
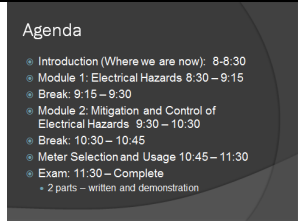
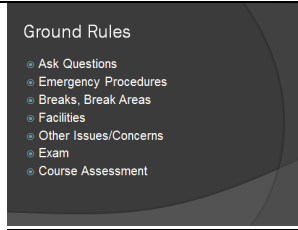
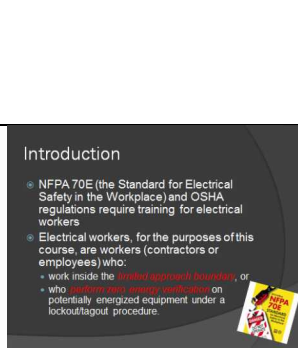

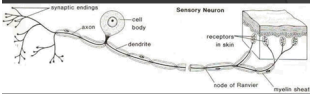


ELC200 Instructor Guide

<u>Slide</u>	<u>Instructor Comments</u>	<u>Activities</u>
	<p>Welcome students to class, identify that the class is for individuals performing energized work activities, including voltage measurements (troubleshooting) and zero energy verification under lockout/tagout.</p>	
 <p>Agenda</p> <ul style="list-style-type: none"> • Introduction (Where we are now): 8-8:30 • Module 1: Electrical Hazards 8:30 – 9:15 • Break: 9:15 – 9:30 • Module 2: Mitigation and Control of Electrical Hazards 9:30 – 10:30 • Break: 10:30 – 10:45 • Meter Selection and Usage 10:45 – 11:30 • Exam: 11:30 – Complete <ul style="list-style-type: none"> • 2 parts – written and demonstration 	<p>Review agenda – state break policy</p>	
 <p>Ground Rules</p> <ul style="list-style-type: none"> • Ask Questions • Emergency Procedures • Breaks, Break Areas • Facilities • Other Issues/Concerns • Exam • Course Assessment 	<p>Review ground rules; ensure ID of restrooms as appropriate; review emergency procedures, including muster location and requirement to wait until verification that all students have exited building. Emphasize the importance of participation and questions. NOTE that the exam is closed book. Explain why the exam is closed book, and note that the questions on page 3 in the book must be answered correctly in order to not retake the class.</p>	<p>Ask if there are any questions before we begin; remind everyone to sign in on the sign in sheet for credit.</p>
 <p>Introduction</p> <ul style="list-style-type: none"> • NFPA 70E (the Standard for Electrical Safety in the Workplace) and OSHA regulations require training for electrical workers • Electrical workers, for the purposes of this course, are workers (contractors or employees) who: <ul style="list-style-type: none"> • work inside the limited approach boundary, or • who perform work on potentially energized equipment under a lockout/tagout procedure. 	<p>Explain what NFPA 70E is and its importance to the electrical world, and to Sandia, specifically (10CFR851). Introduce LAB concept;</p> <p>Explain why zero energy verification is energized work.</p>	<p>ASK: Why is the performance of zero energy verification considered energized electrical work? What other activities fall in the category of energized electrical work?</p>

<p>Why Electrical Safety?</p> <ul style="list-style-type: none"> In 2009, 155 workers were electrocuted (death by electricity) in workplace accidents, and another 2,100 people were injured sufficiently from electrical contact to require time away from work. Since 1992, over nearly 1,000 workers have died, and almost 45,000 workers have been injured in electrical accidents. At Sandia, we continue to experience shocks – while few have been traumatic, many had the potential to be... 	<p>Review stats</p> <p>Review/discuss most recent shock events (consistent with time available in module)</p>	<p>ASK: Has anyone experienced an electric shock?</p> <p>ASK: What could have been done to prevent this event?</p> <p>ASK: Why is electrical safety at Sandia more challenging? (note answers on board)</p>
<p>Why is Sandia More Challenging?</p> <ul style="list-style-type: none"> Custom built electrical equipment Wide range of energy levels, from batteries with low voltages and high currents, to regular equipment, to accelerators with millions of volts and amps Varied training and experience of workers Assumption that "training = qualification" 	<p>Review answers from previous question; discuss in depth the assumption that training = qualification.</p> <p>Clarify, after discussion, the importance of not only being trained, but having something (knowledge, skills, abilities etc.) in addition to the training.</p>	<p>ASK: Who has perform energized work activities (zero energy verification, live troubleshooting, live work)?</p> <p>Follow up: What qualified you to perform that activity? (ask 3-4 people)</p> <p>Show video "an unnecessary incident"</p>
<p>Objectives</p> <ul style="list-style-type: none"> Upon completion of this course, the student will be able to: <ul style="list-style-type: none"> Understand the specific hazards associated with electrical energy Identify and understand the relationship between electrical hazards and possible injury Describe the methods of release of victims from contact with exposed energized electrical conductors or circuit parts Be familiar with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulating tools and test equipment Select an appropriate voltage detector and demonstrate how to use a device to verify the absence of voltage, including interpreting indications provided by the device. Understand all limitations of each specific voltage detector that may be used. 	<p>Review objectives</p>	
<p>Objectives</p> <ul style="list-style-type: none"> Upon completion of this course, the student will be able to: <ul style="list-style-type: none"> