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An Evaluation of Recent Events Involving Hazardous Energy at INL Facilities

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Analysis Report

An Evaluation of Recent Events Involving Hazardous Energy at INL Facilities

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EXECUTIVE SUMMARY

Idaho National Laboratory (INL) Facilities and Site Services (F&SS) has experienced 14 reportable events relating to work performed under lockout / tagout (LOTO) and/or work involving hazardous energy during the period of March 4, 2019 through August 18, 2020. The 14 events are described in Appendix A and were numerous enough and similar enough in nature to be indicative of an adverse trend that warranted further evaluation. A qualified cause analyst was asked to lead a team in the review of these non-compliances, to determine commonalities, and to provide recommendations to the sponsoring organization. The team focused on both individual and institutional behaviors as well as the LOTO process and procedure. The non-compliances were reported in the Department of Energy (DOE) Occurrence Reporting and Processing System (ORPS) and/or the INL issues tracking system. The most significance of the 14 events were:

- There was a willful violation of work control instructions which resulted in contact with and damage to a 480-volt line (CO 2020-1471).
- The insulation of an electrical lighting conductor (277 Vac) was damaged by the chuck of a hand drill and resulted in an electrical short and potential exposure to personnel performing work (CO 2019-0768).
- Failure to use a spotter resulted in a damage to a guywire and potential contact with a 13.8 KV electrical line (CO 2019-1288).
- Improperly installed 120-volt electrical lines posed a hazard to those working in the area (CO 2020-0532).
- When it was noted that multiple cables were present in a junction box, personnel did not take appropriate action to identify the correct cable and, instead cut what they thought was the correct cable. As a result, a live 277 V cable was severed exposing personnel to a hazardous electrical source (CO 2020-0747).

An apparent cause analysis was completed for the willful noncompliance that resulted in damage to the 480-volt power cable. Human Performance Improvement (HPI) reviews were performed on seven events and six events had no documented analysis. To gain a better understanding of what occurred, the investigation team reviewed issue and action documentation for each event. Once the team members understood the event, they used several different methods of analysis to discover commonalities among the events. These included binning of events into general failures, specific failures, and HPI concerns. Commonalities identified during this binning exercise are as follows:

- General Failures
    - In eleven of the fourteen events, there was a failure to follow work process requirements and expectations.
    - In eight of the fourteen events, hazard identification and mitigation were less-than-adequate (LTA).
- HPI Analyses:
    - In nine events there was LTA knowledge of human performance modes.
    - In nine of the events there was a poor risk perception by personnel performing work.
    - In eight events there existed a culture of production over safety.
    - In eight events there was LTA knowledge of or the use of HPI tools.
    - In seven events there was an LTA knowledge of or experience with the INL safety culture.

Recognizing that the number of LOTO/hazardous energy events is small when compared to the number of successful work evolutions that are executed each day, the team believes the common failures noted in the 14 events may be indicative of problem with training of subcontractor personnel and oversight of their work. To address the common themes and noted concerns identified in this analysis, the team offers the following recommendations.

1. Continue the ongoing effort to improve the "onboarding" process for sub-contractors.
    a. Use results of management, peer and other structured INL observation processes, as well as results of other performance improvement tools (critiques, Lessons Learned, etc.) to keep this training current and focused on identified weaknesses.
2. Strengthen oversight and supervision of subcontractor personnel.
    a. Use tools identified in recommendation #1, such as management, peer and other structured INL observation processes and results of other performance improvement tools - critiques, Lessons Learned, etc.), to increase the effectiveness of this effort.
    b. Consider adding personnel to the affected organizations (e.g., construction management, safety, and quality etc.) that could provide additional eyes "in the

field" to monitor for safety and compliance. These could be either former employees that have a useful background in the areas (safety, construction, maintenance, or operations) or lower skilled employees "assistants" that would be available to spot check ongoing work and that would bring any concerns or questions up to the CFR and/or supervisor, as appropriate. They could also be temporary, to cover periods of high activity, and thus be added or discontinued, as workload dictated.

c. Evaluate tools that can be used to help determine the appropriate level of oversight needed for each individual job.

3. Perform a follow-up effectiveness review of any prior performance assessments that have been done on the organizations of concern in this common cause analysis (Construction Management or maintenance for example), to provide deeper insight on whether previously identified issues and recommendations have been effectively addressed.

4. Include HPI training for subcontracted personnel so they understand performance modes, HPI tools, etc.

1. Introduction

Idaho National Laboratory (INL) facilities have experienced an increase in reportable events relating to work performed under Lockout/Tagout (LOTO) and/or work involving hazardous energy during the period of March 4, 2019 through August 18, 2020. Fourteen events reported during this time were numerous enough and similar enough in nature to be indicative of an adverse trend warranting an analysis to determine if commonalities exist. A qualified cause analyst led a team to review these non-compliances, to identify any similarities, and to provide recommendations to the sponsoring organization. The team consisted of the following individuals:

- Lisbeth A. Mitchell, INL Performance Management, Team Leader and Lead Cause Analyst
- Van Sandifer, Consultant, Applied Engineering Services
- John K. Epperson, INL Facilities & Site Services, Human Performance Improvement Specialist
- Danielle C. Hampton, INL Facilities & Site Services, Lead Performance Analyst and Cause Analyst
- Dusty L. Hawker, INL Facilities & Site Services, Safety Representative
- Timothy A. Hollis, INL Facilities & Site Services, Lockout Tagout Subject Matter Expert
- Shawn M. Williams, INL Environment Safety & Health Facilities and Site Services, Central Facilities Area Lead Safety Representative

2. Analysis Methodology

Because this analysis was chartered as a “common cause analysis”, the analysis team did not conduct any field observations of current on-site LOTO/hazardous energy work. Instead, the team used existing data provided in the individual LabWay condition reports, including cause analysis reports, critique reports, fact finding meeting notes, and human performance improvement (HPI) reviews. If deemed necessary, the team interviewed persons involved in or knowledgeable of a particular event to get a better understanding of what caused or contributed to the non-compliances. The information learned through the analyses were compiled on a spread sheet for a comparative analysis of the events. The results of each of these analyses are summarized below.

3. Findings from Analysis of Lockout Tagout Events

A detailed analysis of each event is provided in Appendices A and B. The following summarizes the observations made from the analysis.

- Notable Practice – There has been an ongoing effort to improve the "onboarding" process for sub-contractors, initiated early in the period covered for the evaluated events. This has had a positive impact in increasing sub-contractor's knowledge of INL processes.

