Fermilab

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Memorandum

July 14, 2009

To: Bruce Chrisman

From: Nancy L. Grossman

Subject: Revised FESHM Chapter 5041 Electrical Utilization Equipment Safety

FESHM Chapter 5041 Electrical Utilization Equipment Safety has been revised to address the proper storage and removal of capacitors and capacitor banks to eliminate possible dangerous residual charge. Any capacitor capable of storing 10 joules or greater and having a voltage rating greater than 50 volts must have their terminals short circuited with a bare conductor.

After final approval, please return this approval page to Katie Kosirog at MS119 for posting on the web.

Encl.

Recommended for Approval:

Bruce Chrisman — Date 7/20/09

Approved:

Piermaria Oddone — Date 7/22/09

ELECTRICAL UTILIZATION EQUIPMENT SAFETY

INTRODUCTION

This Chapter describes requirements related to and for working safely on electrical utilization equipment. These requirements are somewhat similar yet distinguished from those in FESHM Chapter 5042 and those developed separately by FESS that relate to AC Power Distribution System safety. While the installation, maintenance and repair of utilization equipment can only be performed by qualified workers, it is the responsibility of Fermilab supervisory personnel to insure that the work on any particular job is done safely and according to the applicable codes (OSHA, NFPA 70E, etc.).

DEFINITIONS

A **Competent Person** is an individual knowledgeable in the design, construction, operation, and maintenance of the subject electrical utilization equipment. The competent individual has familiarity with the electrical requirements of the NEC, OSHA and NFPA, has received safety training on the hazards involved with electricity, and by virtue of training and experience is fully aware of the work practices and procedures necessary to mitigate or eliminate those hazards. A person can be considered competent with respect to certain equipment and requirements but still not competent for others.

Electrical Utilization Equipment is equipment that utilizes electric energy after the Point of Outlet for electronic, electromechanical, chemical, heating, lighting, or similar purposes. Examples of such equipment include fixed and variable output power supplies, motors, motor controllers, motor control units mounted in a motor control center, variable frequency drives for motors (VFDs), process control and monitor equipment, battery powered interruptible or uninterruptible power sources, welding machines, and computers. Cords, plugs, and conductors that facilitate connection of utilization equipment to the AC Power Distribution System up to the Point of Outlet are to be considered as parts of the utilization equipment. While subject to the concurrence of the Permit approving authority, utilization equipment is further classified as low-power and high-power as follows:

Low-Power Electrical Utilization Equipment is characterized by all of the following conditions:

- The primary AC voltage powering the equipment is less than 300 VAC phase to phase and/or 150 VAC phase (line) to neutral or ground
- The primary current is limited to 100 amperes or less by circuit breakers or fuses
- The stored energy in capacitors and inductors is less than 10 joules

High-Power Electrical Utilization Equipment is characterized by not meeting any, but not necessarily all, of the above individual requirements for Low-Power Electrical Utilization Equipment.

Energized Work is any activity on or near exposed energized conductors where a real hazard exists from contact or equipment failure that can result in electric shock, arc flash burn, thermal burn or blast. Reference to FESHM Chapter 5040 is suggested for a more complete discussion of Energized Work and associated definition of terms such as **Electrically Safe Work Condition, Limited Approach Boundary, Flash Protection Boundary, Diagnostic** and **Manipulative Energized Work.**

The **Point of Outlet** is the point of connection to the AC Power Distribution System where electrical current is taken to supply utilization equipment. The point of outlet is further defined as the first disconnecting means upstream of the utilization equipment. Such points include standard wall outlets and receptacles, disconnect switches and circuit breakers. Within a MCC, the point of outlet is considered to be the point of connection between the MCC power bus and the removable motor controller assembly.

A **Qualified Person** or Worker, as applied to electrical work activities, is an individual trained and knowledgeable of the construction and operation of equipment or a specific work method and trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Additional requirements for the Qualified Person are set forth in NFPA 70E Article 110.6 (D)(1). A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others.

REQUIREMENTS

1. Whenever reasonably possible, electrical utilization equipment used at Fermilab shall be approved or listed by a nationally recognized testing laboratory (NRTL) and installed and used in accordance with the approval or listing.
2. Whenever reasonably possible, electrical utilization equipment constructed by or for Fermilab shall utilize approved or listed components. Such components shall be utilized in accordance with the approval or listing.
3. Electrical utilization equipment constructed by or for Fermilab shall have its design and construction reviewed by a competent person or persons commensurate with the electrical hazards posed by the equipment. Such a review shall occur both before the equipment is first energized and before the equipment is placed into service after testing.

