols during emergency events, when accurate transmission of data is crucial. In addition, we considered written communications and documentation to be part of this aspect. As noted, a documented assessment of flooding of the Tagger Dump should be conducted.

b) Additionally, we found no specific emergency response instructions in the standing procedures such as the COO and ESAD other than persons to contact in case of emergency. The COO refers the reader to the "Emergency Response Plan" for emergency information. But as mentioned the Emergency Management Plan does not give guidance for dealing with specific events. Cursory review of Hall C and A documents indicates similar coverage. The Team believes this is a subtle but important organizational weakness. Too many instructions defer entirely to the EMP or other high-level documentation under an apparent assumption that these program plans adequately address any issues that may apply to the topic.

c) Also, although not causal in nature, the Team found that configuration of the floor drain sump system is not well documented, and due to self-imposed limitations requires a good deal of resource-intensive oversight. The sump is managed jointly by FM&L and RadCon. Configuration of the pumps and restrictions on operation are well understood by the responsible staff, but the default operating mode (manual pump operation) carries some risk that off-hours flooding events can result in overflow conditions that would exacerbate the impact of a flood. The Team found that in this event, the sump pump configuration probably only marginally affected hall flooding. However, under different circumstances, having the pumps in automatic mode could improve the outcome of a flood event. Recent changes in permitting requirements allow for this change. Also, the sump alarm system is limited in its ability to provide notifications to key staff. Sump level data is not available, and only a few staff are notified of high level conditions.

Significance to Event:

Poor verbal communications added to stress levels for the TOC, and contributed to poor decision-making. Gaps in formal guidance exist due to weaknesses in written communications. Improved documentation would produce better references for training material.

Recommended Corrective Actions:

1. Emergency management protocols should stress the importance of clear communications. Response protocols implemented as discussed in previous sections should contain steps and guidance that are designed to ensure that information does not degrade during transmission.
2. Some form of formalized pass-down or pre-job briefing should be considered for staff responding to emergencies to ensure they are apprised of important status information (integrated into plans described in sections regarding emergency planning).
3. Documents such as COO, AOD, etc., should be harmonized with the recommended Emergency Manual.
4. Floor drain sump system configuration should be documented. A sump level monitoring system should be installed that provides online status information, and the early warning system for potential high levels should be upgraded to make notifications more flexible and more widely available.