Electrical Safety:

Basic Principles and Hazard Controls

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What We'll Cover

- Basic electrical principles
- Electrical hazards
- Overview of applicable regulations and standards
- Hazard identification
- Equipment requirements
- Hazard controls

…and our Puzzle Winner!

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Sobering Statistics

1,200 fatalities

13,150 lost time

2,000 treated for burns

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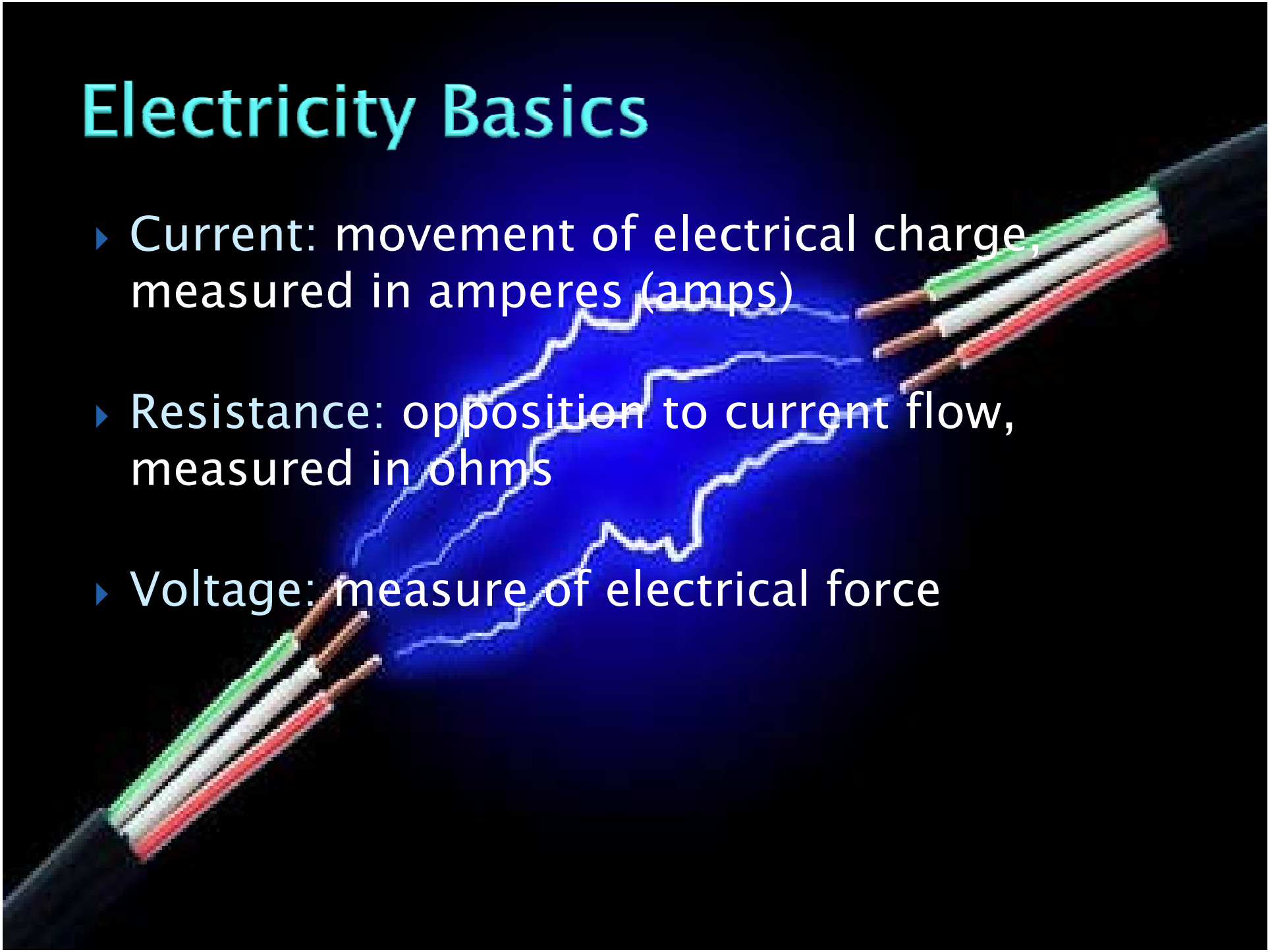
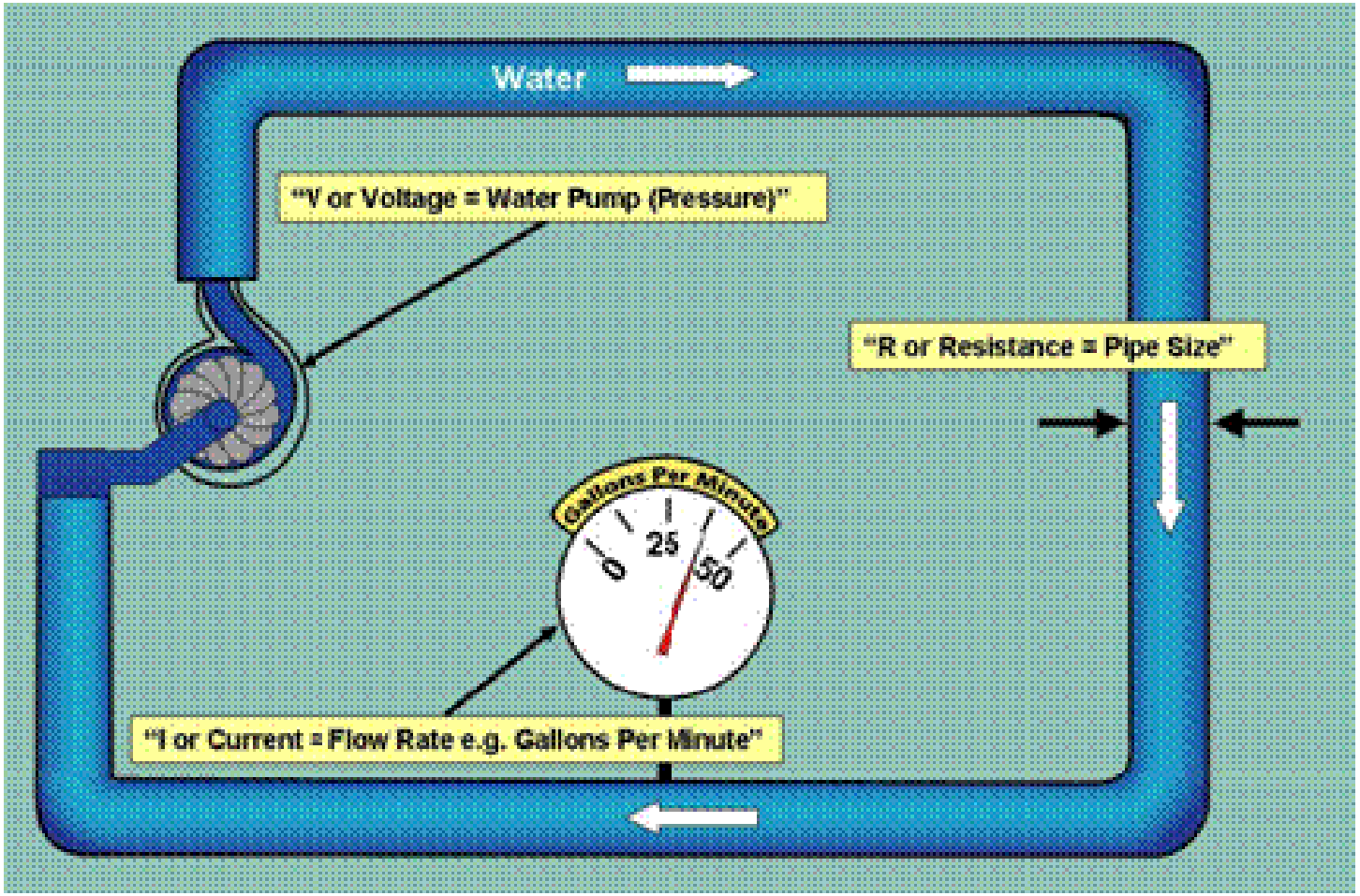
Electricity Basics



