MARQUETTE UNIVERSITY
ELECTRICAL SAFE WORK PRACTICES

PURPOSE
The purpose of this procedure is to protect all workers from injuries resulting from exposure to arc flash, arc blast and electrical shock and to comply with NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces – 2004 Edition and Federal OSHA CFR 1910.300 series Subpart S-Electrical and 1926.400 series - Subpart K-Electrical.

IMPACT
No University employees or contractors engaged by Marquette University are permitted to work on energized equipment unless:

- They are authorized employees.
- They have been trained.
- They are attired and equipped appropriately.

RESPONSIBILITIES
Authorized Employees: Authorized employees and employees of approved electrical contractors are the only individuals qualified to work on electrical equipment on behalf of Marquette University. An authorized employee is a qualified employee who has also completed Marquette University’s 70E Electrical Safety Training Program.

Authorized employees are:
- Responsible for stopping work immediately and notifying the Maintenance Coordinator if he/she is unsure of ability, scope of work or pending safety issue, at any time in the work day;
- Responsible for reporting all unsafe acts or conditions to their immediate supervisor;
- Responsible for inspecting and wearing required personal protective equipment.

Maintenance Coordinator: The Maintenance Coordinator is responsible for determining the feasibility of de-energization depending upon the situation. When de-energization is not feasible, the Maintenance Coordinator must:
- Pre-plan the task and complete an energized electrical work permit;
- Select the most “qualified” individual(s) to perform the task;
- Provide the appropriate personal protective equipment (PPE);
- Follow up to ensure that the PPE is worn and the task pre-plan is executed properly;
- Maintain completed permits on file.

Operations Manager: The Operations Manager is responsible for reviewing completed energized work permits to ensure that work practices are compliant with Marquette’s electrical safety program.
SAFE WORK PRACTICES

Marquette University’s policy is to avoid energized work whenever possible. Appropriate planning and coordination shall be completed to ensure that systems are de-energized.

University employees are permitted to:
- Work in panels (Hazard Class 0 – 2*);
- Change ballasts;
- Install receptacles, outlets, tubes, bulbs and switches;
- Troubleshoot disconnects, starters, contactors and/or similar electrical components.

Marquette personnel are not permitted to:
- Work on electrical systems operating at greater than 600 volts;
- Engage in any activity that is rated higher than Hazard Class 2* (per 70E);
- Work in motor control centers (MCC’s), switchgear and other high voltage equipment (energized or de-energized).

When circumstances mandate that a system must remain energized, the Maintenance Coordinators shall take appropriate action to comply with the requirements of working on energized electrical equipment.

**Lockout/Tagout:** The first consideration is always to de-energize and lockout/tagout, and ground where appropriate, prior to work. Identify all energy sources and apply lockout and tagout devices to all energy isolating devices to provide an electrically safe work condition. Refer to Marquette University’s Lockout/Tagout policy for these requirements. Energy sources may include but are not limited to; electrical, batteries, capacitance, mechanical, hydraulic, air, chemical, and potential stored energy (springs, gravity).

Authorized employees must observe the following practices:
- **Left Hand Disconnect Rule:** Use the left hand rule when opening the disconnect. Stand to the side of equipment. Do not stand in front of it when opening the disconnect.
- **“Test Before Touch” – it could save your life.** Always verify that the equipment was locked out properly by testing for voltage using an adequately rated voltage tester. Wear appropriate personal protective equipment while voltage testing.

The vast majority of tasks should be completely de-energized. Careful planning enables the majority of the work to be completed while de-energized. When terminating or adding a circuit breaker, de-energize the panel and complete the task.

For occupied buildings, scheduling a shutdown is always the preferred method to eliminate the risk of injury and unplanned system outages.
OSHA's position regarding energized work is:
OSHA 1910.333(a)(1) requires that live parts be de-energized before a potentially exposed employee works on or near them. Exception- if de-energizing introduces additional or increased hazards or if de-energizing is infeasible due to equipment design or operational limitations. Examples are:

- Interruption of life support equipment
- Deactivation of emergency alarm systems
- Shutdown of hazardous location ventilation equipment
- Removal of illumination from an area
- Performing diagnostics and testing (e.g. start up and trouble shooting circuits that are part of a continuous process that would otherwise need to be completely shutdown in order to permit work on one circuit or piece of equipment.)

