Section 17: ELECTRICAL HAZARDS

INTRODUCTION

Use of electrical equipment, such as computers, copy machines, tools or even microwave ovens occurs in almost all work areas. There are some basic procedures to follow to prevent electrical shock or fires.

Some Departments have licensed electricians who install and maintain electrical systems and equipment. See Attachments 1 and 2 of this section for procedures for electricians and HVAC engineers.

APPLICABILITY

All employees have some risk of electrical shocks or fires from electrical equipment.

RESPONSIBILITIES

Employees should periodically inspect the electrical equipment they use. Look for obvious problems such as breaks or cuts in cord insulation, wire insulation pulled away from plugs and exposing wires, plugs with any blades or grounding prongs damaged or missing, or any equipment that has a burning smell or is not operating correctly. Report any problems to your supervisor.

Management and supervisors must ensure the purchase of equipment that is listed by a nationally recognized electrical testing laboratory, such as Underwriter's Laboratory (UL listed). When adding business machines, appliances or other equipment that use moderate amounts of power, consult with a licensed electrician to determine if the existing circuit has adequate capacity. Items such as large copy machines, refrigerators and microwave ovens require separate circuits. Space heaters are not permitted, unless specified by a doctor, because they commonly overwhelm the circuit's capacity.

Use equipment only if it is in good condition, and only use in the way it was intended. Defective electrical equipment or improper use can cause serious or fatal injuries.

Employees who are not qualified electricians, working in an elevated position, or on the ground near overhead lines, must stay at least 10 feet away from energized power lines with voltages of 50,000 volts or less. For power lines over 50,000 volts, the minimum distance is 10 feet plus 0.4 inch for every 1000 volts over 50,000 volts. This includes any possible conductive objects.

When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized parts, supervision must have

electricians provide protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts.

Exposed, energized equipment must be insulated or guarded in areas where there are trades workers or others who may handle conductive equipment, such as pipes or vents.

Attachment 1: Electrician and HVAC Engineer Safety Procedures

The following work procedures shall be observed:

Compliance with requirements listed in the National Electrical Code (National Fire Protection Association No. 70 – American Safety Standards C2), Underwriter's Laboratories, Washington Department of Labor and Industries standards, and King County Safety Standards. The most stringent rule or procedure should be accepted as standard operating procedures and any deviation is to be cleared through the Safety and Claims Management Office.

Whenever possible, equipment and circuits must be de-energized, locked out and tagged. Equipment and circuits must then be tested to ensure they have been entirely de-energized.

Before working on capacitor circuits, disconnect external power and discharge capacitors to ground. Use insulated tools or conductors.

Be careful around electrical equipment. Avoid assuming unstable positions, which might lead to falls into equipment.

Portable ladders shall have nonconductive side rails if they are used where the employee or the ladder could contact exposed energized parts or power lines.

Conductive articles of jewelry and clothing, such as watch bands, bracelets, rings, key chains, necklaces, cloth with conductive thread or metal rivets, shall not be worn if they might contact exposed energized parts.

Maintain adequate clearances from energized circuits and components. Minimum safe clearances are 6 inches for 750 volts or less, and 2 feet for 750 volts to 15,000 volts. The minimum distance to be maintained from energized high voltage lines without insulating barriers (rubber blankets) is 10 feet.

Make sure that non-current-carrying metal parts are grounded. Visually inspect or conduct tests as appropriate to determine the adequacy of grounds.

Immediately report to your supervisor any unsafe and hazardous facilities and equipment.

Working on energized equipment

Live parts to which employees may be exposed, shall be de-energized before the employees work on or near them, unless it is infeasible due to additional or increased hazards, equipment design, operational limits or need for testing live

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

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 from an area without minimal natural light. Examples of work on or near energized circuit parts due to design or operational limits includes needed testing of energized circuits, or work on circuits that are part of much larger systems that would require shutting down the whole system in order to work on one circuit or piece of equipment.

The two major risk hazards when working on energized equipment are electrical shock and arc flash. An additional major hazard is falls caused by shocks and arcs.

The procedures and personal protective equipment required by the National Fire Protection Agency, “NFPA 70E, Electrical Safety Requirements for Employee Workplaces, 2000”, shall be followed by King County employees as a minimum to help prevent accidents and injuries. These requirements are listed in Attachment 2 of this section.

Attachment 2:
Electrician Procedures and Personal Protective Equipment
Working On or Near Live Circuits

Working on live circuits means actually touching energized parts. Working near live circuits means working close enough to energized parts to pose a risk even though you make be working on de-energized parts. Common tasks where you need to work on or near live circuits include:

- Taking voltage measurements
- Opening and closing disconnects and breakers
- Racking breakers on and off the bus
- Removing panels and dead fronts
- Opening electric equipment doors for inspection.

