REPORT

OF THE

JEFFERSON LABORATORY ELECTRICAL SAFETY IMPROVEMENT TEAM

July 15, 2004

U. S. Department of Energy's

Jefferson Lab

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY

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Jefferson Laboratory (JLab)
Electrical Safety Improvement Team
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Introduction

In December 2003 an Electrical Safety Improvement Team was created and charged with assessing the Lab's electrical safety program and offering suggestions for improvement. The team is composed of Ed Martin, Paul Powers, Charles Hightower, Mary Jo Bailey, and Walter Chandler (Chairperson). Oversight for the team was provided by a Steering Committee consisting of Christoph Leemann, Kelly Caccetta, Jim Murphy and Bob May.

This report contains the team's final recommendations. These recommendations are based on input from electrical safety staff from neighboring employers, JLab staff, an independent expert in electrical safety and the team's internal discussions. The recommendations are categorized using the traditional safety profession schema of engineering, work practice and administrative controls. The team believes that the Lab's current electrical safety program is generally excellent but could be further enhanced. Toward that end this report contains recommendations for six new engineering controls, eight new work practice controls, and numerous administrative controls.

Methods

The team approached its charge from the following perspectives:

- **Local Employer Group**: A group of 14 staff from other employers in the Lab's geographical vicinity was convened. Each staff member had current responsibilities in fields relating to electrical safety. The employers represented were: Northrop Grumman, a shipbuilding company employing approximately 18,000 people; Harris Electrical Contracting, the Lab's primary electrical subcontractor; Siemens VDO, an automotive fuel components manufacturer employing approximately 70,000 people throughout the United States; Sentara Health System, a group of hospitals and other health care facilities employing approximately 15,000 people.

  This local employer group spent one day touring the Lab. They then were given two weeks to review our written procedures and incident experience. Afterwards they reconvened at the Lab and gave impressions and advice.

- **JLab Staff Group**: A group of JLab staff and subcontractors was created to serve in the same manner as the group from neighboring employers. Members of this group included:

  Jefferson Lab:
  Rich Bundy
  Chris Cuevas
  Jonathan Creel
  Mike Davenport
  Mike Drury
  Rick Nelson
  Barry Shinault
  Mark Stevens

  MRI:
  Scott Weiss
  David Clark

  Harris Electric:
  Otis Mills
  James Mason

- **Focused Interviews**: Focused interviews with Lab management and EH&S staff members were conducted. These lasted for 30-120 minutes each. It should be noted that the focused interviews primarily related to cultural considerations and did not address specific engineering and work practice controls. Staff serving in this manner included: Christoph Leemann, Larry Cardman, Swapan Chattopadhyay, Andrew Hutton, Dennis Skopik, Mark Waite, John Kelly, Bert Manzlak, Bob May, Patty Hunt, Sandy Prior, Carroll Jones.

- **National Laboratory Expert**: Mr. Hugh Bundy, an expert in electrical safety at national laboratories, was consulted. He spent four days on site assessing the JLab program. Mr. Bundy is an electrical engineer who headed the electrical safety program at Sandia for ten years prior to his recent retirement. He is also a National Fire Protection Association-certified electrical inspector. His full assessment is contained in Appendix A of this report.

The groups, interviewees and Mr. Bundy provided the team with suggestions. The team then evaluated each suggestion to assess its utility. Suggestions that the team felt would enhance safety were included in this report as recommendations. There was substantial consistency between the four perspectives in the suggestions that they made. Suggestions that were inconsistent with other input or were controversial were not adopted as recommendations by the team. Therefore, most of the recommendations in this report should be thought of as representing a consensus of opinion between four independent perspectives and the Lab's Electrical Safety Improvement Team. Some of the recommendations were developed *de novo* by the team. All of those were by team consensus. The team's recommendations are the result of over 500 person hours of work.

Report Format

All workplace safety interventions can be placed into one of the following categories: engineering controls, work practice controls, administrative controls. The team's recommendations are categorized using this hierarchy of controls. An explanation of these categories follows:

- **Engineering Controls**: These are interventions that are built into equipment and supplies to enhance safety. The ground fault circuit interrupter is an example. In the safety profession and regulatory arena, employers are expected to place first and greatest emphasis on engineering controls.

- **Work Practice Controls**: These are procedures of work that serve to protect employees. They are essentially safety rules. Employers should give second highest priority to work practice controls.

- **Administrative Controls**: Administrative controls are programs and procedures created and conducted directly by employers, as opposed to equipment manufacturers (engineering controls) or employees (work practice controls). In this report, "administrative controls" refers to Electrical Safety Subcommittee activities, employee education, safety inspection, enforcement, accident investigation, staffing, and the Lab's approach to ISM.