- Observation - Due to the number and frequency of similar events, it is evident that the corrective action process, as being executed, is not as effective in some parts of the F&SS organization as desired. This represents a potential missed opportunity to use low-consequence events, like many of those represented in this review, to identify an increase in adverse behaviors that, if not corrected, can result in more significant and unacceptable consequences. This is evident by the lack of documentation for critiques and other processes required by the INL issues management system, indicating these processes are not being followed by some F&SS organizations. This also made it difficult for the common cause analysis team to determine potential contributing common causes.

- Observation - Post-work acceptance testing, and inspections are not being required or are not being done effectively. Changing the way post-work acceptance testing is performed would reduce the chances that an exposed wire or improperly installed device would expose INL employees to unacceptable hazards.

a. Summary of Common Causes

1. Most events evaluated represented a failure to follow INL process requirements and expectations for work, by both INL and sub-contracted personnel (11 out of 14), resulting in ORPS reportable conditions that could lead to unacceptable consequences.

2. Hazards identification and mitigation was judged to be deficient in 8 of the 14 events evaluated. This resulted in the use of LTA work documents in 5 of the 14 events. LTA walkdowns, both planning and pre-work, were judged to contribute to several of the events. This was also true in events that resulted from a failure to verify energized electrical sources are not present in work areas. LTA hazard identification and mitigation were a common issue with respect to following requirements of the Lockout/Tagout process, specifically in the identification and isolation of all hazards associated with the servicing/maintenance to be performed. There are 3 main steps to the Lockout/Tagout process to ensure the safety of the individuals performing the work task:

    - Hazard identification

    - Hazard isolation

- Verification of the isolation.

Failure of any of these three steps places the employees in unsafe work condition. Hazard identification is the responsibility of all employees. This weakness fails to achieve the "fail safe" approach to planning work espoused at INL.

3. Inadequate oversight and/or supervision was also a factor in at least 4 of the events. This was specifically true for events involving subcontractors, in which their supervisors did not control events adequately to prevent an issue. In addition, improving the level of oversight by CFRs, facility personnel, and construction safety may also have prevented some of these events.

4. Findings from an Analysis of Human Performance

The fourteen events were analyzed to identify commonalities related to less than adequate human performance. The analysis identified the following:

- Subcontractors involved in the following events had little to no knowledge of or experience with the INL safety culture. (CO-2019-0768, CO-2019-1288, CO-2019-1837, CO-2019-2217, CO-2020-0747, CO-2020-1288, CO-2020-1471)

- The concept of performance modes (e.g., skill based, rule based, and knowledge based) is foreign to most individuals involved in the events. As such, they were ill prepared to recognize when they moved from one performance mode to another. (CO-2019-0768, CO-2019-1288, CO-2019-1837, CO-2019-2217, CO-2019-2222, CO-2019-2290, CO-2020-0747, CO-2020-1288, CO-2020-1471)

- Procedure use is marginal or non-existent when the workers are performing what they consider a skill of the craft or a routine task. (CO-2019-0768, CO-2019-1288, CO-2019-2217, CO-2019-2290, CO-2020-1471)

- Employees had a poor perception of risk for the work they were performing. (CO-2019-0768, CO-2019-1288, CO-2019-1837, CO-2019-2217, CO-2019-2222, CO-2020-0565, CO-2020-0747, CO-2020-1288, CO-2020-1471)

- A culture of production over safety existed for several events. (CO-2019-0768, CO-2019-1288, CO-2019-1837, CO-2019-2217, CO-2019-2222, CO-2020-0747, CO-2020-1288, CO-2020-1471)

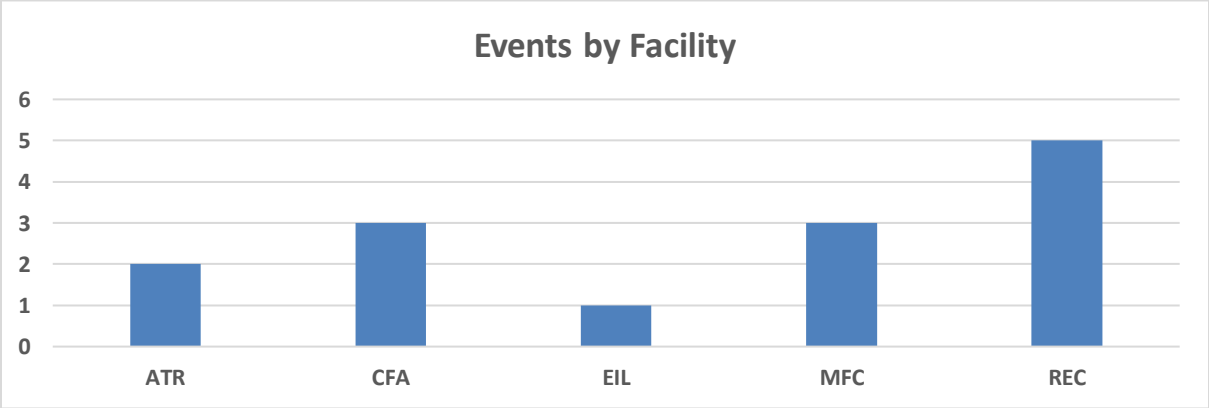
- Personnel had a fundamental lack of knowledge of and/or failed to use HPI tools. (CO-2019-0768, CO-2019-1288, CO-2019-1837, CO-2019-2217, CO-2019-2222, CO-2020-0747, CO-2020-1288, CO-2020-1471)
- Several events were related to unknown or newly discovered conditions and personnel were ill prepared to respond to these new conditions. (CO-2020-0257, CO-2020-0532, CO-2020-0565, CO-2020-0935, CO-2020-1006)
- Several events involved legacy issues that were not expected or planned for. (CO-2019-2290, CO-2020-0532, CO-2020-0935, CO-2020-1006)