There should be standard written procedures and training for these common tasks. For instance, when opening and closing disconnects, use the **left-hand rule** when possible (stand to the right side of the equipment and operate the disconnect with your left hand). For other situations where you might need to work on or near live circuits, your employer should institute a written live work permit system which must be authorized by a qualified supervisor.

Live-work permit system

A live work permit should, at a minimum, contain this information:

- A description of the circuit and equipment to be worked on and location
- The date and time covered by the permit
- Why live work will be done
- Results of shock hazard analysis and determination of shock protection boundaries
- Results of flash hazard analysis and determination of flash protection boundary
- PPE to be worn and description of safe work practices to be used
- Who will do the work and how unqualified persons will be kept away
- Evidence of completion of job briefing, including description of job-specific hazards.

Approach distances to exposed live parts

The National Fire Protection Association defines three approach distances for shock hazards and one for arc flash.*** **Electric shock** (see table 1).

- The **limited approach boundary** is the closest distance an unqualified person can approach, unless accompanied by a qualified person.
- The **restricted approach boundary** is the closest distance to exposed live parts a qualified person can approach without proper PPE and tools. Inside this boundary, accidental movement can put a part of your body or conductive tools in contact with live parts or inside the prohibited approach boundary. To cross the restricted approach boundary, the qualified person must:

  (a) Have a documented plan that is approved by the manager responsible for the safety plan.
  (b) Use PPE suitable for working near exposed live parts and rated for the voltage and energy level involved.
  (c) Be certain that no part of the body enters the prohibited space.
  (d) Minimize the risk from unintended movement, by keeping as much of the

body as possible out of the restricted space; body parts in the restricted space should be protected.

- The **prohibited approach boundary** is the minimum approach distance to exposed live parts to prevent flashover or arcing. Approaching any closer is comparable to making direct contact with a live part. To cross the prohibited approach boundary, the qualified person must:

  (a) Have specified training to work on exposed live parts.
  (b) Have a documented plan with proper written work procedures and justifying the need to work that close.
  (c) Do a written risk analysis.
  (d) Have (b) and (c) approved by the manager responsible for the safety plan.
  (e) Use PPE appropriate for working near exposed live parts and rated for the voltage and energy level involved.

Arc flash. The **flash protection boundary** is the distance at which PPE is needed to prevent incurable burns (2nd degree or worse) if an arc flash occurs. (You still can get 1st or 2nd degree burns.) For systems of 600 volts and less, the flash protection boundary is 4 feet, based on an available bolted fault current of 50 kA (kiloamps) and a clearing time of 6 cycles (0.1 seconds) for the circuit breaker to act, or any combination of fault currents and clearing times not exceeding 300 kA cycles. For other fault currents and clearing times, *see* NFPA 70E.

Remember, when you have de-energized the parts you are going to work on, but are still inside the flash protection boundary for nearby live exposed parts: If the parts cannot be de-energized, you must use barriers such as insulated blankets to protect against accidental contact or you must wear proper PPE.

Proper Personal Protective Equipment

When working on or around live circuits, be sure to wear the right PPE to protect against electric shock and arc flash. Never wear clothing made from synthetic materials, such as acetate, nylon, polyester, or rayon - alone or combined with cotton. Such clothing is dangerous because it can burn and melt into your skin.

The type of PPE worn depends on the type of electric work being done (see table 2).

Once the hazard/risk category has been identified, check requirements for clothing and other PPE when working on or near energized equipment within the flash protection boundary (see tables 3 and 4). These PPE requirements protect against electric shock and incurable arc-flash burns. They do not protect against physical injuries from arc blasts.

The minimum PPE required would be an untreated natural fiber long-sleeve shirt and long pants with safety glasses with side shields (hazard/risk category 0).

For more information, call your local union, CPWR – Center for Construction Research and Training (CPWR) (301-578-8500 or www.cpwr.com), the National Institute for Occupational Safety and Health (1-800-35-NIOSH or www.cdc.gov/niosh).

Table 1. Approach boundaries to live parts for shock prevention

	Limited approach boundary			
Nominal system voltage range, phase to phase	**Exposed movable conductor**	**Exposed fixed- circuit part**	**Restricted approach boundary (allowing for accidental movement)**	**Prohibited approach boundary**
0 to 50 volts	Not specified	Not specified	Not specified	Not specified
51 to 300 volts	10 ft. 0 in.	3 ft. 6 in.	Avoid contact	Avoid contact
301 to 750 volts	10 ft. 0 in.	3 ft. 6 in.	1 ft. 0 in.	0 ft. 1 in.
751 to 15,000 volts	10 ft. 0 in.	5 ft. 0 in.	2 ft. 2 in.	0 ft. 7 in.