  Taken together, these controls often complement each other and provide redundant layers of protection. This can be illustrated by automotive safety efforts. Airbags are ideal engineering controls because they function independently of operator behavior. The protection they provide is enhanced by a second engineering control, the three point safety belt. That engineering control only works if it is linked to a "work" practice control because the operator must actively wear the belt. The work practice control of wearing the belt is only effective if it is supported by two administrative controls: education of the public and enforcement of seatbelt laws. This interplay of engineering, work practice and administrative controls saves more than 40,000 lives and prevents hundreds of thousands of severe injuries each year in the U.S.

Engineering Controls

Engineering controls (defined in "Report Format," above) often represent the most important options to enhance safety because many of them, such as ground fault circuit interrupters, protect employees even in the event of human error. The Team suggests the following engineering controls:

- Proper bonding of electrical equipment should be verified in structures, cable trays, cabinets, beam line components, etc. This verification should be by visual inspection and testing methods. Bonding of the fixed electrical distribution system should be verified every two years. Bonding of structures, cable trays, cabinets and beam line components should be verified at the time of installation and should be visually checked at appropriate intervals thereafter.

- Portable carts that house electrical equipment, such as vacuum carts, should have their cords tested before each use in order to verify proper grounding.

- The location of panel boards within a building should be diagrammed in a central location in each building. This should be done for all buildings similar to existing Fire Evacuation Plans.

- Extension cord safety stations should be more extensively utilized. They should be placed at appropriate locations sitewide.

- Disconnects that are poorly accessible should be moved.

- Welding outlets for portable HVAC units should be installed next to roll up doors in all service buildings.

- Independent Expert: Mr. Bundy recommended the following engineering controls:
  - Continue addressing the extension cord problem.
  - Ground laboratory cable trays and metal topped laser tables.

Work Practice Controls

Work practice controls (defined in the "Report Format" section above) serve as a second layer of protection after engineering controls. Work practice controls are often necessary because no engineering control is available, or an engineering control has been bypassed or removed. For instance, a high voltage panel might be protected by a locked door (an engineering control). In order for work to be performed on the panel, the door must be opened or removed, ending the engineering control. At that point, work practice controls such as lock, tag and try must be relied upon. At other times an engineering control might not be effective without a linked work practice control. For instance, automotive safety belts (an engineering control) are not effective unless they are actively placed over the user and locked (a "work" practice control).

The Team suggests that the following work practice controls be added to the Lab's program:

- Electrical Operating Procedures (SOP's, TOSP's and OSP's):
  - Operating procedures should be authored by subject matter experts and then reviewed by stakeholders.
  - Many operating procedures are too long and complicated. The Electrical Safety Subcommittee should review and, if possible, simplify and clarify them on an ongoing basis. The subcommittee should utilize input from Mr. Dudley Harris, of Harris Electrical Contracting, during this process.
  - Operating procedures should designate PPE requirements. Exceptions for specific circumstances such as operations for which gloves compromise safety should also be noted in operating procedures.
  - The Physics Division's practice of posting operating procedures and requiring that they be signed should be adopted by other divisions.
  - Operating procedures should have a numbering system and be readily accessible on the Lab's intranet.

- Electrical and electronic fabrication, installation and repair work should be reviewed by a co-worker before it is re-energized. This review can be while work is in progress or after it is completed.

- CHL staff members should utilize check lists for electrical work.

- Safety related communication between CHL and Accelerator Operations staff members should be enhanced. This is especially important during periods when cryo is being brought back up.

Administrative Controls

Administrative controls (defined earlier in the "Report Format" section) represent the final tier of a comprehensive approach to safety. Some engineering controls, for instance, ground fault circuit interrupters, are effective independently of work practice and administrative controls. However, work practice controls are typically ineffective without linked administrative controls such as education and enforcement. The fundamental purpose of the administrative controls recommended in this report is to make work practice controls more effective. Without excellent administrative controls, work practice controls are "paper tigers."

In the ideal case, perfect engineering controls would be available. Work practice controls would then become much less important. Therefore, the administrative controls that make work practice controls effective would be almost irrelevant. Unfortunately, this is not the case in electrical safety. Although the technology that drives engineering controls is constantly progressing, work practice and administrative controls are still necessary.

As previously noted, this report recommends only six new engineering controls and eight new work practice controls. However, numerous new administrative controls are recommended below. The fact that the distribution of the recommendations is skewed toward administrative controls reflects the team's belief that the Lab has a tradition of utilizing state of the art engineering and work practice controls but has not paid as much attention to administrative controls. Many employers follow this same pattern because administrative controls are often somewhat amorphous, contentious and difficult to implement. Many administrative controls influence, and are influenced by, workplace culture. Despite these constraints, the team has carefully thought about its administrative controls recommendations and believes that all of them should be seriously considered for implementation.

It is impossible to fully separate administrative controls directed toward electrical safety from those for other aspects of safety. Therefore, some of the recommended administrative controls are not specific to electrical safety. They are, instead, applicable to safety in general.

The Team suggests the following administrative controls:

- **Electrical Safety Subcommittee:**
    - The Electrical Safety Subcommittee's charge is narrow. Its responsibilities should be broadened. Several examples of increased contributions by the subcommittee are contained throughout this report.

- The Electrical Safety Subcommittee currently has 12 members. This creates obstacles to productivity. It should assess this situation and consider making changes. For instance, the JEHSC has only six voting members. Several other non-voting members contribute as needed. This approach allows the committee to benefit from subject matter experts without losing efficiency.

- **Education and Training:** The primary purpose of education and training activities is to assure that employees know the work practice controls relevant to their work. Of equal importance is that education and training must teach the rationale behind the controls. In other words, proper education does not just convey "what," but also "why" and "how." Intelligent people need to understand, not merely know, what is required of them. Without understanding, employees might have difficulty taking all work practice controls seriously enough. Staff members need to "believe in" work practice controls. Excellent training and education enhances that process.

  - On an ongoing basis, the Electrical Safety Subcommittee should review the content and periodicity of all levels of electrical safety training activities and make recommendations to support continuous improvement. Subcommittee members should periodically attend training sessions themselves to assure that they are maximally effective. The team recommends that training and education activities include the following:
    - Relevant supervisors should hold quarterly electrical safety meetings.
    - Each group leader should create an awareness training program for his/her group.
    - SOTR's should hold periodic safety meetings with subcontractors. These meetings should be referenced in new or modified subcontracts. A suggested periodicity is:
      - Harris Electrical: Every 3 months.
      - MRI: Every 6 months.
      - WEBB: Every 6 months.
      - York: Every 6 months.
      - Hillar: Every 6 months.
      - Webster Elevator: Every 12 months.
      - Johnson Controls: Every 12 months.
      - Honeywell: Every 12 months.
      - Web Controls: Every 12 months.
    - All electrical workers should be trained in CPR/AED and be within 90 seconds, one way, of an AED.
    - The Lab's new work order system is operational. Subcontractors should be trained to use it. This will allow needs that they identify in the field to be promptly addressed.

- **Inspections:** Inspections identify the need for new or improved engineering, work practice and administrative controls. They also detect violations of controls. Most importantly, they serve as a format for communication about safety. They start a dialogue. If inspections stop, dialogue stops. Inspections should exist in many layers and feature varying levels of complexity, ranging from frequent and casual with verbal communication only to periodic and formal with written reports.

  - The Electrical Safety Subcommittee should formalize the Lab's electrical safety inspection program[1]. This process should be coordinated with the JEHSC because many aspects of inspections relate to safety considerations other than purely electrical concerns. A suggested approach follows:
    - Electrical workers should essentially conduct continuous inspections. This should be explicitly stated as an expectation by the employee's supervisor. The employee and her/his supervisor should design the inspection plan and create written inspection procedures if needed.
    - Supervisors should design their own inspection procedures in a manner analogous to those for line employees. The content and periodicity of supervisor inspections will often differ from those of line employees. Monthly supervisor inspections would be appropriate in many settings.
    - Safety wardens should create inspection procedures for themselves. In so doing, they should solicit input from line employees, supervisors and EH&S professionals. Weekly safety warden inspections would be appropriate in many settings.
    - EH&S professionals should design inspection protocols for themselves. They should partner with line employees, supervisors, safety wardens and the division safety officer to assure appropriate content and periodicity. Some EH&S inspections should be formalized and conclude with a written list of positive and negative findings to be distributed to line employees, supervisors, the division safety officer, the group leader, the Associate Director, and the Electrical Safety Subcommittee. Formalized EH&S inspections would be appropriate at quarterly intervals in many settings. Lower level EH&S inspections would be appropriate at weekly intervals in many settings.
    - Division safety officers should conduct periodic inspections with EH&S professionals. This should occur at least quarterly.
    - Annually, an outside expert should audit the Lab against the standards of the National Electrical Code and the National Fire

[1] Many of the recommendations in this section are already followed by the Physics Division. Other divisions should partner with the Physics Division to benefit from the experience of the Physics Division.

Protection Association, i.e., NFPA 70 (installation and materials) and NFPA 70E (work practices).

- Inspections should focus on compliance with work practice controls, not just the adequacy of engineering controls.
- Inspections are ineffective if they are seen as adversarial or dictatorial. The tone of inspections should be one of partnership and dialogue with employees, not one of a law enforcement action. However, inspections must make note of non compliance with work practice controls. Inspections are, to a great extent, an art form. The Physics Division has a tradition of excellence in this regard. Other divisions should study the inspection techniques of the Physics Division.
- Staff members conducting inspections should give immediate positive and negative feedback to employees. This feedback should also be shared with the supervisor, EH&S professionals, the division safety officer, and when appropriate, the group leader and Associate Director. Clear positive and negative feedback is critical to safety because it is a primary mechanism to facilitate compliance with work practice controls.
- Although appropriately delivered negative feedback should not be ignored, positive reinforcement is even more important. Employees should be recognized for correctly following work practice controls. Examples of recognition include verbal or written comments from inspectors, supervisors, and/or Lab management. Small gift certificates to the Quark Cafe could also be considered. (These are currently being utilized by the Administration Division.)
- Performance appraisals should reference inspections and their positive and negative findings. For instance, the content and frequency of inspections to be performed by a given supervisor should be defined in her/his performance appraisal. Without such formalization, over time inspections tend to drift toward less frequency and lower quality. Likewise, positive and negative inspection findings and observations for each employee should be expected to appear in the appraisal. Otherwise, performance appraisal reference to "EH&S Performance" becomes so general and amorphous as to be almost meaningless. Human Resources should suggest to the Director's Council a detailed format for use of safety performance in appraisals. In so doing, the safety incentive and penalty system used for some subcontractors should be studied to determine if any of its features can be utilized with modification in individual performance appraisals.
- The Accelerator Division should designate and train a certified electrical inspector to support its electricians.

- Equipment that is brought on site by users or modified or repaired should carry a tag that specifies inspection criteria and frequency.
- Housekeeping should receive greater emphasis during safety inspections.
- Most inspections conducted by staff other than line employees should utilize check lists. This would formalize the process and help to prevent omissions.

- **Enforcement:** Excellent work practice controls serve to minimize the probability of injury and improve the effectiveness and efficiency of work. These controls should be created and improved on an ongoing basis at many levels including line employees, supervisors, EH&S professionals, division safety officers, and the Electrical Safety Subcommittee.

  - Employees should be continuously educated about work practice controls and the rationale behind them. Finally, compliance with controls must be required.
  - Employees should be educated so they fully understand that compliance with work practice controls is a safety expectation and that failure to comply will result in disciplinary action. Such disciplinary action can range from reminders by supervisors to more severe action, depending on the circumstances. The use of performance appraisals is discussed under "Inspections," above.
  - Non compliance with work practice controls must be addressed even if no accident resulted from the non compliance. The Lab must, so to speak, give tickets for reckless driving, even if there is no accident.
  - Enforcement must be consistent. All known violations should be addressed. Inconsistent enforcement creates the appearance of discrimination and sends a message that controls are not truly important.
  - If education is excellent, enforcement is consistent, and positive reinforcement is appropriately used, then enforcement actions are rarely needed. Positive reinforcement is discussed under "Inspections," above.

- **Accident Investigations:** These are important tools to facilitate safety improvement. In order for the Lab to derive maximum value from investigations, the team recommends the following:

  - Each investigation team should be headed by an EH&S professional. Other members such as the supervisor and subject matter experts can be utilized as needed.
  - Investigation teams are not always cognizant of their fundamental charge. Investigation teams should be charged with describing the accident and recommending enhancements in engineering, work practice, and/or administrative controls to prevent recurrence of similar accidents. Suggested

improvements should almost always be recommended by the team. This is because in most circumstances, one of the following occurred:

- A control did not exist that could have prevented the accident. The investigation team should then recommend a new engineering, work practice or administrative control, or enhancement of an existing control.
- A control existed but employees were not adequately educated about it. The investigation team should then recommend improved education. Improved education is an administrative control.
- A control existed and employees were adequately educated but there was a tradition of inconsistent enforcement. The investigation team should then recommend consistent enforcement. Consistent enforcement is an administrative control. If consistent enforcement did not occur, the Associate Director should hold the supervisor (and sometimes the safety warden, EH&S professional and the division safety officer) accountable.
- A control existed, employees were educated and enforcement was consistent but the employee willfully violated it. The team should report that fact and then the Associate Director should assess the circumstances of the violation and issue appropriate disciplinary action, ranging from verbal counseling to more severe measures, depending on the details of the case. Disciplinary action is an administrative control.