5. Commonalities

Reviewing the events for commonalities in organizations responsible for the work, facilities where the events took place, and subcontractors involved showed the following:

a. Event Location and Significance

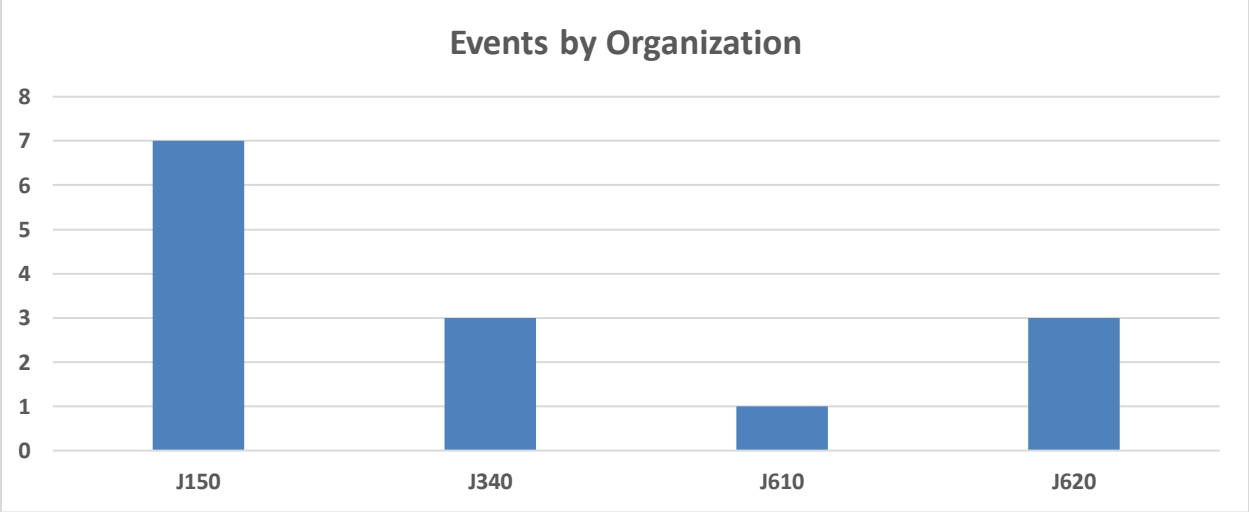
The team found that five events were reported at Research and Education Complex (REC) facilities, three at both the Central Facilities Area (CFA) and the Materials and Fuels Complex (MFC), two events occurred at the Advanced Test Reactor, and one at the Energy Innovation Laboratory (EIL). The table below shows the distributions of and the significance of the events that were reported. The significance levels for each event were applied by the team. The levels for each individual event are shown in the table in Appendix C. The figures shown below represent the number of events that occurred in each facility/mission center by significance and the average significance for the facility/mission center.



Facility	# of Events	Number and Significance of Events			
		A	B	C	Average Sig Level*
ATR	2	0	0	2	**2.55**
CFA	3	0	0	3	**2.35**
EIL	1	0	0	1	**2.85**
MFC	3	0	1	2	**2.8**
REC	5	0	0	5	**2.28**
***Significance**		**High (3)**	**Medium (2.41– 2.9)**		**Low (1.0 – 2.0)**

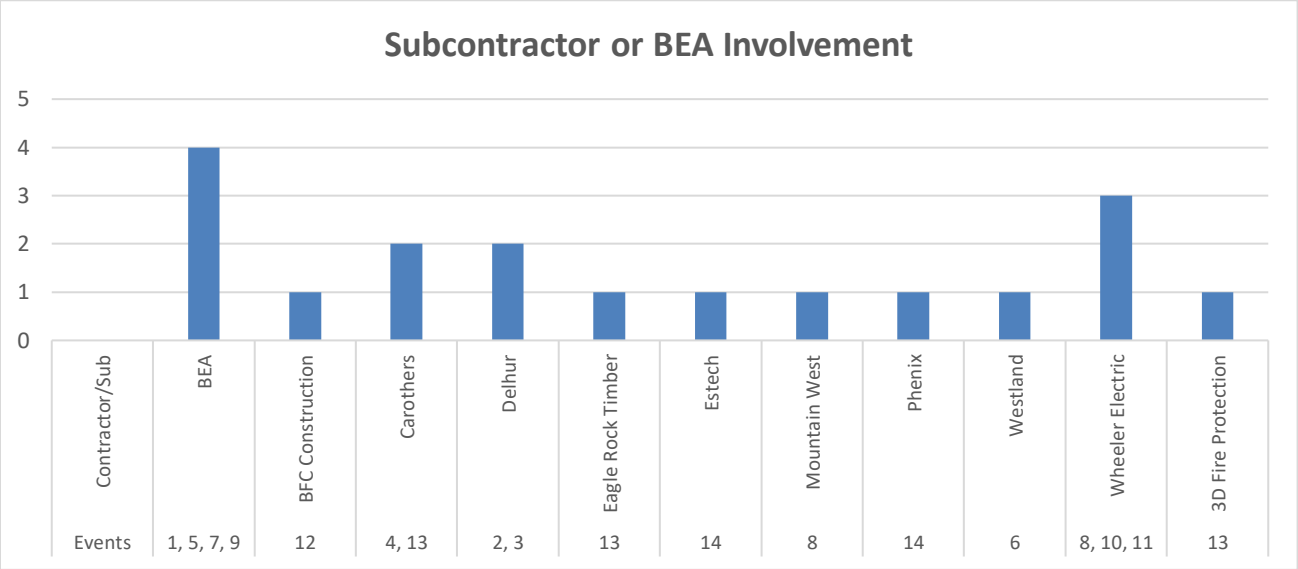
b. Organizations and Subcontractors

Organization J150 (Construction Services) owned seven of the 14 events and had the highest average significance level of the events reported. Organizations J340 (Site Operations and Maintenance) and J620 (REC Facility Operations and Maintenance West Campus) each owned three events and organization J610 (REC Facility Operations and Maintenance) owns one of the events.



Organization	# of Events	Number and Significance of Events			
		A	B	C	Average Sig Level*
J150	**7**	**0**	**1**	**6**	**2.74**
J340	**3**	**0**	**0**	**3**	**2.35**
J610	**1**	**0**	**0**	**1**	**2.6**
J620	3	0	0	3	**2.13**
***Significance**		**High (3)**	**Medium (2.41– 2.9)**		**Low (1.0 – 2.0)**

A breakdown of personnel (either BEA employees or subcontractors) found that BEA employees were involved in four events and subcontractors in the other ten events with Wheeler Electric being involved in three of those 10 and Carothers and Delhur being involved in two events each.



BEA or Subcontractor	# of Events	Number and Significance of Events			
		A	B	C	Average Sig Level*
BEA	4	0	0	4	**2.44**
BFC Construction	1	0	0	1	**2.55**
Carothers	2	0	0	2	**2.36**
Delhur	2	0	0	2	**2.70**
Eagle Rock Timber	1	0	0	1	**2.7**
Estech	**1**	**0**	**0**	**1**	**3.0**
Mountain West	1	0	0	1	**2.8**
Phenix	**1**	**0**	**1**	**0**	**3.0**
Westland	1	0	0	1	**1.0**
Wheeler Electric	3	0	0	2	**2.475**
3D Fire Protection	1	0	0	1	**2.7**
***Significance**	**High (3)**		**Medium (2.41– 2.9)**		**Low (1.0 – 2.0)**

6. Conclusions

Recognition and analysis of "lower consequence" events within F&SS have identified the following weaknesses in Laboratory and sub-contracted construction and maintenance activities:

1. INL expectations, policies and procedures covering work performance and safety are not always being effectively met in the F&SS organizations reviewed.
    a. The identification and mitigation of hazards is LTA.
    b. Supervision and oversight are LTA
2. Performance Improvement processes, techniques, and tools (i.e., HPI, work observations, etc.) are not always being effectively used.

7. Recommendations

The team recommends the following actions to address the commonalities identified with the 14 events.

1. Continue the ongoing effort to improve the "onboarding" process for sub-contractors.
    a. Use results of management, peer and other structured INL observation processes, as well as results of other performance improvement tools (critiques, Lessons Learned, etc.) to keep this training current and focused on identified weaknesses.
2. Strengthen oversight and supervision of subcontractor personnel.
    a. Use tools identified in recommendation #1, such as management, peer and other structured INL observation processes and results of other performance improvement tools - critiques, Lessons Learned, etc.), to increase the effectiveness of this effort.
    b. Consider adding personnel to the affected organizations (e.g., construction management, safety, and quality) that could provide additional eyes "in the field" to monitor for safety and compliance. These could be either former employees that have a useful background in the areas (safety, construction, maintenance, or operations) or lower skilled employees "assistants" that

would be available to spot check ongoing work and that would bring any concerns or questions up to the CFR and/or supervisor, as appropriate. They could also be temporary, to cover periods of high activity, and thus be added or discontinued, as workload dictated.

c. Evaluate tools that can be used to help determine the appropriate level of oversight needed for each individual job.

3. Perform a follow-up effectiveness review of any prior performance assessments that have been done on the organizations of concern in this common cause analysis (Construction Management or maintenance for example), to provide deeper insight on whether previously identified issues and recommendations have been effectively addressed.

4. Include HPI training for subcontracted personnel so they understand performance modes, HPI tools, etc. Provide and implement a continual reinforcement of HPI philosophy and tool usage. *One-and-done training will change nothing.*

8. Other Recommendations

The team also offers additional recommendations that may not specifically address the prevalent problems noted, but the team feels the recommendations can provide opportunities for improvement. These recommendations include:

1. Monitor and mentor F&SS management and supervision in use of, and compliance with contractor assurance requirements and methods.

9. List of Appendices

Appendix A – Description and Analysis of Events
Appendix C – Significance Analysis
Appendix D – Documents Reviewed

Appendix A
Description and Analysis of Events

#	LabWay	Location	Type of Investigation	Description
1	CO 2019-0768	EIL	HPI Review	On 4/10/19 at approximately 1520 the insulation of an electrical lighting conductor (277 Vac) was damaged by the chuck of a hand drill and resulted in an electrical short. Troubleshooting and repair work was being performed per WO275747 on the HVAC exhaust system at IF-688 (EIL). It was identified that installation of three self-taping screws was needed to mechanically secure the associated ventilation ducting to the supporting strut channel to silence vibration noise. During the installation of the second screw the drill's chuck contacted the insulation of an adjacent electrical wire, which was routed within the center of the strut channel, causing insulation damage, and resulted in an electrical short. The damage to the insulating material resulted in a potential exposure to uncontrolled hazardous energy per LWP-9301.
ANALYSIS • Work orders that specify “troubleshoot and repair” are too vague and can allow scope of repairs to bypass hazards ID and mitigation. These work orders should have more specificity, such as “troubleshoot and report, prior to repair” and include limitations on troubleshooting steps that could cause exposure to unmitigated hazards, e.g., electrical, equipment motion, stored energy. Guidance exists in LWP-6200, Section 4.9 on how work orders are to be used for “troubleshooting and repair.” • The process does not provide sufficient direction on situations where hazards change (for crafts). • Hazards identification and mitigation was LTA. There is too much reliance on skill of the worker to be able to prevent nearby energized electrical wiring from coming into contact with rotating tool; Poor judgement.				
2	CO 2019-1288	MFC	None	On June 12, 2019, a Construction Subcontract employee performing work with a skid steer loader, without the use of a spotter, unknowingly contacted a guy-wire anchor separating the guywire from the anchor point on June 12, 2019. The guywire supported a power pole for a 138 kilovolt (kV) transmission line at Materials and Fuels Complex (MFC). The potential for exposure to hazardous energy existed when the guy-wire anchor support was hit. An unsecured guywire does not need to touch the power line for a "step potential" to be present. The acting superintendent for the subcontractor performed a pre-job briefing for his crew working in the area backfilling trenches that had previously dug. Spotters were not assigned as they had been previously, due to the belief that backfilling activities would not be near the guy-wire anchor points. The employee using a skid steer backfilled and smooth the surface of the trench to accommodate upcoming truck traffic. The employee completed the task and went on to other activities in the area. The employee did not notice the guywire had been damaged. At approximately 1640 hours, MFC personnel working inside MFC heard a "crackling sound" coming from the direction

Appendix A
Description and Analysis of Events

#	LabWay	Location	Type of Investigation	Description
				of the power poles, the employees observed a guywire for the pole flapping around due to a light wind. At approximately 1700 on June 12, 2019, it was identified that a guywire for a pole that supports the 138kV power line entering MFC had been severed near the anchor. It appeared that as the wire moved in the wind a potential ground condition may occur. Once identified the Construction Field Representative was notified along with MFC facility management. The pole was located in between the MFC security fences where a subcontractor had been performing work using a skid steer loader. At the time of discovery, the subcontractor had left for the day and the area had been secured. NL Power Management was notified to correct the issue along with MFC security. INL Power Management performed the needed adjustments to the system and installed a temporary guywire to correct the damaged section. Upon initial discussions with the subcontractor, they confirmed that they were working around the pole earlier in the day but did not know if the equipment contacted the guywire. Upon further investigation by BEA management, it was observed that the tracks from the equipment indicate that contact was made between the equipment and the wire at some point. DOE was notified at 18:00 with an initial OPRS categorization. A critique will be held on Monday June 17, 2019 to ascertain additional information.
ANALYSIS • The INL requirements for when spotters are required were not completely followed. • A post-event corrective action was established: Toolbox safety meeting with crew to discuss expectations for spotters, etc. • Another corrective action was: JSA revision to discuss different options more explicitly for equipment operations and spotters, restrictions, delineations. • Critique report identified as an Error Precursor: Lack of or unclear standards. • LTA hazards ID and mitigation compounded by inadequate supervision or oversite.				
3	CO 2019-1837	MFC	None	At 0713 on 8/16/2019 a subcontractor was moving a piece of tracked equipment through the west perimeter security gate at the Materials and Fuels Complex (MFC). The security anti-breach cable that crosses the gate area had been buried earlier in the project to eliminate a tripping hazard. As the tracked equipment passed over the cable it sank in the soft ground and pinched the cable between two of the track sections. This caused the cable to be pulled from its existing location. As this occurred the cable damaged a 480-volt perimeter lighting junction box that was in the vicinity of the security cable. The subcontractor had a spotter staged to monitor the work. The spotter did see the event occur and quickly stopped the operator of the equipment, minimizing the damage to the electrical