**Qualifications & Authorization:** Only “qualified “ employees are permitted to work on or near energized equipment. Qualified employees must be trained in electrical safe work practices by attending Marquette’s NFPA 70E seminar and they must be authorized by Marquette to perform the work.

The Maintenance Coordinator is responsible for selecting the appropriate “qualified” person for energized work activities based on the individual's experience and expertise. When an individual has been trained (i.e. qualified), it doesn’t mean they can automatically perform energized work activities without prior knowledge, input and approval from the Coordinator. The Maintenance Coordinator may determine that the employee is not the most qualified person for the job. Qualified individuals must also be authorized by the Maintenance Coordinator to perform energized work. It is anticipated that the vast majority of electrical work performed by Marquette personnel will be on equipment below 240 volts. Only designated, qualified personnel will be permitted to work on 240-600 volt circuits and these individuals will be identified by the Maintenance Coordinators.

No one shall perform work on or near energized conductors unless authorized by the Maintenance Coordinators.

**General Safe Work Practices:**

a) The Maintenance Coordinators will determine the number of personnel required to complete the task. The Maintenance Coordinator will determine if a standby person or emergency communication is required.

b) Marquette personnel shall not perform energized work on equipment for convenience or take unnecessary risks.

c) All authorized personnel shall be completely familiar with equipment layout and circuitry.

d) All parties involved shall know where and how to de-energize the source of power.

e) Conductive articles of jewelry and clothing, such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear or metal frame glasses, shall not be worn where they present an electrical contact hazard with exposed live parts.

f) When an employee’s alertness is impaired due to illness, fatigue or other reasons, the employee is prohibited from working in areas containing live parts.
g) Protective shields, protective barriers or insulating materials shall be used to protect employees from injury while working on or near exposed energized components/equipment.

h) Employees will not blindly reach into energized equipment.

i) Employees shall avoid working in any position from which a shock or slip will bring the body and/or tools into contact with exposed energized equipment.

j) Tasks that require handling large panel covers and dead fronts with dimensions of 20W x60H and larger will require two employees.

k) Employees will test for phase-to-phase and phase-to-ground potential before installing any circuit breaker bus switch into an energized or de-energized piece of equipment. Verify component voltage rating is compatible for use.

l) Non-conductive “fish” tape or pulling line will be used any time conductors are pulled into energized equipment.

m) Whenever raceways are added to energized equipment, all exposed bus and energized components shall be covered with an approved insulating material (such as voltage rated blanket), and shall be physically protected from shavings or dropped materials.

n) Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

o) It is necessary to determine whether there any possible back-feeds of the circuits.

p) Provide floor matting (insulated) where deemed necessary by the pre-plan.

q) Provide adequate lighting to perform task.

r) Clean up work area to eliminate all tripping hazards.

s) Cordon off the limited approach boundary or flash protection boundary. Ensure that all unqualified people do not enter this area. For systems that are 600 volts or less, the Flash Protection Boundary shall be 4 feet, based on the product clearing times of 6 cycles and the available bolted fault current of 50 kA.

t) Notify affected people of the work to be performed.

u) Treat neutrals and grounds with the same care as “hot” phase conductors. Serious accidents may result when neutrals or grounds are mishandled.

v) All energized work incidents (including near misses) must be reported to the Maintenance Coordinator to investigate possible causes and corrective action.
ELECTRICAL HAZARD ANALYSIS

When de-energizing is not feasible and work must be performed on or near energized conductors operating at 50 volts or more, an electrical hazard analysis must be completed. The electrical hazard analysis consists of a shock hazard analysis and a flash hazard analysis. These analyses shall be documented by using the Energized Electrical Work Permit form. Only qualified, authorized personnel will be permitted to work on or near live parts operating at 50 volts or more. Marquette University personnel are not authorized to perform work that exceeds a Hazard/Risk Category of 2* as defined by NFPA Hazard/Risk Category Classifications (130.7 (c)(9)(a)), under any circumstances.

When the Energized Electrical Work Permit can’t be completed because the task falls outside of the 70E tables, the task should be referred, by the Maintenance Coordinator, to an approved electrical contractor.

