ELECTRICAL SAFETY PROGRAM

Rose-Hulman Institute of Technology
Table of Contents

SECTION

1.0 Purpose
2.0 Regulatory Reference
3.0 Scope
4.0 Responsibility
5.0 Definitions
6.0 Training
7.0 Program Elements
8.0 Personal Protective Equipment
9.0 Tools and Equipment
10.0 Procedures

APPENDICES

A. PPE Matrix
B. Approach Boundaries
C. Hazard/Risk Categories
D. Location Classes and Electrical Clearance
E. Hot Work Permit Form
Electrical Safety Program

1.0 Purpose

This program is intended to provide information to all staff to protect them from electrical shock or other injuries resulting from indirect or direct electrical contact. This program will also:

- Define the differences between qualified staff and unqualified staff.
- Inform unqualified workers of their limitations relative to working with or near electrical equipment or circuitry.
- Protect qualified workers from injury due to electrical shock, burns, arc flash or blast, electrocution or other injuries resulting from working on or near electrical equipment.
- Provide qualified workers with information on determining the risks associated with electrical work, and the tools to safely perform their assigned tasks.
- Reduce or eliminate employee injuries through compliance with electrical work regulations and guidelines.

2.0 Regulatory Reference

OSHA 29 CFR 1910 Subpart K (1926.400 – 1926.499)
NFPA 70E, National Electric Code

3.0 Scope

This program is applicable to all employees of Rose-Hulman Institute of Technology. An Institute employee is defined as any individual who receives compensation from the Institute for work performed. It includes part-time workers and temporaries.

This program covers both unqualified workers and qualified workers. Please see section 5.0 Definitions for further elaboration.

4.0 Responsibility

The Office of Environmental Health & Safety is responsible for maintaining the written program, providing training, and supporting the evaluation and classification of electrical hazards.

Individual departments, both academic and administrative, are responsible for the implementation of this program. This includes ensuring affected employees are adequately trained and are provided with the appropriate tools, safety equipment, and personal protective equipment to safely do complete these tasks. Contact the Office of Environmental Health & Safety for guidance when purchasing personal protective equipment.

Departments shall make certain that work areas and equipment are evaluated for electrical hazards, and whenever possible mitigate those hazards by standard means. When the hazards cannot be mitigated, appropriate signage, training, and work practices shall be implemented.
Supervisors are responsible for ensuring employees are adequately trained, are familiar with the appropriate regulations and procedures, and perform their jobs in a safe and healthful manner.

Supervisors, working with Directors, and others, are responsible for ensuring employees have appropriate equipment to safely do their jobs. This includes any unique safety equipment and personal protective equipment.

Employees are responsible for being aware of electrical safety issues, both in general and specific to their jobs. Employees working with electrically-energized systems shall be knowledgeable about the Rose-Hulman Electrical Safety Program, the applicable OSHA regulations, applicable sections of NFPA 70E, and all job-specific procedures. Employees are responsible for performing their jobs in a safe manner and communicating with their supervisor concerns about safety or their ability to safely perform assigned jobs.

Copies of the written program are located in the Office of Environmental Health & Safety and can also be found on the Office of Environmental Health & Safety website.

5.0 Definitions (per OSHA 29 CFR 1910.399)

Appliances: Utilization equipment, generally other than industrial, normally built in standard configurations, that is installed or connected as a unit to perform one or more functions; can generally be used for its intended purpose by an “unqualified” worker.

Attachment Plug: A device that by insertion into a receptacle establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Certified: Equipment is “certified” if it bears a label, tag, or other record of certification that the equipment has been tested by a nationally recognized testing laboratory and found to meet nationally recognized standards, and is accepted by the laboratory for its intended use.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from the earth.

Energized: Electrically connected to a source of potential difference.

Exposed: Capable of being inadvertently touched or approached nearer than a safe distance by a person. Applies to parts not suitably guarded, isolated, or insulated.

