Management System: Worker Safety and Health

Subject Area: Electrical Safety

Effective Date: Sep 26, 2017 (Rev 10.0)  Periodic Review Due: Feb 29, 2020
Subject Matter Expert: Richard Biscardi  Management System Executive: Gail Mattson  Management System Steward: Gail Mattson

Introduction

The Electrical Safety Subject Area has been developed to promote an electrically safe workplace free from electrical hazards and to provide directions for the implementation of electrical requirements in compliance with 10 CFR 851 DOE Worker Safety and Health Program. This subject area describes the procedures to be used by employees of Brookhaven National Laboratory (BNL) and BNL contractors; employees of a subcontractor; individuals who visit to perform work for or in conjunction with BNL, and use BNL facilities.

The hierarchy of controls of the Electrical Safety Program are:

- Elimination or substitution of the hazard;
- Engineering controls;
- Administrative controls - lockout/tagout or unplug the equipment;
- Energized Work Permits with appropriate PPE.

It is Brookhaven National Laboratory policy that no one works on or near energized components above 50 volts, unless Qualified, Authorized and with an electrical work permit. This permit ensures that the energized work is necessary, the procedures and PPE are in place to protect the worker, and the training is current to perform the work. Live parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs. The hierarchy requires consideration for elimination/substitution of the hazard, engineering controls and Lockout/Tagout or unplugging of equipment before deciding to work energized. For information on Lockout/Tagout see the Lockout/Tagout (LOTO) for Installation, Demolition, or Service and Maintenance Subject Area.

Contents

1. Implementing Electrical Safety
   - Conduct periodic walkthroughs or field checks.
   - Follow electrical safety practices.
   - Design equipment and facilities incorporating safety for operation and maintenance.
   - Perform periodic inspections of electrical work.
   - Do not operate vehicles or mechanical equipment near overhead lines.

2. Operating Electrical Equipment
   - Ensure personnel operating the equipment are trained.
   - Wear required PPE as specified for Hazard/Risk Category rating or follow exhibit if no category rating is posted.
   - Operators of Category 4 equipment must follow two-person rule.
   - Operators of circuit breaker, fused switches, and MCC starters or meters must wear PPE.

3. Energized Work
   - Plan all electrical work using the electrical work permit.
   - Evaluate which type of electrical work permit is required.
4. Personal Protective Equipment (PPE) for Electrical Work

• Use Energized Electrical Work Permit for working on or near energized electrical conductors or circuit parts.
• Issue Electrical Work Permit and list all authorized personnel.
• Evaluate the proper energized electrical work permit.
• Provide feedback following all electrical work.

5. Design and Installation of Electrical Equipment

• Ensure electrical equipment includes energy isolating devices.
• Ensure electrical equipment and installations conform to applicable Codes and Standards.
• Document all electrical additions and changes on system or facility drawings.
• Ensure arc-flash calculations are performed per NFPA 70E.
• Ensure sufficient access and working space is provided.
• When required, ensure ground detection is installed.

6. Electrical Equipment Inspection (EII) and Electrical Materials and Installation Inspection (EMII) Programs

• Implement the following subprocesses:
  ◦ Electrical Equipment Inspection;
  ◦ Electrical Materials and Installation Inspection.

Definitions

Exhibits

Approved Equivalent Electrical Training
BNL Electrical Equipment Inspection (EEI) Program
BNL Electrical Materials and Installation Inspection (EMII) Program
Certification of Personal Protective Equipment (PPE) for Electrical Energized Work
Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment

Design Guide

Electrical Equipment Labels
Electrical Panel/Disconnect Labeling Program
Electrical Safe Work Practices
Reputable Manufacturer Requirements
Selection and Use of Rubber Gloves and Insulating Blankets
Task-based Electrical Safety Training Requirements
Topics to be Covered During Departmental Job-Specific Training
Work Distance Table (Control Zones)

Forms

Electrical Equipment Inspection Forms
Electrical Work Permits with Instructions

Training Requirements and Reporting Obligations

This subject area contains the following training requirements (see the BNL Training & Development website):

• Current, documented safety training is required for all electrical work on or near energized conductors and consists of the following: Electrical Safety 1 (TQ-ELECSAF1); Lockout/Tagout Authorized Worker (HP-OSH-151B-W); and Cardiopulmonary Resuscitation (Adult CPR/AED). Departments/Divisions must maintain a list of these authorized workers.

• For approved equivalent training see the exhibit Approved Equivalent Electrical Training. For other task-based training requirements, see the exhibit Task-Based Training Requirements.

• Organizational-specific and on-the-job training must be conducted at least annually by each Department/Division for all personnel that the organization wishes to define as Authorized Workers.

• Organizational-specific training includes
  ◦ Review of required personal protective equipment and tools appropriate for equipment voltage and current range;
  ◦ Review of the Energized Electrical Work Permit;
Emergency actions that may be required.

This subject area does not contain reporting obligations.

**External/Internal Requirements**

**Active Internal Waiver(s)**

<table>
<thead>
<tr>
<th>ID</th>
<th>Waiver</th>
<th>Supporting Document</th>
<th>Additional Files</th>
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<tbody>
<tr>
<td>2017-07</td>
<td>MS APPROVAL PENDING - PERMANENT REQUEST; Facility Safety - NFPA 70 NEC Request for Relief or Deviation</td>
<td>Deviation Request 2017-07 B-610 MCC-B variance request signed.pdf</td>
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</table>

**Requirements**

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement Title</th>
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<tbody>
<tr>
<td>10 CFR 830, Subpart A</td>
<td>Energy, Nuclear Safety Management, Quality Assurance Requirements</td>
</tr>
<tr>
<td>10 CFR 851</td>
<td>Worker Safety and Health Program</td>
</tr>
<tr>
<td>29 CFR 1910</td>
<td>Labor/Occupational Safety and Health Standards</td>
</tr>
<tr>
<td>29 CFR 1926</td>
<td>Labor/Safety and Health Regulations for Construction</td>
</tr>
<tr>
<td>BSA Contract No. DE-SC00122704 - Clause C.4</td>
<td>Statement Of Work</td>
</tr>
<tr>
<td>BSA Contract No. DE-SC00122704 - Clause H.27 (ACT)</td>
<td>Non-Federal Agreements for Commercializing Technology (Pilot) (ACT)</td>
</tr>
<tr>
<td>BSA Contract No. DE-SC00122704 - Clause I.131 (DEAR 970.5223-1)</td>
<td>INTEGRATION OF ENVIRONMENT, SAFETY, AND HEALTH INTO WORK PLANNING AND EXECUTION (DEC 2000)</td>
</tr>
<tr>
<td>DOE-STD-1086-99</td>
<td>Fire Protection Design Criteria</td>
</tr>
<tr>
<td>NFPA 497</td>
<td>Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas</td>
</tr>
<tr>
<td>NFPA 70</td>
<td>National Electrical Code</td>
</tr>
<tr>
<td>NFPA 70B</td>
<td>Electrical Equipment Maintenance</td>
</tr>
<tr>
<td>NFPA 70E (2009)</td>
<td>Electrical Safety Requirements for Employee Workplaces</td>
</tr>
<tr>
<td>NFPA 73</td>
<td>Standard for Electrical Inspections for Existing Dwellings</td>
</tr>
<tr>
<td>NFPA 79</td>
<td>Electrical Standard for Industrial Machinery</td>
</tr>
<tr>
<td>NFPA 790</td>
<td>Standard for Competency of Third-Party Field Evaluation Bodies</td>
</tr>
<tr>
<td>NFPA 791</td>
<td>Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation</td>
</tr>
<tr>
<td>NFPA Codes</td>
<td>National Fire Protection Association Codes</td>
</tr>
<tr>
<td>O 414.1D Admin Chg 1 (May 8, 2013)</td>
<td>Quality Assurance</td>
</tr>
</tbody>
</table>

**References**

10 CFR 851, DOE Worker Safety and Health Program

**BNL Training & Development** website

DOE Electrical Safety Handbook, DOE-HDBK-1092-2004

**Electrical Equipment Inspection Management System (EEIMS)** website

Managers shall manage work to control risks and hazards, detect wrongdoing, ensure customer satisfaction, and provide a benefit to BNL.

Managers shall perform "field walkthroughs" as a standard practice for assessing performance and identifying areas for improvement.

All staff and guests shall share information based on experience (e.g., lessons learned) to promote continuous improvement in business and work practices.

All staff and users shall ensure that they are trained and qualified to carry out their assigned responsibilities, and shall inform their supervisor if they are assigned to perform work for which they are not properly trained or qualified.

All staff and users shall identify, evaluate, and control hazards in order to ensure that work is conducted safely and in a manner that protects the environment and the public.

All staff and guests shall promptly report accidents, injuries, ES&H deficiencies, emergencies, and off-normal events in accordance with procedures.

The only official copy of this file is the one on-line in SBMS.
### Applicability

This information applies to any person at BNL, or in places under BNL jurisdiction.

### Required Procedure

This section, used in conjunction with 29 CFR 1910 OSHA Subpart S, NFPA 70 National Electrical Code, and NFPA 70E Standard for Electrical Safety in the Workplace, addresses those electrical safety requirements for the practical safeguarding of employees in the workplace.

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Line Management must conduct periodic walkthroughs or field checks of electrical work to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Ensure workers performing lockout/tagout (LOTO) or working on or near live parts are Qualified and Authorized;</td>
</tr>
<tr>
<td></td>
<td>• Verify procedure compliance;</td>
</tr>
<tr>
<td></td>
<td>• Verify personal protective equipment (PPE) use.</td>
</tr>
</tbody>
</table>
Step 2

Staff must follow the electrical safety practices below:

- Make sure hands are dry when plugging/unplugging energized equipment including extension cords;
- Do not use any electrical device that is defective or shows evidence of damage;
- Inspect portable cord and plug equipment and cord sets (extension cords) for
  - External defects (loose parts, deformed or missing pins (especially ground pin), or damage to outer jacket or insulation;
  - Evidence of internal damage (such as pinched or crushed outer jacket);
  - Tears or dry rot in outer jacket.
- Insert plugs fully into receptacle. Do not touch the blades of the plug while inserting and do not force, locking connectors must be properly secured after connection;
- When a plug is to be connected to a receptacle (including cord sets), check contacts to ensure they are of correct mating configuration for voltage and current;
- Adapters which interrupt continuity of equipment grounding connections may not be used;
- Only Qualified Workers may perform testing work on electric circuits or equipment that may expose them to shock or arc-flash hazard;
- Do not reset a circuit breaker that has tripped unless it has been determined that the equipment and circuit can be safely energized (i.e., cause of tripping is known), and then only if trained and approved by the Department/Division. Otherwise contact the F&O Facility Project Manager (FPM);
- Do not use extension cords in place of permanent building wiring, they are for temporary use only;
- Relocatable Power Taps (e.g., six-outlet power strips) cannot be used with extension cords or daisy-chained together;
- Do not remove covers from electrical equipment that could expose energized uninsulated parts, unless authorized by Department/Division and with an energized work permit (see the exhibit Electrical Work Permits with Instructions);
- Keep working space around electrical equipment clear to provide for safe operation and ensure that nothing is stored in this working space (see the section Design and Installation of Electrical Equipment). Marking the floor to indicate the following dimensions is encouraged:
  - 3 feet for 150 volts to ground or less;
Prior to performing work, the electrical worker is responsible for

- Inspection/evaluation of the work site;
- Assembling proper tools for the job;
- Using procedures as tools to assist in planning the job;
- De-energizing the equipment and verifying a zero energy condition;
- Identifying and minimizing hazards;
- Using PPE consistent with the shock and arc-flash hazard (this is the last chance to avoid injury).
### Step 4
The electrical worker is responsible for

- Never leaving the work site in an unsafe condition;
- Ensuring the work site is compliant with National Electrical Code (NEC) when the job is complete;
- Ensuring the work site is compliant with NEC and NFPA 70E throughout the duration of the work.

### Step 5
Electrical engineers and designers must purchase equipment, and design equipment and facilities to conform to current Codes and Standards. They are encouraged to incorporate the latest technologies, which enhance safety during operation and maintenance (e.g., specify arc-resistant switchgear). (See the section [Design and Installation of Electrical Equipment](#)).

**Note:** Facilities in compliance with the National Electrical Code at the time of construction (Code of Record) are acceptable. A subsequent major renovation requires compliance with current codes and standards.

### Step 6
Line management in organizations responsible for ungrounded electrical systems must have written procedures documenting

- Monitoring ground detectors either remotely or by periodic inspections not to exceed monthly.
- The response if a ground is detected, including:
  - The required notifications (both who and time frame) plus affected users and employees;
  - Management/designee notification who determine actions to be taken which may include:
    1. shutdown;
    2. limiting conditions of operations;
    3. changes in PPE to perform operations or work;
    4. additional inspections, and testing required for continued operations.

### Step 7
Safety Engineers and ES&H Coordinators must perform periodic inspections of electrical work in their facilities. During TIER I inspections, use the checklist (see the [Environment, Safety, Health and Quality (Tier I) Inspections](#) Subject Area) and the safety practices in step 2 above, as an aid for inspecting equipment.
Step 8

All personnel working near overhead lines must not approach, nor bring objects closer than 10 feet (see the exhibit Work Distance Table [Control Zones]).

- Do not operate vehicles or mechanical equipment near overhead lines closer than 10 feet. However, clearances are permitted to be reduced if:
  - The vehicle is in transit with its structure lowered, the allowed distance by 4 feet.
  - Aerial lifts insulated for the voltage and operated by an authorized worker are permitted to approach up to the Restricted Approach Boundary.
- Employees standing on the ground must not contact the vehicle or any attachments, unless
  - The employee is using PPE;
  - The equipment is located so that no uninsulated part is closer than the requirement above.

References

Environment, Safety, Health and Quality (Tier I) Inspections Subject Area

Organizations Currently Recognized by OSHA as NRTLs Web page

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Applicability

This information applies to any person at BNL, or in places under BNL jurisdiction, who operates circuit breakers (CB), fused switches, motor control center (MCC) starters, and meter switches with enclosure covers on of 50 volts or greater.

Note: These requirements do not apply to 120-volt utilization equipment switches (such as office light switches).

Required Procedure

Equipment with a calculated Hazard Risk Category of Dangerous (greater than 4 [40 cal/cm²]) or with a DANGER – DO NOT OPERATE label (see the exhibit Electrical Equipment Labels) are not to be operated while energized without formal work planning through an approved work planning process and approval of the Authority Having Jurisdiction.

Racking a circuit breaker or inserting/removing an MCC starter bucket when the main bus remains energized requires an energized work permit (see the exhibit Electrical Work Permits with Instructions) and is not allowed if the Hazard/Risk Category is Dangerous.

All electrical work must be planned to reduce hazards and to protect the worker and others.

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Supervisors must ensure that personnel operating the equipment are trained in Electrical Circuit Breaker and Switch Operation Safety (TQ-ELECTBSOP) or Electrical Safety I (TQ-ELECSAF1). (See the BNL Training and Development website).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Personnel who operate equipment with no Hazard Risk Category rating posted (otherwise go to step 3) must wear PPE as listed in the Certification of Personal Protective Equipment (PPE) For Operating Electrical Equipment.</td>
</tr>
<tr>
<td>Step 3</td>
<td>Operators of electrical equipment posted as Hazard/Risk Category rating 4 must follow the two-person rule (see the Definitions section for two-person rule).</td>
</tr>
</tbody>
</table>
| Step 4 | Personnel who operate circuit breakers (CB), fused switches, and MCC starters or MCC meter switches with enclosure covers on/closed, may wear personal protective equipment (PPE) of one less than the Hazard Risk Category posted (minus one rule) on the equipment, if the conditions below are met. 

Minus One Rule - The required PPE may be reduced as per the table below at the discretion of the work planning team based on a risk assessment. All the following conditions must be satisfied:
1. An arc flash calculation has been done and posted on the switch.
2. It is less than a Hazard/Risk Category 4.
3. Its covers are fully closed and all fasteners are present and properly installed.
4. The equipment is properly installed.
5. The equipment is properly maintained.
6. There is no evidence of impeding failure.

<table>
<thead>
<tr>
<th>Posted Hazard/Risk Category</th>
<th>Hazard/Risk Category with Covers Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+</td>
<td>Insignificant Arc-Flash Hazard (No Category) - Eye protection and ear protection (canal inserts) still required</td>
</tr>
<tr>
<td>1</td>
<td>0+</td>
</tr>
<tr>
<td>2, 2*</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4 (Category not reduced)</td>
</tr>
<tr>
<td>Dangerous</td>
<td>Dangerous (not allowed to operate energized)</td>
</tr>
</tbody>
</table>
Guidelines

When possible, personnel operating a circuit breaker or switch should
  • Not stand in front of the equipment;
  • Turn their face away from the equipment, unless wearing a faceshield.

References

BNL Training and Development website

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Applicability

This information applies to any person at BNL, or in places under BNL jurisdiction, who enter or plan work within a Limited Approach Boundary or an Arc Flash Boundary when there are exposed electrical hazards from electrical conductors or circuit parts that are or can become energized. This does not apply to 50 volts or less if there is no increased exposure to electric burns or explosion due to an arc flash.

Required Procedure

Energized parts to which personnel might be exposed must be put into an electrically safe work condition and lockout/tagout (LOTO) unless:

- De-energizing the equipment introduces additional or increased hazards;
- The component is an integral part of a continuous process and would require that the entire process be shut down in order to work on the piece of equipment; or
- Shutdown is infeasible due to equipment design or operational limitations, including the need to perform diagnostics and testing (e.g., start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized.

Note: LOTO is not required for cord and plug equipment when the worker has exclusive control of the plug.

All electrical work must be planned to reduce hazards and to protect the worker and others.

Equipment with a Hazard Risk Category of Dangerous (greater than 4 [40 cal/cm2]), or with a “DANGER - DO NOT OPERATE” or “DANGER – DO NOT REMOVE COVER WHILE ENERGIZED” label (see the exhibit Electrical Equipment Labels) cannot be operated, serviced, maintained, or other work performed while energized, including operation of a circuit breaker or switch without formal work planning through an approved work planning process and approval of the Authority Having Jurisdiction.
Anyone working on or near energized electrical conductors or circuit parts greater than 50 volts must have the following:

1. Training – Electrical Safety 1 (TQ-ELECSAF1), CPR (TQ-ADULTCPR), LOTO Authorized (HP-OSH-151B-W) [or approved equivalent training, see the exhibit Approved Equivalent Electrical Training. For other task based training requirements see the exhibit Task-Based Training Requirements--add link];
2. Authorization – By the Department/Division they work for, in the case of a non-BNL employee it must be the sponsoring Department/Division;
3. Permits – A BNL energized work permit or approved equivalent procedure. See the exhibit Electrical Work Permits with Instructions.

Step 1
The Supervisor/designee plans all energized electrical work using the electrical work permit (refer to the exhibit Electrical Work Permits with Instructions). The planning may be as simple as a discussion among the electrical workers reviewing the job, or as complex as a specific procedure with multiple engineering reviews.

Planning must include:

- Information about the equipment and the installation;
- Voltage levels, power availability which might be delivered into an arc flash;
- The Flash Hazard/Risk Category for arc-flash rating of the PPE (cal/cm²);
- Any additional requirements necessary to perform the work, including, if required, additional training and non-electrical Work Permit for non-electrical hazards (see the Work Permit Form in the Work Planning and Control for Experiments and Operations Subject Area);
- Applicability of the two-person rule or safety watch (see the Definitions section for two-person rule and safety watch).
### Step 2

The supervisor/designee must evaluate which type of electrical work permit is required for the task.

There are two types of working on or near electrical work permits:

- Testing, Troubleshooting and Voltage Measuring (TTVM) Electrical Work Permit;
- Specific Energized Electrical Work Permit.

The Testing, Troubleshooting, and Voltage Measuring (TTVM) Electrical Work Permit (see the exhibit [Electrical Work Permits with Instructions](#)) is for work performed near or on energized electrical conductors or circuit parts for tasks such as testing, troubleshooting, voltage measuring, diagnostics, etc., for 600 volts or less. The permit may be issued for reasonable periods of time, not to exceed one year.

Use the Energized Electrical Work Permit (see the exhibit [Electrical Work Permits with Instructions](#)) for working on or near energized electrical conductors or circuit parts when they cannot be placed in an electrically safe working condition, for racking LVCB or inserting MCC buckets, and for any testing, troubleshooting, and voltage measuring above 600 volts (this can be a standing permit for a specific task not exceeding a year). A meeting must be held for all personnel involved in the work during which all involved must reach consensus on safety concerns. As a further safeguard against unnecessary exposure to electrical hazards, the electrical range above 600 volts must also be approved by an independent reviewer (see the Definitions section).

**Note:** An electrical work permit is not required for tasks below 50 volts.

**Note:** A detailed switching procedure, which addresses the requirements of the Energized Electrical Work Permit, may be used in lieu of the permit.