Flash Hazard Analysis

The flash hazard analysis is performed to evaluate the possibility of injury due to arc flash. The analysis determines the Flash Protection Boundary and the personal protective equipment that qualified employees working within the flash protection boundary shall use. Use the NFPA 70E table of Hazard Risk Category Classifications listed below for selecting the appropriate PPE. This table identifies tasks by hazard risk category (Class 0-2*) and when V-rated gloves and tools are required. For systems that are 600 volts or less, the Flash Protection Boundary shall be 4.0 ft., based on the product of clearing times of 6 cycles (0.1 second) and the available bolted fault current of 50 kA or any combination not exceeding 300 kA cycles (5000 ampere seconds).

<table>
<thead>
<tr>
<th>Task (Assumes Equipment is Energized, and Work is Performed Within the Flash Protection Boundary)</th>
<th>Hazard/Risk Category</th>
<th>V-Rated Gloves</th>
<th>V-Rated Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panelboards Rated 240V and Below – Notes 1 and 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit breaker (CB) or fused switch operation with covers on</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CB or fused switch operation with covers off</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
<td>1</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Remove/install CBs or fused switches</td>
<td>1</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Removal of bolted covers to expose bare, energized parts</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Opening hinged covers to expose bare, energized parts</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>Panelboards or Switchboards Rated &gt;240V and up to 600V (with molded or insulated case circuit breakers) – Notes 1 and 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB or fused switch operation with covers on</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CB or fused switch operation with covers off</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Notes:
1. 25 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
2. For <10 kA short circuit current available, the hazard/risk category may be reduced by one number.
3. V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
4. V-rated Tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done.
5. 2* means that a double layer switching hood (or equivalent) and hearing protection are required for this task in addition the other 2 requirements.
Shock Hazard Analysis
The shock hazard analysis determines the voltage to which personnel will be exposed, boundary requirements and the personal protective equipment necessary in order to minimize the possibility of electrical shock to personnel. The shock protection boundaries identified as Limited, Restricted and Prohibited Approach Boundaries are applicable to the situation in which approaching personnel are exposed to live parts. Refer to Table 130.2 (c):

<table>
<thead>
<tr>
<th>Nominal System Voltage Range, Phase to Phase</th>
<th>Limited Approach Boundary – Exposed Fixed Circuit Part (qualified/unqualified)</th>
<th>Restricted Approach Boundary; Includes Inadvertent Movement Adder (qualified with protective equip.)</th>
<th>Prohibited Approach Boundary (Work is considered same as making contact with live part)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>50 to 300</td>
<td>3 ft 6 in.</td>
<td>Avoid contact</td>
<td>Avoid contact</td>
</tr>
<tr>
<td>301 to 750</td>
<td>3 ft 6 in.</td>
<td>1 ft 0 in.</td>
<td>0 ft 1 in.</td>
</tr>
</tbody>
</table>

ENERGIZED ELECTRICAL WORK PERMIT
Pre-plan the task using the Energized Electrical Work Permit form (Attachment) for all energized work tasks Class 1 and greater. Describe the task and the specific reason the equipment can’t be de-energized or the work deferred until the next scheduled outage. Identify the personnel assigned the task, the potential hazards, controls, PPE and tools needed. Review the Energized Electrical Work Permit with all employees assisting in the operation and obtain their signatures. This review is considered to be the job briefing and will be documented with the completed permit. A brief discussion is satisfactory if the work involved is routine and if the employee, by virtue of training and experience, can be reasonably expected to recognize and avoid the hazards. A more extensive discussion shall be conducted if the work is complicated or particularly hazardous. The Maintenance Coordinator and Operations Manager shall sign the permit to authorize the energized work per NFPA 70E 110.4.

The permit does not have to be completed for testing, troubleshooting and voltage measuring tasks. However, the Maintenance Coordinator must be notified beforehand of these tasks. PPE use and appropriate electrical safe work practices must still be followed while performing these tasks.

LIMITS OF APPROACH
Flash Protection Boundary: The distance at which there is sufficient energy on the skin surface to result in a second-degree burn (i.e. 1.2 cal/cm²). **Cordon off a work area around the equipment to keep unqualified people out of the arc flash boundary of 4 feet.** Only qualified people wearing appropriate PPE can enter the flash protection boundary.