Ground: A conducting connection between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Ground-fault Circuit-interrupter: A device intended for the protection of personnel that functions to de-energize a circuit or a portion of a circuit within an established period of time when current to ground exceeds some predetermined value that is less than that required to operate the overcurrent device of the supply circuit.
Office of Environmental Health & Safety

**Insulated**: Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

**Isolated**: Not readily accessible to persons unless special means of access are used.

**Live Parts**: Energized conductive components.

**Outlet**: A point on the wiring system at which current is taken to supply utilization equipment.

**Overload**: Operations of equipment in excess of normal, full-load rating.

**Qualified Person**: One who has received training in and has demonstrated skills and knowledge in the construction or operation of electrical equipment and installations and the hazards involved. *Note: a "qualified person" may be qualified to perform certain operations, but unqualified to perform others. "Qualified' pertains to the task or job to be performed.*

**Receptacle**: A contact device installed at the outlet for the connection device of an attachment plug.

**Unqualified Person**: One who has NOT received training nor demonstrated skills for working with the electrical equipment under consideration.

### 6.0 Training

All employees will receive training based upon their job responsibilities. Training will differ depending on employee status as a qualified person or unqualified person as defined in OSHA 29 CFR 1910.399. Training will be conducted at time of hire and refresher training will be provided as needed.

Unqualified workers will be given Electrical Safety Awareness training by Environmental Health and Safety. Training will include:

- Basic definitions and concepts, including conductance, amperage, current
- Effects of electric shock at different levels
- Understanding common electrical equipment (such as extension cords, receptacles, circuit breakers, surge suppressors, ground-fault circuit-interrupters), its use and misuse
- Limits of electrical work that can be done by unqualified workers

A qualified worker, shall, at a minimum be trained in and familiar with:

- The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment
- The skills and techniques necessary to determine the nominal voltage of exposed live parts
- The clearance distance specified in 1910.333 (c) and the corresponding voltage to which the qualified person will be exposed.
• Understand all electrical hazards and be capable of deciding if his/her action might result in a release of energy
• Determine whether personal protective equipment (PPE) is necessary, what type of PPE is necessary, and how the PPE is rated
• Understand the protective characteristics of each PPE item and
• The process necessary to determine the degree and extent of electrical hazards along with the PPE and job planning necessary to perform the task safely.

This level of training will be provided by a competent person, either from Environmental Health and Safety, the employee’s own department, or outside contractors as is most appropriate for the level of training needed.

Additionally, qualified workers will be trained and demonstrate competence on each procedure and type of equipment that he/she will be working on or around. This training will be provided by the employee’s supervisor or other qualified person.

Retraining for qualified workers shall be performed whenever it is determined that an employee does not have the necessary knowledge or skills to safely work at assigned jobs or tasks. Retraining will also be performed when there are changes to electrical equipment, procedures or policies.

Workers with a reasonable risk of encountering Arc Flash hazards shall receive training specific to understanding the conditions that can lead to Arc Flash and preventive measures to be taken.

7.0 Program Elements

Electrical Safety for Unqualified Workers

OSHA defines an “unqualified worker” as a person who has not been trained or demonstrated competence in performing a specific electrical task. In general, this includes administrative personnel, most academic personnel, custodial staff, and other similar positions. Persons in this group are authorized to work only on 110 V circuits (or less), to plug and unplug appliances, turn switches off and on, and reset a circuit breaker in a 110 V system once. Other work, such as repairing equipment, is not authorized.

Electrical Safety for Qualified Workers

Note: a "qualified worker" may be qualified to perform certain tasks, but not others. At all times, it is required that workers do not undertake jobs for which they are not qualified. Qualified electrical workers must be familiar with the Rose-Hulman Electrical Safety Program, all applicable sections of the OSHA Electrical Regulations, all applicable sections of NFPA 70E, and all job-specific procedures. All electrical work performed at Rose-Hulman and all electrical equipment or systems built at Rose-Hulman will conform to NFPA 70E.
Safety-Related Work Practices

All work performed by Qualified Workers will require approval of that person’s supervisor or other qualified person.

Special Arc Flash Considerations

Arc Flash and Arc Blast conditions present specific, severe hazards. Arc Flash occurs with a massive release of energy, capable of melting metals. Temperatures can reach 35,000° F. Typically, Arc Flashes do not occur in 110 Volt systems, but have been reported. Any employee working on electrical systems of 240 V or higher must be trained on the specific hazards and the safe operations associated with Arc Flash, follow approved procedures, and utilize appropriate PPE. The formula for calculating boundary protection where Arc Flash is an issue is included in Appendix C5. Electrical engineering expertise should be utilized in assessing the risks of an arc flash occurring with a specific operation or system.