### Step 3

The Department Chair/Division Manager/designee reviews the permit and ensures that all personnel working under the permit:

- Are qualified for the type and energy levels on the permit;
- Have signed the permit;
- Maintain currency of training as required by this procedure for the length of the permit;
- Receive a pre-job briefing and understand the hazards associated with this task by discussing the following:
  - Limits of the permit, especially limits of only testing with TTVM permit;
  - PPE for various tasks;
Any job specific or general work practices to be observed.

The designee must be a person, either BNL or non-BNL, who understands all the requirements and hazards of working on or near live parts and is responsible for ensuring that personnel working under the permit are knowledgeable about the safety requirements.

Step 4

The Department Chair/Division Manager/designee issues the work permit for BNL and non-BNL employees by signing the permit and ensures that:

- A log is kept for auditing purposes.
- Periodic walkthroughs or field checks are conducted to verify the following:
  - Workers are qualified;
  - Compliance with procedure or permit;
  - Proper PPE (refer to the Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment).

Step 5

The person who performs the energized work must do the following:

- **Prior to starting work:**
  - Review the work plan/permit and inform those involved with the work and those nearby who could be impacted that work will begin.
  - Establish safety barriers to keep unprotected personnel out of the arc flash control zone (see step 1 in the section PPE for Arc-flash Hazard) and shock hazard control zones (see the exhibit Work Distance Table [Control Zones]).

- **While performing the work:**
  - Perform the work in accordance with conditions on the permit and with procedures;
  - Perform any necessary testing.

- **After completing the work:**
  - Replace any physical barriers which were removed in order to do the work;
  - Inform those involved and those nearby who could have been impacted that the work has been completed and conditions are safe;
  - Remove the safety barriers and all tools, equipment, and scrap;
  - Provide feedback to confirm that the work was performed by the plan without incident or to improve future work. Follow the Core...
Functions and Guiding Principles of Integrated Safety Management (see the Integrated Safety Management Program Description).

References

Integrated Safety Management Program Description

Work Planning and Control for Experiments and Operations Subject Area

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Before using a printed copy, verify that it is the most current version by checking the effective date.
Management System: **Worker Safety and Health**

Subject Area: **Electrical Safety**

### 4. Personal Protective Equipment (PPE) for Electrical Work

| Effective Date: Feb 29, 2016 | Subject Matter Expert: Richard Biscardi | Management System Executive: Ed Nowak |

**Applicability**

This information applies to any person doing work at BNL, or in places under BNL jurisdiction.

**Required Procedure**

All personnel must be protected from the hazards associated with electricity. For non-qualified personnel they must be protected by enclosures, insulation, barricades and safety signs, or attendants.

Equipment with a Hazard Risk Category of Dangerous (greater than 4 [40 cal/cm²]), or with a “DANGER - DO NOT OPERATE” or “DANGER – DO NOT REMOVE COVER WHILE ENERGIZED” label (see the exhibit [Electrical Equipment Labels](#)) cannot be operated, serviced, maintained, or other work performed while energized, including operation of a circuit breaker or switch without formal work planning through an approved work planning process and approval of the Authority Having Jurisdiction.

Qualified personnel must be protected from the two hazards of working with electricity:

- **Shock hazard** - by distance, insulation, barricades, and PPE (rubber gloves, insulated tools, etc.);
- **Arc-flash (blast) hazard** - by distance, barricades, and PPE (fire-resistant clothes, eye protection, face shield, etc.).

Personal Protective Equipment (PPE) for Electrical Safety contains two subsections:

- [4.1 PPE for Shock Hazard](#)
- [4.2 PPE for Arc-flash Hazard](#)

### 4.1 PPE for Shock Hazard
Step 1

Supervisors must ensure that Qualified Workers are protected from exposure to shock hazard in the three boundaries (see the exhibit Work Distance Table [Control Zone]):

- **Limited Approach** - Employees must use insulated tools and/or handling equipment inside the Limited Approach Boundary if tools might make accidental contact to live parts. Unqualified workers may not cross the Limited Approach Boundary unless escorted by a qualified worker.

- **Restricted Approach Boundary** - No Qualified Worker can approach or take conductive objects closer to exposed live parts, unless
  - The person is insulated (refer to the Certification of Personal Protective Equipment (PPE) for Electrical Energized Work) or guarded from the live parts and no uninsulated parts of the body crosses the Prohibited Approach Boundary;
  - The live part is insulated from the worker and from other conductive objects at a different potential;
  - The person is insulated from any other conductive object as during live-line bare-hand work.
  - Under no circumstances may an unqualified person cross the Restricted Approach Boundary.

- **Prohibited Approach Boundary** - An approach limit from an energized live part, which is considered the same as making contact with the live part and varies from direct contact to several feet depending on the voltage (the gap is not sufficient to prevent a flashover to a grounded part).

Step 2

Supervisors must ensure that Qualified Workers do not wear conductive articles of clothing (e.g., watchbands, rings, metal-rimmed glasses, necklaces), nor bring metal rulers or other uninsulated tools near energized conductors. Tools must not be covered with electrical tape or otherwise modified to provide insulation.

Voltage rated rubber gloves are required for all work on energized parts (refer to the Certification of Personal Protective Equipment (PPE) for Electrical Energized Work). Leather glove protectors are required over rubber gloves, except as follows:

- Protector gloves are not required with Class 0 or 00 gloves if high finger dexterity is needed. While the exception is necessary to allow work to be performed on small energized parts, extra care is needed in the visual examination of the glove and in avoiding handling sharp objects.
- The other exception to the requirement for protector gloves is when the possibility for damage is low and the gloves are one class higher than
required for the voltage. Example, if a Class 2 glove is used at 7500 volts or less (the maximum use voltage for Class 1 equipment). This exception does not apply when the possibility of damage is significant.

Step 3

Supervisors must ensure that Qualified Workers use and maintain rubber gloves and insulating blankets per the requirements in the exhibit Selection and Use of Rubber Gloves and Insulating Blankets.

4.2 PPE for Arc-flash Hazard

Step 1

Qualified Workers must not allow unqualified personnel to enter the flash protection boundary (as listed in the following table, unless posted otherwise on the equipment) when equipment is being operated or live parts are exposed.

<table>
<thead>
<tr>
<th>Hazard/Risk Category</th>
<th>Nominal Flash Protection Boundary (unless posted otherwise)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4'</td>
</tr>
<tr>
<td>1</td>
<td>5'</td>
</tr>
<tr>
<td>2</td>
<td>6'</td>
</tr>
<tr>
<td>3</td>
<td>10'</td>
</tr>
<tr>
<td>4</td>
<td>16'</td>
</tr>
<tr>
<td>Dangerous</td>
<td>Work Planning required to calculate boundary</td>
</tr>
</tbody>
</table>

Note: The calculated arc-flash boundary is the distance within which a person could receive a maximum of a second degree burn if an arc flash were to occur. In most cases the calculated distance will be smaller than listed in the table. The calculated values of distance and Hazard/Risk Category are the minimum required.

Step 2

Prior to operating equipment, the Qualified Worker must warn personnel of the arc-flash hazard. All personnel must wear the proper PPE within the Flash Protection Boundary

- If an arc-flash analysis was performed, based on the minus one rule (see the section Operating Electrical Equipment), the minimum required PPE to
operate the equipment is one level less than listed on the warning sticker, but as a minimum, safety glasses and ear protection (canal inserts must be worn).

- If no analysis is performed, use the PPE in the tables (refer to the Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment).
- Operating equipment is NOT allowed if incident energy exceeds 40 cal/cm².

**Step 3**

Prior to working on or near live parts, the Qualified Worker must warn personnel of the arc-flash hazard. All personnel within the arc-flash boundary must wear the required PPE.

- If an arc-flash analysis was performed, the proper PPE is listed on the warning sticker.
- If no analysis has been performed use the PPE in the tables (see the exhibit Certification of Personal Protective Equipment (PPE) for Electrical Energized Work).
- No working on or near is allowed if incident energy exceeds 40 cal/cm².

**Step 4**

As a minimum, Qualified Workers must wear eye protection while operating or working on equipment which has been identified as having no arc-flash hazard. If using the Minus One Rule, the minimum PPE is eye protection and ear protection (canal inserts). For example, if the warning sticker indicates Hazard/Risk Category 0+, then based on the minus one rule (see the section Operating Electrical Equipment), eye protection and ear protection (canal inserts) must be worn.

**Step 5**

Personnel who are required to wear long-sleeve shirts must ensure the wrists and neck are buttoned. Outer layer clothing must cover as much exposed area as possible.

**Step 6**

Supervisors must ensure that personnel inspect flame-resistant apparel before each use. Personnel must not use work clothing or flash suits that are contaminated, or damaged to the extent their protective qualities are impaired. Do not use protective items that become contaminated with grease, oil, or flammable liquids or combustible materials. Do not apply DEET insect repellent (K70766) to Flame Resistant Clothing. Use Permethrin Clothing Spray (K70764) if needed.

**Step 7**

Personnel must verify that the insulating capability of the following equipment is retained by appropriate tests and visual inspection:

- Grounding equipment;
• Hot sticks;
• Rubber gloves, sleeves, and leather protectors;
• Voltage test indicators;
• Blanket and similar insulating equipment;
• Protective barriers;
• External circuit breaker rack-out devices;
• Portable lighting units;
• Safety grounding equipment;
• Dielectric footwear;
• Protective clothing;
• Insulated tools.

These tests or inspections must be performed prior to use or, as a minimum, at intervals as required by the manufacturer, but in no case greater three years.

Qualified Workers must inspect protective ground cable sets for cuts in the protective sheath and damage to the conductors and check clamps and connector strain relief devices for tightness. These inspections must be made at intervals as required by service conditions, but the interval must not exceed one year. Contact the LESO for requirements for testing safety grounds that have been repaired or modified.
**Applicability**

This information applies to any person at BNL, or in places under BNL jurisdiction, who designs and installs electrical equipment and systems.

**Required Procedure**

All electrical designs and construction, whether it be for facilities or experiments, must have the safety of workers as the highest priority. When still in the design or development stage, eliminating hazards from the design and substituting devices with lower hazards may be inexpensive and simple to implement. Safety and Code compliance must be paramount at every stage of a project, from the initial concept to the final construction and use. Use this subject area in conjunction with the National Electrical Code NFPA 70 and the Engineering Design Subject Area for all electrical designs and installations.

This subject area is not meant to take the place of knowledge of Codes and Standards. The Guidelines section discusses equipment commonly used in R&D and recommendations for design, construction, and operation.

Equipment and installations undergoing major repair, renovation, or modification must be in compliance with current codes and standards. The design basis must be supported by calculations including available short-circuit current and arc-flash incident energy. Results must be documented in project files and equipment properly labeled (contact the Facilities and Operations Electrical Project Engineer of the Energy and Utilities Division for standards for equipment labels and Hazard/Risk Category Labels).

### Step 1

Ensure that the electrical equipment has energy isolating devices (disconnect switches or circuit breakers) that accept a lockout device.

A lockout device is not required for cord and plug connected electrical equipment provided that the plug has the ability to be under the exclusive control of the person
performing any maintenance or service. Each disconnecting means must be legibly marked to indicate its purpose unless located and arranged so the purpose is evident.

Step 2 Ensure that electrical equipment and installations are acceptable to the Authority Having Jurisdiction (AHJ), Laboratory Electrical Safety Officer (LESO), an Electrical Equipment Inspector (EEI), and/or a National Electrical Code Inspector (NECI). Refer to the section Implementing the Authority Having Jurisdiction (AHJ) Program for more detailed information.  

**Note:** OSHA requires that NRTL-labeled equipment (see Organizations Currently Recognized by OSHA as NRTLs) must be acquired whenever available, even if similar unlabeled equipment can be used. Contact the LESO or an EEI for review of non-NRTL equipment prior to acquisition.

**Note:** For installation around flammable liquids and gases, the electrical classification of the equipment must be established. Contact Fire Protection Engineering and see subsection 5.1 When a Fire Hazards Analysis (FHA) is Needed in the Fire Safety Subject Area.

Step 3 Ensure drawings and diagrams are kept up-to-date (see the section Preparing and Revising Specifications and Drawings in the Engineering Design Subject Area). Ensure that panel schedules of all new or re-worked distribution panels are updated and current to maintain good configuration management.

Any errors or omissions discovered in existing installations must be brought to the attention of the appropriate supervisor for correction.

Step 4 Ensure that the arc-flash calculations are performed as per NFPA 70E and the equipment is labeled appropriately (contact Facilities and Operations Electrical Project Engineer of the Energy and Utilities Division if assistance is required). For new projects or equipment replacement other than like-in-kind, the short circuit analysis, protective device coordination study, and arc flash analysis must be performed during design phase. Refer to the Electrical Facilities Design Criteria (MPO-100I).

Step 5 Ensure all electrical panels and disconnects are labeled with a unique ID number, device fed from, voltage and amperage rating (if used for lower voltage utilization voltage must be indicated). Refer to the Electrical Panel/Disconnect Labeling Program exhibit.

Step 6 Ensure that sufficient access and working space is provided around all electrical equipment to allow safe operation and maintenance. The width of the working space for 600 volts or less must be 30 inches minimum (measurement may start from either
side with equipment centered), or the width of the equipment, whichever is greater, and the door must be able to open 90 degrees. For equipment with a nominal voltage to ground of 150 volts or less, the depth must be 3 ft, and for greater than 150 volts, with a grounded surface opposite, 42-inch depth is required. The height of the dedicated working space must extend from the grade to 6½ ft above grade.

Only equipment associated with this installation that is located above or below, may extend not more than 6 in. beyond the front of the above equipment. It is recommended the exclusion zone be marked or otherwise noted to protect against other trades or users violating zone boundaries.

**Note:** These measurements are illustrated in the NFPA 70 National Electrical Code Handbook, Article 110.26.

For other electrical equipment, necessary access and working space requirements must conform to NFPA 70 Article 110.

<table>
<thead>
<tr>
<th>Step 7</th>
<th>All switchboards, panelboards, distribution boards, and motor control centers are to be located in dedicated spaces and protected from damage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 8</td>
<td>Ensure that ground detection is installed for ungrounded or high resistance alternating-current systems.</td>
</tr>
</tbody>
</table>

## Guidelines

### Recommendations for Design and Installation of Equipment

Consider contacting the Authority Having Jurisdiction (AHJ) or local Electrical Equipment Inspector (EEI) early in the design for review of the equipment and the installation. This step will be accomplished most effectively through a working relationship with the AHJ or EEI during the design and installation phases.

### Guidance for Use of Components

Designers and engineers should review the general guidance for use of electrical and electronic components, as per the DOE Electrical Safety Handbook, and the special hazards associated with the equipment (see the exhibit [Design Guide](#)).

- Capacitors and Capacitor Banks;
- Electrical Conductors and Connectors;
- Enclosures for Electrical Equipment;
- Inductors, Electromagnets, and Coils;
• Instrumentation and Control Systems;
• Power Supplies;
• Resistors and Resistor Banks;
• Electrical Switches;
• Storage Batteries and Battery Banks;
• Chemical, Biological, Fire, and Other Hazards Associated with Electrical Equipment
  o Ozone;
  o Hydrogen;
  o Superconducting Devices;
  o Chlorinated Oils;
  o Batteries;
  o Noise;
  o Coolants;
  o Environmental Effects;
  o Fire Hazards;
  o Thermal Sources;
  o Moving Mechanical Devices;
  o Light Sources;
  o Magnetic Fields;
  o Electromagnetic Radiation;
  o Bio-Electric Implants;
  o X-rays;
  o Nuclear Radiation;
  o Stored Energy Equipment.

References

DOE Electrical Safety Handbook, DOE-HDBK-1092-2004

Engineering Design Subject Area

Fire Safety Subject Area

National Electrical Safety Code, ANSI C-2

Organizations Currently Recognized by OSHA as NRTLs Web page

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Management System: Worker Safety and Health

Subject Area: Electrical Safety

6. Electrical Equipment Inspection (EEI) and Electrical Materials and Installation Inspection (EMII) Programs

Effective Date: Sep 26, 2017

Subject Matter Expert: Richard Biscardi

Management System Executive: Gail Mattson

Applicability

This information applies to any owners/stewards of electrical equipment, electrical installations, or electrical modifications at BNL, and to electrical inspectors.

Required Procedure

Materials and equipment required or permitted by the National Electrical Code must be approved by the Authority Having Jurisdiction. The Authority Having Jurisdiction for approval of electrical installations and equipment at BNL is the Laboratory Electrical Safety Committee (LESC). The LESC has approved inspectors to approve electrical equipment on their behalf. This approval must be received prior to applying power to the equipment. "Cord and Plug" equipment must not be plugged in prior to receiving approval.

All personnel who are owners/stewards of electrical equipment, new electrical installations or modifications to electrical systems must ensure that the equipment, installation or modification is accepted by an LESC-approved Inspector. All Inspectors must ensure that assigned inspections are completed according to this procedure. There are two groups of Inspectors:

- The first group, Electrical Equipment Inspection (EEI) Inspectors, have the authority to accept for use at BNL all newly acquired, purchased, constructed, modified and repaired equipment operating above 50 volts.
- The second group, Electrical Materials and Equipment Installation Inspection (EMII) Inspectors, have the authority to accept all electrical distribution installations and facility hard-wired electrical utilization equipment, including repairs and modifications to the electrical systems and facility utilization equipment.

This procedure consists of two subsections:

6.1 Electrical Equipment Inspection

6.2 Electrical Materials and Installation Inspection

6.1 Electrical Equipment Inspection

Step 1
Organization ensure that they have an LESC-approved program (see Electrical Equipment Inspection Program) for documenting the acceptance of electrical equipment. For new purchases, Nationally Recognized Testing Laboratory (NRTL)-certified equipment must be acquired whenever available, even if similar uncertified equipment can be used. A list of OSHA-approved NRTLs is available (see the OSHA's Nationally Recognized Testing Laboratory (NRTL) Program web page). Some types of equipment that are non-NRTL have been pre-approved at BNL (see the Reputable Manufacturers Models listed in the Electrical Safety ESH Guide).

Step 2
If no NRTL equipment can be found for the required application, or the equipment is custom built, modified NRTL, or BNL built, the owner/steward or designee must arrange for an LESC-approved Electrical Equipment Inspection (EEI) Inspector to review the equipment for approval. EEI Inspectors must not approve equipment if similar equipment that is NRTL-certified and performs the same function as the non-NRTL equipment can be procured.

Step 3
The owner/steward initiates the inspection process by contacting an EEI Inspector. The review process must be complete before energizing or plugging in equipment.

Note: The equipment approval by an EEI Inspector applies to a piece of equipment ready for its intended use. For approval of materials or electrical distribution installations, see section 6.2 Electrical Materials and Installation Inspection.

Step 4
The EEI Inspector applies a bar coded reference number to the equipment and a colored sticker that indicates its approval status. The sticker indicates the following status:

- Green: Approved
- Yellow: Conditional Approval (as documented on the review form)
- Blue: NRTL (for items which have been approved by an NRTL and the NRTL marking is not readily visible in installed location)
- Blue: DNA/NIS (does not apply/not in system)
- Red: Rejected
6.2 Electrical Materials and Installation Inspection

Step 1 Organizations ensure that they have an LESC-approved program (see Electrical Materials and Installation Inspection (EMII) Program) for documenting the acceptance of materials, electrical designs, repairs, installations and/or modifications. The program must include a list of Local Electrical Inspectors (LEI) who are approved by the Chief Electrical Inspector (CEI) and the LESC. Local Electrical Inspectors and the Chief Electrical Inspector must also be authorized as EEI Inspectors under the EEI Program. This enables Inspectors to accept distribution equipment as necessary under the EEI program.

Step 2 Organizations ensure that all electrical installations are
   • Designed to Code of Record and
   • Installed to the Code of Record

Organizations ensure repairs or modifications meet the Code of Record and are
   • Installed by a Qualified Worker
   • Accepted by an Electrical Materials and Installation Inspection (EMII) Inspector

Step 3 A Qualified Worker (see Definitions) repairs and installs electrical equipment and components that fall under the jurisdiction of the EMII Program.

Step 4 The Qualified Worker is responsible for the installation of their work in a Code-compliant and in a workman-like manner. The Qualified Worker can provide the basis for approval of installations of Like-in-Kind replacements only during service and maintenance. All new installations require an approval by either a Local Electrical Inspector (LEI) or the Chief Electrical Inspector (CEI).

Step 5 Local Electrical Inspectors: Using the LESC-approved checklists, an LESC-approved Local Electrical Inspector must approve materials, modifications to electrical distribution equipment, new electrical distribution installations, and electrical designs that fall under the jurisdiction of the National Electrical Code (NEC).
   A Local Electrical Inspector:
   • Reviews drawings and designs, and accepts modifications, materials, new installations, as well as mechanical execution of work for the basis of approval by the LESC;
   • Approves work performed on electrical distribution equipment and installations by non-inspectors.