Appendix A
Description and Analysis of Events

#	LabWay	Location	Type of Investigation	Description
				equipment. Subcontractor reversed the equipment to move it off the cable. Then secured the scene in a safe condition and notified their point of contact.

ANALYSIS
• Hazards ID and Mitigation appears to be inadequate. Assignment of spotter did not prevent significant damage to energized electrical equipment. No documentation on what alternatives were considered to driving over the "buried" cable.
  ○ There was an acknowledgement that the potential existed to cause damage by running over the cable, hence burying the cable a little deeper with more dirt. But overestimated the effectiveness of this action (amount of dirt placed over cable was inadequate to mitigate hazard.)
  ○ Not enough explanation as to why LOTO not used.
• As a result of the event, a corrective action was prescribed to "Publish a newsletter to the members of EICA that talks about spotters and the importance of using spotters/LL." This was like the corrective actions performed after the event of 6/12/2019 (Damaged guy wire at MFC), suggesting it lacked effectiveness.				

4	CO 2019-2217	ATR	HPI Review	NTS Report: A Lockout/Tagout (LOTO) conducted on 9/24/2019, was not performed in accordance with an approved General Contractor (GC) owned procedure allowed under an Interface Agreement with Battelle Energy Alliance. The General Contractor assisted two sub-tiered subcontractors in establishing a LOTO on a firewater post indicator valve (PIV) to allow work inside an excavation trench. As the sub-tier subcontractor employees hung their locks, they incorrectly attached them to an existing lock on the firewater PIV (e.g., daisy chained) and not to an approved LOTO device. In this configuration there was no exclusive control for the individuals who had placed their personal locks on the existing lock. Later, the subcontractor, who had first placed his lock, removed his lock and the three daisy chained locks came with it. The procedure required that a LOTO Authorized Employee place the first lock and then subsequent locks could be attached to a locking devise. Then, when locks are removed, the Authorized Employee would remove his/her lock last. When the other sub-tier employees' locks were inadvertently removed from the firewater PIV on 9/24/2019, all personnel were out of the excavation trench and no one reentered. During the pre-job activities on 9/25/2019, the sub-tier subcontractor employees noted that their locks were missing from the firewater PIV and identified that a LOTO was needed to enter the excavation trench. There was no actual impact to the safety and health of the subcontractors' employees.

Appendix A
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#	LabWay	Location	Type of Investigation	Description
ANALYSIS Notable concerns of this event: • Subcontractor involved. • Setting and reinforcing expectations for new subcontractors LTA. • Onboarding of new subcontractors LTA. • Due diligence on LOTOs LTA. • Appears to be "general lack of knowledge of LOTO procedure" by subcontractor superintendent. (subcontractor new to INL) • Previous contracts worked by subcontractor superintendent allowed "daisy-chain" locking for LOTO (violates subcontractor procedure.) • INL's oversight of subcontractor, especially a new one, LTA. • This subcontractor was working under an interface agreement and had an error carried forward in which the second employee hung their lock incorrectly and subsequent employees followed suit. This seemed to be caused by a lack of understanding/training on the Lockout/Tagout process. The additional locks should have been hung on a gang hasp or lock box to prevent this event.				
5	CO 2019-2222	REC	HPI Review	On 9/26/2019, during the decommissioning and demolition (D&D) activities in Lab W-1 in IF 657 a 120V lighting flex conduit was cut while sizing research equipment wiring conduit for removal from a conduit tray. The activity called for the use of an insulated shearing tool to do the cutting which protected the worker from a shock and resulted in a tripped breaker. Prior to the D&D of the research equipment conduit all the wires were physically removed from the electrical panels and marked as a validation of the wire removal from the electrical panels. During the shearing activity, a lighting circuit flex conduit was snagged with the research equipment conduit the worker was attempting to shear. The lights went out when the breaker tripped, and the crew stopped work and notified BEA management.
ANALYSIS • Confusing procedures or vague guidance was identified. • So was inadequate pre-planning walkdowns. • Hazards were inadequately addressed in work package. • Misalignment between Operations and D&D personnel on work activity classification.				

Appendix A
Description and Analysis of Events

#	LabWay	Location	Type of Investigation	Description
• Workers incorrectly believed work package allowed performing steps out of order. • Workers did not understand an energized cable was near cable they were cutting. • F&SS management/supervision should be included in scope increases to project work to ensure hazard identification and mitigation occurs. • Ensure workers understand all work area hazards. • Ensure pre-job briefings occur and are effective. • Ensure deliberate discussions occur as work scope/methods evolve. • Ensure type of work is clearly identified in work document preparation and product. • Review compliance with Conduct of Operations principles in work packages (work release, scope change, work execution). • Practice/review conservative approach to electrical work to ensure they result in fail safe conditions. • Ensure proper turnover between different organized/purposed work groups within performance of the same job.				
6	CO 2019-2290	REC	HPI Review	On 10-4-19 a sub-contractor was working on a project to refresh offices in EROB. The refresh effort included adding "sound-soak" wall board to the office walls which in turn required electrical box extensions to be added to each outlet and data port in the room. Prior to the work commencing a LOTO walkdown and zero energy verification of all the outlets identified on the electrical drawings was performed by the Facility Manager, the Hazardous Energy Specialist, in house electrical contractor and the work group representative from the construction contractor. During the walk down the group found and checked 5 outlets in the room. The work was released, and the contractor began the construction activity. During the removal of the outlets from the boxes a 6th unmarked outlet was identified by the contractor which had been hidden behind a bookcase during the walkdown and was not on the drawings. The contractor removed the outlet from the box and then checked it with his electrical polarity tester and found power in the outlet. The contractor stopped work and notified BEA management.
ANALYSIS Identified concerns/deficiencies: • There was a lack of, or unclear standards. • LOTO walkdown failed to identify a hidden energized electrical outlet.				