Posting and Labeling

All electrical sources and equipment over 240 volts must be labeled per NFPA 70E, denoting caution or warning as appropriate. All equipment calculated to provide an Arc Flash risk must also be labeled as an Arc Flash hazard; such calculations can be made by an electrical engineer and are to be posted by said engineer.

8.0 Personal Protective Equipment

Employees working in areas where there are potential electrical hazards shall be provided with and use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed.

Protective equipment shall be maintained in a safe, reliable condition and shall be visually inspected before each use. Refer to the Rose-Hulman Personal Protective Equipment Program for more information on inspecting and testing PPE.

The following types of personal protective equipment may be necessary depending on the risk of exposure to electrical hazards. The exact personal protective equipment to be worn shall be determined by referring to NFPA 70E Table 130.7(C)(9)(a), “Hazard/Risk Category Classifications” or see Appendix D of this document.

Head, Face, Neck, and Chin Protection

Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from electrical explosion. The head protection shall comply with ANSI Z89.1, Requirements for Protective Headwear for Industrial Workers, 1997. Face, neck, and chin protection shall be provided wherever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion.
Eye Protection

Employees shall wear eye protection whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion. The eye protection shall comply with ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, 1998.

Body Protection

Employees shall wear flame-resistant (FR) clothing wherever there is possible exposure to an electric arc flash above the threshold incident-energy level for a second degree burn, 5J/cm². Flash suits are required for a category 4 hazard/risk category. The flash suit shall permit easy and rapid removal by the wearer and have an arc rating that is suitable for the arc flash exposure.

Hand and Arm Protection

Employees shall wear rubber insulating gloves where there is danger of hand and arm injury from electric shock due to contact with live parts or where there is a possible exposure to arc flash burn. Gloves shall comply with ASTM D120-2, *Standard Specification for Rubber Insulating Gloves*, 2002. Leather or FR gloves shall be worn where required for arc flash protection. Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.

Foot and Leg Protection

Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required. Insulated soles shall not be used as primary electrical protection. Heavy-duty leather work shoes provide some arc protection to the feet and shall be used in all tasks in hazard/risk category 2 and higher.

Selection of Personal Protective Equipment

Employees working within the Flash Protection Boundary shall wear protective clothing and other personal protective equipment identified by the flash hazard analysis and the incident energy exposure of the employee. The specific protection to be worn within the Flash Protection Boundary can be determined by one of the following two methods:

- Complete a detailed flash hazard analysis under Electrical Engineering supervision that determines the incident exposure energy of each employee. Appropriate protective clothing can then be selected based on the calculated exposure level;
- Determine the hazard level of the task by referring to NFPA 70E Table 130.7(C)(9)(a), "Hazard/Risk Category Classifications" or see Appendix D of this document.

After the hazard level of the task has been determined, the required PPE can then be ascertained from NFPA 70E Table 130.7(C) (10), "Protective Clothing and PPE Matrix" or see Appendix E of this Document.
Flame-Resistant (FR) Apparel and Underlayers

FR clothing shall consist of materials, such as flame-retardant treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers. These materials can ignite but will not continue to burn after the ignition source is removed.

FR clothing made from flammable synthetic materials that melt at temperatures below 315 °Celsius, such as acetate, nylon, polyester, polypropylene, and spandex, either alone or in blends, shall NOT be used.

Clothing made from non-melting flammable natural materials, such as cotton, wool, rayon, or silk may be used as under layers beneath FR apparel.

FR apparel shall be visually inspected before each use. FR apparel that is contaminated or damaged shall not be used. Follow all manufacturers’ instructions for care and maintenance of FR apparel shall be followed.

9.0 Tools and Equipment

Insulated Tools and Equipment

Only insulated tools and equipment shall be used within the Limited Approach Boundary of exposed energized parts.

Insulated tools shall be rated for the voltages on which they are used and shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.

Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.

Ropes and hand lines used near exposed live parts operating at 50 volts or more or where an electrical hazard exists, shall be nonconductive.

Portable ladders shall have nonconductive side rails and shall meet the requirements of ANSI standards for ladders.

Rubber Insulating Equipment

Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.