Note: Upon approval as a Local Electrical Inspector in the EMII program, training will be provided that allows access to inspection forms and checklists, and also provides instructions to submit the inspections to the program’s SharePoint site.

Step 6 The LESC is the AHJ for the EMII Program, and the LESC-approved Chief Electrical Inspector manages the program.
   The Chief Electrical Inspector will:
   • Perform quality checks to ensure consistency in interpretation of the Codes and Standards;
   • Provide oversight of the program;
   • Coordinate supplemental training;
   • Update BNL inspection guideline documents;
• Support Local Electrical Inspectors;
• Request interpretations or equivalent means to meet the intent of the Codes and Standards from the LESC; and
• Be an ex-officio member of the LESC.

**Note:** The EMII Inspectors are not authorized to approve equivalencies or variances to the Codes or Standards.

**References**

**Electrical Equipment Inspection Management System (EEIMS) website**

**Laboratory Electrical Safety Committee** website

**OSHA's Nationally Recognized Testing Laboratory (NRTL) Program** website

**Reputable Manufacturers Models, ESH Guide: Electrical Safety, Safety and Health Services** website

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<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>approved line-organization electrical procedures</td>
<td>Procedures written by Department/Division staff and approved by the Department Chair/Division Manager of that organization.</td>
</tr>
</tbody>
</table>
| Authority Having Jurisdiction (AHJ)      | Over electrical safety matters is the Laboratory Electrical Safety Committee composed of members having experience and knowledge of electrical codes and standards to make sound judgments with respect to Laboratory electrical safety policy as defined in NFPA 70, National Electrical Code, Section 90-4. The Laboratory Electrical Safety Officer (LESC) acts for the LESC as the AHJ in the field. The LESC has established two groups of Electrical Inspectors whose acceptance supplies the basis for approval by the Committee:  
  - The first group, Electrical Equipment Inspectors (EEI), has the authority to accept for use at BNL all newly acquired, purchased, constructed, modified, and repaired equipment operating above 50 volts.  
  - The second group, National Electrical Code Inspectors (NECI), has the authority to accept all electrical distribution installations and facility hard wired electrical utilization equipment, including repairs and modifications to the electrical systems and facility utilization equipment. |
<p>| Authorized Worker                        | A Qualified Worker who is formally identified (listed) by the operating organization as authorized to perform a lockout/tagout and authorized to work on or near energized conductors with an Energized Work Permit. For this Standard, authorized workers equate to NFPA and OSHA's qualified workers with respect to approach distances. |
| backfed or &quot;sneak&quot; circuits              | A condition, inadvertently built into a system, which causes an unwanted function to occur or inhibits a desired function, without regard to component failure. Backfed circuits may also increase the probability of personnel shock. |</p>
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>control zone</td>
<td>A generic term applied to the working space surrounding exposed live parts. It is the greater of the arc-flash or limited approach boundary.</td>
</tr>
<tr>
<td>Dangerous (when used in context of Hazard/Risk Category)</td>
<td>Hazard/Risk Category for equipment calculated greater than H/R Cat 4 (energy level greater than 40 Cal/cm²).</td>
</tr>
<tr>
<td>de-energized</td>
<td>Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.</td>
</tr>
<tr>
<td>electrical hazard</td>
<td>A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.</td>
</tr>
<tr>
<td>electrically safe work condition</td>
<td>A state in which the energized live part to be worked on or near has been disconnected from energized parts, and controlled by lockout/tagout or administrative means (e.g., a person) in accordance with established standards; tested to ensure the absence of voltage; and grounded, if determined necessary.</td>
</tr>
<tr>
<td>Energized Electrical Work Permit</td>
<td>This permit is to be used when live parts can not be placed in an electrically safe working condition and for any testing, troubleshooting and voltage measuring above 600 volts. A “two-person rule” must be implemented for work above 250 volts, and a “safety watch” is required for work above 600 volts. Instructions for completing the electrical work permit, and a copy of the permit, may be found in the exhibit Electrical Work Permits with Instructions.</td>
</tr>
<tr>
<td>exposed (as applied to live parts)</td>
<td>Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not suitably guarded, isolated, or insulated.</td>
</tr>
<tr>
<td>flame-resistant (FR)</td>
<td>The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source.</td>
</tr>
<tr>
<td>flash hazards</td>
<td>A dangerous condition associated with the release of energy caused by an electric arc, often with high current flow, through an unintentional low impedance path. Hazardous characteristics associated with an arc flash are heat, light, noise, and thrown molten metal.</td>
</tr>
</tbody>
</table>
| **Hierarchy of Controls** | A prioritized list of hazard control. They are 1) Elimination or substitution of the hazard; 2) Engineering controls; 3) Lockout/tagout or unplug the equipment; 4) Energized Work Permits with appropriate PPE. Representative examples for elimination and substitution are given below:

- Elimination - a) removing hazardous voltages from a system design; b) removing a damaged piece of equipment from service.
- Substitution - replacing a component that uses a hazardous voltage with one that uses a less hazardous voltage in a system. |

| **independent reviewer** | A person knowledgeable in electrical safety and not part of the work group covered under the Energized Electrical Work Permit. |

| **Job Safety Analysis (JSA)** | A hazard analysis technique which breaks down a job into functional steps, identifies the hazards with each step, and defines controls for each identified hazard. |

| **labeled** | Equipment or materials to which has been attached a label, symbol, or otherwise identifying mark of a Nationally Recognized Testing Laboratory (NRTL). |

| **Laboratory Electrical Safety Officer (LESO)** | The employee designated by Safety and Health Services Division as the Laboratory-level Authority Having Jurisdiction in the field. The LESO is a defacto member of the LESC. |

| **like-in-kind** | **Application:** Like-In-Kind can only be applied if the component to be replaced is already installed in a code-compliant manner. **Definition:** Used for maintenance and repair, Like-in-Kind pertains to two or more electrical components that can be used interchangeably and have the following characteristics:

- Share similar physical, electrical, and operational characteristics, such as:
  - Voltage requirement,
  - Current draw,
  - Circuit overcurrent, and
  - Short circuit/arc flash characteristics.
- Serves the same function within a given system. |
• Are mounted or located in the same physical location; and
• Includes any electrical component that is authorized and NRTL-listed by the original equipment manufacturer as being a suitable replacement part.

**Note:**

- All new installations downstream of transformers that directly supply buildings (e.g., disconnects, panel boards, switchgear, motor control centers, and branch circuits) must be inspected by a Local Electrical Inspector (LEI).
- All new equipment or replacement of complete equipment that have hard-wired utilization and skid-mounted equipment must be inspected by an LEI, with certain exceptions, such as, for example, the following equipment:
  - Spot replacement of existing light fixtures,
  - Existing fixture ballast,
  - Existing light control switches,
  - Existing receptacles, and
  - The replacement of components in existing in place or skid-mounted equipment.
- The local LEI should be contacted for those situations that are unclear, as to equipment inspection, requirement, or responsibility.

<table>
<thead>
<tr>
<th>limited approach boundary</th>
<th>A shock protection boundary to be crossed only by qualified persons which is not to be crossed by unqualified persons unless escorted by a qualified person.</th>
</tr>
</thead>
<tbody>
<tr>
<td>listed</td>
<td>Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>live parts</strong></td>
<td>Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists.</td>
</tr>
<tr>
<td><strong>lockout and tagout (LOTO)</strong></td>
<td>The physical isolation of an energized system from the source of energy, verification of isolation, the application of a barrier for each person or group working on the system (padlock: BNL dedicated Stock #I65064), and identification for accountability at each barrier/red tag.</td>
</tr>
<tr>
<td><strong>low-hazard operations</strong></td>
<td>Tasks which present no immediate hazard of electrocution. These operations are not classified as working on or near energized conductors; but may contain other electrically-related dangers such as flash hazards and secondary injury from falls.</td>
</tr>
<tr>
<td><strong>prohibited approach boundary</strong></td>
<td>A shock protection boundary to be crossed only by qualified persons which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.</td>
</tr>
<tr>
<td><strong>qualified worker</strong></td>
<td>Personnel, both employees and contractors, who have relevant electrical education and experience; who are familiar with the construction, operation, and hazards of the equipment involved; and who have current electrical safety training. Only Qualified Workers are eligible to be designated by their operating organization as Authorized Workers for the equipment involved.</td>
</tr>
<tr>
<td><strong>restricted approach boundary</strong></td>
<td>A shock protection boundary to be crossed only by authorized persons, which due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.</td>
</tr>
<tr>
<td><strong>Safety Watch</strong></td>
<td>A second qualified person, knowledgeable in rescue techniques to the level taught in Electrical Safety I (TQ-ELECSAF1) and Cardiopulmonary Resuscitation (Adult CPR/AED). The Safety Watch must</td>
</tr>
<tr>
<td></td>
<td>• Have personal protective equipment (PPE) to be able to enter the area, if needed, for safety actions; stay out of area while observing;</td>
</tr>
<tr>
<td></td>
<td>• Have knowledge of breakers and switches that need to be operated in an emergency;</td>
</tr>
<tr>
<td></td>
<td>• Know where the phone is located or have a radio to summon help;</td>
</tr>
<tr>
<td></td>
<td>• Be in visual and audible range of the person doing the work, but not in the control zone;</td>
</tr>
</tbody>
</table>
- Check for unsafe acts or error traps while observing work and warn the worker of potential problems;
- Have no other duties.

The Safety Watch may operate breakers and switches without a second person if an emergency should arise.

### Testing, Troubleshooting, and Voltage Measuring Electrical Work Permit

A permit for testing, diagnostics and voltage measuring (including Zero Energy Checks when performing LOTO) for 600 V or less. This permit is used for similar hazards (e.g., troubleshooting power supplies) and is approved for defined classes or types of work. The permit may be issued for reasonable periods of time, not to exceed one year.

Instructions for completing the Testing, Troubleshooting, and Voltage Measuring Electrical Work Permit, and a sample of the permit, may be found in exhibit [Electrical Work Permits with Instructions](#). An electrical work permit is not required for tasks below 50 volts.

### tower line workers

Utility workers tasked with installing and maintaining electrical power generation, transmission and distribution systems, specifically substations and all work more than 600 Vac. All work associated with this electrical range is considered to have a high hazard potential; therefore, these workers must be trained to a level commensurate with that risk category. This group must work in compliance with 29 CFR 1910.269.

### troubleshooting

Troubleshooting is the process of investigating, identifying, and locating problems in machinery, circuits, or systems. Given an approved Testing, Troubleshooting, and Voltage Measurement (TTVM) or other Energized Work Permit, activities may include taking voltage, current, or impedance measurements; testing and replacing fuses or motor overload heaters; and removing enclosure covers for investigation.

The following troubleshooting-related activities are specifically allowed for an authorized electrical worker when performed under an approved TTVM Permit:

- Manipulating energized control circuit components up to 150 volts (such as lifting of control circuit wires and
tightening of control circuit terminals or connectors)

- Removing wire nuts on branch circuits, provided the wire size is #10 AWG or smaller (e.g., #12) and voltage is no greater than 300 volts phase-to-ground, in order to measure voltage, or to trace or tone a circuit for the purpose of identifying the appropriate LOTO location (such as a specific circuit breaker or switch)
- Verifying zero energy as part of the multi-step Lockout/Tagout process to make the circuit electrically safe.

The TTVM Permit requires the authorized electrical worker to

- Keep all uninsulated body parts outside of the prohibited approach boundary
- Use required shock and arc-flash personal protective equipment (PPE), per the permit

Line management is responsible for evaluating the experience and qualification of the workers involved prior to planning the scope of work authorized.

two-person rule

A second qualified person, knowledgeable in rescue techniques to the level taught in Electrical Safety I and CPR qualified, is required when ANY of the following criteria exists:

- Performing work within the Arc-Flash Boundary of exposed live parts that has an arc-flash Hazard/Risk Category of 3 or 4;
- Operating switches or breakers with an arc-flash Hazard/Risk Category of 4;
- Any time there are exposed live parts with >250V but <600V and when either of the following exists:
  
  - A barricade is not established;
  - When performing tasks where there are multiple sources of exposed live parts with voltage >50V (e.g., multiple terminal strips, including some control panels and power supplies). **Examples:**

Examples:
- Two persons NOT required: Hazard Risk Category is less than 3 AND a single source of exposed voltage, such as a manually operated disconnect switch. (One set of 3 phase connections is considered a single source.)
- Two persons required: Multiple sources of exposed voltage, such as a control panel with 480V exposed terminal lugs and 120V control terminals, regardless of which one is being worked on.

- Any time work planning, including worker-planned work, determines the need for two-persons to perform a given task.

The second person must wear the appropriate PPE if assisting the primary worker in the same control zone.

**Note:** The second person may operate breakers and switches without an additional second person if an emergency should arise.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage (of a circuit)</td>
<td>The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. Nominal Voltage is a value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 volts, 480Y/277 volts, 600 volts).</td>
</tr>
<tr>
<td>work</td>
<td>Any task performed on equipment such as operating, testing, troubleshooting, repairing, modifying, etc.</td>
</tr>
<tr>
<td>working near (live parts)</td>
<td>Any activity inside a limited approach boundary.</td>
</tr>
<tr>
<td>working on (live parts)</td>
<td>Coming in contact with live parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing.</td>
</tr>
</tbody>
</table>

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Approved Equivalent Electrical Training

Effective Date: Aug 23, 2017

The BNL Laboratory Electrical Safety Committee must review and approve all equivalent electrical training for workers who may enter the Limited Approach Boundary or the Arc-Flash boundary. This review may consist of reviewing the class syllabus or may include members of the committee auditing the training classes. The Training and Development Program Office approves all non-electrical training required for this subject area.

All workers with approved equivalent training must receive a copy of the Addenda to NFPA 70E for Contractors as well as a tool-box talk from an electrically knowledgeable supervisor or the Electrical Safety Subject Matter Expert to answer any questions they may have. The approved equivalent training courses are the following:

Electrical Training
- Long Island Joint Apprenticeship & Training Committee (must have a card showing 70E training).

CPR Training
- Red Cross
- American Heart Association

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Management System: Worker Safety and Health

Subject Area: Electrical Safety

BNL Electrical Equipment Inspection (EEI) Program

Effective Date: Sep 26, 2017

The BNL Electrical Equipment Inspection (EEI) Program is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.

Questions/Comments  Disclaimer
BNL Electrical Equipment Inspection (EEI) Program

For

Review and Approval of Electrical Equipment

Scope
The Laboratory Electrical Safety Committee (LESC) has been vested as the Authority Having Jurisdiction (AHJ) for electrical safety at Brookhaven National Laboratory (BNL) by the Department of Energy (DOE) through the Laboratory Director and the Associate Laboratory Director for Environment, Safety and Health. The AHJ for electrical matters is responsible for interpreting the requirements of electrical codes and standards and for approving electrical equipment, materials, installations, and procedures at BNL. To fulfill the requirements as AHJ, the LESC has established the AHJ Program, which consists of two acceptance programs:

1) the Electrical Equipment Inspection Program (EEI) and
2) the Electrical Materials and Installation Inspection (EMII) Program.

This document describes the EEI Program.

Definitions
Approved: Acceptable to the Authority Having Jurisdiction.

Authority Having Jurisdiction (AHJ): The organization responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. For electrical issues, the AHJ is the Laboratory Electrical Safety Committee (LESC).

Basis for Approval: The acceptance of equipment, materials, and workmanship for compliance to the electrical codes and standards by persons approved by the LESC to perform field inspections. Note: The LESC is not delegating the authority to approve equivalent means to meet the intent of the codes and standards, nor is it delegating the authority to provide formal interpretation, equivalency, or variance to the codes and standards.

The goal of the EEI Program for review and approval of electrical equipment is to ensure that approved equipment is free from reasonably foreseeable risk due to electrical hazards. This program applies to all equipment built, acquired, or brought onto the BNL site by workers, guests and contractors, when the equipment will be connected to a source of electrical power.

1) EEI Program Manager - After being approved by the LESC, the EEI Program Manager shall be responsible for the overall coordination of the EEI program. The EEI Program Manager must also be an LESC-approved EEI Inspector.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

BNL Electrical Materials and Installation Inspection (EMII) Program
Effective Date: Sep 26, 2017

The BNL Electrical Materials and Installation Inspection (EMII) Program is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
BNL Electrical Materials and Installation Inspection (EMII) Program

For

Review and Approval of Electrical Materials and Installations

**Scope**
The Laboratory Electrical Safety Committee (LESC) has been vested as the Authority Having Jurisdiction (AHJ) for electrical safety at Brookhaven National Laboratory (BNL) by the Department of Energy (DOE) through the Laboratory Director and the Associate Laboratory Director for Environment, Safety and Health. The AHJ for electrical matters is responsible for interpreting the requirements of electrical codes and standards and for approving electrical equipment, materials, installations, and procedures at BNL. To fulfill the requirements as AHJ, the LESC has established the AHJ Program, which consists of two acceptance programs:

(1) the Electrical Equipment Inspection Program (EEI) and
(2) the Electrical Materials and Installation Inspection (EMII) Program.

This document describes the EMII Program.

**Definitions**

Approved: Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction (AHJ): The organization responsible for enforcing the requirements of a code or standard or for approving equipment, materials, an installation, or a procedure. For electrical issues, this is the Laboratory Electrical Safety Committee (LESC).

Basis for Approval: The acceptance of equipment, materials, and workmanship for compliance to the electrical codes and standards by persons approved by the LESC to perform field inspections. Note: The LESC is not delegating the authority to approve equivalent means to meet the intent of the codes and standards, nor is it delegating the authority to provide formal interpretation, equivalency, or variance to the codes and standards.

Electric Materials and Equipment Installation Inspection Program (EMII): The scope of this program covers the review and approval of the materials and installation of the electrical distribution for facilities and facility connections to hard-wired equipment. There are two levels of inspectors: Chief Electrical Inspector (CEI) and Local Electrical Inspector (LEI) as described below.

1) Chief Electrical Inspector (CEI), after being approved by the LESC, shall be responsible for the overall coordination of the EMII program. Qualifications for this position are ten years of experience with industrial/commercial facility electrical systems as a Master or journeyman electrician, electrical supervisor, or electrical engineer, and an LESC-approved external Electrical Inspector Certification. Acting independently of line responsibility for electrical installations within organizations, the CEI shall:
a. Perform quality checks by re-inspection of a sampling of installations previously inspected by Local Electrical Inspectors (LEI) and installed by the Qualified Worker to ensure consistency in the interpretation of code requirements;
b. Provide oversight of the LEIs;
c. Coordinate supplemental training (over and above required training indicated in the Job Training Assessment) to address specific issues as they arise, based on any perceived deficiencies resulting from the above inspections or from lessons-learned from other DOE facilities or industry;
d. Support LEIs by assisting as requested, including in their absence;
e. Assist the Laboratory Electrical Safety Officer (LESO) in electrical matters when requested, including in his absence;
f. Be an ex-officio, voting member of the LESC.

2) Local Electrical Inspector (LEI) The LEI is a qualified electrical worker, recommended by the cognizant organization and submitted to the LESC and CEI for approval. The LEI is the delegate of the CEI in the field and can provide the basis for approval of modifications and new installations. The organization shall retain the primary responsibility for the compliance with codes and standards in their organization and authorize the LEI to provide the basis for approval for the electrical installations for the LESC.

Qualifications include five years of work experience in the areas they will be responsible for approving, formal NEC training, and passing a BNL NEC-based examination or receiving a LESC waiver for the examination. The formal NEC training is by an LESC-approved NEC course, by an LESC-recognized electrical training program, or by an LESC-approved external Electrical Inspector certification.

The Qualified Worker (as defined in the Electrical Safety Subject Area) is responsible for installing electrical equipment in a code compliant manner. The installation of Like-In-Kind or NRTL listed replacement performed by a qualified worker provides the basis for approval and acceptance of the installation. All other installations must be inspected by an LEI or the CEI. The qualified worker must have LESC approved training that demonstrates the worker is knowledgeable to install electrical equipment in compliance with applicable codes and standards. All parts must be Original Equipment Manufacturer produced or NRTL listed.

Local Electrical Inspectors and the Chief Electrical Inspector shall meet the qualifications to be EEI Inspectors under the EEI Program.
Acting independently of line responsibility for electrical equipment within organizations, the EEI Program Manager shall:

a. Perform quality checks by re-inspection of a sampling of equipment previously inspected by EEI Inspectors to ensure consistency in inspections;
b. Provide oversight of the EEI program for inspectors;
c. Coordinate supplemental training (over and above required training indicated in the Job Training Assessment) to address specific issues as they arise, based on any perceived deficiencies resulting from the above inspections or from lessons-learned from other DOE facilities or industry;
d. Support EEI Inspectors in the field on inspection questions;
e. Assist the Laboratory Electrical Safety Officer (LESO) in electrical installation matters when requested;
f. Be an ex-officio, non-voting member of the LESC.

2) EEI Inspector - The EEI Inspector is recommended by their organization and their qualifications and training are reviewed and approved by the LESC and EEI Program Manager. The EEI Inspector is the delegate of the EEI Program Manager in the field and can provide the basis for approval for acceptance of electrical equipment. The organization shall retain the primary responsibility for the compliance with codes and standards in their organization and authorize the EEI Inspector to provide the basis for approval for electrical equipment acceptance for the LESC.

**Introduction**

Electrical equipment is acceptable at BNL only if approved, that is, acceptable to the Authority Having Jurisdiction (AHJ). The AHJ for electrical matters at BNL is the LESC, represented in the field by the Laboratory Electrical Safety Officer (LESO). The LESC has designated a group of Electrical Equipment Inspectors and given them the authority to review and approve electrical equipment at BNL on their behalf. While electrical equipment includes any physical device connected to a source of electrical power, devices connected to electrical sources below 50 volts are generally exempt from detailed review. All equipment that has a power source internal or external, operating above 50 volts or an output exceeding 50 volts needs to be inspected. Basically, if it plugs into an AC outlet or has an internal battery above 50 volts it shall be inspected. If there is an output voltage above 50 volts for the device, it shall be inspected.

Approval is straightforward for electrical equipment bearing the seal of a Nationally Recognized Testing Laboratory (NRTL), such as Underwriters Laboratories, Inc. (UL) or the Canadian Standards Association (CSA). The Nationally Recognized Testing Laboratory (NRTL) Program website has a [list of acceptable NRTLs](#).

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Please note that the generic CE mark is a European self-certification applied to a product by a manufacturer or vendor who declares that their product complies with European standards. The CE mark does not represent a third-party product evaluation and is not comparable with the NRTL listing.
OSHA requires that NRTL-labeled equipment must be acquired whenever labeled equipment is available, even if similar unlabeled equipment can be used. OSHA allows for approval of custom-made equipment or related installations if equipment is determined to be safe for its intended use by its manufacturer, on the basis of test data, which the employer [BNL] keeps and makes available for inspection.

There are cases where the above pathway cannot be followed. These include cases where BNL manufactures equipment or causes the equipment to be manufactured in accordance with a specification, non-listed or foreign equipment is acquired to perform a unique experimental function in support of BNL’s scientific mission, and legacy equipment – some from vendors long out of business, is still used. The LESC deals with such issues through NEC Article 90.4, Enforcement, which allows the AHJ to waive specific requirements in this Code or permit alternate methods that ensure equivalent objectives can be achieved by establishing and maintaining effective safety. The alternate method lies in a graded approach to approval of all electrical equipment by the Electrical Equipment Inspectors who devote increased attention to review of non-NRTL equipment.

**Following the Process**

**Review by Electrical Equipment Inspectors**
The desired result of an AHJ electrical equipment inspection is that the approved equipment is free from reasonably foreseeable risks due to electrical hazards. Review and approval of electrical equipment must be obtained prior to connecting the equipment to the BNL power grid (before plugging the equipment into a receptacle outlet).

The EEI process has inherent limitations since inspections are limited in scope, they are relatively brief, and there is no significant device testing – certainly not to destruction. Electrical Equipment Inspector approval does not indicate total conformance with all applicable standards, nor does it indicate quality, reliability or functionality. Electrical Equipment Inspector approval indicates that the equipment appears to meet minimum safety criteria; the equipment should not cause a shock, burn, or fire if used properly; the equipment is examined to the extent indicated on the inspection forms; and the equipment is permitted to be connected to the BNL electrical system.

Note that the equipment review by the Electrical Equipment Inspector applies to a final configuration. A re-inspection is not needed when qualified personnel gain access to the equipment for maintenance or troubleshooting, or when equipment is relocated and its function has not changed. When electrical equipment is modified, Electrical Equipment Inspectors are allowed to approve modifications to NRTL equipment if the modification has documented approval by the Department Manager/designee and the modification does not diminish the safety of the equipment.

Under the BNL Electrical Equipment Inspection Program, trained and qualified Electrical Equipment Inspectors use an approved checklist to guide and document their review. The checklist was developed using the DOE Electrical Safety Handbook as a reference. The Handbook is also used during the review process as an outline. Current leakage, grounding continuity and residual voltage (where applicable) will be objectively
evaluated on all electrical and electronic components used at BNL. The actual scope of the Electrical Equipment Inspector review may be more extensive, at the discretion of the Electrical Equipment Inspector. Such expansion of activity, while providing minimum documentation, is recognized in electrical codes such as NEC Article 90-1(c) that states “This Code is not intended as a design specification nor an instruction manual for untrained persons.” An Electrical Equipment Inspector must apply professional judgment to performing a standards-based inspection or hazard-based inspection, as appropriate. In a standards-based inspection, usually applied to new equipment, there is verification that:

- The product conforms to an applicable standard;
- There is enforced consistency among all products; and
- The inspection criteria are determined by the standard.

A hazard-based inspection:

- Allows making judgments about the safety of a product even though it may not totally conform to a standard;
- Allows for a realistic analysis within the confines of a given location or equipment situation;
- Follows criteria determined and documented by the Electrical Equipment Inspector, and can be applied to existing in-service equipment.

Electrical Equipment Inspector review must be independent, like that of an NRTL, and credible when viewed by a third party. Any appearance of conflict of interest must be avoided. There is no requirement that an Electrical Equipment Inspector provide a design solution; the burden of conformity with accepted standards is on the equipment owner, not the Electrical Equipment Inspector. Regarding standards, there is no need to justify the content of the NEC or any other standard, just a requirement to follow the provisions of the standard. Issues involving any dispute can be referred to the LESC for resolution. Also, Electrical Equipment Inspectors must be aware that even though an item is a recognized component, it does not mean that it is automatically acceptable for any use, and relatively standard items are used in unique ways in research projects. Technical assistance is available to any Electrical Equipment Inspector having questions regarding electrical equipment approval. The Electrical Equipment Inspector should consult with the EEI Program Manager as necessary and certain equipment approvals may require guidance by members of BNL’s scientific community.

**Equipment Identification**

**Equipment Reference Number:** Apply permanent, individually numbered bar code stickers to all electrical equipment used at BNL. The labels include the two-letter designation of the organization performing the review and a unique identification number.

**Equipment Name:** Electrical equipment may be items of commercial or industrial equipment and may be contained in a chassis, rack, panel, console, cage, room or building. Identify the equipment by name and use. The equipment may be a commercial product used on a benchtop or in a rack, or the equipment may consist of a rack or room...
full of power supplies, capacitors, or triggered-discharge electronics that can be reviewed and approved as an entity.

**Equipment Origin:** Identify the origin of the equipment. The inspected item(s) may be commercial off-the-shelf (COTS), commercial catalog items constructed when ordered, items constructed according to BNL specification, equipment built in-house by BNL workers, or devices brought to BNL by scientists or others. The equipment may be of domestic or foreign origin.

**Equipment ID Number:** All equipment must bear a uniquely numbered identification label. Commercial equipment must have an identifying product and/or serial number.

**Cognizant Group:** There is a person or group that is responsible for each item of equipment at BNL. This cognizant person or group “owns” the equipment, is responsible for obtaining equipment approval from the Electrical Equipment Inspector before operating new equipment, and is responsible for informing the Electrical Equipment Inspector upon any changed equipment configuration.

**Equipment Inspection Checklist:** Items to be considered by the Electrical Equipment Inspector performing the inspection are listed in three approved checklists.

**Actions Following Equipment Review**
Following the equipment review, the Electrical Equipment Inspector enters a summary of the inspection results in the “comments” section of the review form, briefly describing the installation and noting any restrictions on use or operational limitations of the equipment. The Electrical Equipment Inspector should especially note deficiencies that support rejecting the equipment. (Note that equipment approval by an Electrical Equipment Inspector applies to a finished, enclosed, grounded, item or installation with appropriate overcurrent protection, ready for its intended use. The Electrical Equipment Inspector is not the owner of the equipment, is not responsible when equipment is disassembled for maintenance or troubleshooting, and is not responsible when equipment is relocated or used for another purpose.)

The Electrical Equipment Inspector next applies a colored sticker in addition to the equipment reference number to indicate equipment approval status. The stickers indicate the following status:

<table>
<thead>
<tr>
<th>Color</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Approved</td>
</tr>
<tr>
<td>Yellow</td>
<td>Conditional Approval (as documented on the review form)</td>
</tr>
<tr>
<td>Blue</td>
<td>NRTL (for items which have been approved by an NRTL and the NRTL marking is not readily visible in installed location)</td>
</tr>
<tr>
<td>Blue</td>
<td>DNA/NIS (does not apply/not in system)</td>
</tr>
<tr>
<td>Red</td>
<td>Rejected</td>
</tr>
</tbody>
</table>
A copy of the checklist should be provided to the owner/steward of the equipment. The user should be informed that unauthorized modifications to the equipment after the approval are not permitted and that the colored sticker on approved equipment that is no longer used for its intended purpose should be removed.

Reports of the equipment and installation review by an Electrical Equipment Inspector are entered into a lab wide computer database by the assigned department representative. SHSD staff will spot check information entered into the database to verify the data entered on inspection forms is accurate and precise. The database is open for review by the EEI Program Manager and has search and trending capabilities that can be performed by review of the data.

Periodic (quarterly) group meetings will be held with Electrical Equipment Inspectors to reinforce inspection requirements of the program to verify the consistency of inspections from one Electrical Equipment Inspector to another.

**Electrical Equipment Inspector Qualifications, Training and Approval**

**Qualification:** The qualification for becoming an Electrical Equipment Inspector is a minimum of ten years combined schooling/experience with electrical/electronic system design and/or electrical system construction/installation/inspection/safety.

**Training:** Electrical Equipment Inspectors attend an NEC training session conducted by the EEI Program Manager or delegate.

**Job Performance Measure:** Electrical Equipment Inspectors are evaluated in the field by the EEI Program Manager or delegate.

**Final Approval:** The Electrical Equipment Inspector’s qualifications, completion of necessary training and Job Performance Measure are reviewed by the LESC and, if appropriate, final approval is granted by the LESC. The Electrical Equipment Inspector may then begin inspections without being accompanied by the EEI Program Manager or delegate.

**Retraining:** Retraining of Electrical Equipment Inspectors will occur every NEC Code cycle (nominally 3 years).

**Additional Comments**

1. OSHA General Industry Standard, Section 1910.303, General Requirements, allows for approval of custom-made equipment, if the equipment is determined to be safe for its intended use by its manufacturer on the basis of test data that the employer [BNL] keeps and makes available for inspection by the Assistant Secretary of Labor and his authorized representatives.

2. Personal electrical equipment may be determined to be acceptable for use at BNL through the process of review and approval by Electrical Equipment Inspectors. It is suggested that equipment approvals involving complex issues be reviewed by the EEI Program Manager.
3. For multiple units by a reputable vendor, one item will be inspected and the remaining database entries will reference the initial items. Some items, such as those constructed in-house by a variety of technicians over an extended time period, will be individually inspected.
Certification of Personal Protective Equipment (PPE) for Electrical Energized Work

Effective Date: Feb 29, 2016

The exhibit Certification of Personal Protective Equipment (PPE) for Electrical Energized Work is provided as a PDF.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
This exhibit is the personal protective equipment (PPE) required for electrical energized work on electrical equipment rated 50 volts and above.

In all cases, personal protective equipment (PPE) from analysis or arc flash calculations must be used as a minimum. In the absence of calculations, PPE from the table Hazard Risk Category Classifications (below) is required.

If the arc-flash incident energy is above 40 cal/cm², the task must not be performed until an electrically safe work condition exists (equipment is de-energized and Locked out/Tagged out).

**Clothing Material Characteristics**

Flame-resistant (FR) material, such as flame-retardant treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers provide thermal protection. These materials can ignite, but will not continue to burn after the ignition source is removed. FR fabrics can reduce burn injuries (but not eliminate them) during an arc flash exposure by providing a thermal barrier.

Synthetic materials, such as polyester, nylon, and synthetic-cotton blends will melt into the skin when exposed to high temperatures and aggravate the burn injury. Clothing made from synthetic materials such as acetate, nylon, polyester, either alone or in blends with cotton, should not be worn.

Clothing made from non-melting flammable natural materials, such as cotton and polyester-cotton, silk, wool, rayon, and nylon fabrics are flammable and will burn but will not melt on the skin causing further injury.

<table>
<thead>
<tr>
<th>Hazard Risk Category Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)</strong></td>
</tr>
<tr>
<td>Panelboards rated 240 V and below</td>
</tr>
<tr>
<td>CB or fused switch operation with covers off</td>
</tr>
<tr>
<td>Activity</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Remove/install CBs or fused switches</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td><strong>Panelboards or Switchboards rated &gt;240 V and up to 600 V (with molded case or insulated case circuit breakers)</strong></td>
</tr>
<tr>
<td>CB or fused switch operation with covers off - less than or equal to 225 Amp</td>
</tr>
<tr>
<td>CB or fused switch operation with covers off - greater than 225 Amp</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing - less than or equal to 225 Amp</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing - greater than 225 Amp</td>
</tr>
<tr>
<td><strong>600-V Class Motor Control Centers (MCCs)</strong></td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
</tr>
<tr>
<td>CB or fused switch or starter operation with enclosure doors open</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
</tr>
<tr>
<td>Work on control circuits with energized parts &gt;120 V exposed</td>
</tr>
<tr>
<td>Insertion or removal of individual starter “buckets” from MCC — Note 4</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td><strong>600 V Class Switchgear (with power circuit breakers or fused switches) - Notes 5 and 6</strong></td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
</tr>
<tr>
<td>CB or fused switch operation with enclosure doors open</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
</tr>
<tr>
<td>Work on control circuits with energized parts &gt;120 V exposed</td>
</tr>
<tr>
<td>Insertion or removal (racking ) of CBs from cubicles,</td>
</tr>
<tr>
<td>Insertion or removal (racking) of CBs from cubicles, doors closed – if within arc flash boundary</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td><strong>Other 600 V Class Equipment (277 V through 600 V, nominal)</strong></td>
</tr>
<tr>
<td>Lighting or small power transformers (600 V, less than or equal to 225 A)</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
</tr>
<tr>
<td><strong>Revenue meters (kW-hour, at primary voltage and current)</strong></td>
</tr>
<tr>
<td>Insertion or removal</td>
</tr>
<tr>
<td>Cable trough or tray cover removal or installation</td>
</tr>
<tr>
<td>Miscellaneous equipment cover removal or installation</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
</tr>
<tr>
<td><strong>NEMA E2 (fused contactor) Motor Starters, 2.3 kV through 7.2 kV</strong></td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
</tr>
<tr>
<td>Contactor operation with enclosure doors open</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
</tr>
<tr>
<td>Work on control circuits with energized parts &gt;120 V, exposed</td>
</tr>
<tr>
<td>Insertion or removal (racking) of starters from cubicles, doors open</td>
</tr>
<tr>
<td>Insertion or removal (racking) of starters from cubicles, doors closed</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
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<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td><strong>Metal Clad Switchgear, 1 kV and above</strong></td>
</tr>
<tr>
<td>Activity</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
</tr>
<tr>
<td>CB or fused switch operation with enclosure doors open</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
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<tr>
<td>Work on control circuits with energized parts &gt;120 V, exposed</td>
</tr>
<tr>
<td>Insertion or removal (racking) of CBs from cubicles, doors open</td>
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<tr>
<td>Insertion or removal (racking) of CBs from cubicles, doors closed</td>
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<td>Application of safety grounds, after voltage test</td>
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<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening voltage transformer or control power transformer compartments</td>
</tr>
<tr>
<td><strong>Other Equipment 1 kV and above</strong></td>
</tr>
<tr>
<td>Metal clad load interrupter switches, fused or unfused</td>
</tr>
<tr>
<td>Switch operation, doors closed</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
</tr>
<tr>
<td>Outdoor disconnect switch operation (gang-operated, from grade)</td>
</tr>
<tr>
<td>Insulated cable examination, in manhole or other confined space</td>
</tr>
<tr>
<td><strong>Insulated cable examination, in open area</strong></td>
</tr>
</tbody>
</table>

**Legend:**
- **V-rated Gloves** are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
- **V-rated Tools** are tools rated and tested for the maximum line-to-line voltage upon which work will be done.
- **2* means that a double-layer switching hood or Salisbury Model AS1000FS Hard Hat with face shield and chin cup used with 10 cal/cm² AFHOOD 10 Nomex-Lenzing Balaclava/Racing hood and hearing protection are required for this task in addition to the other Hazard/Risk Category 2 requirements of the table below.**
- **Y = yes (required)**
- **N = no (not required)**

**Notes:**
5. 35 kA short circuit current available, up to 0.5 second (30 cycle) fault clearing time.
6. For < 25 kA short circuit current available, the Hazard/Risk Category required may be reduced by...
## Protective Clothing and Personal Protective Equipment (PPE) Matrix

<table>
<thead>
<tr>
<th>Hazard/Risk Category</th>
<th>Protective Clothing and PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard/Risk Category 0</strong>&lt;br&gt;Protective Clothing, Nonmelting or untreated natural fiber Minimum Arc Rating of N/A</td>
<td>Shirt (long sleeve)&lt;br&gt;Pants (long)&lt;br&gt;Safety glasses or safety goggles (SR)&lt;br&gt;Hearing Protection (ear canal inserts)&lt;br&gt;Leather gloves</td>
</tr>
<tr>
<td><strong>Hazard/Risk Category 1</strong>&lt;br&gt;FR Clothing, Minimum Arc Rating of 4</td>
<td>Arc-Rated long sleeve shirt&lt;br&gt;Arc-Rated pants&lt;br&gt;Arc-Rated coverall (Note 2)&lt;br&gt;Arc-Rated face shield or arc flash suit hood&lt;br&gt;Arc-rated jacket, parka, or rainwear (AN)&lt;br&gt;Hard hat&lt;br&gt;Safety glasses or Safety goggles (SR)&lt;br&gt;Hearing protection (ear canal inserts)&lt;br&gt;Leather gloves (Note 1)&lt;br&gt;Leather work shoes (AN)</td>
</tr>
<tr>
<td><strong>Hazard/Risk Category 2</strong>&lt;br&gt;FR Clothing, Minimum Arc Rating of 8</td>
<td>Arc-Rated long sleeve shirt&lt;br&gt;Arc-Rated pants&lt;br&gt;Arc-Rated coverall (Note 2)&lt;br&gt;Arc-Rated face shield or arc flash suit hood&lt;br&gt;Arc-rated jacket, parka, or rainwear (AN)&lt;br&gt;Hard hat&lt;br&gt;Safety glasses or Safety goggles (SR)&lt;br&gt;Hearing protection (ear canal inserts)&lt;br&gt;Leather gloves (Note 1)&lt;br&gt;Leather work shoes (AN)</td>
</tr>
<tr>
<td><strong>Hazard/Risk Category 2</strong>&lt;br&gt;FR Clothing, Minimum Arc Rating of 8</td>
<td>Arc-Rated long sleeve shirt&lt;br&gt;Arc-Rated pants&lt;br&gt;Arc-Rated coverall (Note 2)&lt;br&gt;Arc-Rated face shield and balaclava (sock hood) or arc flash suit hood&lt;br&gt;Arc-rated jacket, parka, or rainwear (AN)</td>
</tr>
<tr>
<td>Hazard/Risk Category 3</td>
<td>FR Clothing, Minimum Arc Rating of 25</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Hard hat</td>
</tr>
<tr>
<td></td>
<td>Safety glasses or Safety goggles (SR)</td>
</tr>
<tr>
<td></td>
<td>Hearing protection (ear canal inserts)</td>
</tr>
<tr>
<td></td>
<td>Leather gloves (Note 1)</td>
</tr>
<tr>
<td></td>
<td>Leather work shoes (AN)</td>
</tr>
<tr>
<td>FR Protective equipment</td>
<td>Arc-Rated long sleeve shirt (AR) (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated pants (AR) (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated coverall (AR) (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit jacket (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit pants (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit hood (Note 3)</td>
</tr>
<tr>
<td></td>
<td>Arc-rated jacket, parka, or rainwear (AN) (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Hard hat</td>
</tr>
<tr>
<td></td>
<td>FR hard hat liner (AR)</td>
</tr>
<tr>
<td></td>
<td>Safety glasses or Safety goggles (SR)</td>
</tr>
<tr>
<td></td>
<td>Hearing protection (ear canal inserts)</td>
</tr>
<tr>
<td></td>
<td>Arc-rated gloves (Note 1)</td>
</tr>
<tr>
<td></td>
<td>Leather work shoes (AN)</td>
</tr>
<tr>
<td>Hazard/Risk Category 4</td>
<td>FR Clothing, Minimum Arc Rating of 40</td>
</tr>
<tr>
<td>FR Protective equipment</td>
<td>Arc-Rated long sleeve shirt (AR) (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated pants (AR) (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated coverall (AR) (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit jacket (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit pants (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-Rated arc flash suit hood (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Arc-rated jacket, parka, or rainwear (AN) (Note 4)</td>
</tr>
<tr>
<td></td>
<td>Hard hat</td>
</tr>
<tr>
<td></td>
<td>FR hard hat liner (AR)</td>
</tr>
<tr>
<td></td>
<td>Safety glasses or Safety goggles (SR)</td>
</tr>
<tr>
<td></td>
<td>Hearing protection (ear canal inserts)</td>
</tr>
<tr>
<td></td>
<td>Arc-rated gloves (Note 1)</td>
</tr>
<tr>
<td></td>
<td>Leather work shoes (AN)</td>
</tr>
</tbody>
</table>

AN = As needed  
AR = As required  
SR = Selection required

**Notes:**
1. If rubber insulating gloves with leather protectors are required, additional leather or arc-rated gloves are not required.
2. Alternate is to use FR coveralls instead of FR shirt and FR pants.
3. An alternate is to use a total FR clothing system and hood, which shall have a minimum arc rating of 25.
Management System: **Worker Safety and Health**

Subject Area: **Electrical Safety**

**Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment**

Effective Date: **Feb 29, 2016**

The exhibit **Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment** is provided as a PDF.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the **effective date**.
Laboratory Electrical Safety Committee Certification of Personal Protective Equipment (PPE) for Operating Electrical Equipment

Date: June 26, 2014

This exhibit is the BNL Personal Protective Equipment (PPE) requirements for operating circuit breakers and disconnect switches (not utilization equipment switches such as light switches or on-off switches) that are rated 50 volts to 600 volts. If flame-resistant (FR) clothing is required, it must cover associated parts of the body, as well as all flammable apparel while allowing movement and visibility. PPE equipment will normally be used in conjunction with one another as a system to provide the appropriate level of protection. Clothing must cover potentially exposed areas as completely as possible. Shirt sleeves must be fastened at the wrists, shirts must be tucked in and closed at the neck and jackets must be closed at the neck. (See Table 2 below for required PPE.)