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Description and Analysis of Events

#	LabWay	Location	Type of Investigation	Description
• LOTO procedure revision failed to include revision to form documenting training for escorted personnel that would have required "safe to work check" prior to work as per LWP. • LOTO walkdowns need to identify all hazardous energy which may require moving furniture or use of other means to find all sources of energy. • LOTO briefing form should include safe to work check requirements as part of FAS LOTO briefing. • Ensure subcontractors understand the right to Stop Work and it is brought up in pre-job briefings. • Evaluate process in which documents are released to ensure all associated documents and training reflect changes prior to issuance. • Blanket Master General Subcontractors need to understand the applicable Subcontractor Manual documents. • Hazards identification and mitigation was LTA. Worker who found additional outlet failed to initiate a discussion with supervision and person releasing work as to whether new outlet fell under previously identified scope/hazards and subsequent mitigations. • During the fact finding, the worker believed he was working on the final outlet of the five the work documentation had called for and had yet to realize there were 6 instead of 5 outlets. What the worker performed was not considered a safe to work check, because work had already commenced at the time of removal. Inadequate system drawing and site walk down should be considered contributing factors				
7	CO 2020-0257	CFA	None	On 2/6/2020, After repairing a known damaged plug end on a 120 V GFCI protected Hot Line used to plug in heavy equipment, the Electrician cleared the Lockout/Tagout on the Hot Line panel and noticed that an additional circuit within the same panel was "tripped" and did not reset. He re-installed the Lockout/Tagout on the Hot Line circuit and walked the Hot Line where he discovered a severed cable laying under 3 feet of snow that had also been pulled away from the Hot Line leaving the exposed ends of the cable visible. The Electrician notified the Facility Manager and repaired the cable under the correct Work Control and Lockout/Tagout procedures.
ANALYSIS • Did not find a critique report in record. • The fact-finding report and LabWay report provided little or no detail on the reason for the severed cable. This is not a LOTO or a process issue.				
8	CO 2020-0532	WCB	HPI Review	At approximately 1600 on 3/24/2020 a construction subcontractor was working on the 3rd floor of the Willow Creek Building. The subcontractor was preparing existing ceiling tiles for the installation of new lighting. When the subcontractor employee moved a ceiling tile, that they were working on, a spark occurred from unidentified

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#	LabWay	Location	Type of Investigation	Description
				exposed live conductors that were coiled up in the overhead. (The conductors were part of the power/data pole assembly for the cubicles in the area.) Upon investigation it was identified that the live conductors were connected to the newly installed cubicle system. It was determined that the individual(s) who installed the cubicles, approximately 3 months ago, left the manufacturer provided electrical whip colloid up in the overhead with exposed conductors. Then, sometime during the cubicle installation process the whip was inadvertently energized by those who were finishing the electrical system for the cubicles. No injury occurred due to this event.

ANALYSIS

Issues identified:

- Unclear goals, roles & responsibilities
- Hidden system response
- Communication between the different subcontractors and INL crafts is lacking.
- Crafts from multiple subcontractors are working at different times on the job. This led to a poor understanding of what activities have been started, were being worked, and completed by the different crafts.
- Agreements on which working group or craft(s) are responsible for performing individual tasks/steps during assembly and installation of cubicles are not documented.
- The statement included in the LabWay documentation that "Then, sometime during the cubicle installation process the whip was inadvertently energized by those who were finishing the electrical system for the cubicles." Leads to the following questions/observations:
  - Poor oversight.
  - Should whip have been locked out? How could whip be "inadvertently energized"? (The process should have been an out of service tag since there was no active work being conducted on the whip.)
  - Are there requirements to perform work acceptance walkthroughs by INL personnel when work is performed by sub-contractors? If so, are they being performed effectively? Safety-type inspection should be required as part of the work acceptance process in closing out contracts.
  - Was this covered in the periodic meeting between the INL and sub-contractors (leaving work areas safe when work is completed?)

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#	LabWay	Location	Type of Investigation	Description
9	CO 2020-0565	CFA	None	On March 17, 2020, a Mechanic from Central Facilities (CF-696) noticed a 480 V a/c panel cover was open in his area (CF-696). The Mechanic contacted his Industrial Hygienist (IH) who also looked at the panel and was unfamiliar enough with electrical components that he did not want to close the door. The IH wondered if the door latch could shock him (or others) while attempting to close the door. He placed a traffic cone in front of the panel and went to contact the CF Electrical Supervisor. It was found by the Electrical Supervisor a single 90-degree (directional) screw had vibrated loose and allowed the door to open, exposing the hazardous energy. At this time, the Electrical Supervisor closed the panel door. No one was harmed by the brief exposure, and no work had been going on in the area for several days. The CF Maintenance and Operations Manager (M&O) was informed of the event by a Performance Analyst who received a LabWay on this event. At this time, the M&O Manager notified his Division Director of the event, and they notified the DOE-FR immediately. A Fact Finding was scheduled for March 25. It was later discovered the Electrical Supervisor was unfamiliar with the importance of this discovery as he was not ORPS familiarization trained. The Supervisor believed the problem was fixed on the spot and went back to work, not recognizing he needed to tell his Manager of the encounter.
ANALYSIS No documentation of: • Effort to understand basis of failure. • Search of like panels for similar screws. (Note: Events occurring in this organization (J340 Site Operations & Maintenance) appear to be handled differently than others in F&SS. This Dept. Manager may need help with understanding/use of Issues Management tools - Critique Reports. Are HPI Reviews not used because of union contract limitations?)				
10	CO 2020-0747	WCB	HPI Review	On April 29, 2020, at approximately 1120, a construction subcontractor was installing metal clad (MC) cabling and cutting ceiling tiles in preparation for new lighting fixtures to be installed on the 3rd floor of the Willow Creek Building (WCB). During the walkdown and the verification that all the junction boxes were installed and wired; the subcontractor identified that a junction box had not been installed. There are multiple MC cables running through this work location and the worker misidentified an active MC cable as the one that needed to be cut, to install the junction box, instead of the newly installed MC cable. The subcontractor cut the MC cable which contained a live 277-volt circuit. When the MC cable was cut, it tripped the main breaker for WCB causing the power to go off which