Source: From a portion of table 2-1.3.4, Approach Boundaries to Live Parts for Shock Protection (NFPA 70E *Standard for Electrical Safety Requirements for Employee Workplaces, 2000 edition*). Tables are reprinted with permission. Copyright ©2000 National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association on the referenced subject, which is represented only by the standard in its entirety.

Table 2. Hazard risk category classification (within flash protection boundary)

For low-voltage tasks (600 volts and below), this table applies only when there is an available short-circuit capacity of 25 kA or less, and when the fault clearing time is 0.03 seconds (2 cycles) or less. For 600-volt-class motor control centers, a short-circuit current capacity of 65 kA or less and fault-clearing time of 0.33 seconds (20 cycles) is allowed. For 600-volt-class switchgear, you need a short-circuit current capacity of 65 kA or less and fault-clearing time of 1 second (60 cycles). For tasks not covered in this table and tasks involving equipment with larger short-circuit current capacities or longer fault-clearing times, a qualified person must conduct a flash hazard analysis (see section 2-1.3.3, Part II, NFPA 70E).

	Hazard/risk category	**Voltage-rated Gloves**	**Tools**
Opening Doors and Covers			
Opening hinged covers (to expose bare, energized parts)			
240 volts or less	0	N	N
600-volt-class motor control centers	1	N	N
600-volt-class lighting or small power transformers	1	N	N
600-volt-class switchgear (with power circuit breakers or fused switches)	2	N	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	3	N	N
1 kV and over (metal clad switchgear)	3	N	N
1 kV and above metal clad load interrupter switches, fused or unfused	3	N	N
Removing bolted covers (to expose bare, energized parts)			
240 volts or less	1	N	N
600-volt-class motor control centers or transformers	2*	N	N
600-volt-class lighting or small power transformers	2*	N	N
600-volt-class switchgear (with power circuit breakers or fused switches)	3	N	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	4	N	N
1 kV and above (metal clad switchgear)	4	N	N

1 kV and above metal clad load interrupter switches, fused or unfused	4	N	N
Opening transformer compartments for metal clad switchgear 1 kV and above	4	N	N
Installing, Removing or Operating Circuit Breakers (CBs), Fused Switches, Motor Starters or Fused Contactors			
Installing or removing circuit breakers or fused switches, 240 volts or less	1	Y	Y
Inserting or removing (racking) CBs from cubicles, doors closed			
600-volt-class switchgear (with power circuit breakers or fused switches)	2	N	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	2	N	N
1 kV and above metal clad switchgear	2	N	N
Inserting or removing (racking) CBs or starters from cubicles, doors open			
600-volt-class switchgear (with power circuit breakers or fused switches)	3	N	N
NEMA E2 (fused contactor) Motor Starters, 2.3 kV through 7.2 kV	3	N	N
1 kV and above metal clad switchgear	4	N	N
Operating circuit breaker (CB), fused switch, motor starter or fused contactor, covers on/doors closed			
240 volts or less	0	N	N
>240-<600 volt panelboards/switchboards (molded case or insulated case CBs)	0	N	N
600 volt class motor control centers	0	N	N
600 volt class switchgear (with power circuit breakers or fused switches)	0	N	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	0	N	N
1 kV and above (metal clad switchgear)	2	N	N
1 kV and above metal clad load interrupter switches, fused or unfused	2	N	N
Operating circuit breaker, fused switch, motor starter or fused contactor, covers off/doors open			
240 volts or less	0	N	N
>240-<600 volt panelboards/switchboards (molded case or insulated case CBs)	1	N	N
600 volt class motor control centers	1	N	N
600 volt class switchgear (with power circuit breakers or fused switches)	1	N	N
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	2*	N	N
1 kV and above (metal clad switchgear)	4	N	N