WARNING: Equipment with a DANGER label that says

<table>
<thead>
<tr>
<th>Arc Flash Hazard</th>
<th>Equipment Overdutied Do Not Remove Cover or Operate Breakers/Switches While Energized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard/Risk Category</td>
<td>Or</td>
</tr>
<tr>
<td>Dangerous</td>
<td>Energized Work Prohibited</td>
</tr>
</tbody>
</table>

must not be operated while energized. See the Required Procedure in the section Operating Electrical Equipment for further information.

The following table is only to be used if the equipment has a Generic Arc Flash label that does not list PPE or no label defining required PPE.
## Table 1. Hazard Risk Category Classifications

If there is a label on the equipment that lists required PPE, you must use that PPE and hearing protection (ear canal inserts).

Light and Power panels fed from 30-KVA transformers that do not list PPE only require safety glasses and hearing protection (ear canal inserts).

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Voltage</th>
<th>Ampere [Notes 3 and 4]</th>
<th>BNL PPE Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Breaker Panels or Disconnect Switches operating at less than or</td>
<td>Less than or equal 240 V</td>
<td>Less than or equal 225 A</td>
<td>NFPA 70E Cat. 0</td>
</tr>
<tr>
<td>equal to 240 V and rated less than or equal to 225 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit Breaker Panels or Disconnect Switches (excluding 277 V wall light</td>
<td>More than 240 V</td>
<td>Less than or equal 225 A</td>
<td>NFPA 70E Cat. 2</td>
</tr>
<tr>
<td>switches) operating at more than 240V and rated less than or equal to</td>
<td></td>
<td></td>
<td>(8 Cal/cm²)</td>
</tr>
<tr>
<td>225 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit Breaker Panels or Disconnect Switches operating at less than or</td>
<td>Less than or equal 240 V</td>
<td>Greater than 225 A</td>
<td>NFPA 70E Cat. 2</td>
</tr>
<tr>
<td>equal to 240 V and equipment rated greater than 225 A</td>
<td></td>
<td></td>
<td>(8 Cal/cm²)</td>
</tr>
<tr>
<td>Operating controls on 480V individual motor starters</td>
<td>Less than 600 V</td>
<td>Any Starter Motor Size</td>
<td>Arc Flash Hazard</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Analysis completed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PPE as listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on Panel and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>hearing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>protection (ear</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>canal inserts).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Work Planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>performs arc flash analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PPE as listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on Permit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Starter Size &lt;4</td>
<td>No Arc Flash Hazard Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(50 HP or less)</td>
<td>NFPA 70E Cat. 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(8 Cal/cm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Starter Size 4+</td>
<td>No Arc Flash Hazard Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(51 HP or more)</td>
<td>NFPA 70E Cat. 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(40 Cal/cm²)</td>
</tr>
<tr>
<td>Circuit Breaker Panels, Motor Control Centers, or Disconnect Switches</td>
<td>More than 240 V</td>
<td>Greater than 225 A</td>
<td>Arc Flash Hazard</td>
</tr>
<tr>
<td>operating at greater than 240V and rated greater than 225A</td>
<td></td>
<td></td>
<td>Analysis completed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PPE as listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on Panel and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>hearing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>protection (ear</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>canal inserts).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Work Planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>performs arc flash analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PPE as listed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on Permit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Arc Flash</td>
<td>NFPA 70E Cat. 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hazard Analysis</td>
<td>(40 Cal/cm²)</td>
</tr>
</tbody>
</table>
These new PPE requirements are based on arc-flash calculations or voltage and ampere rating of the equipment rather than only voltage. Do not wear “meltable” fiber clothing (acetate, nylon, polyester, polypropylene, or spandex) underneath any required PPE clothing (exception is incidental amount of elastic on underwear or socks). The BNL required PPE differs from the NFPA 70E tables to provide an enhanced margin of safety.

Table 2. Protective Clothing Characteristics for Operating Switches or Disconnects

<table>
<thead>
<tr>
<th>NFPA Cat.</th>
<th>PPE Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Long-sleeve shirt and long pants made of non-melting, flammable natural materials (untreated 100% cotton, wool, rayon², or silk, or blends of these materials with a fabric weight of at least 4.5 oz/yd²) leather gloves (minimum leather palm with cotton back: BNL # K62980), and safety glasses with side shields and hearing protection (ear canal inserts).</td>
</tr>
<tr>
<td>1</td>
<td>FR long-sleeve shirts and FR long pants with an Arc Rating of 4, safety glasses, all leather gloves: BNL # K62902, leather work shoes, hearing protection (ear canal inserts).</td>
</tr>
<tr>
<td>2</td>
<td>FR long-sleeve shirts and FR long pants with an Arc Rating of 8, hardhat with arc rated face shield, hearing protection (ear canal inserts): BNL # K64942 (protective storage bag for face shield and hat: K64793), safety glasses, all leather gloves: BNL # K62902, leather work shoes.</td>
</tr>
<tr>
<td>4</td>
<td>FR shirt and FR pants plus multilayer flash suit, hardhat, safety glasses, Flash Suit hood, hearing protection (ear canal inserts), leather gloves, and leather work shoes. (Cal/cm² 40),</td>
</tr>
</tbody>
</table>

Note 1: These requirements are for operating switches and disconnects
Note 2: Rayon, a natural fiber made from cellulose, is allowed in NFPA 70E.

Note 3: The equipment Ampere rating is always the nameplate rating of the panel that the switch or circuit breaker is installed in and the Voltage is the line-to-line operating Voltage of the equipment.

Note 4: In the C-AD complex, switches and breakers tapped from “Royal Switches” must use the Royal Switch Rating (greater than 225 A).
### Protective Clothing Characteristics

#### Typical Protective Clothing Systems

<table>
<thead>
<tr>
<th>Hazard Risk Category</th>
<th>Clothing Description (Typical Number of clothing layers is given in parentheses)</th>
<th>Total Weight oz/yd²</th>
<th>Required Minimum Arc Rating of PPE cal/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-melting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight of at least 4.5 oz/yd² (1)</td>
<td>4.5 – 7</td>
<td>N/A</td>
</tr>
<tr>
<td>1</td>
<td>FR shirt and FR pants, or FR coverall (1)</td>
<td>4.5 – 8</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>FR shirt and FR pants (1 or 2)</td>
<td>9 – 12</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>FR shirt and FR pants plus FR coverall (2 or 3)</td>
<td>16 – 20</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>FR shirt and FR pants plus double layer switching coat and pants (3 or more)</td>
<td>24 – 30</td>
<td>40</td>
</tr>
</tbody>
</table>

*ATPV is defined in the ASTM P S58 standard arc test method for flame resistant (FR) fabrics as the incident energy that would just cause the onset of a second degree burn (1.2 cal/cm²). EBT is reported according to ASTM P S58 and is defined as the highest incident energy which did not cause FR fabric breakopen and did not exceed the second-degree burn criteria. EBT is reported when ATPV cannot be measured due to FR fabric breakopen.

Portions reprinted from NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Design Guide

Effective Date: Feb 29, 2016

The exhibit Design Guide is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Design Guide

A. Capacitors and Capacitor Banks

1. Description
This section deals with capacitors and capacitor banks with stored energy in excess of 10 J and voltage to ground exceeding 300 V. It is particularly directed to the application of capacitors which are used as a source of pulsed power, for blocking and filtering, and in oscillator and resonant circuits.

2. Hazards, Design, and Operating Criteria

a. General
Capacitor banks shall be isolated by elevation, NEC barriers, or enclosures to preclude accidental contact with charged terminals, conductors, or support structures. Enclosures and barriers shall be used to protect personnel from projectiles that might be expelled from the capacitors during a fault: for capacitor banks capable of storing more than 50 kJ of energy, special enclosure requirements may be required to provide protection.

Oil filled capacitors should be avoided in radiation environments. Experience has shown that the radiation breaks down the oil and causes a potential over pressure hazard. Access to capacitor areas shall be restricted until all capacitors have been discharged, shorted, and grounded.

All capacitors in storage shall be short-circuited with a conductor securely fastened to the terminals and left in place until the capacitors are used again or scrapped. Ventilation to keep the temperature of ambient air at capacitor installations at recommended levels shall be provided.

Capacitor cases, unless obviously connected to a recognized grounding conductor or grounded structure, shall be considered “charged”, and shall be grounded in the same manner as capacitor terminals. The capacitor cases should be properly labeled, with their operating voltages identified in accordance with OSHA regulations.

b. Stored Energy
Capacitors or capacitor banks with stored energy of 10 J or more constitute a LETHAL SHOCK HAZARD. Although they have been disconnected and discharged, capacitors may accumulate a charge without benefit of connection to an external power source. This charge is caused by the slow release of electric charges from within the dielectric material, because of the phenomenon known
as “dielectric absorption”. It also is possible for capacitors to acquire a charge from local atmospheric electrical disturbances and by corona from a nearby high-voltage terminal, such as on an adjacent capacitor.

During transient conditions, capacitors could acquire a charge hazardous to personnel, or an over-voltage harmful to the capacitor itself because of inductance in the circuit. This inductance can be in the form of coils or magnets, or in wiring and leakage.

c. Discharging
Discharging a capacitor by a grounding hook can cause an electric arc at the point of contact. Such release of energy can also cause burns from thermal radiation or flying molten metal. Any residual charge shall be removed from capacitors by grounding the terminals with a low-impedance grounding hook before beginning to work with them. Automatic discharge and grounding devices shall not be relied upon for personnel safety; grounding hooks must be used to ensure safe operations. Grounding hooks shall be inspected prior to use to ensure that all connections are secure, and that the grounding conductor is in good condition. Grounding the output typically will not discharge internal capacitor banks.

Short circuit all capacitors in storage with a conductor not smaller than 14 AWG, securely fastened to the terminals and left in place until the capacitors are to be used again.

d. Connecting
A dangerously high voltage can exist across the impedance of a few feet of grounding cable at the moment of contact with a charged capacitor. Operating personnel shall stand clear of cables attached to grounding hooks at the moment of application to a capacitor terminal.

e. Safety Devices
Safety devices, such as shorting switches and grounding switches, and their associated cables and cable connectors, shall be designed to withstand the mechanical forces from the large currents which result from their operation.

Protective devices, such as automatic shorting switches and grounding hooks, shall be tested after installation, and at a minimum of every 3 years thereafter to verify their operation.

f. Faults
Internal faults may rupture capacitor containers, particularly when
many capacitors are connected in parallel. This rupture is normally caused by the boiling of the insulating liquid in the capacitor and may even occur where the peak fault current is not high. Metal case capacitors will usually swell and vent before large amounts of overpressure occur. Cast or phenolic cased units present a more serious hazard: the force of the explosion may cause serious injury.

Capacitors should be provided with current-limiting devices, such as fuses and resistors, which are capable of interrupting available fault current or limiting it to safe and manageable values. When this is not possible, alternate means to ensure personnel protection should be incorporated (i.e., enclosure). Rupture of a container by an internal fault can create a fire hazard because combustible dielectric could be ignited.

g. PCBs
For capacitors with any quantity of poly-chlorinated biphenyls (PCBs), refer to the PCB Management Subject Area.

h. Fuses
Fuses may be used to interrupt the discharge of energy from a power source or a capacitor bank into a faulted individual capacitor. If fuses and the capacitors are not adequate for this application, they could explode, expelling dangerous projectiles. Fuses designed for AC operation depend on the current passing through zero on the next reversal of the line voltage to guarantee that the fuse will clear. Even if the correct DC-rated fuses are used, a complete capacitor bank may discharge through a fault at very high currents before the fuse clears. The fuse in this type of application usually does not allow a shorted capacitor to permanently load a power source that is feeding it, such as in factor correcting service on power transmission lines.

i. Bleeder Resistors
It is essential that bleeder resistors be used on each capacitor that is fused to ensure that the capacitor discharges when it becomes isolated. If bleeder resistors are not used to discharge the capacitors, the capacitors must be automatically discharged (See National Electric Code [NEC] 460-6). The residual voltage on capacitors must be reduced to 50 V or less, within one minute.

B. Electrical Conductors and Connectors

1. Description
The conductors and connectors covered in this section are those used in special
R&D activities and include pulsed or continuous high-current, high-voltage, high-frequency, liquid-cooled, and other special conductor and connector applications.

2. Hazards, Design, and Operating Criteria

a. Conductor Overheating
Dense packing of electrical cables in cable trays or raceways can cause overheating and insulation deterioration, leading to electrical arcing and fire. Conductor current capacities shall be de-rated commensurate with density of packing. Conductors shall also have capacity ratings sufficient for the capability of the energy supply system.

b. Insulation
Conductor insulation must be appropriate for the operating and environmental conditions. Insulation shall be selected based on thermal ratings, voltage ratings, mechanical strength, and resistance to moisture, chemical, and radiation environments. Cable exposed outdoors should be identified as being sunlight-resistant. Cable used in air-handling plenums must be specifically rated for this application. The general use of flame-retardant insulation/jacketing systems rated to pass the IEEE-383 vertical tray flame test shall be used where commercially available. Examples are XLP/Hypalon, Hypalon, or a combined insulation/jacket of Hypalon for all cable.

c. Shielded Cable
Shielding confines the electric field of the inner conductor to the conductor insulation system. Insulated cables constructed with metallic sheath armor or with a discharge resistant jacket should be shielded if operated at or about 5 kV. For insulated cables constructed without armor or discharge resistant jacket, shielding should be used when operated at 2 kV or above.

d. Physical Installation
High fault currents, or pulsed operation of cables, can produce large electromagnetic forces, resulting in physical movement of components. Bracing and conductor supports shall be provided that can physically and electrically withstand expected mechanical forces and voltages. Physical barriers shall be provided to separate high-voltage conductors from low-voltage conductors, and they shall be designed to withstand fault conditions. Spacing or loops between high-current supply and return conductors should be avoided to prevent inducing current in adjacent circuits or structural members. Suitable routing and additional protection shall be provided for coaxial cables used in pulsed-power applications,
where the braid of the coaxial cable may have significant voltage with respect to nearby structures. Single conductors installed in cable tray shall be AWG 1/0 or larger.

c. Metal Pipes
Metal pipes that are used as electrical conductors present shock hazards because they may not be readily recognizable as electrical conductors. Accordingly, labeling, insulation, or other protection shall be provided for metal piping used as conductors.

f. Liquid-Cooled Conductors
Where liquid-cooled pipes or cables are used, sensing devices for coolant flow or overheating shall be provided for equipment shutdown if the cooling system malfunctions.

g. Cable Care
Cables and their insulation systems shall be physically protected. Walking or climbing on cable trays shall not be permitted. Individual or bundled cables shall not be run unprotected across floors for experimental work: suitable protection and suitable cables shall be provided where electrical systems must be run across floors. Cables used in recurring experimental activities shall be carefully handled and stored between uses.

h. Terminations
Improper selection, application, or installation of connectors can cause overheating, arcing, and shock hazards. Connectors shall have adequate current-carrying capacity and voltage rating for their application. Adequate separation shall be provided between adjacent high- and low-voltage cable terminations. Appropriate connectors shall be provided for use with aluminum conductors, and they shall be assembled in accordance with approved techniques. Connectors wired to sources of power should be female. Cable connectors shall be checked periodically and adjusted for tightness in accordance with normal maintenance procedures. Plug-in cable connectors, particularly those for high voltages or high currents, shall be mechanically fastened in place, and the power source shall be energized before inserting or removing these connectors. Cable splices are not permitted in conduit runs or where inaccessible, but may be used in cable trays provided they remain accessible and do not project outside the side rails. Cable splices must be adequately insulated.

i. Wiring Methods:
Flexible cords and cables are not permitted to be used as a
substitute for fixed wiring of a structure, unless permitted by the National Electrical Code. In accordance with the National Electrical Code, wires and cables must be physically protected by being run in cable tray (considered below) or in raceway, a general term denoting enclosed channels (rigid and flexible conduit, wiring trough, etc.) designed expressly for holding wires, cables, or busbars. Just as ac power systems are afforded superior protection by installation in raceway, related or similar important systems should also be installed in raceway. Cables that share raceway or cable tray shall all have insulation ratings adequate for the voltage expected on any conductor in the raceway or cable tray.

**ii. Use of CABLE TRAY is limited:**
The National Electrical Code (Article 392) requires that only qualified persons may install and maintain cable tray systems. Cable trays shall be installed as complete systems, shall be exposed and accessible, and shall be electrically continuous and grounded. Single conductors installed in cable tray shall not be smaller than #1/0 AWG. Power and control cables supported by cable tray should be rated for use in cable tray. Power cables should be installed in cable trays separate from control, signal, and instrumentation cables. Listed fire stops should be provided when tray penetrates floors or other fire cutoffs. Wires may not be spliced where hidden in conduit, although splices are permitted in trough or in cable tray (splices may not project outside the tray rails). Note that screwed and bolted connections and poorly soldered lugs tend to loosen and overheat; crimped connections are more uniform in application and are recommended. Cable tray is generally provided to support cables: the integrity of cable tray systems should not be compromised by any items added to the cable tray cross-section, outside rails, or supports. Other restrictions apply to raceway or cable tray installations; appropriate knowledgeable professionals should be consulted when such installations are considered. They will consider the maximum allowable percentage of cable cross-section allowed to be filled with cable, the flammability rating and flame propagation characteristics of items within the tray, the cable tray support system and weight restrictions placed on the cable tray installation, and other items.

**C. Enclosures for Electrical Equipment**

**1. Description**
This section covers all enclosures for equipment and also includes equipment where RF radiation or stored energy electrical components are contained.
2. Hazards, Design, and Operating Criteria

a. General
All cabinets and enclosures shall be of appropriate materials and finish for the environment in which they will be placed. Enclosures structurally adequate for their intended use shall be provided. Adequate material shall be used in viewing windows to protect personnel from flying parts that may result from electrical faults. Enclosures shall be designed so that no contact with live electrical parts can be made from outside, and so that adequate interior working space is provided. Enclosures shall be grounded.

b. Eddy Current, RF, or Microwave Heating
Signs and/or warning lights shall be provided to indicate these hazards. Properly shielded enclosures shall be provided for RF power equipment, and particular attention shall be paid to all openings, such as doors, access ports, and viewing windows as inadequate shielding can result in burns. Compliance with the Non-Ionizing Radiation Safety Subject Area shall be provided by the use of proper equipment at the operating frequency to perform initial and routine measurements of radiation leakage and taking special measurements after equipment modifications or changes in radiation levels.

c. Interlocks
Electrical interlocks shall be provided as appropriate on doors, easily removable panels, and swinging panels that interrupt the circuit whenever open. Door locks should limit access to authorized personnel only. When a temporary enclosure is necessary, it should be electrically interlocked, if possible, and should meet the same requirements as a permanent enclosure where hazardous conditions exist, before energizing equipment. Interlocks provide additional protection to systems and should be used as appropriate.

d. Compartmentalization
Separate high- and low-voltage and/or instrumentation and control compartments shall be provided in all enclosures, especially large, high power systems.