- Current: movement of electrical charge, measured in amperes (amps)
- Resistance: opposition to current flow, measured in ohms
- Voltage: measure of electrical force

Electricity/Water Analogy



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Electricity Basics

- **Circuit** – a complete path for the flow of current
- **Ground** – a physical, conductive, electrical connection to the earth
- **Disconnecting means** – device(s) used to disconnect conductors from the electrical source

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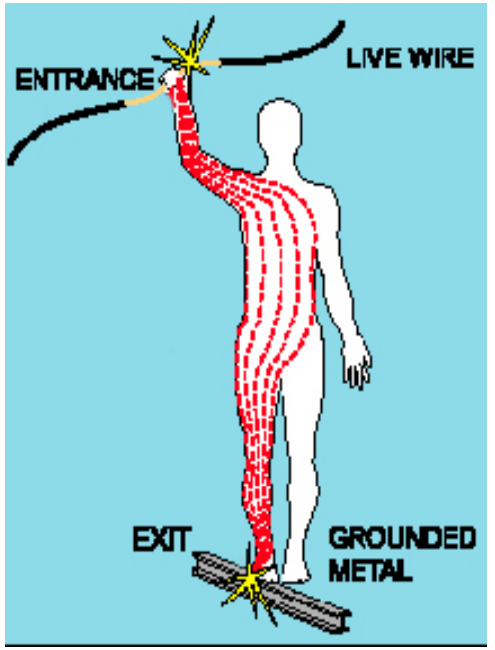
Electrical Shock

- Received when current passes through the body
- Severity of the shock depends on:
  - Path of the current
  - Amount of current
  - Length of time
  - Contact area and pressure
  - Skin condition



Acute Effects of Electric Shock

Asphyxia	Heart Fibrillation	Respiratory Arrest	External and Internal Burns
Passage of current through the chest cavity causes chest muscles to contract, making breathing difficult	Electrical shock interferes with natural impulses regulating heart rhythm	Electrical shock passes through the brain's medulla, interrupting diaphragm muscle control	Increased resistance and rapid heating of electrolytic fluid and nerve pathways

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Electrical Shock Hazard

Current (mA)	Effect/Feeling
0.5–3	Tingling sensation
3–10	Painful shock
10–20	"Let-go" threshold
20–30	Respiratory paralysis
75–200	Ventricular fibrillation
1500 +	Tissue and organs start to burn

- 2,300 mA – Amount of current drawn by a small electric drill
- 15,000 mA – Lowest overcurrent trip!

Electrical Fire Hazards

- Electrical fire statistics:
  - 2005 to 2009 – 115,500 non-residential structural fires
- Typical Causes:
  - Overloaded circuits
  - Undersized wiring