Rubber insulating equipment shall comply with the following American Society for Testing and Materials (ASTM) standards:

- Specification for Rubber Insulating Gloves (D120-87);
- Specification for Rubber Insulating Matting (ASTM D178-93 or D178-88);
- Specification for Rubber Insulating Blankets (ASTM D1048-93 or D1048-88a);
- Specification for Rubber Insulating Covers (ASTM D1049-93 or D1049-88);
All electrical protective equipment shall be subjected to periodic electrical tests conducted in accordance with appropriate voltages identified by ASTM standards to reliably indicate whether the insulating equipment can withstand the voltage involved. Insulating equipment failing to pass inspections or electrical tests shall NOT be used by employees.

Rubber insulating equipment test intervals shall occur as follows:

- Rubber insulating line hoses shall be tested upon indication that the insulating valve is suspect;
- Rubber insulating covers shall be tested upon indication that the insulating valve is suspect;
- Rubber insulating blankets shall be tested before first issue and every twelve months thereafter;
- Rubber insulating gloves shall be tested before first issue and every six months thereafter; and
- Rubber insulating sleeves shall be tested before first issue and every twelve months thereafter.

Note: If the insulating equipment has been electrically tested but not issued for service, it shall not be placed into service unless it has been electrically tested within the previous twelve months. All departments using rubber insulating equipment shall make the appropriate arrangements through the Office of Environmental Health and Safety for testing of such equipment.

**Portable Electric Tools and Equipment**

Attachment plugs, receptacles, cover plates, and cord connectors shall be maintained such that the following apply:

- There are no breaks, damage, or cracks exposing internal wiring
- There are no missing cover plates. Missing cover plates are to be reported to Facilities immediately.
- Terminations have no stray strands or loose terminals
- There are no missing, loose, altered, or damaged blades, pins, or contacts.
- Polarity must be correct

Any electric tools or equipment not meeting the above criteria shall be taken out of service immediately and repairs scheduled.

**Electrical Closets**

All electrical closets or boxes are to remain locked for the protection of both unqualified workers and qualified workers. Keys to these boxes can be obtained through Facilities. Any individual wishing to obtain a key must at a minimum attend an Electrical Safety Awareness training session. The Office of Environmental Health and Safety is responsible for conducting this training.
10.0 Procedures

Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards.

De-energized parts

Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. The following are the only examples in which work on electrical equipment may be acceptable:

- Examples of increased or additional hazards include interruption of life support equipment, deactivation of emergency alarm systems, shutdown of hazardous location ventilation equipment, or removal of illumination for an area.
- Examples of work that may be performed on or near energized circuit parts because of infeasibility due to equipment design or operational limitations include testing of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous industrial process in a chemical plant that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

Live parts that operate at less than 50 volts to ground need not be de-energized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Refer to Rose-Hulman’s Lockout Tagout Program for procedures to de-energize live parts and establish an electrically safe working condition.

Energized Parts

Every effort shall be made to ensure live parts are de-energized before beginning work. No work above a Category 2* shall ever be performed on live equipment without first being assessed by the Manager of Environmental Health and Safety, Director of Buildings and Systems, and staff electrician. Refer to Appendix D Hazard/Risk Category Classifications or NFPA Table 130.7(C)(9)(a), for those tasks.

If the exposed live parts are not de-energized (i.e., for reasons of increased or additional hazards or infeasibility), other safety-related work practices shall be used to protect employees who may be exposed to the electrical hazards involved. Such work practices shall protect employees against contact with energized circuit parts directly with any part of their body or indirectly through some other conductive object. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the exposed electric conductors or circuit parts.
Working On or Near Exposed Energized Parts

This section applies to work performed on exposed live parts (involving either direct contact or by means of tools or materials) or near enough to them for employees to be exposed to any hazard they present.

Work on Energized Equipment

Only qualified persons shall be permitted to work on electric circuit parts or equipment that has not been put into an electrically safe work condition. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

Permits

If live parts are not placed in an electrically safe work condition, work to be performed shall be considered energized electrical work and shall be performed by a written permit only and must be approved of by the Supervisor responsible for the job. A copy of the written permit can be found in Appendix E of this document.

Permit Exemptions

Work related to testing, troubleshooting, and voltage measuring may be completed without a permit, provided appropriate safe work practices and personal protective equipment are provided and used.

Approach Boundaries to Live Parts

Observing a safe approach distance from exposed energized parts is an effective means of maintaining electrical safety. As the distance between an individual and the live parts increase, the potential for an electrical injury decreases.

Shock Hazard Analysis

A shock hazard analysis shall be conducted to determine the voltage to which employees will be exposed, boundary requirements, and the personal protective equipment necessary in order to minimize the possibility of electric shock to employees.