D. Inductors, Electromagnets, and Coils

1. Description
This section covers inductors, electromagnets, and coils with stored energy of more than 10 joules, which are used in the following applications:
Energy storage systems.
Inductors used in a pulsed system with capacitors, to provide oscillatory wave-shaping or resonant conditions.
Electromagnets and coils which produce magnetic fields to guide or confine charged particles.
Inductors used in DC power supplies.

2. Hazards, Design, and Operating Criteria

a. Inductor Damage
Overheating from overloads, insufficient cooling, or failure of the cooling system could cause damage to the inductor and possible rupture of the cooling system. Sensing devices (temperature, coolant-flow) shall be provided for water or air-cooled inductor and magnet coils, interlocked with the power source. These devices are for safe shutdown if temperatures are abnormally high or the cooling system fails.

b. Fringe Fields
Large electromagnets may produce external fields which can affect the calibration and operation of protective instrumentation and controls. Refer to the Static Magnetic Fields Subject Area for guidance.

c. Eddy Currents
Whenever a magnet is suddenly de-energized, production of large eddy currents in adjacent conductive material can cause excessive heat. A fast rate-of-change of field strength produces high turn and terminal voltage and also can induce voltages in adjacent conductors, which can be hazardous. Equipment supports and bracing to withstand forces produced during normal operation and fault conditions shall be provided.

d. Leads
Loose and broken inductor or magnet connections can produce excessive heat and arcing. Extreme caution shall be exercised when disconnecting the leads of any large inductor. First, the power source should be locked out, as per the Lockout/Tagout (LOTO) for Installation, Demolition, or Service and Maintenance Subject Area and then, when the current has decayed to zero, the leads can be disconnected.

e. Quench
Large amounts of energy stored in the field of an energized inductor can damage equipment and injure personnel if the energy is suddenly discharged in an inappropriate manner. A means shall be provided for safely dissipating stored energy when excitation is interrupted or when
a fault occurs. The relatively long-time constants in large inductive circuits can cause the continuous release of energy into a fault, producing severe equipment damage and possible fire. An appropriate emergency off system shall be provided to dissipate stored energy and to disconnect it from the source. All terminals must be covered to protect from accident shorting.

f. Grounding
Electrical supply circuits and magnetic cores shall be grounded wherever feasible and fault protection shall be provided. Ground-fault detection shall be provided for grounded and ungrounded electrical circuits (floating systems), for alarm purposes or for equipment shutdown.

g. Warnings
Signs and/or warning lights shall be provided to indicate equipment hazards.

E. Instrumentation and Control Systems

1. Description
Instrumentation and control systems covered in this section are those used in R&D applications.

2. Hazards, Design, and Operating Criteria

a. Process Isolation
Instrumentation and control (I&C) systems may be connected to circuits operating at hazardous voltage levels or with the capability of delivering high currents. Failure of insulating or isolating devices could extend such dangerous conditions to personnel, or could alter the components in such a way that control of the process is lost, or information about the process is distorted. To prevent this from occurring, isolation must be provided for all such systems, between the I&C components and the process or equipment that is being monitored and controlled. Isolation shall include physical separation between power and signal circuitry and equipment, and the use of surge protectors and isolation devices such as transformers, high impedances, optical coupling, and telemetering. Both normal and fault conditions shall be considered during the design of such systems. Signal wiring shall not be bundled with power wiring. Consistent grounding methods shall be used in each facility for shields in instrumentation cables.

b. Hazardous Systems
Failure or malfunction of a system can produce erroneous readings
which can prevent recognition of hazardous conditions, can cause unintentional operation of hazardous equipment, or can inhibit the operation of safety devices such as enclosure interlocks, warning devices, or overload protection. Redundant controls and instrumentation shall be provided on sections of a system where a single failure could otherwise result in hazardous conditions or operation. Redundant instrumentation should monitor actual conditions and provide independent verification of process conditions by monitoring required system attributes, i.e., flow derived from a flow monitor and not simply from operation of a solenoid valve. Control circuits shall be designed to be fail-safe, so that loss of power or a similar equipment failure does not result in a hazardous operating condition. A clear indication shall be provided of the status of hazardous remotely-controlled equipment, and each specific command shall be verified by definite feedback to the operator. Control circuits shall be designed to preclude the existence of “sneak” circuits (undesired circuits through series-parallel configurations), and shall be arranged so that accidental grounding of one conductor cannot cause safety devices to become inoperative.

c. Electrical Ratings
Electrical ratings of equipment and conductors shall be consistent with requirements of the National Electrical Code. Relay and interlock contacts on instrumentation and protective circuits shall be rated at least as high as the voltage of the circuit, and current ratings shall be as high as the normal disconnect rating of the protective fuse or circuit breaker used. Circuit inductance shall be considered in the application of relays and interlocks. Terminals in instrumentation and control compartments shall be covered and conspicuously labeled.

d. Computers/Programmable Controllers
Systems controlled by computers or programmable controllers shall be integrated to be fail-safe, so that failure of the stored-program device will result in a safe condition. The failure monitor shall be arranged in the form of a “heartbeat” circuit or equivalent, such that, a failure will not cause an unsafe condition in which must be continually refreshed by the computer/programmable controller. Manual overrides shall be provided so that a process connected to a computer or programmable controller can be interrupted by an operator regardless of the state of the stored-program device.

e. Manual Restart
Protective interlock circuits and process equipment controls shall
be designed so that restoration of control or interlock circuits, or resetting of equipment that caused a process trip, will not automatically restart the process, without operator reset.

f. Safety
Immediate attention shall be given to malfunctions or failures of I&C systems adversely affecting safety, and corrective action should be taken in accordance with the Occurrence Reporting and Processing System (ORPS) Subject Area. All new or modified instrumentation and control systems shall be carefully inspected and tested to assure that they perform in accordance with operating and safety requirements. Interlocks provided for personnel safety shall be tested and documented initially and at least annually to assure operability. Written checklists, including simulation of failures, operation of upper- or lower-limit control features, safety interlocks, and interlock systems should be incorporated into the procedures. Safety interlocks shall not be used in lieu of lockout/tagout.

g. Graphic Display Panels
Graphic control displays should be provided for large or complex systems. Consistent labeling types and nomenclature shall be used for control panels.

F. Power Supplies

1. Description
This section covers power supplies that are used in R&D activities. The power source can be either AC or DC, and from a protection point of view, the circuit extends to the connected load.

2. Hazards, Design, and Operating Criteria

a. General
Before initial operation and at least annually thereafter, the power supply shall be carefully inspected, calibrated, and the inspection documented, and all protective devices shall be checked.

b. Covers
Personnel could unknowingly come in contact with energized equipment. All terminal strips and live components shall be covered or protected by barriers; where visibility of the components is necessary (e.g., relays, contactors) the covers shall be made of transparent material. To the extent possible, access to incoming power to a power supply shall be limited, preferably through use of a separate compartment, or barriers.
c. Power Sources
Multiple input sources shall be avoided. A power supply in a remote location could be energized and personnel could unknowingly come into contact with the energized equipment (connected load). Where other sources are connected to a power supply, either externally or coupled into the power supply from the load itself, the power supply shall be clearly labeled with the source name and its location. Equipment shall be labeled to identify input power sources, which shall be labeled to identify their connected power-supply loads. Induced or back emf sources shall also be identified. Equipment which is remotely controlled or unattended while energized shall be labeled with emergency shutdown instructions, and the identity of the personnel who are responsible for the equipment shall be on the power supply, or prominently displayed in the building or area location.

When power supplies serve more than one load, switching errors can result in energizing the wrong equipment (load) creating hazards to nearby personnel.

d. Faults
Electrical faults or switching transients can cause voltage surges in excess of the normal terminal voltage rating of the power supply. Electrical faults can cause conductors to melt, and other components such as insulating materials could melt, burn, or explode. Protection from AC and DC instantaneous and continuous overcurrent, overheating, shall be provided, as applicable. Load protection and ground protection shall be coordinated with the above, including cables (insulation, rating, and size).

e. Wiring
Power supply power, control wiring, and load cable insulation shall be high temperature rated wherever possible, shall be selected for low oxygen content, and shall have passed IEEE or UL flame tests.

f. Component Failure/Overload
Overload or improper cooling can cause excessive rise in temperature, resulting in possible damage to equipment and associated hazards. Internal component failure can cause excessive voltages on external metering circuits and low-voltage rated components of the power supply. Provide overcurrent, undervoltage, or other protection for both power supply and load as appropriate.
g. Shutdown
The design of the power supply shall include a positive means of interlocking (preferably mechanically) its cabinet so that accidental access to energized components is prevented. The main input circuit breaker or disconnect switch shall be clearly identified, located as near as possible to the power supply, and equipped with lockout provisions coordinated with interlocks of the power supply. Control power should be generally derived from the AC input power so that the disconnect de-energizes both. In addition, a second means of shutdown shall be installed at the power supply, when the power supply is not in sight of the main disconnect device. Before entering power-supply or associated equipment enclosures the following precautions shall be taken:

(1) Open and lockout the main input power circuit breaker and verify that the input voltage is off (see the Lockout/Tagout (LOTO) for Installation, Demolition, or Service and Maintenance Subject Area).
(2) Check for auxiliary power circuits which could still be energized.
(3) Inspect automatic shorting devices if installed, to verify proper operation.
(4) Short power from each terminal-to-ground and terminal-to-terminal, with grounding hooks.

An automatic switch or a bleeder resistor shall be provided in the power supply to discharge all stored energy when the power supply is turned off. This feature shall be interlocked with the other power supply safety systems, especially where large capacitive filters or capacitor banks are used. The residual voltage on capacitors must be reduced to 50 V or less within one minute. In the control systems of the power supply, remote/local mode switches are desirable. Remote shutdown or means for emergency stop shall also be provided.

h. Discharge
Output circuits and components can remain energized while input power is interrupted, because of parallel power sources or stored energy in reactive components (e.g., capacitors). For inductive loads, discharge paths for the stored energy, including, but not limited to, thyrites, MOVs, and reverse connected diodes, shall be provided.

i. Indicators
Auxiliary and control power circuits can remain energized when
the main power circuit is interrupted. Alarms, signs, or lamps shall be provided to indicate that a power supply is energized. If the local switch is remote from the power supply, there should also be a lamp to indicate a load.

G. Resistors and Resistor Banks

1. Description
Resistors and resistor banks used in R&D are typically used to connect instruments to a high-voltage circuit (as in a voltage divider and filter damping resisters), and to absorb the discharge of stored energy, where they may carry pulsed current exceeding their steady-state rating. Resistors and resistor banks may also be used in safety-related functions, such as resistive grounding.

2. Hazards, Design, and Operating Criteria

a. Resistor Ratings
Each resistor should be operated within its rating or capability. Large currents from faults or abnormal circuit operation may produce forces capable of destroying resistors. Resistors used where large pulse or fault currents may be expected shall be robust enough to withstand the resulting magnetic forces.

b. Physical Installation
Improperly installed resistors may injure personnel or damage adjacent equipment, because resistors may operate at temperatures high enough to cause severe burns or to ignite combustible materials. They may also be used in applications involving high voltages or currents. Resistors used in hazardous applications should be installed in an enclosure to prevent injury and minimize damage if a failure should occur. The enclosure should be well-ventilated, constructed of non-combustible material, grounded, and interlocked to prevent entry while the resistors are energized. Signs should be posted to warn personnel of the hazards present in resistor installations; warning lights and barriers may also be required.

Resistors should be installed in a manner to preclude damage to adjacent components from heat. The insulation of conductors used to connect resistors should be able to withstand the temperatures and voltages encountered. Resistors used in high-voltage circuits should be protected from surface contamination caused by adverse environmental conditions.

c. Transient Conditions
Resistors should be capable of withstanding any transient
overvoltage to which they may be subjected. Resistors used in pulsed circuits or discharge circuits can be physically damaged when operated at high-current or high-voltage levels, or when subjected to overvoltages, which might cause electrical arcs. Resistors applied in pulsed circuits should be sized to accommodate any possible succession of pulses. Resistors in grounding circuits may develop hazardous voltages during the flow of fault or discharge currents.

d. Hazards Introduced by Resistor Failures
When failure of a resistor could expose personnel to hazardous voltages, the installation of two or more resistors in parallel should be considered, each rated for maximum operating conditions. For example, failure of a resistor used in the low-voltage section of a voltage divider will result in applying the high voltage to the divider output terminal. Also, failure of a capacitor bleeder resistor could expose personnel to hazardous voltages. Failure of an inductor discharge resistor, such as that used for a motor field winding, can result in hazardous and destructive voltages in the motor circuit. Failure of a resistor used as a discharge device for an energy storage system may create a hazardous condition when the discharge circuit does not function as intended.

e. Water-cooled and Forced-Air Cooled Resistors
Temperature-sensing or flow-sensing devices should be installed in resistor installations which require liquid cooling or air cooling. Water-cooled resistors may explode if insufficiently cooled; electrolytic resistors may simply open if the fluid level gets low. Resistors can operate at temperatures that are high enough to cause burns to personnel or ignite combustible material.

f. Inspections
The resistor installations including enclosure interlocks should be inspected periodically.

H. Electrical Switches

1. Description
This section covers special non signal electrical switches used in R&D where safety requirements are not specifically covered by existing codes.

2. Hazards, Design, and Operating Criteria

a. Electrical Shock
Electrical shock from contact with live exposed switch parts is a
common hazard. Lockable and grounded switch enclosures shall control access to the switches. Protective covers and/or barriers shall be provided when practical to prevent personnel from coming in contact with live parts.

b. Location
Switches shall be located as close as practical to equipment they are servicing (within line of sight). Switches shall be labeled as to where they are fed from. Switches, contactors and relays shall be mounted so that gravity tends to open the contacts or switch blades with loss of power or poor mechanical connection.

c. Phase Arrangement
Both line and load conductors shall be phased A-B-C from left to right on all three-phase switches, circuit breakers and contactors.

d. Operation
There must be assurance that switches not designed to disconnect under load conditions cannot be opened when the circuit is energized. Switches not intended to be opened under load conditions can create severe arcing.

e. Maintenance
A system of interlocks which interrupts the normal operating control power to remotely-controlled switches during testing or maintenance shall be provided. Locking features on switches to prevent operation when personnel are working shall accommodate the requirements of the Lockout/Tagout (LOTO) for Installation, Demolition, or Service and Maintenance Subject Area.

Periodic (at least annual) inspections of switch and switch operating tests shall be performed and documented for critical or high value equipment.

f. Fault Conditions
Sufficient energy may be developed under fault conditions to cause a switch to explode. Arcing at switch terminals under transient fault conditions can subject the isolated section of a circuit to hazardous voltages and power levels. Switches used above their voltage and current ratings can cause shocks or other electrical hazards. Switches shall be selected so that under fully loaded and fault conditions their voltage, current, and interrupting ratings are not exceeded.

g. Unintentional Operation
Electrically controlled switches operated unintentionally, because
of malfunction of the control circuits, present a shock hazard. All switches shall have a positive indication of switch position and function; unlabelled or improperly switches also present a shock hazard. Operating procedures for checking that no one is working on the load and that all protective grounds have been removed before restoring power shall be established and implemented.

**h. Switch Locking**
Suitable means shall be provided for locking secondary isolating and/or transfer-type switches in the desired position. Wherever possible, however, disconnect switches should not be locked in the ON position, preventing circuits from being readily de-energized.

**I. Storage Batteries and Battery Banks**

1. **Description**
This section covers rechargeable-type batteries used for storage of electrical energy. These criteria are not limited to batteries of a particular voltage and energy rating, because the nature of the associated electrical hazards is similar for any battery size, except that the severity of the hazard increases with increased battery rating. This section is not intended to cover small batteries, i.e., watches, calculators, computer backup or hearing aids.

2. **Hazards, Design, and Operation Criteria**

   a. **General**
   All storage battery installations, including handling and storage areas, require special attention to ensure that batteries have a safe operating and storage environment.

   b. **Access**
   Access to station storage battery areas should be limited to authorized personnel only, through the use of locked doors and/or locked gate enclosures. Warning signs shall be posted prohibiting smoking.

   c. **Location**
   Batteries shall be located in a dedicated clean, dry room where there is sufficient ventilation to prevent an accumulation of explosive mixture of gases from the batteries. Unrestricted natural air movement in the vicinity of the batteries, together with normal air changes for occupied spaces or heat removal, may be sufficient. Mechanical ventilation in the vicinity of the batteries will be required for confined spaces. Ventilation can consist of a fan, roof ridge vent, louvered areas, or combinations of these. The
ventilation system must be Class I Division I, as per NEC 500 and approved by the Safety and Health Services Division (SHSD).

d. Vapors
The vapors given off by storage batteries are very corrosive; therefore, wiring and its insulation is required to be of a type that will withstand corrosive action. Metal battery racks and metal raceways shall be constructed of treated material to make them resistant to corrosion.

The floor of storage battery areas should be of an acid-resistive material, or be painted with resistive paint, or otherwise protected.

e. Physical Installation
Choice of battery type, charging circuitry, and construction of storage area shall be consistent with the intended application of the installation. Protection devices installed shall be as required by applicable codes and/or specified by manufacturer of packaged battery/charger system. Large battery banks, used for uninterruptible power supply service (UPS) should have fused disconnects installed as per NEC Article 480.

Battery racks shall be firmly anchored to either the floor or to the wall. Metal battery racks shall meet the requirements of NEC 480.8.

f. Maintenance
Procedures for regularly scheduled maintenance, testing, and inspection shall be developed and implemented. These procedures should include testing and recording voltages and specific gravity of batteries, and the routine cleaning and torquing of connections. Maintenance, testing, and inspection of package battery/charging systems should follow the manufacturer’s recommendations. Use NFPA 70B as guidance when no specific manufacturer’s information can be found.

g. Spills
Provisions for neutralizing acid spills (bicarbonate of soda and water solution) should be provided. Equipment shall be provided to prevent spills from entering the facilities drainage systems, (i.e., secondary containment).

h. Personnel Protection Equipment
Personal protective equipment for personnel working in the battery areas are goggles and face shields, acid resistant gloves, and protective aprons. An eye wash station and an emergency shower
in close proximity to the storage area shall be installed, and shall be easily accessible.

J. Chemical, Biological, Fire, and Other Hazards Associated with Electrical Equipment

1. Description
Electrical apparatus may contain hazards, which, while not electrical in nature, are intimately associated with the equipment. These hazards may involve physiological effects, toxicity, fire, explosion, corrosives, failure of safety systems from non-electrical causes, and many others. This section is not intended to present a detailed description of the hazards, with a full set of design and operation criteria for each. Rather, it is a list of some of the more probable dangers which may be encountered and which need to be considered during the safety review.

For most of the items listed, detailed codes, references, and standards exist. These explain the safety aspects of each area in great detail and may be consulted for more information. This list can never be complete since new equipment, materials, applications, and designs continue to provide further sources of unusual and hazardous situations. Therefore, it is essential that all new systems are reviewed commensurate with the hazards involved.

2. Hazards, Design, and Operating Criteria

a. General
Warning signs shall be displayed indicating the presence of any potential hazard such as gas, fumes, laser light, UV, noise, toxic chemicals, nuclear radiation, fire hazards, magnetic fields, electromagnetic radiation, hydrogen, or other explosive gases. Operating permits flashing lights and audible alarms may be necessary in some cases. Warning signs should conform to OSHA guidelines.

Provide sufficient access and illumination around electrical equipment.

Areas where any toxic fumes may be present should be adequately ventilated. Permits may be required for air emissions (see the Environmental Monitoring Subject Area).
Grounded protective covers or barriers shall be provided for high voltage terminals and for low voltage terminals that have high currents available, to protect from inadvertent contact with energized parts.
Eye wash and safety showers near battery banks or other acid-containing equipment shall be provided, maintained, and kept assessable. Protective devices, equipment, and/or systems shall be designed to be FAIL-SAFE, wherever practical.

Intercoms and telephone should be near hazardous equipment for use in emergencies. Their locations should be reported to Fire/Rescue and be properly posted, well-marked so that proper instructions can be given to responding emergency personnel.

A distinctive orange color-code and/or label shall identify any component which in its common use is non-hazardous, but in its actual use may be hazardous (e.g., a metallic cooling-water pipe also used as an electrical conductor, carrying high voltage or high current).

Warning or pilot lights shall be installed on the equipment and clearly indicate when equipment is energized.

b. Grounding
Metal cabinets, enclosures, and structural components and equipment shall be grounded with easily recognizable external grounding conductors sized for the maximum available fault currents.