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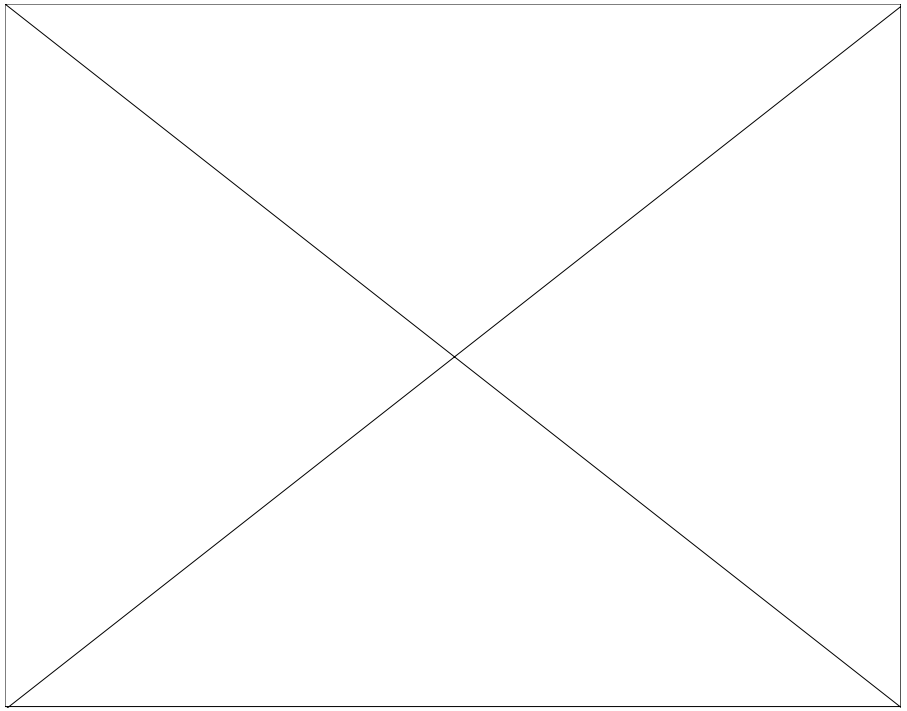
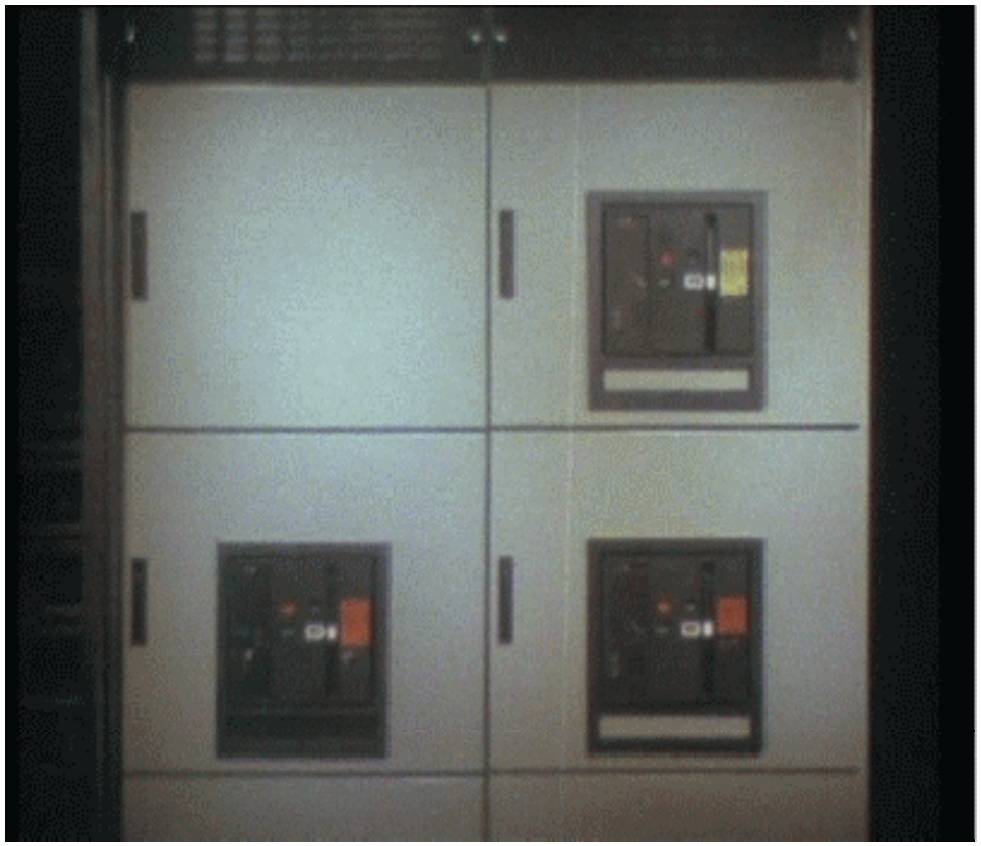
Arc Flash/Blast Hazards



Racking a breaker

Arc Flash/Blast Hazards



Bolted covers

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Questions?

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Managing Electrical Safety

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Rules and Standards

- Three main sources
  - OSHA – Subpart S: Electrical
  - NFPA 70 – National Electrical Code
  - NFPA 70E – Standard for Electrical Safety in the Workplace
- Plus the local regulations

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Electrical Safety Regulations

Design safety standards

OSHA

Safety related maintenance requirements

Safety related work practices

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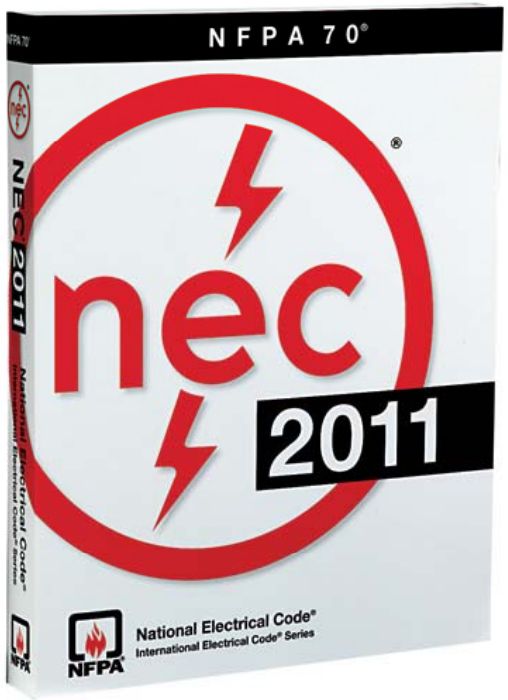
Electrical Safety Standards



Primary focus on electrical design standards

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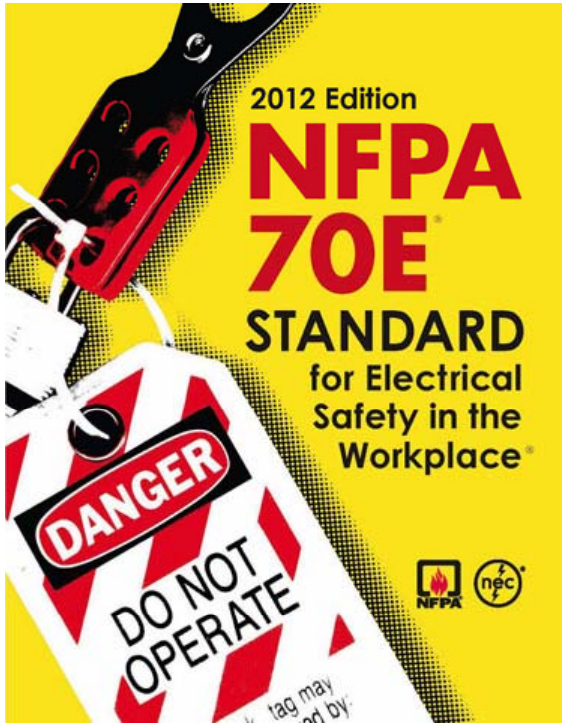
Electrical Safety Standards