Shock Protection Boundaries

Limited, Restricted, and Prohibited Approach Boundaries are applicable to the situation in which approaching employees are exposed to live parts. Safe approach distances to live parts can be determined by referring to Appendix B, “Approach Boundaries to Live Parts for Shock Protection”. 
Approach to Exposed Live Parts Operating at 50 Volts or More

Qualified persons shall not approach or take any conductive object closer to exposed live parts operating at 50 volts or more than the Restricted Approach Boundary set forth in Appendix B unless on the following conditions apply;

- The qualified person is insulated or guarded from the live parts, and no uninsulated part of the qualified person’s body crosses the Prohibited Approach Boundary set forth in Appendix B.
- The live part operating at 50 volts or more is insulated from the qualified person and from any other conductive object at a different potential.

Approach by Unqualified Persons

An unqualified person shall not be permitted to enter spaces that are to be accessible to qualified employees only, unless the electric conductors and equipment involved are in an electrically safe work condition.

Entering the Limited Approach Boundary

Where there is a need for unqualified person(s) to cross the Limited Approach Boundary, a qualified person shall advise the unqualified person of the potential hazards and continuously escort the unqualified person(s) while inside the Limited Approach Boundary. Under no circumstances shall the escorted unqualified person(s) be permitted to cross the Restricted Approach Boundary.

Entering Prohibited Approach Boundary

Crossing the Prohibited Approach Boundary is considered the same as making contact with energized parts. Qualified persons may only cross this boundary when all of the following precautions have been taken:

- The qualified person has specific training to work on energized parts;
- The qualified person has obtained an approved Energized Electrical Work Permit; and
- The qualified person uses personal protective equipment (PPE) appropriate for working on energized parts which are rated for the voltage and energy level involved.

Flash Hazard Analysis

A flash hazard analysis shall be done in order to protect employees from the possibility of being injured by an arch flash. This analysis shall determine the Flash Protection Boundary and the personal protective equipment that employees within the Flash Protection Boundary shall use.

Flash Protection Boundaries

For systems that are 600 volts or less, the Flash Protection Boundary shall be a minimum of 4 feet. The formula in Appendix C can be used to determine the exact Flash Protection Boundary.
Boundary for systems under 600 volts and shall be determined by a qualified electrical engineer, a qualified journeyman electrician, or the equivalent. For systems that are above 600 volts, the Flash Protection Boundary shall be determined through engineering analysis.

Other Precautions for Personnel Activities

Alertness

• Employees shall be instructed to be alert at all times when they are working near live parts operating at 50 volts or more in work situations where unexpected electrical hazards might exist.
• Employees shall not knowingly be permitted to work in areas containing live parts operating at 50 volts or more or other electrical hazards while their alertness is recognizably impaired due to illness, fatigue, or other reasons.
• Employees shall be instructed to not reach blindly into areas that might contain exposed live parts where an electrical hazard exists.

Illumination

Employees shall not enter spaces containing live parts unless illumination is provided that allows work to be performed safely.

Conductive Articles Being Worn

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.

Conductive Materials, Tools, and Equipment Being Handled

Conductive materials, tools, and equipment that are in contact with any part of an employee’s body shall be handled in a manner that prevents accidental contact with live parts. Such materials and equipment include, but are not limited to, tools, ducts, pipes, tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, and chains.

Confined or Enclosed Work Surfaces

When an employee works in a confined space or enclosed space (such as a manhole or vault) that contains or may contain exposed live parts, the employee shall use protective shields, barriers, and insulating materials as necessary to avoid contact with these parts. A buddy system shall be used in these situations. Doors, hinged panels and the like shall be secured to prevent them from swinging into employees.

Safety signs, safety symbols and accident prevention tags shall be used where appropriate to warn employees about electrical hazards.
Barricades shall be used in conjunction with safety signs to limit employee access to work areas containing live electrical parts. Barriers shall be placed no closer than the Limited Approach Boundary for the site.