- The investigation team should only assess possible controls to prevent recurrence. It should not make value judgments about the feasibility of its recommended controls. Such value judgments should be made by Lab management. The investigation team should give advice. Lab management should decide whether or not the advice will be followed. In making its decision, Lab management should solicit input from others such as the Electrical Safety Subcommittee, the JEHSC, EH&S professionals and others.
- Occasionally, the investigation team will conclude that no enhanced controls are possible. For instance, if an employee trips on his/her shoe laces, the investigation team would not recommend enhanced controls.

- **Miscellaneous Administrative Controls**:

  - CHL should add a mechanical-electrical technician because understaffing in that group currently compromises safety, especially during periods of repair and machine restart.
  - Mechanical and vacuum staff members do not always have sufficient electrical expertise to construct or repair electrical equipment. A mechanism should be found that would allow them to work more closely with Accelerator electricians.

- The Electrical Safety Subcommittee should review plans and progress for Lab expansion in order to assure that electrical safety concerns are addressed.
- The Physics Division has a relatively low number of safety wardens and each warden has an indefinite tenure. This approach tends to increase the status and expertise of wardens and should be considered by other divisions.
- The Director's Council should clearly communicate its vision of ISM in practical terms. ISM is fundamental and important. However, its implications are subject to interpretation. The Director's Council should explain its interpretation. There is a widespread belief at the Lab that the concept of supervisor responsibility for safety has come to be used as an enabler for "unresponsibility" (and therefore, inaction) at other levels. All levels should be highly responsible and active. The implications of this should be considered. For instance, the primary role of many EH&S professionals at JLab is to serve as a consultant. Such a role is important but it should not be the "primary" role because consultants tend to act only when asked to. Supervisors might not always know when they should request advice from consultant EH&S professionals. Clarity about ISM details is especially critical in an environment as complex as the Lab's.
- The team recommends that all levels should clearly understand their responsibilities and expected actions. These roles and activities should include, but not necessarily be limited to, the following:

    - **Director's Council:**
        - Communicate its vision of ISM.
        - Frequently communicate its commitment to, and expectations regarding, safety performance. For instance, safety excellence is not only ethical, but it also saves time and money. It is only a matter of creating safe habit systems. Once this occurs, safety excellence is relatively easy and is not time consuming. Transitioning to safe habit systems can be difficult and time consuming, but once this is done, safety is on automatic pilot. It is difficult to drive the speed limit if one is accustomed to speeding. The more one drives safely, the easier it becomes. (By the way, it has been shown that speeding does not actually save significant time. Likewise, unsafe work practices do not save time. Lab management should regularly convey this fact.) The primary role of the Director's Council is to assure that safe habit systems are developed and nurtured. This is the essence of a culture of safety excellence.

    - **Associate Directors:**
        - Communicate and bring fruition to the ideals and expectations of the Director's Council (explained above).

- Expect other levels to create excellent engineering, work practice and administrative controls. This must be an ongoing process, not a temporary project.
- Actively participate in assessing proposed engineering, work practice and administrative controls.
- Actively and frequently participate in giving positive and negative reinforcement to all levels in the division.
- Frequently showcase safety performance and expectations in meetings and other forums.
- Expect the division safety officer or other qualified designee to give the Associate Director detailed advice about exactly what the Associate Director should do on an ongoing basis to enhance safety. In other words, Associate Directors can be expected to provide general safety leadership without assistance from others. However, they cannot be expected to have a detailed action plan. The division safety officer should suggest safety "marching orders" to the Associate Director. This dialogue between the Associate Director and the division safety officer should be frequent. Safety activism by Associate Directors is critical to safety. It is important for Associate Directors to generically convey that safety is important. However, division safety officers should suggest more specific actions for Associate Directors to follow.
- Day in and day out, show by action and word that safety is more important than all else. At the same time, emphasize that safety poses no conflict with other needs, but rather enhances all other activities by making them more efficient and effective. Unless this occurs, safety excellence is impossible.

- **Division Safety Officers:**
  - Give the Associate Director advice about how the Associate Director can best fulfill his/her responsibilities. As mentioned above, the Associate Director should expect the division safety officer to make frank, frequent and detailed suggestions about what specifically the Associate Director should do next to enhance safety.
  - Actively and frequently support EH&S professionals. Meet with them at least weekly and join them on inspections.

- **EH&S Professionals:**
  - Conduct excellent and frequent inspections.

- Give advice and support to safety wardens and the division safety officer.
- The EH&S professional is the primary expert in safety and should be responsible for proposing engineering, work practice and administrative controls to management.

- **Safety Wardens:**
  - Conduct inspections.
  - Work closely with supervisors and EH&S professionals.