Focus on worker safety standards to protect against:

- Shock hazards
- Arc flash/blast hazards

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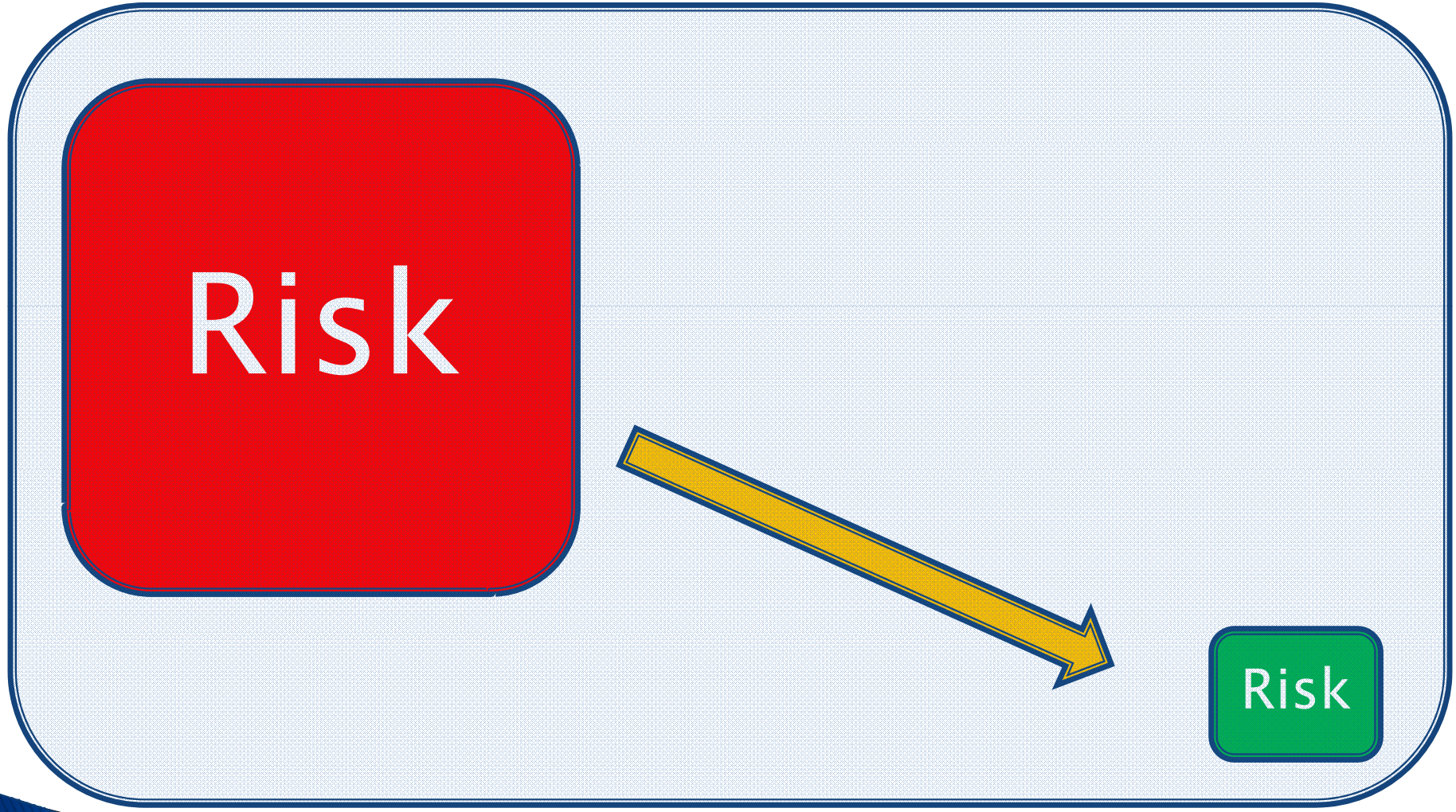
What's Your Electrical Safety Goal?



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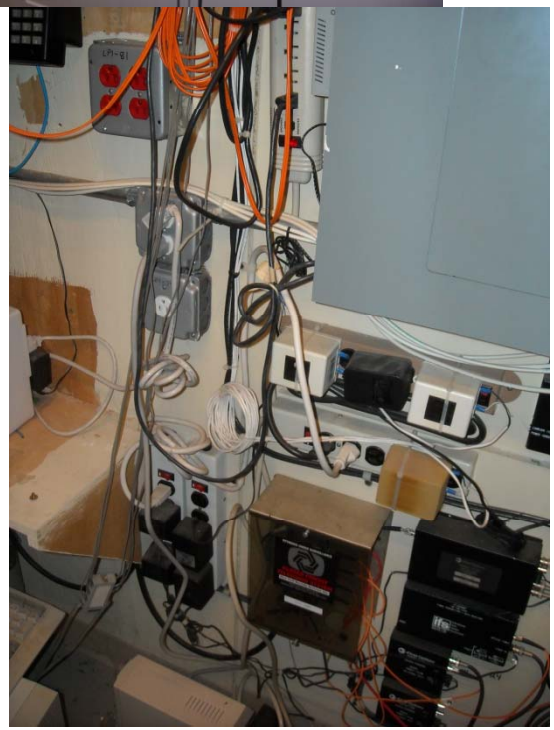
Hazard Identification

- Types/methods of hazard identification
  - Physical inspections
  - Analysis of tasks
  - Analysis of processes
  - Analysis of accidents and near miss incidents