If signs and barriers do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to keep unqualified workers out of the area. The attendant shall remain in the area as long as there is a potential for exposure to electrical hazards.
### Appendix A

#### PPE Matrix

<table>
<thead>
<tr>
<th>Protective Clothing and Equipment</th>
<th>Protective Systems for Hazard/Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard/Risk Category Number</td>
<td>-1</td>
</tr>
<tr>
<td>Non-melting (according to ASTM F 1506-00) or Untreated Natural Fiber</td>
<td></td>
</tr>
<tr>
<td>a. T-shirt (short-sleeve)</td>
<td>X</td>
</tr>
<tr>
<td>b. Shirt (long-sleeve)</td>
<td></td>
</tr>
<tr>
<td>c. Pants (long)</td>
<td>X</td>
</tr>
<tr>
<td>FR Clothing (Note 1)</td>
<td></td>
</tr>
<tr>
<td>a. Long-sleeve shirt</td>
<td>X</td>
</tr>
<tr>
<td>b. Pants</td>
<td></td>
</tr>
<tr>
<td>c. Coverall</td>
<td></td>
</tr>
<tr>
<td>d. Jacket, parka, or rainwear</td>
<td>AN</td>
</tr>
<tr>
<td>FR Protective Equipment</td>
<td></td>
</tr>
<tr>
<td>a. Flash suit jacket (multilayer)</td>
<td></td>
</tr>
<tr>
<td>b. Flash suit pants (multilayer)</td>
<td></td>
</tr>
<tr>
<td>c. Head protection</td>
<td></td>
</tr>
<tr>
<td>1. Hard hat</td>
<td></td>
</tr>
<tr>
<td>2. FR hard hat liner</td>
<td>AN</td>
</tr>
<tr>
<td>d. Eye protection</td>
<td></td>
</tr>
<tr>
<td>1. Safety glasses</td>
<td>X</td>
</tr>
<tr>
<td>2. Safety goggles</td>
<td></td>
</tr>
<tr>
<td>e. Face and head area protection</td>
<td></td>
</tr>
<tr>
<td>1. Arc-rated face shield, or flash suit hood</td>
<td></td>
</tr>
<tr>
<td>2. Flash suit hood</td>
<td></td>
</tr>
<tr>
<td>3. Hearing protection (ear canal inserts)</td>
<td></td>
</tr>
<tr>
<td>f. Hand protection</td>
<td></td>
</tr>
<tr>
<td>Leather gloves (Note 2)</td>
<td>AN</td>
</tr>
<tr>
<td>g. Foot protection</td>
<td></td>
</tr>
<tr>
<td>Leather work shoes</td>
<td>AN</td>
</tr>
<tr>
<td>PPE Arc Flash Gear Required</td>
<td>N/R</td>
</tr>
</tbody>
</table>

AN = As needed  AR = As required  AL = Select one in group  X = Minimum required

### Notes:

1. See Table 130.7 (C) (11). Arc rating for a garment is expressed in cal/cm².
2. If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.
3. Hazard/Risk Category Number "-1" is only defined if determined by Notes 3 or 6 of Table 130.7 (C) (9) (a).
4. Regular weight (minimum 12 oz/yd² fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. The FR pants used for Hazard/Risk Category 1 shall have a minimum arc rating of 11 cal.
5. Alternate is to use FR coveralls (minimum arc rating of 11 cal) instead of FR shirt and FR pants.
6. If the FR pants have a minimum arc rating of 11 cal, long pants of non-melting or untreated fiber are not required beneath the FR pants.
7. Alternate is to use FR coveralls (minimum arc rating of 11 cal) over non-melting or untreated natural fiber pants and T-shirt.
8. A face shield with a minimum arc rating of 11cal, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or alternatively, a flash suit hood), is required.
9. Alternate is to use two sets of FR coveralls (the inner with a minimum arc rating of 4cal and outer coverall with a minimum arc rating of 5 over non-melting or untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over non-melting or untreated natural fiber clothing.)
Appendix B

Approach Boundaries

<table>
<thead>
<tr>
<th>Nominal System Voltage (Phase to Phase)</th>
<th>Limited Approach Boundary</th>
<th>Limited Approach Boundary</th>
<th>Restricted Approach</th>
<th>Prohibited Approach Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50 Volts</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
</tr>
<tr>
<td>50 Volts to 300 Volts</td>
<td>10 feet</td>
<td>3 feet 6 inches</td>
<td>Avoid Contact</td>
<td>Avoid Contact</td>
</tr>
<tr>
<td>301 Volts to 750 Volts</td>
<td>10 feet</td>
<td>3 feet 6 inches</td>
<td>1 foot</td>
<td>1 inch</td>
</tr>
<tr>
<td>751 Volts to 15 kilovolts</td>
<td>10 feet</td>
<td>5 feet</td>
<td>2 feet 2 inches</td>
<td>7 inches</td>
</tr>
</tbody>
</table>

- **Limited Approach Boundary**: Distance from an exposed live part within which a shock hazard exists. An unqualified employee may not cross this boundary unless they are continuously escorted by a qualified employee.