Cordon off the area using a method appropriate for the environment. For example, when working in a panel in a hallway of an occupied office, set up a plastic barricade with chain or similar method to keep unqualified people out of the arc flash boundary. When working in a locked electrical room or remote area of a building, simply using some cones/signs and caution tape may be an appropriate warning/barrier.
Limited Approach Boundary: Only qualified people may cross the limited approach boundary. Unqualified people must stay outside the boundary because they are unfamiliar with the electrical shock hazards.

Restricted Approach Boundary: A qualified person must wear PPE for protection (typically rubber gloves and use insulated tools) from the electrical shock hazard when working within the restricted approach boundary.

Prohibited Approach Boundary: A qualified person must avoid performing work within the prohibited approach boundary.

Personal Protective Equipment
Employees working in areas where electrical hazards are present shall be provided with, and shall use, protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed. Protective equipment shall be maintained in safe, reliable condition and shall be visually inspected prior to each use. The PPE matrix shall be used to identify requirements by hazard/risk category 0-2* (See attachment).

Definitions of Hazard Risk Categories in NFPA 70E Table:

<table>
<thead>
<tr>
<th>Hazard Class</th>
<th>ATPV (cal/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 0</td>
<td>0 - 1.2</td>
</tr>
<tr>
<td>Class 1</td>
<td>1.2 - 4.0</td>
</tr>
<tr>
<td>Class 2</td>
<td>4.1 - 8.0</td>
</tr>
<tr>
<td>Class 3</td>
<td>8.1 – 25.0</td>
</tr>
<tr>
<td>Class 4</td>
<td>25.1 – 40.0</td>
</tr>
</tbody>
</table>

ATPV: Arc Thermal Performance Value: It is defined in ASTM P S58 standard arc test method for flame resistant fabrics as the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second degree burn (1.2 cal/cm²). Consensus standards define an injury when the energy reaches the skin to begin a second-degree burn or “curable burn”.

Safety Glasses
Safety Glasses are required for all energized work tasks. All safety glasses must be non conductive (no metal frames). This includes prescription safety glasses.

Face Shield and Hoods: For low-level electrical hazards (Class 1-2), an arc flash face shield attached to the hard hat will provide adequate protection (8-10 cal/cm²). Safety glasses must be worn underneath the face shield. Clear face shields do not provide adequate arc flash protection.

Safety glasses are required for all hot work tasks including Class 0.

2* tasks require a double layer switching hood or its equivalent.

Flame Resistant (FR) Clothing: FR clothing is available depending upon the application. The electrical safety kits are equipped with hooded jackets made of Indura Ultrasoft. The jacket provides a minimum of 11 cal/cm² of protection (9.0 oz fabric).
Wear a long sleeve natural fiber shirt and pants (cotton) preferably denim for all hot work tasks including Class 0.

Complete a visual inspection of protective garments before each use and after washing. Report any defects (torn fabric, ripped stitching, etc) to the Maintenance Coordinator.

**Underlayers:** Remember to wear natural fiber clothing (cotton) under your flame resistant clothing. These underlayers not only include your shirt and pants but also underwear. An arc flash can create enough heat to melt clothing underneath your flame resistant clothing. The heat will pass through the flame resistant clothing even though it will not catch on fire or break open. Absolutely no synthetic materials, such as polyester, nylon, and synthetic-blends can be worn during energized work.

**Washing:** Machine wash FR clothing separately using a detergent. Do not use chlorine bleach. Tumble dry on low. Do not line dry in sunlight.

**Insulating Gloves With Protectors:** Verify that gloves have passed a voltage test within the past 6 months. 500-volt gloves are located in the electrical safety kits. When insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.

Before each use, visually inspect your gloves and complete an air test. Inspect rubber gloves for holes, rips or tears, ozone and UV damage and signs of chemical deterioration. Complete an air test to make it easier to detect damage. Roll the cuff of the glove tight to trap air inside then apply pressure to areas of the glove to inspect and listen for escaping air. Then repeat the procedure with the glove turned inside out.

If there are any defects or irregularities in the rubber gloves, remove them from service and contact a Maintenance Coordinator immediately. Damage would include physical damage (punctures, cuts, abrasions), chemical deterioration (swelling, softness, hardening, stickiness) ozone deterioration and other irregularities. Rubber insulating gloves can be damaged by many chemicals, especially petroleum based products (oil, gasoline, hydraulic fluid), solvents, hand creams, pastes and salves. If contact is made with these or other chemical products, the contaminant should be wiped off immediately. Gloves should be cleaned using a mild soap and rinsed with clear water. The gloves can then air dry.