Flexible Cords and Cables



Flexible Cords

- Used in continuous lengths without a splice or tap

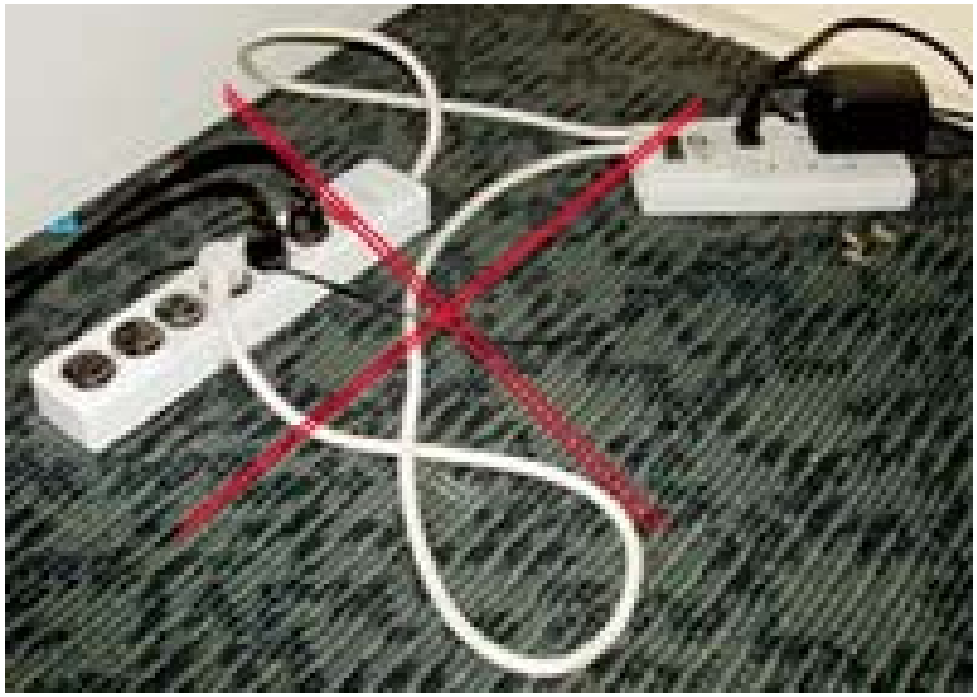
- Provided with strain relief

Flexible Cords

- Extension Cords
  - Follow flexible cord restrictions
  - Maintenance or temporary use
  - Must be equipped with a grounding conductor
  - Appropriate conductor size
  - Energized from an approved receptacle

Relocatable Power Taps

- OSHA Standard Interpretation 11/18/2002 – *Compliance requirements for relocatable power taps or "power strips."*



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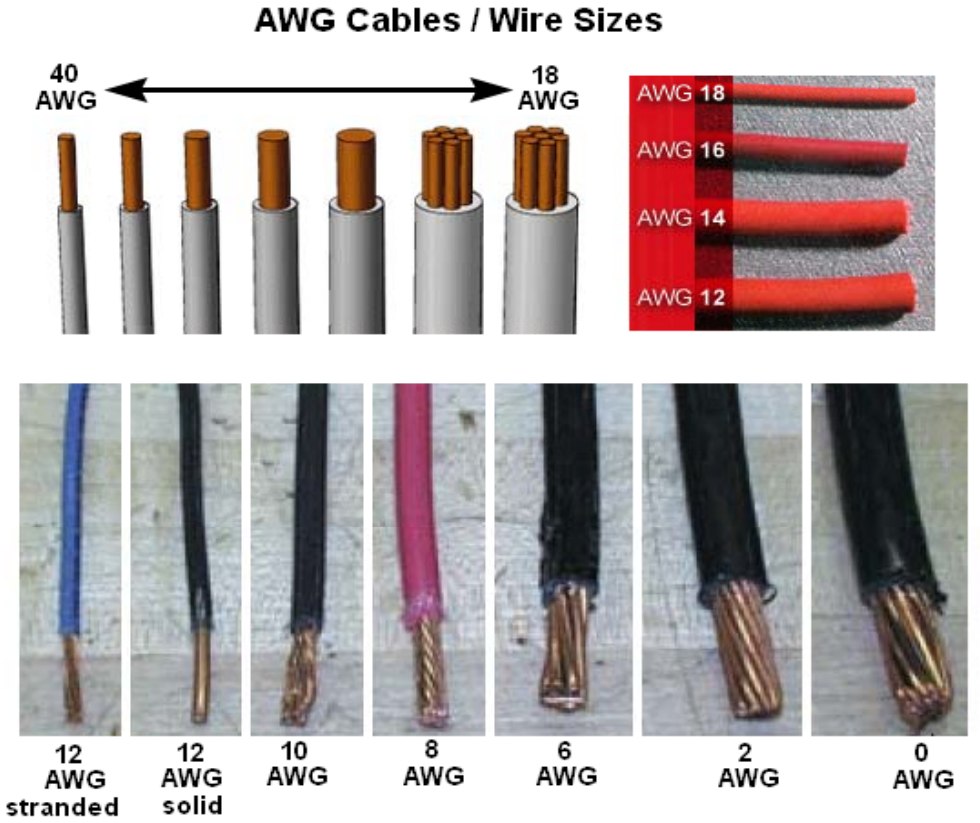
Electrical Wiring Hazard

- When the conductor is too small
  it can overheat without tripping the circuit breaker



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Overload Hazard

- Too many devices plugged into a circuit
  - Overheating
  - Arcing
  - Fire

Table S-4: Maximum Cord/Plug Connected Load to Receptacle		
Circuit Rating (Amperes)	Receptacle Rating (Amperes)	Maximum Load (Amperes)
15 or 20	15	12
20	20	16
30	30	24

Equipment Labeling

- Required by OSHA and NFPA 70E

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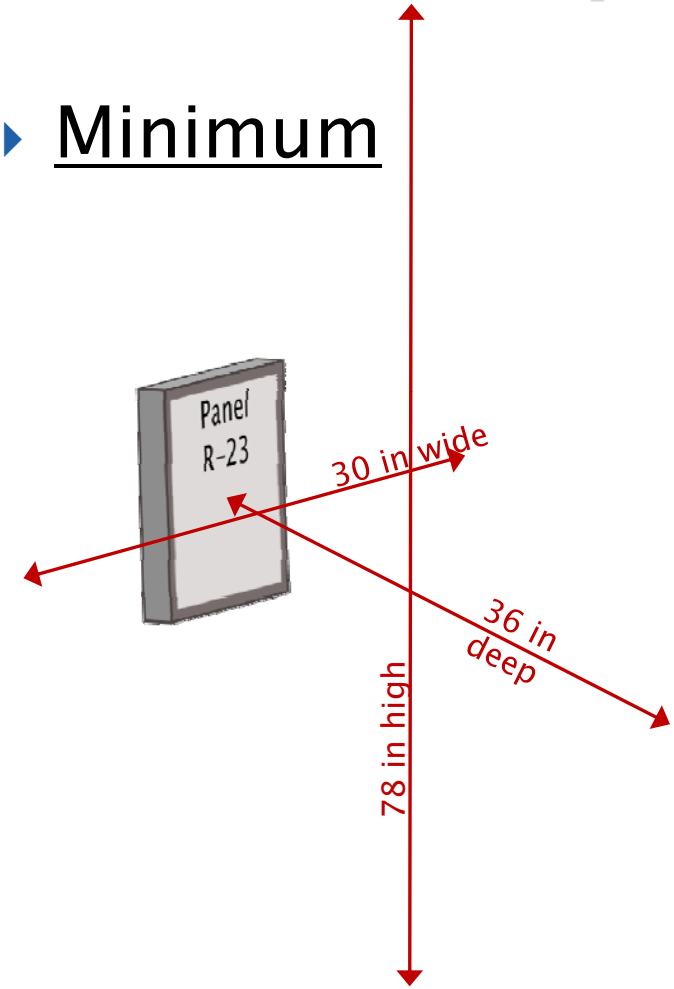
Electrical Equipment Access