- **Supervisors and SOTRs:**
  - Conduct inspections.
  - Assure consistent compliance with engineering, work practice and administrative controls. This is the greatest contribution of supervisors and SOTRs to safety. If the supervisor or SOTR follows the short term path of least resistance and "turns a blind eye" to violations of controls, safety excellence is impossible. The phrase "assure consistent compliance" should not be interpreted as implying adversarialism. As explained previously, positive feedback is vastly more important than negative. However, there are occasions when negative reinforcement is necessary. The supervisor must do both.

- **Line Employees:**
  - Comply with engineering, work practice and administrative controls.
  - Give supervisors and coworkers positive and negative feedback regarding compliance.
  - Make suggestions to supervisors to enhance controls.

The roles and responsibilities described above might not, in some cases, be adopted without ongoing training regarding them. A person with excellent communication and diplomatic skills and appropriate qualifications and standing should be given ownership of this ongoing process. This person should be responsible for assuring that all levels understand what their roles and responsibilities are and how to fulfill them. Division safety officers would be appropriate for this process.

- **Independent Expert:** Mr. Bundy recommended the following administrative controls:

  - Develop a uniform safety culture among Divisions.
  - Create an atmosphere where safety personnel are known, trusted, and contacted.

- DOE Lessons Learned should be distributed more often.
- More internal Bulletins and Lessons Learned should be created.
- Keep a camera on hand to address incidents and accident response.
- Resolve Inspection Findings quickly.
- Combine safety meetings with job briefings.
- Develop uniform, regular safety inspections throughout the Lab.
- Develop Electrical Safety Awareness Training and require periodic refresher.
- Have SOPs signed by the users.
- Create better control for electrical gloves used by JLab employees.
- Create an approval process to assure safety of internally fabricated equipment.
- More formal Q/A evaluations are needed for equipment and installations.
- MRI (HVAC) workers should be trained to NFPA 70E and work to a SOP.
- Update the Electrical Safety Manual and SOPs to include the latest NFPA 70E requirements.
- Basic AC wiring standards should be taught to technicians.
- Give the Electrical Safety Subcommittee responsibility and recognition.

Appendix A

Report

to the

Jefferson Laboratory Electrical Safety Improvement Team

June 24, 2004

By

Hugh R. Bundy, Electrical Safety Consultant

Report to the Jefferson Laboratory Electrical Safety Improvement Team
June 24, 2004
By
Hugh R. Bundy, Electrical Safety Consultant

SUMMARY

The general safety knowledge and attitude of the Lab workers is very good and this carries over to the work areas and to the work practices they use in performing their jobs. There are many positive aspects of the electrical safety program for which credit should be taken. Some of these are pointed out in the supporting documentation.

The purpose of my assessment is to evaluate the electrical safety program and offer suggestions for improving the program. Suggestions are based on OSHA Regulations, the National Electrical Code (NFPA 70), the Standard for Electrical Safety in the Workplace (NFPA 70E), and the DOE Electrical Safety Guidelines. A punch list of these improvement suggestions appears below and the supporting documentation follows.

- Develop a uniform safety culture among Divisions.
- Create an atmosphere where safety personnel are known, trusted, and contacted.
- DOE Lessons Learned should be distributed more often.
- More internal Bulletins and Lessons Learned should be created.
- Continue addressing the extension cord problem.
- Keep a camera on hand to address incidents and accident response.
- Resolve Inspection Findings quickly.
- Combine safety meetings with job briefings.
- Develop uniform, regular safety inspections throughout the Lab.
- Develop Electrical Safety Awareness Training and require periodic refresher.
- Have SOPs signed by the users.
- Create better control for electrical gloves used by JLab employees.
- Ground laboratory cable trays and metal topped laser tables.
- Create an approval process to assure safety of internally fabricated equipment.
- More formal Q/A evaluations are needed for equipment and installations.
- MRI (HVAC) workers should be trained to NFPA 70E and work to a SOP.
- Update the Electrical Safety Manual and SOPs to include the latest NFPA 70E requirements.
- Basic AC wiring standards should be taught to technicians.
- Give the Electrical Safety Subcommittee responsibility and recognition.

SUPPORTING DOCUMENTATION

Prior to arriving on site June 21, 2004 for a 4 day assessment I used the Jefferson Lab web site to review the Electrical Safety sections of the EH&S Manual and the Lessons Learned distributed from JLab incidents and other incidents shared across the DOE complex. I also reviewed some Standard Operating Procedures that were sent to me. The 4 days provided a comprehensive tour of the Lab buildings and work places and interviews with 15 people concerning workplace electrical safety.