4. Such design and construction reviews shall be documented and kept on file for a period of at least three years by the responsible Division/Section Department or organization.
5. All work on electrical utilization equipment is preferentially performed only when the equipment is de-energized, in an electrically safe work condition, and when all hazardous energy has been isolated.
6. Diagnostic energized work on electrical utilization equipment is allowed when justified and when performed by qualified persons. When performing such work, the worker shall be protected from any associated electrical hazards including shock and arc-flash.
7. Manipulative energized work on electrical utilization equipment is not allowed unless justified. When such work is allowed by a properly executed Electrical Hazard Analysis / Work Permit, the person(s) performing the work must be qualified and shall be protected from any associated electrical hazards including shock and arc-flash.
8. If there is a significant potential of injury, work by a single individual on energized utilization equipment in an isolated location is not allowed.
9. When any qualified worker is working within either the Shock or Arc-Flash Protection Boundaries of energized high-power electrical utilization equipment, at least one other person must be assigned to the work. The other person shall be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. The other person shall also be trained in methods of release.
10. All electrical utilization equipment for personal use in the workplace, such as coffee pots, refrigerators, space heaters, fans, and radios, shall be listed and exhibit a NRTL label.
11. All AC power connectors on foreign made utilization equipment brought to Fermilab shall be inspected by the Division/Section Electrical Coordinator to assure that no safety hazard or confusion with U.S. standard connectors exists. When failing this inspection, all foreign power plugs shall be replaced with U.S. standard connectors if they are to be plugged into the outlets or receptacles of the Fermilab AC Electrical Power Distribution System outlets and receptacles.
12. Electrical utilization equipment for which there is no longer a perceived requirement shall be completely de-energized and permanently disconnected from the AC Electrical Power Distribution System. Particular circumstances may require posting of such abandoned equipment as "NOT IN SERVICE" prior to its physical removal. When feasible and when future use is not anticipated, powering conductors between the point of outlet and the utilization equipment, ancillary cabling, and other external hardware associated with such equipment shall be removed.

13. Capacitor and Capacitor Bank Safety

Capacitors may store and accumulate a dangerous residual charge after equipment has been de-energized and the capacitors or capacitor banks removed. To protect personnel from the potential hazards from residual charge in capacitors, the following safety precautions shall be followed.

Capacitors capable of storing 10 Joules or greater ***and*** *a voltage rating greater than 50 volts shall have their terminals short circuited with a conductor (bare wire – non insulating) no smaller than # 20 AWG.*

a. $W = \frac{1}{2}CV^2$

Where: *W = Energy in Joules (watt-seconds)*
C = Capacitance in Farads
V = Voltage across capacitor terminals in volts

b. Wires must be securely fastened to the terminals and left in place until the capacitors are returned to service.

c. If a capacitor is to be disposed, the shorting wires shall remain in place.

d. Appropriate (commensurate with voltage rating) verification required before installing shorting wires for capacitors capable of storing 10 Joules or greater.

ELECTRICAL HAZARD ANALYSIS / WORK PERMIT REQUIREMENTS

1. An Electrical Hazard Analysis / Work Permit (EHAWP or "Permit") is required for justified manipulative energized work on electrical utilization equipment.
2. An EHAWP is required for diagnostic energized work on electrical utilization equipment that is judged by competent person to be significantly complex and/or hazardous.
3. The Permit requires a Description of Work, a description and analysis of Associated Hazards, and required elements of Hazard Mitigation that will bring exposure to attendant hazards to an acceptably low risk. The Hazard Mitigation section, to the extent applicable, shall include safe work practices, means employed to restrict the access of unqualified persons from the work area, indication of the determined Hazard/Risk Category, results of shock and flash hazard analyses if other than default values, and required PPE. Complex work activities may need to be broken down into identifiable work phases. For such situations, the Associated Hazards and Hazard Mitigation descriptions and steps should be developed for each phase of work.

4. The Associated Hazards listed in the Permit most frequently pertain to exposure to unguarded or bare conductors or circuit parts that have not been tested and found to be in an Electrically Safe Work Condition. However, this part of the Permit is appropriate and, in lieu of a separate HA, may be used for listing of other non-routine and significant hazards associated with the electrical work activity at hand. Such hazards might include falls, interception of buried utilities, oxygen deficiency or vehicular traffic.
5. The justification to perform Manipulative Energized Work must be documented on the Permit. Such justifications are not for convenience, but rather must show that de-energization introduces additional or increased hazards, or is infeasible due to equipment design or operational limitations. Multiple approvals are required on the Permit form for Manipulative Energized Work.
6. The Permit must be filled out and approved prior to the work activity. At a minimum, the Permit must be approved by a competent person within the Division/Section Department or organization performing the work activity. This person is usually the Department Head although approving authority may be delegated to one or more other competent persons within the Department or organization. The Permit preparer and approver are generally not the same individual. For situations where the normal approving authority is not fully knowledgeable in the particular equipment and/or associated hazards, the preparer may approve the Permit if so knowledgeable and authorized.
7. A job briefing shall always be conducted before beginning work by the competent person in charge with all individuals directly participating in the work activity. Topics will include scope of work, hazards associated with the work, procedures and special precautions, energy source controls, and personal protective equipment requirements. Those in attendance will sign the Permit, thereby indicating their understanding of the scope of work and associated hazard mitigation requirements.
8. In case of doubt about any aspect of energized work activity upon utilization equipment, by either the normal approving authority or any of the qualified workers assigned to the work activity, a technical subject matter expert who is familiar with the equipment in question shall be consulted. The technical expert shall reconsider the need to leave the equipment energized and shall consider further steps that may be taken to ensure the safety of the personnel on the job. If, after this review, workers are still not satisfied that an adequate margin of safety is assured, they may refuse participation in the work activity. This refusal shall not be the cause for disciplinary action.
9. The Permit will be available at the work site.
10. Copies of approved Permits shall be kept on file for a period of at least one year by the originating Division/Section Department or organization.