- Minimum



Electrical Work Practices

Work performed on or near exposed electrical circuits, components, or systems while they are energized

Exposes workers to shock and arc flash hazards with potentially severe consequences

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De-Energize through Lockout

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Energized Electrical Work

Only allowable if de-energizing would:

- Infeasible
- Increase hazards

- Interrupt life safety systems

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Energized Electrical Work Permit

(A) ENERGIZED ELECTRICAL WORK

Max permit duration is one shift up to 12 hou

(B) Description of work

01 **Specific task to be performed:** Install Break

02 **Justification for not doing this work while DE-EN schedul outage:** Shutting down the pane hazardous conta

(D) NAME(S) OF PERSON(S) PERFORMING

01 *Safety Observer's Printed Name & Signature*
Barney Fife / Barney Fi

02 *Printed Name & Signature*
Daniel Whitney / Larry TC Gu

ER #
123SAP123

0800 AM 120610

tion:

(A) ENERGIZED ELECTRICAL WORK PERMIT (>50 VOLTS) | WORK ORDER #

MAX PERMIT DURATION IS ONE SHIFT UP TO 12 HOURS | 01 start time/date | 02 end time/date

(B) DESCRIPTION OF WORK

01 Specific task to be performed:

02 Justification for not doing this work while DE-ENERGIZED or deferring the work until the next scheduled outage:

(C) LOCATION OF WORK - AREAS AFFECTED

01 Equipment/Panel: _____

02 Voltge of Equipment: _____V

03 Specific equipment to be worked on and location:

(D) NAME(S) OF PERSON(S) PERFORMING WORK; MINIMUM OF TWO. ONE MUST BE THE SAFETY OBSERVER.

01 *Safety Observer's Printed Name & Signature* | 02 *Printed Name & Signature*

03 *Printed Name & Signature* | 04 *Printed Name & Signature*

(E) ARC FLASH AND SHOCK HAZARD INFORMATION AND CONTROL

01 Arc Flash Hazard Category: | 02 Arc Flash Hazard Boundary: _____ ft

03 Protective Clothing and PPE (check all that apply). Rating of Arc Flash Clothing: _____ cal/cm²

- ☐ Cotton Undergarments
- ☐ Long Sleeve Shirt (Natural Fibers)
- ☐ Arc Rated Long Sleeved Shirt
- ☐ Arc Rated Long Pants
- ☐ Are Rated Coveralls
- ☐ Are Rated Arc Flash Suite Jacket
- ☐ Arc Rated Arc Flash Suit Pants
- ☐ Arc Rated Arc Flash Suite Hood
- ☐ Rubber gloves. Date of last test: _____
- ☐ Arc Rated Leather Gloves or Insulating Gloves w/Protectors
- ☐ Non-Conductive Dielectric Safety Shoes
- ☐ Other: _____

04 Voltage Rated (Insulated) Tools (*indicate*):

(F) REQUIRED PRECAUTIONS, notifications, and approvals

01 ☐ Location and type of upstream disconnect | *List Location:*
02 ☐ Safety observer has been instructed in the method and way to perform emergency disconnect upstream.
03 ☐ Only Qualified or Authorized Electrical Person performing this work and means to restrict access to unqualified persons.
04 ☐ Electrical testing equipment is properly rated for the voltage and in good working order.
05 ☐ Removal of all conductive jewelry and personal accessories (keys or coins in pocket, belt, radio, cell phone, etc.).
06 ☐ GFCI(s) are used in moist/damp environments and for portable powered tools for construction activates.
07 ☐ A trained CPR safety observer, not performing the work, must be present.
08 ☐ All other hazardous energy sources which could impact job have been identified and controlled.
09 ☐ Diligence completed to ensure there are no conflicting jobs in the area.
10 ☐ Communication and emergency procedures have been discussed and established.

(G) WORK CREW LEADER'S ACKNOWLEDGEMENT

I have read, understood and agree that all work will be performed by the Work Crew in accordance with the conditions stated on this permit and the related Safe Work Authorization form.

01 *Work Crew Leader's Signature* | 02 *Cell Phone/Pager No.*

03 *Work Crew Leader's Printed Name* | 04 *Work Crew Leader's Company Name*

(H) PERMIT APPROVAL | Yes

Preparation work (Job Plan and Precautions) properly completed?	01 ☐
Safe Work Authorization form properly completed?	02 ☐
Required notifications & approvals have been given (*review site-specific notifications and approvals list attached*).	03 ☐
Permit schedule approved by: 04 *Area Owner's Signature*	
Permit work approved by: 05 *Authorized Contractor "Energized Electrical Work" Permit Assessor's Signature*	