- **Restricted Approach Boundary**: Distance from an exposed live part within which there is an increased risk of shock (due to electrical arc-over combined with inadvertent movement) for personnel working in close proximity to the live part. This boundary may only be crossed by a qualified person who is safely insulated or guarded from the live parts.

- **Prohibited Approach Boundary**: Distance from an exposed live part within which work is considered the same as making contact with the live part. This boundary may only be crossed by a qualified person who has specific training to work on energized parts; has obtained an approved Energized Electrical Work Permit; and uses PPE appropriate for working on energized parts which are rated for the voltage and energy level involved. (Note: A permit is not required for work related to testing, troubleshooting, and voltage measuring).

- **Flash Protection Boundary (not listed in table)**: Distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur. This boundary may only be crossed by a qualified person wearing the appropriate PPE. For systems that are 600 volts are less, the Flash Protection Boundary shall be a minimum of four feet. An engineering analysis must be performed to determine the Flash Protection Boundary for systems that are above 600 volts.
### Appendix C

**Hazard/Risk Categories**  
NFPA 70E Table 130.7(C)(9)(a)

<table>
<thead>
<tr>
<th>Task (Assumes equipment is energized, and work is done 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>Panel boards Rated 240 V and Below – Notes 1 and 3</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>Panel boards or Switchboards Rated &gt; 240 V and up to 600 V (with molded case or insulated case circuit breakers) – Notes 1 and 3</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>
<tr>
<td><strong>600 V Class Motor Control Centers (MCCs) – Notes 2 (except as indicated) and 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB or fused switch or starter operation with enclosure doors closed</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>CB or fused switch or starter operation with enclosure doors open</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Work on energized, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Activity</td>
<td>0</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work on control circuits with energized parts &gt;120 V, exposed</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

**600 V Class Motor Control Centers (MCCs) (continued)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>3</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion or removal of individual starter “buckets” from MCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
<td>2*</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
<td>2*</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**600 V Class Switchgear (with power circuit breakers or fused switches) – Notes 5 and 6**

<table>
<thead>
<tr>
<th>Activity</th>
<th>0</th>
<th>Y</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB or fused switch operation with enclosure door closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading a panel meter while operating a meter switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB or fused switch operation with enclosure doors open</td>
<td>1</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Work on control circuits with energized parts 120 V or below, exposed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work on control circuits with energized parts &gt;120 V, exposed</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Insertion or removal (racking) of CBs from cubicles, doors open</td>
<td>3</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Insertion or removal (racking) of CBs from cubicles, doors closed</td>
<td>2</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage test</td>
<td>2*</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Removal of bolted covers (to exposed bare, energized parts)</td>
<td>3</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
<td>2</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**Other 600 V Class (277 V through 600 V, nominal) Equipment – Note 3**
• 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 that are rated and tested for the maximum line-to-line voltage upon which work will be done.
• 2(*) means that a double-layer switching hood and hearing protection are required for this task.
• Y = Yes (required)
• N = No (not required)

Notes:
(1) 25kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
(2) For < 10kA short circuit current available, the hazard/risk category required may be reduced by one number.
(3) For <10 kA short circuit current available, the hazard/risk category required may be reduced by one number.
(5) 65 kA short circuit current available, up to 1.0 second (60 cycle) fault clearing time.
(6) For <25 kA short circuit current available, the hazard/risk category required may be reduced by one number.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting or small power transformers (600 V, maximum)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Removal of bolted covers (to expose bare, energized parts)</td>
<td>2*</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Opening hinged covers (to expose bare, energized parts)</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Other 600 V Class (277 V through 600 V, nominal) Equipment (continued)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work on energized parts, including voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Application of safety grounds, after voltage testing</td>
<td>2*</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Revenue meters (kW-hour, at primary voltage and current)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Insertion or removal</td>
<td>2*</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Cable trough or tray cover removal or installation</td>
<td>1</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Miscellaneous equipment cover removal or installation</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>
<tr>
<td>Application of safety grounds, after voltage test</td>
<td>2*</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
Appendix D