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#	LabWay	Location	Type of Investigation	Description
				initiated the backup generators. The employee stopped work, notified his Foreman, and stood guard at the location to ensure no one entered the area. All needed notifications were made. No shock or injuries occurred due to this event.
ANALYSIS Identified issues: • Interpretation requirements • Lack of or unclear standards • Past and current practices in the WCB, likely dating back to when the building was built, did not require cables above the ceilings to be labeled for immediate identification (voltage, circuit unit number, system, etc.) • Crafts from multiple subcontractors have performed work above the ceilings at WCB for decades, all with different methods/styles (including none) of marking cables, ducts, piping, etc. This has led to conditions where old and new systems look very similar and can be confused with each other. • The discovery of the main breaker for WCB tripping before the local breaker for the emergency lighting circuit, was a surprise and if fact did not function as expected nor designed and led to an exposed hazardous energy situation. The normal or expected sequence would have been for the circuit breaker for the cut MC cable would have tripped before the building main. So, when the emergency generator supplied power the circuit for the cut cable would have already tripped and there would not have been any exposed hazardous energy at the cut point in the MC cable. • Corrective Action-Whenever possible MC cable will only be cut above ceilings as a last measure. • Corrective Action-Implement a 2-person “pull test” or a “hand over hand” verification prior to cutting any MC cable above the ceiling. • Corrective Action- Implement process to label new installations of items/system above the ceiling. • Corrective Action-Evaluate the sequencing of the electrical power distribution system in WCB to ensure local breakers trip before upstream breakers trip. • Corrective Action- Identify critical steps and integrate as high as reasonably achievable level of resilience for all given critical steps. • The process used by the sub-contractor to confirm the wire is dead before cutting was LTA and they have subsequently added additional verification steps/techniques to correct this.				
11	CO 2020-0935	CFA	None	On 06/11/2020, Subcontractors working on a less than 50-volt (24 volt nominally) fire panel demolition project, discovered control power from a duct detector relay box going to a shunt trip relay breaker that would turn off the

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#	LabWay	Location	Type of Investigation	Description
				ventilation when smoke was detected in the duct. Subcontracting Craftsmen recognized this unexpected condition, and stepped back, notified their management, verified power using a proximity tester, and then traced it back to the shunt trip breaker. No Lockout was on this low voltage system at this time as their scope of work was for the less than 50 volts, as it is not required until greater than 50 volts.
ANALYSIS Post work acceptance checks to ensure work/installation by sub-contracted personnel meets INL and code standards are inadequate or not occurring at all.				
12	CO 2020-1006	REC	None	Occurrence Report - On June 25, 2020, a sub-contracted electrician observed an electrical arc within a nearby light fixture as ceiling tiles were being replaced as part of a remodel in IF-60ork was stopped and the light fixture was placed under Lockout/Tagout (LO/TO). The investigation that followed determined the electrical arc was between the wires in the fixture and the metal case of the light fixture. No breakers tripped and the metal case was properly grounded. When installed, the wire ends were twisted together but no wire nuts were placed on the bare wire ends. It was determined that the flexible conduit holding the wires had been bumped, which caused the exposed wires to contact the case. Initial investigation determined this to be a legacy issue from when the light fixture was installed. The sub-contractor was not shocked. Further investigation will take place to determine any other instances. The event was initially categorized as not ORPS reportable, however upon further investigation, the event was re-categorized as Group 02-D-2, based on information gathered during the investigation.
ANALYSIS Again, if post work acceptance inspections were performed, they should have caught this.				
13	CO 2020-1288	ATR	HPI Review	On August 18, 2020, at approximately 0730 hours, the Construction Field Representative (CFR) was performing a routine walkdown of the Material Storage Building (MSB) construction site. The CFR observed an air conditioning unit with a panel removed, exposing the electrical conductors. The CFR found the electrical subcontractor responsible for the installation and inquired about the condition of the unit. The subcontractor informed the CFR they had removed the cover to take a photograph to aid engineering support to complete the installation. At that time, the subcontractor was focused on the need to provide the information and had forgotten that the LOTO for that unit had been released the week prior. There was no power to the 120/208-volt unit due to a service switch being in the off position during this event. No one was injured or shocked due to this LOTO violation

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#	LabWay	Location	Type of Investigation	Description
ANALYSIS Issues identified: • Removal of the LOTO before the thermostat for the AC unit was installed. • Work control process LTA. Improper sequencing of work, i.e., LOTO removed before work complete. • Sub-contractor performed activity without verification that it was safe to do so. • In this case, oversight was effective in identifying this non-compliance. • Not technically a LOTO issue as the unit was not under LOTO protection at the time of event. The worker failed to identify hazard prior to performing task.				
14	CO 2020-1471	MFC	Apparent Cause	On September 14, 2020, at approximately 1140 hours, at the Material and Fuels Complex (MFC) a sub-tier to a construction subcontractor was performing excavation operations in support of the Sample Preparation Laboratory (SPL). During the work evolution a sub-tier employee decided to use a backhoe to excavate over known, live, 480-volt electrical lines which directly violated RD-2014. This was different from the soft digging methods that had previously been used to identify the electrical lines.
ANALYSIS Issues identified: • Willful violation by sub-contracted employee did not comply with ISMS core function; the workers failed to perform work inside the RD-2014 controls. • During the investigation, the cause analyst discovered the sub-tier subcontractor does not review or obtain a copy of the Penetration/Excavation Permit. This is a concern, and the cause analyst suggested the Construction Management office review this and see if, and why, permits are not getting flowed down to sub-tier subcontractors. • There is a legacy issue at INL of drawings not being kept up to date. • Was supervision adequate? The workers were violating excavation rules for some time before the event occurred and this was not caught by supervision or oversight. • Numerous discrepancies found between comments made by personnel during interviews for the causal analysis, fact-finding, and contractor-initiated discussions. This complicates the ability to get to the root of issues during casual investigations.				