(I) PERMIT CLOSURE

01 Permit work has been completed. ☐-yes ☐-no-explain:

02 Temporary equipment was removed & permanent barriers or covers were reinstalled: ☐-yes ☐-no-explain:

03 Area Owner has been notified that normal operations may be safely restarted: ☐-yes ☐-no-explain:

04 *Time/Date Work Completed* | 05 *Work Crew Leader's Signature*

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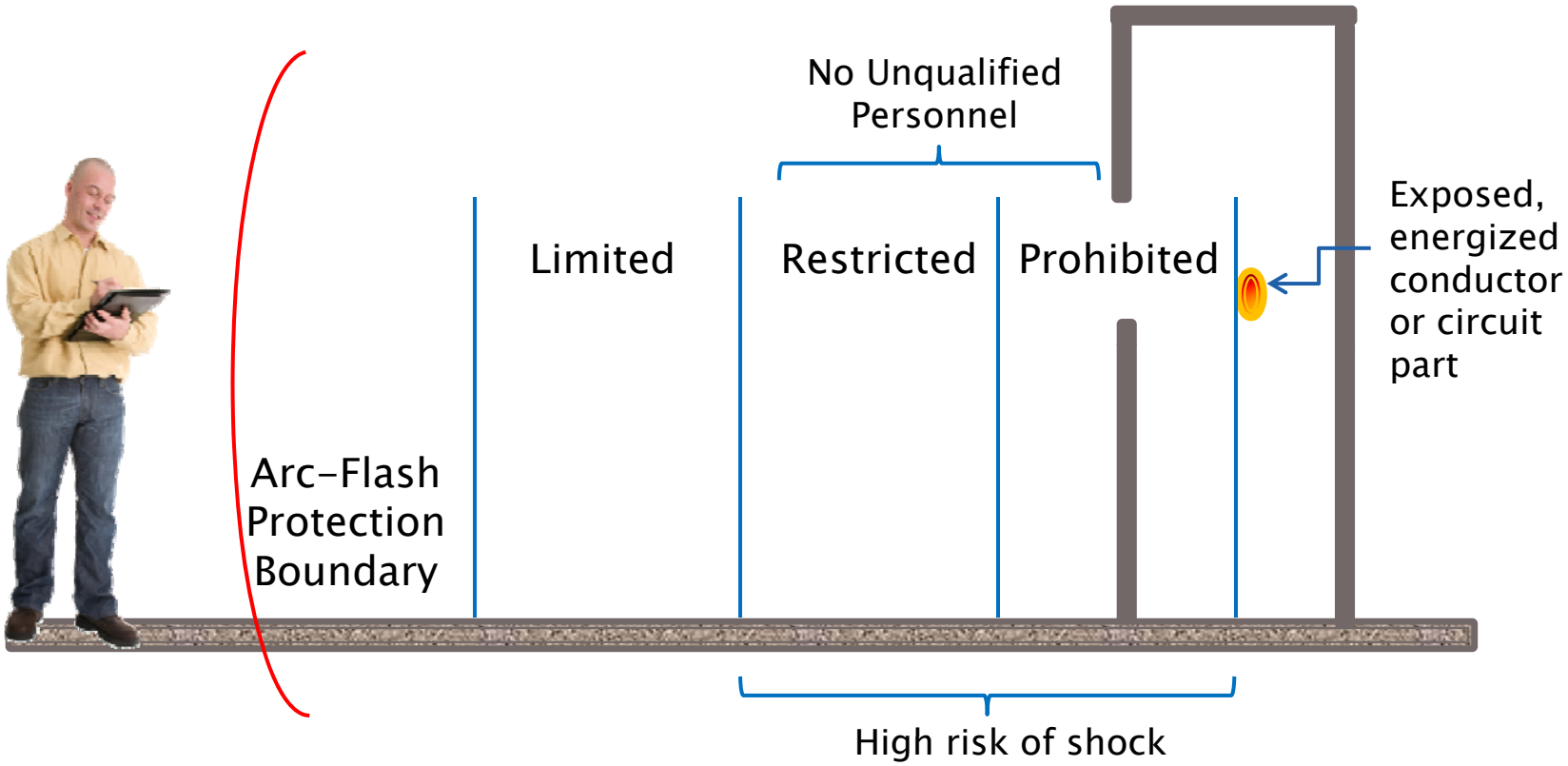
Arc-Flash Label

Approach Boundary



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Electrical PPE

Tested according to ASTM F-2178-02a and ANSI Z87.1-2003.

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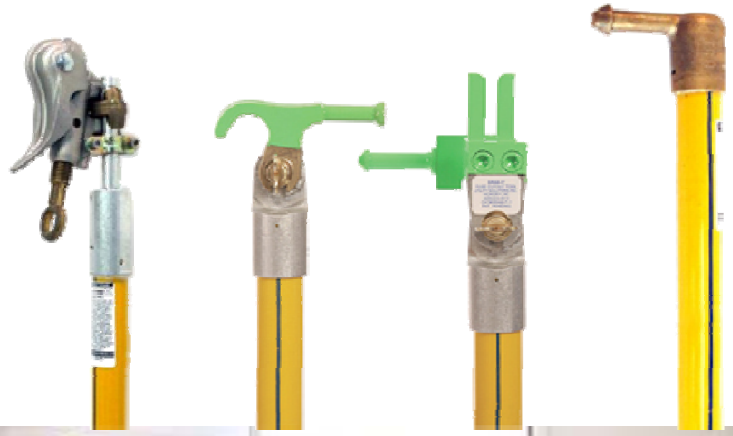
Electrical Tools



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Engineering Controls

Shielding

Remote racking system

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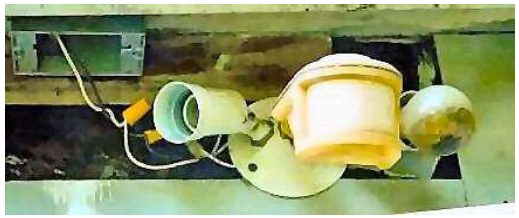
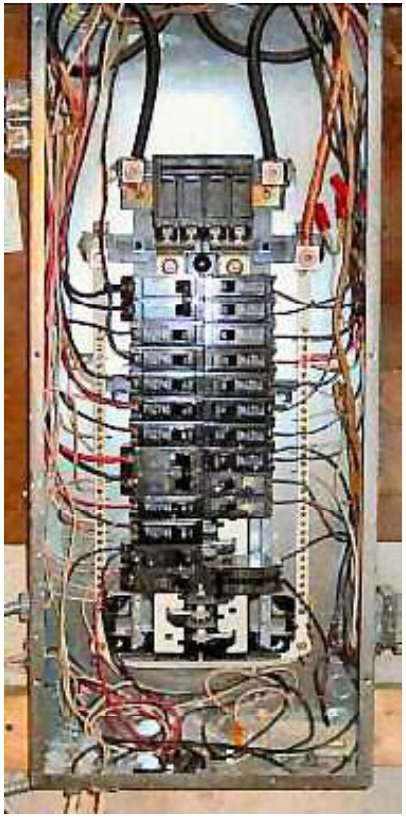
Guarding Exposed Live Parts





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Shock Hazard Protection

- Ground Fault Interrupt Device
  - Protects you from dangerous shock caused by current “leakage” known as a ground fault
  - GFCI detects a difference in current between the black and white circuit wires
  - If a ground fault is detected, the GFCI can shut off electricity flow in as little as 1/40 of a second, protecting you from a dangerous shock

Overload Hazard Protection

- Overcurrent devices
  - Fuses or circuit breakers
  - Make a weak link in the circuit
  - When there is too much current:
    - Fuses melt
    - Circuit breakers trip open

Questions?