I'm impressed with the manual and the way the contents are presented. The SOPs are well written and provide appropriate worker protection guidance. Although, some are old and need review/revision to incorporate the latest 2004 NFPA 70E requirements for arc-blast protection. The newer SOPs address the proper PPE so it is obvious that the requirement is understood. Interviews with JLab and Harris electricians found that they have and use the proper PPE for arc-blast protection. The Lessons Learned section appeared overly light on Electrical Safety for the 4 to 5 most recent years compared to the number of Lessons Learned available for sharing in the DOE network.

During the tour portions of the assessment I observed the installation and condition of the electrical power distribution system. This indicates how the National Electrical Code (NEC, NFPA 70) is incorporated and followed to provide a safe workplace. This portion of the assessment exposed no underlying problems affecting the safe condition of the workplace. The installations are good; switches and receptacles are labeled for power source identification; and Motor Control Centers and Switchgear are properly labeled. Some older portions of the power distribution equipment have been replaced and others have been identified for replacement. Ground Fault Circuit Interrupters (GFCIs) are in place at appropriate locations throughout the Lab.

Other NEC issues include workplace clutter, use and care of extension cords, and workspace around switches and panelboards (circuit breaker panels). These issues were within expectations considering the nature of the R&D work being performed. Use and care of extension cords is being actively pursued from the safety perspective. Several new Extension Cord Safety Stations allow workers to test and store extension cords. Inadequate workspace around switches and panelboards frequently appears in older buildings or where construction has not allowed for it. Keep in mind that the 3 ft. requirement is required if 'energized' work is likely to be performed on that equipment. If space can't be provided label it "NO ENERGIZED WORK ALLOWED" and assure it is deenergized upstream before covers are removed. For switches or breakers that must be operated in an emergency there must be sufficient space available and this is not a 3 ft. requirement.

Accident response and investigation is very good. Shock victims go to Medical Services for evaluation. The medical staff evaluates the injury and the conditions that caused it. An EKG is provided and nearby emergency medical facilities are used when necessary. There are plans to provide emergency defibrillators on site within 90 seconds of any work

area. Accident investigations should provide a camera for documentation. In one case a personal camera is used. A Lessons Learned is created from accidents.

Other functions of safety personnel appear to vary by Division. Workers in the Physics Div. see and talk to their safety personnel regularly as they walk their spaces. Some

people in the Accelerator Division say they only see their safety personnel when something happens. It could be that I didn't talk to enough people or there is a definite difference in the way they function. One interviewee felt the Accelerator Division has too many people reporting to a manager and their locations are too far apart. Safety people should be known, trusted, and the first called when any project is started that involves safety (most every project). From my experience as an electrical safety person this process doesn't happen overnight. It takes a concerted effort from many people including upper management. Becoming known takes some advertising. Go to safety meetings of different groups and talk about an issue. Issue Safety Bulletins on pertinent topics. Distribution of safety information such as Lessons Learned and equipment recalls appears to work well at the Lab. This information includes Lessons Learned and equipment recalls.

Inspection findings should be resolved quickly. The process of giving these to the Safety Warden to be fixed appears to be slow. The Work Order process may be quicker. Inspection findings as well as accidents and incidents should be tracked and trended for use in safety improvement.

Weekly formal safety inspection are performed by check list in the Physics Division. This should be adopted by all Divisions although the frequency could be changed as appropriate. The Physics Division also has monthly[2] safety meetings. This should be routine in all Divisions for workers who deal with industrial hazards. It appears that job briefings occur regularly throughout the Lab. An occasional job briefing could also include a safety meeting. Technical and safety oversight inspections by other organizations within the Lab would be beneficial.

Given that a safe workplace is provided the other important issue "Safety Related Work Practices" must be addressed with more focus on NFPA 70E which is referenced by the DOE as a requirement. While no unsafe work practices were observed, the lack of formal electrical safety training and periodic refresher training could lead to lax behavior and unsafe practices. Employees are qualified for their work with on-the-job training, mentoring, and job briefings. These parts of the qualification process appear to be done well. It is my belief that formal classroom hazard awareness training with a written test is also a necessary part of the qualification process. This provides assurance that appropriate hazards and how to work safely with them are presented uniformly to all workers. OJT, mentoring, and site specific training is also required at the workplace.

Hazard awareness training for the R&D worker is critical. Technicians and more notably engineers often arrive on the job with little or no hazard awareness training. Electricians above the apprentice grade are more thoroughly schooled in the hazards of their trade. Electricians who work on R&D projects other than routine power distribution should also receive the R&D training. While the manual provides good safe work practices for energy storage devices many people would better understand how to apply that knowledge if learned in a classroom setting. Formal training in this discipline with a test would indicate that workers are currently aware of electrical hazards.