Appendix B
Significance Analysis

Date of Occurrence	LabWay #	Event Title	Hazard	Area	Consequence*	Risk*	Significance Score **	Explanation of Score
4/10/19	**CO 2019-0768**	**Electrical Conductor Insulation Damaged During Repair Activity at IF-688 (EIL)**	**277 V**	**EIL**	**Moderate (2.7)**	**High (3)**	**2.85**	**Failure to follow procedure, tool contact with live hazardous energy.**
6/12/19	**CO 2019-1288**	**MFC Damaged Guywire**	**13.8 KV**	**MFC**	**Moderate (2.9)**	**High (3)**	**2.95**	**Failure to use spotter, potential contact with 138 KV transmission line**
8/16/19	**CO 2019-1837**	**MFC West Utility Corridor Project Damage to Energized Utility**	**480 V**	**MFC**	**Low (1.9)**	**High (3)**	**2.45**	**Spotter stopped activities as soon as problem was identified. Risk was high because event involved a 480-volt junction box.**
9/25/19	**CO 2019-2217**	**Subcontractor Owned Procedure LOTO Violation**	**High H2O Pressure**	**ATR**	**Low (2.5)**	**Moderate (2.9)**	**2.7**	**Personnel were not aware of or trained on LOTO procedure.**
9/26/19	**CO 2019-2222**	**120-volt lighting circuit conduit cut during decommissioning and demolition activity.**	**120 V**	**REC**	**Moderate (2.2)**	**High (3)**	**2.6**	**Insulated tools used however live 120 V line cut.**
10/4/19	CO 2019-2290	Live electrical discovered in 120V receptacle during office refresh at EROB	120 V	REC	Low (1)	Low (1)	1.0	The outlet was discovered and access to it immediately secured. Contact with the energy source would have required deliberate action by persons involved.
2/6/20	**CO 2020-0257**	**Severed 120 Volt Hot-Line Cable**	**120 V**	**CFA**	**Low (1.8)**	**High (3)**	**2.4**	**120 V line severed and laying under snow. Breaker was tripped when work was performed.**
3/17/20	**CO 2020-0532**	**WCB Live Electrical Identified**	**120 V**	**CFA**	**Moderate (2.6)**	**High (3)**	**2.8**	**Exposed electrical lines. Could have been an unmitigated hazard to anyone working in the overhead.**
3/24/20	CO 2020-0565	Discovered a 480 V a/c Panel Cover Open	480 V	WCB	Low (1.5)	High (3)	2.25	Personnel are trained to not leave panels open and to respond appropriately if an

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Significance Analysis

Date of Occurrence	LabWay #	Event Title	Hazard	Area	Consequence*	Risk*	Significance Score **	Explanation of Score
								unsecured panel is discovered. High risk because 480 volts were present.
4/29/20	**CO 2020-0747**	**Live Wire Inadvertently Cut at WCB**	**227 V**	**WCB**	**High (3)**	**High (3)**	**3.0**	**When it was noted that multiple cables were present in the junction box, action to identify the proper cable were not taken and an energized line was cut.**
6/11/20	CO 2020-0935	120 v AC Operating Power Discovered During >50 v System Demo.	120 V	CFA	Low (1.4)	Moderate (2.3)	1.85	Personnel immediately identified unexpected condition and took a step back. Moderate risk because there was no LOTO on system due to low voltage.
6/25/20	**CO 2020-1006**	**Small electrical arc at IAB (IF-606)**	**120 V**	**REC**	**Moderate (2.1)**	**High (3)**	**2.55**	**Improperly grounded metal case, exposed electrical wiring, improper installation of wiring.**
8/18/20	**CO 2020-1288**	**ATR Maintenance Support Building LOTO Violation**	**120 V**	**ATR**	**Low (1.8)**	**High (3)**	**2.4**	**Electrical panel cover removed to take photographs. The panel was not powered at the time the cover was removed.**
9/14/20	**CO 2020-1471**	**MFC Sample Preparation Lab Construction Electrical Wire Damaged**	**480 V**	**MFC**	**High (3)**	**High (3)**	**3.0**	**Willful violation, contact with and damage to 480-volt line**

* Consequence – Realized outcome or impact.
* Risk – Potential consequence including risks, hazards, near misses.
** Significance Scores for Consequence and Risk Levels (Low between 1 and 2.0, Moderate between 2.1 and 2.9, High 3). The Significance Score is the average of the both the consequence and risk scores. For the purpose of this analysis, the most significant events

Appendix C
Documents Reviewed

LabWay CO 2019-0768, 4/10/19, NE-ID--BEA-STC-2019-0001, Electrical Conductor Insulation Damaged During Repair Activity at IF-688, and supporting documentation

LabWay CO 2019-1288, 6/12/19, NE-ID--BEA-MFC-2019-0001, MFC Damaged Guywire, and supporting documentation

LabWay CO 2019-1837, 8/16/19, NE-ID--BEA-MFC-2019-0003, MFC West Utility Corridor Project Damage to Energized Utility, and supporting documentation

LabWay CO 2019-2217, 9/25/19, NE-ID--BEA-ATR-2019-0015, Subcontractor Owned Procedure LOTO Violation, and supporting documentation

LabWay CO 2019-2222, 9/26/19, NE-ID--BEA-REC-2019-0002, 120-volt lighting circuit conduit cut during decommissioning and demolition activity, and supporting documentation

LabWay CO 2019-2290, 10/4/19, NE-ID--BEA-REC-2019-0003, Live electrical discovered in 120V receptacle during office refresh at EROB, and supporting documentation

LabWay CO 2020-0257, 2/6/20, NE-ID--BEA-CFA-2020-0001, Severed 120 Volt Hot-Line Cable, and supporting documentation

LabWay CO 2020-0565, 3/17/20, NE-ID--BEA-CFA-2020-0002, Discovered a 480 V a/c Panel Cover Open, and supporting documentation

LabWay CO 2020-0532, 3/24/20, NE-ID--BEA-REC-2020-0003, WCB Live Electrical Identified, and supporting documentation

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Documents Reviewed

LabWay CO 2020-0747, 4/29/20, NE-ID--BEA-INLLABS-2020-0001, Live Wire Inadvertently Cut at WCB, and supporting documentation

LabWay CO 2020-0935, 6/11/20, NE-ID--BEA-CFA-2020-0003, 120 v AC Operating Power Discovered During >50 v System Demo, and supporting documentation

LabWay CO 2020-1006, 6/25/20, NE-ID--BEA-REC-2020-0004, Small electrical arc at IAB (IF-606), and supporting documentation

LabWay CO 2020-1288, 8/18/20, NE-ID--BEA-ATR-2020-0024, ATR Maintenance Support Building LOTO Violation, and supporting documentation

LabWay CO 2020-1471, 9/14/20, NE-ID--BEA-MFC-2020-0007, MFC Sample Preparation Lab Construction Electrical Wire Damaged, and supporting documentation

LWP-9400, Lockouts and Tagouts, Revision 11, dated February 26, 2018