Working on Energized Parts			
Working on energized parts, voltage testing, applying safety grounds			
240 volts or less	1	Y	Y
>240-<600 volt panelboards/switchboards (molded case or insulated case CBs)	2*	Y	Y
600-volt-class motor control centers	2*	Y	Y
600-volt-class switchgear (with power circuit breakers or fused switches)	2*	Y	Y
600-volt-class lighting or small power transformers	2*	Y	Y
600-volt-class revenue meters	2*	Y	Y
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	3	Y	Y
1 kV and above metal clad switchgear	4	Y	Y
1 kV and above metal clad load interrupter switches, fused or unfused	4	Y	Y
Working on control circuits with exposed energized parts, 120 volts or below			
600-volt-class motor control centers	0	Y	Y
600-volt-class switchgear (with power circuit breakers or fused switches	0	Y	Y
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	0	Y	Y
1 kV and above metal clad switchgear	2	Y	Y
Working on control circuits with exposed energized parts, over 120 volts			
600-volt-class Motor Control Centers	2*	Y	Y
600-volt-class switchgear (with power circuit breakers or fused switches)	2*	Y	Y
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	3	Y	Y
1 kV and above metal clad switchgear	4	Y	Y
Other Tasks			
Reading panel meters while operating meter switches	0	N	N
Metal clad load interrupter switches, fused or unfused, 1 kV and above			
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	2	N	N
Insulated cable examination, in open area	2	Y	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Removing/installing other equipment			
Starter "buckets" for 600-volt-class motor control centers	3	Y	N
600-volt-class revenue meters	2*	Y	N
Covers or cable troughs for 600-volt-class revenue meters	1	N	N

2* = A double-layer switching hood and hearing protection are required, in addition to the other hazard/risk category 2 requirements of table 3-3.9.2 of Part II of NFPA 70E. See tables 3 and 4.

kV = kilovolt

Note: Applying safety grounds after voltage testing does not require voltage-rated tools. Voltage-rated gloves or tools are rated and tested for the maximum line-to-line voltage on which work will be done. The hazard/risk category may be reduced by one number for low-voltage equipment listed here where the short-circuit current available is less than 15 kA (less than 25 kA for 600-volt-class switchgear).

Source: Adapted from table 3-3.9.1, Hazard Risk Category Classifications (NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces, 2000 edition). Tables are reprinted with permission. Copyright ©2000 National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association on the referenced subject, which is represented only by the standard in its entirety.

Table 3. Simplified, two-category, flame-resistant clothing system

Applicable tasks	Clothing requirement
All hazard/risk category 1 and 2 tasks listed in table 2 On systems operating at less than 1000 volts, these tasks include work on all equipment except • Insertion/removal of low-voltage motor starter "buckets" • Insertion/removal of power circuit breakers with the switchgear doors open • Removal of bolted covers from switchgear. On systems operating at 1000 volts or more, tasks also include the operation, insertion, or removal of switching devices with equipment enclosure doors closed.	Everyday work clothing Flame-resistant long-sleeve shirt (minimum ATPV of 5) worn over an untreated cotton T-shirt with FR pants (minimum ATPV of 8) Or FR coveralls (minimum ATPV of 5) worn over an untreated cotton T-shirt (or an untreated natural-fiber long-sleeve shirt) with untreated natural-fiber pants.
All hazard/risk category 3 and 4 tasks listed in table 2 On systems operating at 1000 volts or more, these tasks include work on energized parts of all equipment. On systems of less than 1000 volts, tasks include insertion or removal of low-voltage motor-start motor control center "buckets," insertion or removal of power circuit breakers with the switchgear enclosure doors open, and removal of bolted covers from switchgear.	Electric "switching" clothing Double-layer FR flash jacket and FR bib overalls worn over either FR coveralls (minimum ATPV of 5) or FR long-sleeve shirt and FR pants (minimum ATPV of 5) worn over untreated natural-fiber long-sleeve shirt and pants worn over an untreated cotton T-shirt Or Insulated FR coveralls (minimum ATPV of 25, independent of other layers) worn over untreated natural-fiber long-sleeve shirt with untreated cotton blue jeans ("regular weight," minimum 12 oz./sq. yd. fabric weight), worn over an untreated cotton T-shirt.

FR - flame resistant.
ATPV - arc thermal performance exposure value of the clothing in calories/cm2.
Source: Based on Table F-1 in appendix F of NFPA 70E, Electrical Safety Requirements for Employee Workplaces, 2000.

Table 4. Flame-resistant protective clothing and equipment

Flame-resistant protective clothing and equipment	Protective systems for hazard/risk category (4 = most hazardous)			
Hazard/risk category number	1	2	3	4
Flash suit jacket (2-layer)				X
Flash suit pants (2-layer)				X
Head protection				
Hardhat	X	X	X	X
Flame-resistant hardhat liner			X	X
Eye protection (safety glasses + side shields or safety goggles)	X	X	X	X
Face protection (double-layer switching hood)			X	X
Hearing protection (ear canal inserts)		2* tasks		
Leather gloves or voltage-rated gloves with leather protectors		2*tasks	X	X
Leather work shoes			X	X
	As needed	X	X	X
	As needed	X		

Source: Based on personal protective equipment requirements of table 3-3.9.2 of NFPA 70E, Electrical Safety Requirements for Employee Workplaces. Tables are reprinted with permission. Copyright ©2000 National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association on the referenced subject, which is represented only by the standard in its entirety.