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[2] Clarification from the Electrical Safety Improvement Team: The Physics Division has weekly safety meetings and quarterly safety warden meetings. In addition, groups including each Hall and the Computer Center hold weekly safety meetings. Physics EH&S professionals attend these sessions and also meet with the division safety officer weekly. EH&S professionals from the Physics and Accelerator Divisions meet monthly to share lessons learned.

SOPs are used extensively and appear to be appropriate for the tasks. In addition to the approval signatures, the users should sign them as a sign that they have been read.

Energized electrical work is well controlled and only performed by qualified people. Electricians (Harris contractors) are the only workers who do energized work. Electricians work in 2 man teams. Energized work is only done when absolutely necessary and all appropriate PPE is used. JLab electricians who have electrically rated gloves purchase new gloves instead of having old gloves tested according to ASTM Standards. This process is not well controlled. A data base should be used to remind those electricians that gloves that have been in used for 6 months must be replaced.

Hazards in the Halls are thoroughly identified and tracked. Walkdowns for new experiments are performed to identify new hazards. These are documented.

Work space and conditions in R&D laboratories are more than adequate, but some safety requirements have been overlooked. Cable trays are used extensively overhead to manage cables run throughout the lab. Because these do not contain building power distribution cables the R&D workers are allowed some leniency (see Chapters 9 & 10 of the DOE Electrical Safety Guidelines). These cable trays must be grounded and a good grounding block is provided in the back of many labs. Utilities (water and gas tubing, e.g.) that support experiments are allowed in these trays, but the user must assure that they remain in good condition. Extension cords can also be in the trays when needed as long as the connection points hang below the tray. Metal topped laser tables should also be grounded to the provided ground block.

Equipment fabrication by the Electronics Group in the Physics Division is a routine task. These include circuit boards, rack components, and other electronics needed to support experiments. However, there are no measurements made to assure they are “Safe to Operate”. The UL listing on bought equipment provides this for us as required by the DOE. Builders of equipment on site must document similar safety. Parts of UL Standard 1244(?) for laboratory equipment are used by other DOE labs to assure appropriate safety. Appropriate wiring of the AC power section is the easiest part. More importantly is the leakage current produced by the equipment. If the leakage current is over 3 mA (the UL limit) it can be used under certain conditions with appropriate controls of which the user must be aware. Equipment using electronic switching power supplies and certain filters produce leakage current. Evaluation foreign made equipment (non-UL) for safety is necessary. Instruments are available to easily measure leakage current.

More formal Q/A evaluations should be performed on fabricated electrical and electronic equipment and installations. This should be part of the process to assure the equipment is

‘Safe to Operate’. Have a coworker or supervisor look over the work before the cover is attached.

MRI workers (HVAC contractor) should be trained to the arc-blast hazard as presented in the new NFPA 70E. Their work procedures should relate to some SOP. It is not known if they have an SOP.

The Electrical Safety Manual, Standard Operating Procedures, and similar documents should be reviewed/revised to include NFPA 70E requirements as appropriate.

In R&D areas such as the Test Lab changes to the AC power distribution should be documented. Because conditions change in that area a label maker could be used to mark power sources on receptacles. An incident occurred when a Personal Safety Systems tech thought he had removed power from a wire and discovered it was still energized. Conditions were different from what was expected.

The Personal Safety Systems group, although small, uses a log to track work, maintains their equipment drawings, and perform thorough Q/A tests on their electronic work.

Basic AC wiring standards should be taught to technicians to assure consistency in the AC portion of equipment fabricated by technicians. This knowledge is not obvious nor understood by all technicians. This concern exists at other DOE labs as well.

The Electrical Safety Subcommittee includes members who represent the entire Lab. These people should become known in their department and Divisions. They should be called for participation on new projects involving electrical safety and for electrical safety evaluations and accident investigations. They should work closely with their area safety people. They should be given a purpose and responsibility by upper management. A charter signed by management and yearly goals and objectives. Announcements, Bulletins, and Lessons Learned involving electrical safety should come from the committee or one of the members. At least 4 publications a year from the subcommittee to lab workers will give credibility to the subcommittee. Upcoming changes to the Manual should first appear as a Bulletin. Using May (National Electrical Safety Month) to present electrical safety issues to the Lab is great advertising. This team is a valuable asset to the Lab and should be used accordingly. They are currently addressing pertinent issues requiring their involvement. At least one member should be a Certified Electrical Inspector and a member of the NFPA. Participation in the annual DOE Electrical Safety Advisory Committee meeting should be regular. Some DOE laboratories have Electrical Safety Officers who inspect, evaluated, and approved all things electrical. The subcommittee could act as Electrical Safety Officers as necessary. The subcommittee should review changes to the National Electrical Code (every three years) and declare when the new code will be adopted for lab use.