Please type them in the question box at right

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Electrical Safety Management Case Study

- Jerry Reid

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Case Study: Large Industrial Manufacturer

- Several “near miss” situations
- Evaluation of electrical safety program
- Gap analysis:
  - Live work limitations
  - Arc flash hazard analysis
  - Personnel qualification
  - PE care and testing
  - Use of EEW Permit

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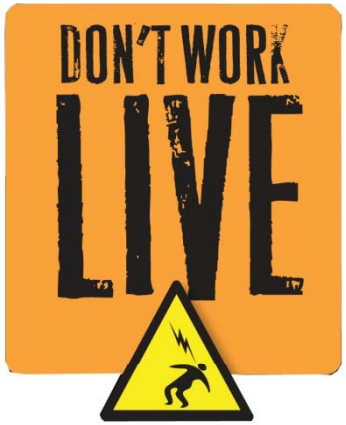
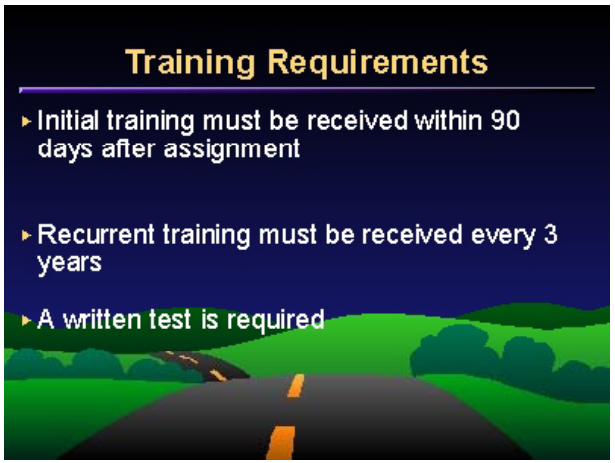
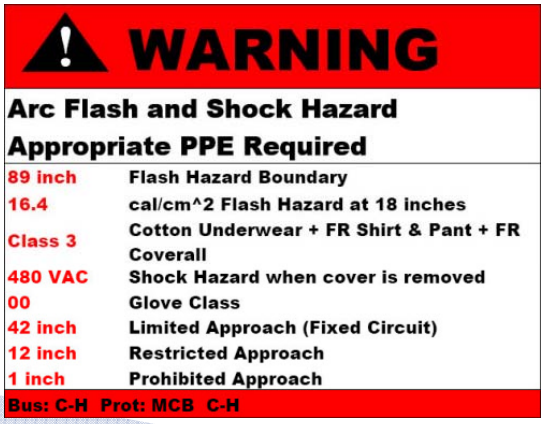
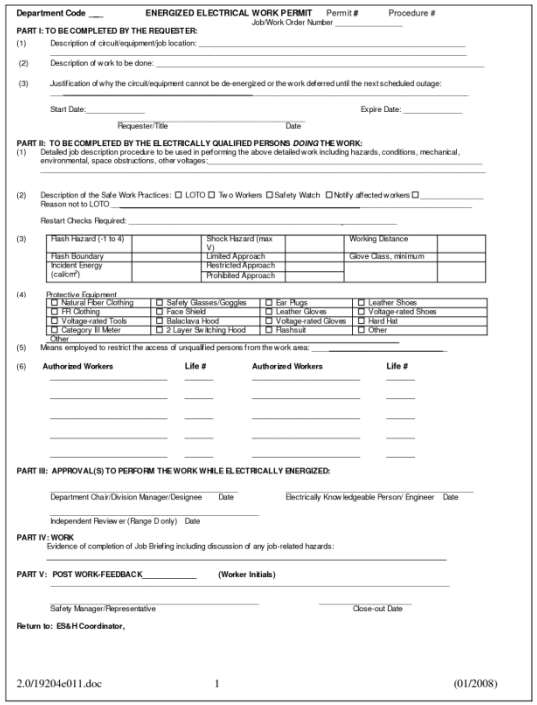
Case Study: Actions Taken

- Corrective actions – identified issues
- Revision of written safety program









Department Code ___ ENERGIZED ELECTRICAL WORK PERMIT Permit # Procedure #
Job/Work Order Number _____

PART I: TO BE COMPLETED BY THE REQUESTER:

(1) Description of circuit/equipment/job location: _____

(2) Description of work to be done: _____

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

Start Date:_____ Expire Date: _____

Requester/Title Date

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

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

(2) Description of the Safe Work Practices: ☐ LOTO ☐ Two Workers ☐ Safety Watch ☐ Notify affected workers ☐ _____
Reason not to LOTO _____
Restart Checks Required: _____

(3)

Flash Hazard (=1 to 4)		Shock Hazard (max V)		Working Distance	
Flash Boundary		Limited Approach		Glove Class, minimum	
Incident Energy (cal/cm²)		Restricted Approach			
		Prohibited Approach			

(4) Protective Equipment

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

Other _____

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

(6)

Authorized Workers	Life #	Authorized Workers	Life #

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

Department Chair/Division Manager/Designee Date Electrically Knowledgeable Person/ Engineer Date

Independent Reviewer (Range D only) Date

PART IV: WORK
Evidence of completion of Job Briefing including discussion of any job-related hazards: _____

PART V: POST WORK-FEEDBACK_____ (Worker Initials)

Safety Manager/Representative Close-out Date

Return to: ES&H Coordinator,

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Case Study: Actions Taken

- Implementation
  - Management awareness
  - Training:

- Results
  - Improved compliance
  - Reduced risk

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And the winner is…

Valori Ranson
Environmental Manager
Dixie Chemical Company

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Thank You

Barbara Jo Ruble, QEP, CPEA
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Program Manager
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