Safety grounding hooks for hazardous electrical equipment for R&D shall have the following features:
(1) A visible, extra-flexible copper conductor of adequate size.
(2) Connectors crimped and/or soldered, and
(3) A bare conductor clearly visible through its insulating sheath.
(4) A bolted on connection from the conductor to the building ground. Spring connectors should be avoided.

Grounding hooks shall have a clearly visible metal-to-metal bolted connection to equipment ground, shall be of sufficient number to satisfy the equipment grounding requirements, and shall be located in a visible and accessible location.
Where it is necessary for safety in equipment grounding, a discharge point should be provided, with impedance capable of limiting the current to 50 A or less. A direct grounding point shall also be provided and the discharge and grounding point shall be clearly labeled.

c. Specific Hazards
• **Ozone**
  Many electrical devices generate significant quantities of ozone from sparking, corona, or ultraviolet light. Ozone, in concentrations as low as 0.1 ppm, can result in observable physiological effects. In areas where ozone may be produced, ventilation shall be provided (see the Indoor Air Quality Subject Area).

• **Hydrogen**
  Hydrogen is used often in R&D for accelerator targets and cryogenic magnets and is also a by-product of battery charging or other electrolytic type of operations. It is a highly flammable, highly explosive gas with a lower explosive limit of about 4% in air. There are usually pieces of electrical equipment used in conjunction with the hydrogen device, and any one of these may act as an ignition source during a hydrogen release. All sources of ignition should be removed from the area or explosion proof equipment used as per National Electric Code Article 500. (See the Fire Safety and Cryogenics Safety Subject Areas.) All Hydrogen use must be reviewed by SHSD.

• **Superconducting Devices**
  The increasing use of superconducting magnets and other devices presents several different hazards. If hydrogen is the cryogenic fluid, it is a potential fire and explosion hazard. Cryogenic temperatures may cause severe “burns”. When a cryogenic magnet “quenches”, it may cause a sudden pressure buildup as the liquid turns to gas. This pressure buildup can rupture the containment vessel and create an explosion-type hazard. (See the Cryogenics Safety Subject Area.)

• **Chlorinated Oils**
  Oils, with trade names such as Chlorinal, Arochlor, Inerteen and Askarel, which have been modified to be fire-resistant, are not to be used on-site. (See the PCB Management Subject Area.)

• **Batteries**
  In addition to the electrical hazards associated with high current storage batteries, there are other problems. The most commonly used batteries have a sulfuric acid electrolyte which requires careful handling. During charging, hydrogen is generated in the cells and an inadvertent spark can cause the battery to explode. Other
toxic gases may also be generated (See section I. Storage Batteries and Battery Banks).

- **Noise**
  Continued exposure to very high noise levels such as may be present in the vicinity of some electrical equipment causes hearing to deteriorate. Sudden loud noises, such as a spark gap firing or capacitor bank discharging, can create a safety hazard by startling individuals who might be working on hazardous equipment such as machine tools or electrical equipment. (See the Noise and Hearing Conservation Subject Area.)

- **Coolants**
  The coolants used in electrical equipment are most commonly water, oil, and antifreeze, such as solutions of ethylene glycol. Release of the coolant near energized components can be a hazard. Water may create a leakage path for voltage, initiate short circuits, interfere with interlock systems, and create ground paths. Oil and glycol, when released, may cause a slippery surface as well as accidental electrical shock, and could become an environmental issue. Appropriate floor drainage shall be provided wherever electrical equipment is located, to minimize electrical shock hazards from accumulated moisture.

- **Environmental Effects**
  Any device which is used as part of a safety system is subject to malfunction as a result of environmental conditions. A relay may fail to release in the presence of a large stray magnetic field. Dirt or dust may make a contact inoperative and such failures may make a safety system inoperative. The environmental factors which have to be considered include temperature, dirt and dust, moisture, ice, dc magnetic fields, and electromagnetic fields.

- **Fire Hazards**
  Many of the materials used to construct electrical equipment are flammable. Inherent ignition sources are present in most electrical equipment and a fire is always a potential danger. Wire-insulating materials and capacitor oils that are commonly used can generate large amounts of smoke with toxic fumes arising from the chlorine used in many insulating materials.
- **Thermal Sources**
  Electrical equipment contains devices operating at temperatures which can cause thermal burns or initiate fires.

- **Moving Mechanical Devices**
  Unprotected actuators, fans, blowers, gears, and pulleys present a safety hazard. Guarding should be in conformance with OSHA. Automatic starting equipment also poses a hazard, and shall be as such.

- **Light Sources**
  Lasers, ultraviolet and infrared light sources, spark gaps, and other devices can constitute severe eye hazards. The ultraviolet light can cause conjunctivitis, which may lead to permanent eye damage during very short exposures. Laser beams can cause retinal damage and severe burns to exposed body areas. (See the [Laser Safety](#) Subject Area.)

- **Magnetic Fields**
  There is concern that there may be effects to biological organisms from exposure to dc magnetic fields. Carrying magnetic tools or equipment near magnets with large stray fields can lead to physical injuries (See the [Static Magnetic Fields](#) Subject Area.)
  Electromagnetic Radiation High-power pulses electromagnetic radiation can cause secondary effects near the source, such as sparking between any conducting materials in the area, heating of nearby objects, and biological effects such as tissue burning. (See [Non-ionizing Radiation Safety](#) Subject Area.)

- **Bio-electronic Implants**
  Many people have implants, such as pacemakers, which may be sensitive to electromagnetic fields. Exposure to electromagnetic fields should be avoided.

- **X-rays**
  Many high voltage devices (greater than 10 kV in vacuum such as klystrons, high voltage rectifiers, and high voltage tubes generate x-rays as an unwanted by-product. Proper attention to personnel protection shall be considered. Shielding for x-ray sources as well as high voltage devices producing x-rays as a by-product shall be provided. (see the [Radiation-Generating Devices](#) Subject Area)
• **Nuclear Radiation**
  Electrical and electronic equipment, which has been subjected to nuclear radiation may become activated and present a radiation exposure hazard to personnel.

• **Stored Energy Equipment**
  In addition to the electrical hazard, energy storage devices are capable of creating severe arcs and fireballs involving the vaporization and scattering of copper, steel, or other materials in the arc vicinity. Severe skin and eye damage can result from such an arc. An exploding capacitor can project busing and other material a considerable distance. In structural failures strong magnetic forces in coil and magnets can in some cases, produce hazards.
Management System: **Worker Safety and Health**

Subject Area: **Electrical Safety**

**Electrical Equipment Labels**

Effective Date: **Feb 29, 2016**

The exhibit **Electrical Equipment Labels** is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the *effective date*. 
### Exhibit Electrical Equipment Labels

<table>
<thead>
<tr>
<th><strong>DANGER</strong></th>
<th>If the calculated Hazard/Risk Category of the equipment is greater than 4, BNL is defining this as “Hazard/Risk Category DANGEROUS”. This equipment shall not be operated or work performed on while energized. The equipment has to be de-energized at an upstream disconnect to operate or remove covers.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO NOT REMOVE COVER OR OPERATE BREAKERS/SWITCHES WHILE ENERGIZED</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DANGER</strong></td>
<td>If the electrical equipment does not meet the Working Space requirements of National Electrical Code Section 110.26 or 110.34, BNL is not allowing removal of covers while energized. This label may be on equipment that also has the calculated hazard/risk category WARNING label below, but the haz/risk category can only be used for operating the equipment while energized not for removal of covers.</td>
</tr>
<tr>
<td><strong>REMOVAL OF COVER FOR EXAMINATION, ADJUSTMENT, SERVICING, OR MAINTENANCE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>REQUIRES LOCKOUT/TAGOUT OF SUPPLY DUE TO WORKING SPACE LIMITATIONS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>WARNING</strong></td>
<td>After BNL completes the arc flash hazard analysis calculations this label will be installed on the equipment with the calculated Hazard/Risk Category. Also listed are the arc flash boundary and the minimum PPE to work on the equipment energized. If the cover is in good shape with all the mounting hardware installed, the circuit breakers or switches may be operated using the “minus 1” rule for PPE only if the equipment is less than haz/risk cat 4.</td>
</tr>
<tr>
<td><strong>ARC FLASH HAZARD</strong></td>
<td></td>
</tr>
<tr>
<td><strong>HAZARD/RISK CATEGORY 0+</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1.2 Cal/cm²</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Arc Flash Boundary &gt; 4 Feet</strong></td>
<td></td>
</tr>
<tr>
<td><strong>REQUIRED PERSONAL PROTECTIVE EQUIPMENT</strong></td>
<td></td>
</tr>
<tr>
<td><strong>NON-MELTING LONG SLEEVE SHIRT &amp; PANTS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>LEATHER GLOVES</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SAFETY GLASSES</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Calculation No.</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Archived Labels That Are Acceptable

<table>
<thead>
<tr>
<th><strong>WARNING</strong></th>
<th>This label (or similar) was installed by the manufacturer or by BNL on legacy equipment. This is a generic label that does not tell workers the magnitude of the arc flash nor does it list the protective equipment required to operate or work on the equipment. If this is the only label on equipment that is rated greater than 208 volts/225 Amps you must contact F&amp;O or your electrical supervisor for the calculated Haz/Risk Cat.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arc Flash and Shock Hazard.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Do not operate disconnect switch or remove any cover without appropriate PPE.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Refer to BNL SIMS for PPE requirements.</strong></td>
<td></td>
</tr>
</tbody>
</table>

This label was used to tell operators and electricians that the maximum energy in the equipment will not sustain an arc flash. There is still a hazard of burning your hands and receiving a shock, but an arc flash that might cause a second-degree burn to the body or face can not happen. The last line is missing and should say “Hazard/Risk Category 1.”

<table>
<thead>
<tr>
<th><img src="image" alt="DANGER" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQUIPMENT HAS BEEN EVALUATED FOR ARC-FLASH</strong></td>
</tr>
<tr>
<td><strong>FED FROM 30VA OR LESS TRANSFORMER</strong></td>
</tr>
<tr>
<td><strong>PPE REQUIRED TO THROW CIRCUIT BREAKERS</strong></td>
</tr>
<tr>
<td><strong>SAFETY GLASSES</strong></td>
</tr>
<tr>
<td><strong>ALL WORK WITH COVERS OFF.</strong></td>
</tr>
</tbody>
</table>

If the calculated Hazard/Risk Category is greater than 4, BNL is defining this as “Hazard/Risk Category DANGEROUS”. This equipment shall not be operated or work performed on while energized. This label and the one below will be replaced by the Danger label in the above table.

<table>
<thead>
<tr>
<th><img src="image" alt="DANGER" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARC FLASH HAZARD</strong></td>
</tr>
<tr>
<td><strong>HAZARD/RISK CATEGORY</strong></td>
</tr>
<tr>
<td><strong>DANGEROUS</strong></td>
</tr>
<tr>
<td><strong>ENERGIZED WORK PROHIBITED</strong></td>
</tr>
</tbody>
</table>

This label is used to prohibit operation of the circuit breakers or switches while the equipment is energized. This label may be used with WARNING labels or used with the above DANGER label.

<table>
<thead>
<tr>
<th><img src="image" alt="DANGER" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO NOT OPERATE</strong></td>
</tr>
</tbody>
</table>

Equipment discovered during the arc flash analysis not rated for the calculated short circuit current will have this label attached. This label will be replaced by the Danger label in the above table.

<table>
<thead>
<tr>
<th><img src="image" alt="DANGER" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQUIPMENT OVERDUTIED</strong></td>
</tr>
<tr>
<td><strong>DO NOT REMOVE COVER OR OPERATE BREAKERS/SWITCHES WHILE ENERGIZED</strong></td>
</tr>
</tbody>
</table>

| Calculation No. |
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Electrical Panel/Disconnect Labeling Program

Effective Date: Feb 29, 2016

The Electrical Panel/Disconnect Labeling Program is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Electrical Panel/Disconnect Labeling Program
Typical Field Layout Drawing

Typical-Disconnect

097-SW-1
Fed From 097-PP-1
Feed to Sump Pump 1
Arc Flash

Typical- Electrical Panel

097-LP-1
Fed From 097-PP-1
Arc Flash

Panel Index

1___ 2___
3___ 4___
5___ 6___
7___ 8___
9___ 10___
11___ 12___

Panel Index affixed to inside of Door.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Electrical Safe Work Practices

Effective Date: Feb 29, 2016

The exhibit Electrical Safe Work Practices is provided as a Word file.

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Before using a printed copy, verify that it is the most current version by checking the effective date.
Electrical Safe Work Practices

Electricity is inherently dangerous and must be treated with respect:
• Always anticipate failure and protect yourself by
  o Unplugging equipment before working on it;
  o Never using flammable materials near electrical equipment that is capable of igniting them;
  o Always turning your face away when operating circuit breakers or disconnect switches;
  o Always being alert when working with electrical equipment, especially in work situations where unexpected electrical hazards might exist.
• Never plug or unplug electrical connectors with wet hands.
• Keep fingers away from terminals when plugging or unplugging connectors (there have been problems with the new telephone chargers that the contacts move).
• Cord and plug equipment must be visually inspected prior to use for external defects, such as
  • Loose parts;
  • Deformed or missing pins (especially ground pin);
  • Evidence of possible internal damage (such as pinched or crushed outer jacket);
  • Tears or dry rot in outer jacket.
(Excepti0n: Equipment and extension cords that remain connected and are not subject to damage are not required to be re-inspected until they are relocated).
• Cords and extension cords shall not be fastened with staples or hung in such a fashion to damage outer jacket.
• Flexible cords shall not be used to raise or lower equipment.
• GFCIs shall be used outside or in wet or damp locations.
• GFCIs must be tested per manufacturer’s requirements (usually monthly).
• Prior to performing work, always de-energize electrical equipment.
• Never put conductive material near live parts (knife in a toaster).

Light and power panel circuit breakers (20 A) are allowed to be reset only once after tripping if you know why the breaker tripped (used toaster while microwave on and breaker tripped). Otherwise, call Plant Engineering to evaluate. You can only operate circuit breakers and disconnect switches if you are trained.

Per the NEC, all electrical equipment (including equipment designed for plug-in operation, cable tray and associated components, electrical distribution equipment, etc.) shall not be installed, modified, or put into service without first being accepted by the Authority Having Jurisdiction.
A reputable manufacturer must meet the following criteria:

- The manufacturer has a North American office/distributor (e.g., Thomas Register®)
- The manufacturer services their products and can provide technical support.
- The manufacturer provides adequate documentation (acceptable to the LESC-approved Electrical Equipment Inspection [EEI] Inspector).
- One piece of unlisted electrical equipment from the manufacturer has been examined and approved by an LESC-approved Electrical Equipment Inspection (EEI) Inspector. Field Evaluation should be done according to the requirements for in-house built/modified equipment.

**Note:** Manufacturers meeting these criteria are not considered reputable when the manufacturer no longer exists. The age of equipment should be considered when determining the level of field examination with equipment made by a reputable manufacturer.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Selection and Use of Rubber Gloves and Insulating Blankets

Effective Date: Feb 29, 2016

The exhibit Selection and Use of Rubber Gloves and Insulating Blankets is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Selection and Use of Rubber Gloves and Insulating Blankets

Rubber gloves are marked on the cuff area with their service class as follows:

<table>
<thead>
<tr>
<th>Class of Equipment</th>
<th>Proof-Test Voltage (rms)</th>
<th>Maximum Use Voltage (rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>0</td>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>1</td>
<td>10,000</td>
<td>7,500</td>
</tr>
<tr>
<td>2</td>
<td>20,000</td>
<td>17,000</td>
</tr>
<tr>
<td>3</td>
<td>30,000</td>
<td>26,000</td>
</tr>
<tr>
<td>4</td>
<td>40,000</td>
<td>36,000</td>
</tr>
<tr>
<td>Type I</td>
<td></td>
<td>non-ozone-resistant</td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td>ozone-resistant</td>
</tr>
</tbody>
</table>

Rubber insulating gloves are particularly sensitive to physical damage. Insulating equipment must be inspected for damage before each day's use and immediately following any incident that might be suspected of having caused damage. Insulating gloves must be given an air test, along with the inspection. Insulating equipment with any of the following defects may not be used:

- A hole, tear, puncture, or cut;
- Ozone cutting or ozone checking (the cutting action produced by ozone on rubber under mechanical stress into a series of interlacing cracks);
- An embedded foreign object;
- Any of the following texture changes: swelling, softening, hardening, or becoming sticky or inelastic.
- Any other defect that damages the insulating properties.

Rubber gloves and other rubber insulating materials must be used within the manufacturer’s time recommendations. Rubber insulating gloves must be electrically tested before they are first issued, and every 6 months thereafter. If the gloves were tested but not issued for service, they must have been tested within the previous 12 months.

Rubber gloves and insulating material must be maintained and stored as per the manufacturer’s requirements.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Task-based Electrical Safety Training Requirements

Effective Date: Feb 29, 2016

Task-based Electrical Safety Training Requirements is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
## Task-based Electrical Safety Training Requirements

<table>
<thead>
<tr>
<th>Task</th>
<th>Electrical Safety Training Course</th>
<th>CPR (ADULT CPR/AED)</th>
<th>LOTO with Electrical JPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical energized work at or above 50 volts that requires a specific electrical energized work permit</td>
<td>Electrical Safety I (TQ-ELECSAF1)</td>
<td>Needed</td>
<td>LOTO Authorized per JTA: GE-68B LOTO Authorized Employee</td>
</tr>
<tr>
<td>Testing, Troubleshooting and Voltage Measuring on circuits at or above 50 volts</td>
<td>Electrical Safety I (TQ-ELECSAF1)</td>
<td>Needed</td>
<td>LOTO Authorized per JTA: GE-68B LOTO Authorized Employee</td>
</tr>
<tr>
<td>Tasks in vicinity of electrical utilities where it has been determined through work planning that the task does not require an Electrical Energized Work Permit$^{1,2}$</td>
<td>Not Needed</td>
<td>Not needed</td>
<td>Not needed$^{3}$</td>
</tr>
<tr>
<td>Electrical work on cord and plug benchtop equipment 50 volts to 120 volts with cord unplugged and plug in exclusive control of worker</td>
<td>Electrical Safety for Benchtop Workers (TQ-ELECT-BENCHTOP) or Electrical Safety I (TQ-ELECSAF1)</td>
<td>Not needed</td>
<td>Not needed$^{3}$</td>
</tr>
<tr>
<td>Electrical work on cord and plug benchtop equipment 50 volts to 120 volts using TTVM or specific Electrical Energized Work permit</td>
<td>Electrical Safety for Benchtop Workers (TQ-ELECT-BENCHTOP) or Electrical Safety I (TQ-ELECSAF1)</td>
<td>Needed</td>
<td>LOTO Authorized per JTA: GE-68B LOTO Authorized Employee</td>
</tr>
<tr>
<td>Electrical Circuit Breaker/Switch operation less than or equal to 250 Volts and rated less than or equal to 225 A</td>
<td>Electrical Circuit Breaker/Switch Operation Safety (TQ-ELECT-BSOP) or Electrical Safety I (TQ-ELECSAF1)</td>
<td>Not needed</td>
<td>Not needed$^{3}$</td>
</tr>
<tr>
<td>Electrical Circuit Breaker/Switch operation greater than 250 volts</td>
<td>Electrical Safety I (TQ-ELECSAF1)</td>
<td>Not needed</td>
<td>Not needed$^{3}$</td>
</tr>
<tr>
<td>Aggressive Penetration of Concrete and Masonry</td>
<td>Electrical Safety for Shock Hazard (TQ-ESHOCK) or Electrical Safety I (TQ-ELECSAF1)</td>
<td>Not needed provided a second person who has unobstructed sight of the worker, is within 50 feet of the worker and; trained in CPR, methods of release and the use of an AED and emergency first aid procedures.</td>
<td>LOTO Authorized per JTA: GE-68B LOTO Authorized Employee</td>
</tr>
<tr>
<td>Electrical Welding with welding Open Circuit Voltages (OCV) at or above 50 volts</td>
<td>Electrical Safety for Welders (TQ-EWELD) or Electrical Safety I (TQ-ELECSAF1)</td>
<td>Needed</td>
<td>Not needed$^{3}$</td>
</tr>
</tbody>
</table>

1. Extra care must be taken in work planning briefings and oversight to keep unqualified workers safe.
2. An Electrical Energized work permit is either a TTVM or specific permit.
3. Lockout/Tagout (LOTO) training is needed if LOTO is being implemented as required by the Lockout/Tagout (LOTO) for Installation, Demolition, or Service and Maintenance Subject Area.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

Topics to be Covered During Departmental Job-Specific Training

Effective Date: Feb 29, 2016

The exhibit Topics to be Covered During Departmental Job-Specific Training is provided as a Word file.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
Topics to be Covered During Departmental Job-Specific Training

Authorizations and Limitations
1. Describe equipment authorized to work on;
2. Describe tasks permitted without consulting supervision;
3. Describe actions and/or equipment to be avoided.