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ELECTRICAL HAZARD ANALYSIS / WORK PERMIT

For Selected Work Activities on the AC Power Distribution System or Electrical Utilization Equipment

JOB NAME & LOCATION: _____

EFFECTIVE DATES OF PERMIT: **Start:** _____ **End:** _____

WORK TO BE PERFORMED BY: _____

QUALIFIED PERSON IN CHARGE: _____ **PHONE:** _____

Does the Work Involve Diagnostic Energized Work? **Yes** _____ **No** _____ (Includes LOTO Verification)

Does the Work Involve Manipulative Energized Work? **Yes** _____ **No** _____ (Justification Required)

Is an Inspection Required After Work is Completed? **Yes** _____ **No** _____ (Reqd for New AC Pwr Installs)

If the Work Activity Involves Manipulative Energized Work, State the Justification Here.

_____

DESCRIPTION OF WORK:

ASSOCIATED HAZARDS:

HAZARD MITIGATION: **Indicate Hazard/Risk Category (-1, 0, 1, 2, 2*, 3 or 4):** _____

SHOCK PROTECTION BOUNDARIES for ENERGIZED WORK

from NFPA 70E Table 130.2(C) for Fixed Circuit Parts and Article 130.3(A). Indicate if Otherwise.

For 120/208 VAC: **Shock Protection: Limited Approach:** 3' 6". **Restricted & Prohibited Approach:** Avoid Contact

For 480/277 VAC: **Shock Protection: Limited Approach:** 3' 6". **Restricted Approach:**. 1 Ft. **Prohibited Approach:** 1"

Class _____ **Voltage-Rated Gloves and Leather Protectors** Required for Subject Work Activity

ARC-FLASH PROTECTION BOUNDARY and REQUIRED PPE for ENERGIZED WORK

PPE Requirements for Shock & Arc Flash Protection are Fully Described in NFPA 70E, Article 130.7. Indicate if Otherwise. Clothing Must be Non-Melting or Untreated Natural Fiber, Unless Specified as Flame-Resistant (FR).

The Fermilab Default Flash Protection Boundary is 4 Feet (as Qualified by Article 130.3(A) at 300 kA Cycles)

If Calculated, Indicate Flash Protection Boundary: _____ **feet and/or inches**

If Calculated, Indicate Incident Energy Level for Arc Flash Protection: _____ **cal/cm^2**

HRC -1 Short-Sleeve Cotton T-Shirt, Long Cotton Pants, Safety Glasses (0 to 1.2 cal/cm^2)

HRC 0 Long-Sleeve Cotton Shirt, Long Cotton Pants, Safety Glasses (0 to 1.2 cal/cm^2)

HRC 1 FR Coverall, Safety Glasses, Hard Hat, Leather Protectors or Gloves (>1.2 to 4 cal/cm^2)

HRC 2 Cotton Clothing under FR Coverall, Safety Glasses, Hard Hat, Arc-Rated Face Shield, Hearing Protection, Leather Protectors or Gloves, Leather Work Shoes (>4 to 8 cal/cm^2)

HRC 2* Cotton Clothing under FR Coverall, Safety Glasses, Hard Hat, Double-Layer Switching Hood, Hearing Protection, Leather Protectors or Gloves, Leather Work Shoes (>4 to 8 cal/cm^2)

HRC 3 Cotton Clothing under 2 FR Coveralls, Safety Glasses, Hard Hat, Flash Suit Hood, Hearing Protection, Leather Protectors or Gloves, Leather Work Shoes (>8 to 25 cal/cm^2)

HRC 4 Cotton Clothing under Multilayer FR Flash Suit Jacket and Pants Safety Glasses, Hard Hat, Flash Suit Hood, Hearing Protection, Leather Protectors or Gloves, Leather Work Shoes (>25 to 40 cal/cm^2)

PREPARED BY: _____ **Date:** _____

APPROVED BY: _____ **Date:** _____

ADDITIONAL APPROVALS FOR MANIPULATIVE ENERGIZED WORK

Approval of D/S Electrical Coordinator _____

Approval of Area Division/Section Head _____

Approval of Fermilab Directorate _____

Job Briefing Signature Sheet

Person(s) Conducting Briefing: _____ **Date:** _____

Personnel Present at the Job Briefing will Sign Below, thereby Indicating their Understanding of the Scope of Work and Associated Hazard Mitigation Requirements.

Print Name	Fermi ID #	Div/Sec or Company	Signature