Leather protectors must also be inspected. Metal particles, embedded wire, and abrasive materials that could physically damage the rubber glove must be removed before using the protector.

Properly store rubber gloves in canvas bags to protect them from damage and extend service life. Place the gloves flat in the canvas bag, and never force more than one pair into a bag. Folds and creases strain rubber and cause it to crack from ozone prematurely.

Gloves should be retested after all energized work incidents.

**INSULATING TOOLS**

**Voltage Rated Tools:** Use Voltage rated tools when there is the potential for the tool to come in contact with energized parts. Refer to the NFPA 70E table of Hazard Risk Category Classifications for details on which tasks require voltage rated tools. Voltage rated tools are rated for 1000 volts and labeled with a symbol. ▲
Inspect the condition of the tools prior to use. Remove damaged tools from service and contact a Maintenance Coordinator.

**ELECTRICAL SAFETY KIT**
The contents of the electrical safety kit include:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Pair 500 Volt Max Rubber Gloves</td>
<td>1</td>
</tr>
<tr>
<td>1 Pair Leather Glove Protectors</td>
<td>1</td>
</tr>
<tr>
<td>1 Canvas Glove Bag</td>
<td>1</td>
</tr>
<tr>
<td>1 Arc Protection Face Shield</td>
<td>1</td>
</tr>
<tr>
<td>1 Flame Retardant Shirt/Jacket</td>
<td>1</td>
</tr>
<tr>
<td>1 Pair Non-Prescription Safety Glasses</td>
<td>1</td>
</tr>
</tbody>
</table>

**Note:** All items shall be returned to the Electrical Safety Kit after using.

Rubber Gloves: Twice a year, safety kit rubber gloves shall be exchanged for testing/inspection.

Electrical Safety Kit: The Maintenance Coordinators will check the Electrical Safety Kit on a monthly basis to replace/repair any items. Employees will check the contents of the electrical safety kit prior to each use and will report any deficiencies to a Maintenance Coordinator.

**LABELING**

Arc flash warning labels are posted on equipment – installed per NEC 2002. This is not a requirement for equipment installed prior to 2002.

Switchboards, panelboards, industrial control panels and motor control centers shall be marked to warn qualified persons of potential electrical arc flash hazards per NEC 2002 110.16. The markings shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing or maintenance of the equipment.

For panels, the markings should be placed on the outside cover where possible, because they need to be visible before examination. On unit substations or large switchboards, the markings should be placed on each compartment or section so they are clearly visible from the direction one approaches the equipment. A marking/label is not required for individual switches but rather each access compartment. Larger labels may be appropriate on larger equipment such as substations to make them clearly visible.

The marking or labels will be similar to the one pictured below. These generic labels simply warn of the arc flash hazard and to wear appropriate PPE.

Do not fill out and install labels that identify the Hazard Class (0-4), approach boundaries, incident energy in calories/cm² or similar information. A Professional Engineer must perform the incident energy calculations to determine the appropriate information to put on these labels.
TRAINING
Qualified personnel receive education on electrical safe work practices through several methods:

NFPA 70E: Qualified personnel are required to attend Marquette’s 4 Hour NFPA 70E seminar. All workers must successfully complete a NFPA 70E seminar before they are authorized to perform energized work tasks. Unqualified, untrained workers are not authorized to work on or near energized equipment until it is placed into an electrically safe condition.

Marquette University- Electrical Safe Work Practices: This training expands upon the concepts presented in NFPA 70E. It is a one hour session that details Marquette University’s electrical safety program.

Tool Box Safety Talks: Safety talks on arc flash hazards, electrical safe work practices and NFPA 70E are available. The Maintenance Coordinators should conduct electrical safety toolbox talks as necessary.

Job Site Specific Training: Additional on site training is provided as necessary. Electrical safe work practices specific to the facility should be discussed with the affected authorized employees.

CONTRACTORS
All contractors engaged by Marquette University, who work on energized equipment on behalf of the University, must be in compliance with the most recent edition of NFPA 70E Standard for Electrical Safety in the Workplace and all other applicable local, state and federal regulations.

Attachments
Energized Electrical Work Permit form
Protective Clothing and Personal Protective Equipment (PPE) Matrix
Electrical Safety Toolbox Talks