Equipment
1. General hazards associated with this equipment;
2. Specific and unique hazards of this equipment;
3. Location of documentation for equipment;
4. Location of lockout/tagout devices;
5. Specific approach distances and personal protective equipment (PPE) for this equipment;
6. Acceptable parts replacement without need to re-evaluate safety and performance.

Work Tools and Techniques
1. Review safe and proper use of standard test equipment;
2. Review safe and proper use of special and unique test equipment;
3. ISM requirement to provide feedback on work with equipment;
4. Desirability of suggestions to modify equipment for improved worker safety.

Before Each Job
1. How to conduct an effective pre-job review;
2. Extent of pre-job review required depending on work tasks and hazards;
3. Common work factors to be included in each pre-job review;
4. Review errors that may have occurred on group equipment, and lessons learned.

Personal Protective Equipment (PPE)
1. Discuss proper testing and use of PPE;
2. Explain limitations of PPE.

Energized Electrical Work Permit
1. Review generic permits, purpose, and limitations;
2. Review requirements for specific permits;
3. Discuss PPE required for each permit.
The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
**Work Distance Table (Control Zones)**

<table>
<thead>
<tr>
<th>Training Requirements</th>
<th>Nominal System Voltage Range Phase-to-Phase – greater than 10 joules</th>
<th>Authorized Personnel ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited Approach Boundary</td>
<td>Restricted Approach Boundary</td>
</tr>
<tr>
<td></td>
<td>Exposed Movable Conductor(s) (Overhead lines)</td>
<td>Exposed Fixed Circuit Part(s)</td>
</tr>
<tr>
<td>Less than 50 V</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>50 V to 300 V</td>
<td>10'-0&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>301 V to 750 V</td>
<td>10'-0&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>751 V to 15 kV</td>
<td>10'-0&quot;</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>15.1 kV to 36 kV</td>
<td>10'-0&quot;</td>
<td>6'-0&quot;</td>
</tr>
<tr>
<td>36.1 kV to 46 kV</td>
<td>10'-0&quot;</td>
<td>8'-0&quot;</td>
</tr>
<tr>
<td>46.1 kV to 72.5 kV</td>
<td>10'-0&quot;</td>
<td>8'-0&quot;</td>
</tr>
</tbody>
</table>

Clearances required by OSHA for construction projects may be greater than stated above, as per 29 CFR 1926.416(g)(2)(i, ii). Consult the Laboratory Electrical Safety Officer for required clearances for construction activities in areas containing high voltages, or for voltages greater than those listed above.

Clearances as stated above are required for work on or adjacent to live sources capable of either fault currents greater than 10 mA or instantaneous release greater than 10 J.
Management System: Worker Safety and Health

Subject Area: Electrical Safety

**Electrical Equipment Inspection Forms**

Effective Date: Sep 26, 2017

The Electrical Equipment Inspection Forms are to be used only by LESC-approved Electrical Equipment Inspectors. They are provided as fillable Word files:

- In-house Built Non-NRTL/Modified NRTL-Listed Electrical Equipment
- Facility Unlisted Electrical Equipment
- Unlisted Non-Facility Electrical Equipment

For further information, please contact Eugene Santiago at esantiago@bnl.gov or extension 8326.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.

Questions/Comments  Disclaimer
## In-house Built Non-NRTL/Modified NRTL-Listed Electrical Equipment

<table>
<thead>
<tr>
<th>Department:</th>
<th>EEI Barcode:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsible Person:</td>
<td>Group:</td>
</tr>
<tr>
<td>Building:</td>
<td>Requestor:</td>
</tr>
<tr>
<td>Manufacturer:</td>
<td>Location:</td>
</tr>
<tr>
<td>Equipment Name:</td>
<td>Model #:</td>
</tr>
</tbody>
</table>

Operating Environment: [ ] Indoor/dry [ ] Outdoor/wet/damp [ ] Hazardous Locations (Flammable/Explosive)

### External Inspection

1. No evidence of hazard to operator [ ] Yes [ ] No [ ] N/A
2. Not damaged [ ] Yes [ ] No [ ] N/A
3. Appropriate material [ ] Yes [ ] No [ ] N/A
4. Protects contents from operating environment [ ] Yes [ ] No [ ] N/A

### Power Source – Cords and Plugs:

1. Proper voltage and current rating for plug and cord [ ] Yes [ ] No [ ] N/A
2. Grounding conductor included if required [ ] Yes [ ] No [ ] N/A
3. Not frayed or damaged [ ] Yes [ ] No [ ] N/A
4. Proper wiring of plug (Visual inspection required on field installed plugs.) [ ] Yes [ ] No [ ] N/A
5. Strain relief on cord [ ] Yes [ ] No [ ] N/A

### Power Source – Direct wired into facility covered

1. Proper voltage and current rating for wiring method [ ] Yes [ ] No [ ] N/A
2. Suitable for permanent installation by a qualified person [ ] Yes [ ] No [ ] N/A
3. Proper loading and overcurrent protection in branch circuit [ ] Yes [ ] No [ ] N/A

### Grounding

1. Is an equipment grounding conductor included in the circuit [ ] Yes [ ] No [ ] N/A
2. Is the equipment grounding conductor properly terminated [ ] Yes [ ] No [ ] N/A
3. Are all non-current carrying exposed metal surfaces properly bonded [ ] Yes [ ] No [ ] N/A

### Foreign power supplies and equipment

1. The connection to facility power is made with appropriate adapters [ ] Yes [ ] No [ ] N/A
2. Correct wire ampacity for use in the United States [ ] Yes [ ] No [ ] N/A
3. Is the voltage, frequency, and phasing correct for application [ ] Yes [ ] No [ ] N/A

### Marking Requirements

1. Is equipment marked with potential hazards (stored energy, open buss, etc.) [ ] Yes [ ] No [ ] N/A
2. Is the voltage, Current, and frequency properly marked on equipment [ ] Yes [ ] No [ ] N/A
3. Is the make, model, and drawing number included [ ] Yes [ ] No [ ] N/A
4. Is supporting document adequate [ ] Yes [ ] No [ ] N/A

### Internal Inspection

1. Is the Polarity correct [ ] Yes [ ] No [ ] N/A
2. Is the phasing correct [ ] Yes [ ] No [ ] N/A
3. Is the equipment grounding conductor properly attached [ ] Yes [ ] No [ ] N/A
4. If different voltages are being used, is the separation adequate [ ] Yes [ ] No [ ] N/A
5. Are the wiring terminals the correct size for the conductors [ ] Yes [ ] No [ ] N/A
6. Is the wire sized adequately for the load [ ] Yes [ ] No [ ] N/A
7. Clearance/Creepage distances for high voltage equipment adequate [ ] Yes [ ] No [ ] N/A
8. Are all conductors being used listed by an NRTL [ ] Yes [ ] No [ ] N/A
9. Are all cables installed in neat workman like manner [ ] Yes [ ] No [ ] N/A
10. Are all conductors protected from any sharp edges [ ] Yes [ ] No [ ] N/A
11. If equipment generates heat does it have sufficient room for air circulation and/or cooling [ ] Yes [ ] No [ ] N/A
12. Does equipment have an automatic discharge for any stored energy (capacitor) [ ] Yes [ ] No [ ] N/A
### Test performed
13. Actual ohm’s reading during test

14. If field plug is installed are the wires properly phased and tightened  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
</table>

### Inspection Decision

<table>
<thead>
<tr>
<th>Inspection Date:</th>
<th>Inspector:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quantity:</th>
<th>Single</th>
<th>Multiple</th>
<th>Additional EEI Barcode #s for uninspected similar equipment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

☐ This equipment is **APPROVED** for installation and use at BNL. IF THIS EQUIPMENT IS MODIFIED, DAMAGED OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS APPROVAL IS VOID PENDING REEXAMINATION.

☐ This equipment is **REJECTED** for installation and use at BNL.

☐ This equipment is **CONDITIONALLY APPROVED** for installation and use at BNL as follows:

<table>
<thead>
<tr>
<th>Conditional Requirements:</th>
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This equipment is **APPROVED** for installation and use at BNL. IF THIS EQUIPMENT IS MODIFIED, DAMAGED OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS APPROVAL IS VOID PENDING REEXAMINATION.

This equipment is **REJECTED** for installation and use at BNL.

This equipment is **CONDITIONALLY APPROVED** for installation and use at BNL as follows:
### Facility Unlisted Electrical Equipment

**EEI Barcode:**

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<tr>
<th>Department:</th>
<th>Group:</th>
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<tbody>
<tr>
<td>Responsible Person:</td>
<td>Requestor:</td>
</tr>
<tr>
<td>Building:</td>
<td>Location:</td>
</tr>
<tr>
<td>Manufacturer:</td>
<td>Model #:</td>
</tr>
<tr>
<td>Equipment Name:</td>
<td>Function:</td>
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</tbody>
</table>

Operating Environment: □ Indoor/dry  □ Outdoor/wet/damp  □ Hazardous Locations (Flammable/Explosive)

#### Inspection Questions

1. Suitable for permanent installation by a qualified person. [ ] Yes  [ ] No  [ ] N/A
2. Mechanical strength and durability. [ ] Yes  [ ] No  [ ] N/A
3. Wire bending and connection space. [ ] Yes  [ ] No  [ ] N/A
4. Electrical insulation. [ ] Yes  [ ] No  [ ] N/A
5. Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service. [ ] Yes  [ ] No  [ ] N/A
6. Classification by type, size, voltage, current capacity, and specific use. [ ] Yes  [ ] No  [ ] N/A
7. Equipment sufficiently enclosed to prevent accidental contact with energized parts. [ ] Yes  [ ] No  [ ] N/A
8. Exposed metal parts bonded and grounded. [ ] Yes  [ ] No  [ ] N/A
9. Overcurrent protection appropriate for intended use. [ ] Yes  [ ] No  [ ] N/A

#### Inspection Decision

**Inspection Date:**
**Inspector:**
**Comments:**

**Quantity:** □ Single  □ Multiple  
Additional EEI Barcode #s for uninspected similar equipment:

☐ This equipment is **APPROVED** for installation and use at BNL. IF THIS EQUIPMENT IS MODIFIED, DAMAGED OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS APPROVAL IS VOID PENDING REEXAMINATION.

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**Conditional Requirements:**

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# Unlisted Non-Facility Electrical Equipment

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<td>[ ] Indoor/dry [ ] Outdoor/wet/damp [ ] Hazardous Locations (Flammable/Explosive)</td>
</tr>
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</table>

## Inspection Questions

1. The case is grounded through the power cord to the grounding pin on the plug.  
   - Yes  
   - No  
   - N/A

2. The plug is polarized, if necessary.  
   - Yes  
   - No  
   - N/A

3. Field installed plugs are visually inspected.  
   - Yes  
   - No  
   - N/A

4. Equipment sufficiently enclosed to prevent accidental contact with energized parts.  
   - Yes  
   - No  
   - N/A

5. Exposed metal parts bonded and grounded.  
   - Yes  
   - No  
   - N/A

6. Overcurrent protection appropriate for intended use.  
   - Yes  
   - No  
   - N/A

7. The equipment input voltage and frequency match those of the building's electrical system.  
   - Yes  
   - No  
   - N/A

8. The equipment construction is suitable for the intended operating environment.  
   - Yes  
   - No  
   - N/A

9. The equipment is in its original, unmodified and undamaged condition.  
   - Yes  
   - No  
   - N/A

## Inspection Decision

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Electrical Work Permits with Instructions

Effective Date: Feb 29, 2016

A. Description and Use of Permits

1. Description of Permits

There are two permits used to demonstrate that deenergizing the equipment introduces additional hazards or is infeasible due to design or operational limitations. Both permits describe the circuit and equipment to be worked on, justification for energized work, safe work practices, shock hazard analysis and protection boundary, flash hazard analysis and protection boundary, personal protective equipment (PPE) required, means employed to restrict access to unqualified persons, evidence of pre-job briefing and any post job feedback, and approving signatures. The Energized Electrical Work Permit is to be used when live parts cannot be placed in an electrically safe condition to perform the work. The Testing, Troubleshooting, and Voltage Measuring (TTVM) Electrical Work Permit, or approved equivalent procedure, is to be used for testing, troubleshooting, voltage measuring, and related tasks that are exempt from an electrical work permit in NFPA 70E, but require safe work practices and PPE. The TTVM may only be used for work under 600 V.

2. Use of Permits

All work on or near energized conductors requires a permit, which must include the following information:

Part I - to be filled out by the requestor for the electrical work permit

1. Description of the Location and Circuit.
2. Description of the task.
3. Justification of why the task must be done working on or near live parts.
4. The Start Date and Time and the Estimated Finish Date and Time for the job. On TTVM electrical work permits, it may be for a reasonable time span up to a maximum of a year.

Part II - to be filled out by the worker or supervisor/designee
1. Detailed job description. On the Energized Electrical Work Permit, the hazards of the job are to be identified, such as:
   i. Electrical conditions: massive ground(s) adjacent to the work, live input or output terminals;
   ii. Mechanical conditions: rotating equipment, pinch points or shear hazards of the equipment or adjacent equipment that may need to be locked out.
   iii. Environmental Conditions: flammable vapors, combustible, toxic vapors, or other physical or biological hazards.
   iv. Working space constraints: spaces in front of electrical boxes not meeting standards, energized circuits or parts behind the employee, or irregular working surface.
   v. Obstructions in the area: obstructions that make emergency escape difficult and obstructions to the work.
   vi. Other energized circuits or parts: other energized circuits close by that may have different voltage, different phase, or require different lockout locations to de-energize.

2. Procedures of the task are to be reviewed to ensure that proper precautions have been included, such as:
   . Warnings specified: before a step involving a particular hazard, define it in unique clear type.
     i. Caution notes: are used to warn employee of actions that may damage equipment.
     ii. Warning notes: are used to warn employee of actions that may cause severe injury or death.

3. The shock and arc-flash hazard and boundaries.
4. Personal Protective Equipment required.
5. Clearance Zone and means to restrict unqualified personnel if required.
6. The Authorized Worker signs and includes their life number in the space provided only on the Energized Electrical Work Permit.

**Part III**

1. The supervisor is to verify that the employee has current generic and also task-specific training. Those not trained are not to be allowed to undertake the work.
2. Signature of supervisor of the employee: the supervisor must review the job before dispatching the employee, according to departmental procedures. The supervisor is responsible for the job being performed safely.

*For voltages above 600 Vac or 6000 Vdc, the following must be performed:*
a. Independent Review of High-Hazard tasks ensures that the hazards have not been overlooked. The person who conducted the review signs in the space provided.

b. Job Safety Analysis completed or equivalent review is required for periodic high-hazard tasks. The hazards and the necessary controls are to be identified for each step of the task.

c. Employee briefing before the task: specific instructions or training may be required to clarify particular hazards for the workers. Warnings are to be pointed out and clarified when questions arise during briefing.

d. Approval to proceed: signature of the Department Chair/Division Manager or designee is required.

**Part IV**

Include evidence of completion of the Job Briefing, which may be the signature of the person performing the briefing, or the initials of the Authorized Worker verifying he reviewed for any job-related hazards.

**Part V**

For the Energized Electrical Work Permit, provide post-work feedback, if required. The worker initials the permit at job completion, and notes any feedback.

For the TTVM Electrical Work Permit, provide the signatures and life numbers of all the Authorized Workers allowed to perform the tasks associated with this specific permit.

*A copy of the permit* is to be kept by workers at the work site. A copy is to be sent to the facility's ES&H Coordinator and another copy to the Safety and Health Services Division Representative.

**B. Review and Issuance of Permit**

1. The supervisor obtains the permit and reviews the background information of the job or task, the hazards and the precautions to be taken, and the distance for the clearance zone(s).

2. The supervisor verifies that the employee has the necessary current training for this type of task.

3. After discussing the procedure and job with the worker, the supervisor and the worker sign the permit.

4. The signature of the Department Chair/Division Manager or formal designee is required to assure that the energized circuit work is appropriate.

5. For voltages above 600 Vac, or 6000 Vdc, an independent review must be conducted. The independent review must include the following:
i. The itemized procedural steps for the job or task.

ii. A Job Safety Analysis or equivalent review to identify the hazards and their controls for each job step.

iii. Signature of the independent reviewer(s) indicating that the controls for the job or task are adequate to protect the employee.

6. Copies should be sent to the facility ES&H Coordinator, or retained in accordance with the policy of the organization.

The only official copy of this file is the one on-line in SBMS.

Before using a printed copy, verify that it is the most current version by checking the effective date.
**PART I: TO BE COMPLETED BY THE REQUESTER:**

1. **Description of circuit/equipment/job location:**
   ________________________________________________________________
   __________________________________________________________________

2. **Description of work to be done:**
   _______________________________________________________________________________

3. **Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:**
   _______________________________________________________________________________

   **Start Date:**______________     **Expire Date:** ______________

   **Requester/Title**
   ____________________________ ____________________________

**PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THE WORK:**

1. **Detailed job description procedure to be used in performing the above detailed work including hazards, conditions, mechanical, environmental, space obstructions, other voltages:**
   _______________________________________________________________________________
   _______________________________________________________________________________

2. **Description of the Safe Work Practices:**
   - LOTO
   - Two Workers
   - Safety Watch
   - Notify affected workers
   - Reason not to LOTO
   - Restart Checks Required: ___________________________________________________

3. **Flash Hazard (-1 to 4) | Shock Hazard (max. V) | Working Distance**

   | Flash Boundary | Limited Approach | Glove Class, minimum |
   | Incident Energy (cal/cm²) | Restricted Approach | Prohibited Approach |

4. **Protective Equipment**

   - Natural Fiber Clothing
   - Safety Glasses/Goggles
   - Ear Plugs
   - Leather Shoes
   - FR Clothing
   - Face Shield
   - Leather Gloves
   - Voltage-rated Shoes
   - Voltage-rated Tools
   - Balaclava Hood
   - Voltage-rated Gloves
   - Hard Hat
   - Category III Meter
   - 2 Layer Switching Hood
   - Flashsuit
   - Voltage-rated Gloves
   - Other
   - Other

5. **Means employed to restrict the access of unqualified persons from the work area:**
   ________________________________________________________________

6. **Authorized Workers | Life # | Authorized Workers | Life #**

   ____________________________________ ____________________________
   ____________________________________ ____________________________
   ____________________________________ ____________________________
   ____________________________________ ____________________________

**PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:**

   **Department Chair/Division Manager/Designee**
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________

   **Electrically Knowledgeable Person/Engineer**
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________

   **Independent Reviewer (Range D only)**
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________

**PART IV: WORK**

   Evidence of completion of Job Briefing including discussion of any job-related hazards:
   _______________________________________________________________________________
   _______________________________________________________________________________

**PART V: POST WORK-FEEDBACK**

   **(Worker Initials)**
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________

   **Safety Manager/Representative**
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____________________________ ____________________________

   **Close-out Date**
   ____________________________ ____________________________
   ____________________________ ____________________________

Return to: ES&H Coordinator,
PART I: TO BE COMPLETED BY THE REQUESTER:

(1) Description of circuit/equipment/job location: _________________________________________________________________
____________________________________________________________________________________________________

(2) Description of work to be done: ___________________________________________________________________________
____________________________________________________________________________________________________

(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:
____________________________________________________________________________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

Requester/Title: ____________________________ Date: __________________

PART II: HAZARD ANALYSIS:

(1) Detailed job description procedure to be used in performing the above detailed work: __________________________________
____________________________________________________________________________________________________
____________________________________________________________________________________________________

(2) Description of the Safe Work Practices to be employed: ☐ LOTO ☐ Reason not to LOTO
____________________________________________________________________________________________________

(3) | Flash Boundary | Flash Hazard | Working Distance |
    |                |              |                 |
    | Shock Hazard  | Limited Approach | Restricted Approach | Prohibited Approach | Glove Class |

(4) Protective Equipment
☐ None
☐ Earplugs ☐ Leather Gloves ☐ Leather Shoes
☐ Cotton Clothing ☐ Face shield ☐ Voltage-rated Gloves ☐ Voltage-rated Shoes
☐ FR Clothing ☐ Flash suit ☐ Hard Hat ☐ Safety Glasses/Goggles
____________________________________________________________________________________________________

(5) Means employed to restrict the access of unqualified persons from the work area: __________________________________
____________________________________________________________________________________________________

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

Group Leader/Supervisor: ____________________________ Date: __________________

Electrically Knowledgeable Person/Lead Engineer: ____________________________ Date: __________________

Department Chair/Division Manager/Designee: ____________________________ Date: __________________

PART IV: WORK
Evidence of completion of Job Briefing including discussion of any job-related hazards:
Daily pre-work briefing
Post work feedback, if required

PART V: AUTHORIZED WORKERS:

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<th>Name</th>
<th>Life #</th>
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Authorizing Supervisor: ____________________________ Date: __________________

Supervisor acknowledges the above personnel are properly trained, knowledgeable and experienced to work under the permit. Forward a copy to group's safety department.