Location Classes and Electrical Clearance
OSHA 29 CFR 1910.307 and NFPA 70E

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following:

(1) Class I, Division 1. A Class I, Division 1 location is a location:

(i) In which ignitable concentrations of flammable gases or vapors may exist under normal operating conditions; or

(ii) In which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

(iii) In which breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

Note to the definition of "Class I, Division 1:" This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where flammable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(2) Class I, Division 2. A Class I, Division 2 location is a location:

(i) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in the event of accidental rupture or breakdown of such containers or systems, or as a result of abnormal operation of equipment; or

(ii) In which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or

(iii) That is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Note to the definition of "Class I, Division 2:" This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.
Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

(3) **Class I, Zone 0.** A Class I, Zone 0 location is a location in which one of the following conditions exists:

(i) Ignitable concentrations of flammable gases or vapors are present continuously; or

(ii) Ignitable concentrations of flammable gases or vapors are present for long periods of time.

**Note to the definition of "Class I, Zone 0:"** As a guide in determining when flammable gases or vapors are present continuously or for long periods of time, refer to *Recommended Practice for Classification of Locations for Electrical Installations of Petroleum Facilities Classified as Class I, Zone 0, Zone 1 or Zone 2*, API RP 505-1997; *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous Areas*, IEC 79-10-1995; *Area Classification Code for Petroleum Installations, Model Code -- Part 15*, Institute for Petroleum; and *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous (Classified) Locations*, ISA S12.24.01-1997.

(4) **Class I, Zone 1.** A Class I, Zone 1 location is a location in which one of the following conditions exists:

(i) Ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or

(ii) Ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

(iii) Equipment is operated or processes are carried on of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electric equipment in a manner that would cause the electric equipment to become a source of ignition; or

(iv) A location that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

(5) **Class I, Zone 2.** A Class I, Zone 2 location is a location in which one of the following conditions exists:

(i) Ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and if they do occur will exist only for a short period; or

(ii) Volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors are normally confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or

(iii) Ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilation equipment; or
(iv) A location that is adjacent to a Class I, Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Class II locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(1) Class II, Division 1. A Class II, Division 1 location is a location:

(i) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or

(ii) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, through operation of protection devices, or from other causes; or

(iii) In which combustible dusts of an electrically conductive nature may be present.

Note to the definition of "Class II, Division 1:" This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations that contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures. Combustible dusts that are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and wood flour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme caution is necessary to avoid ignition and explosion.

(2) Class II, Division 2. A Class II, Division 2 location is a location where:

(i) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations will normally be insufficient to interfere with the normal operation of electric equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment; and

(ii) Resulting combustible dust accumulations on, in, or in the vicinity of the electric equipment may be sufficient to interfere with the safe dissipation of heat from electric equipment or may be ignitable by abnormal operation or failure of electric equipment.

Note to the definition of "Class II, Division 2:" This classification includes locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following:
(1) **Class III, Division 1.** A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

**Note to the definition of "Class III, Division 1:"** Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(2) **Class III, Division 2.** A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled, other than in the process of manufacture.
# Appendix E

## Hot Work Permit Form

### Part I: To be completed by the Job Supervisor

<table>
<thead>
<tr>
<th>Description of Circuit &amp; Equipment:</th>
<th>Job Location:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Description of Work to Be Done:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Justification of why the circuit cannot be de-energized or the work delayed until the next scheduled outage:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
</table>

### Part II: To be completed by the qualified person(s) completing the work

(1) Detailed description of procedure to be used in performing the above work:

(2) Description of safe work practices to be employed:

(3) Voltage exposure (shock hazard analysis):

(4) Determination of shock protection boundaries:

(5) Results of flash hazard analysis:

(6) Determination of flash protection boundaries:

(7) PPE required to safely perform the task:

(8) Method used to restrict access to the work area:

(9) Do you agree the above work can be done safely?  YES (proceed to Part III)  NO (return to requestor)

<table>
<thead>
<tr>
<th>Qualified Person(s):</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part III: To be completed by Associate Director or Equivalent

<table>
<thead>
<tr>
<th>Approvals To Perform The Work While Electrically Energized:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Job Title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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Prepared by: Jacob Campbell

April 1, 2010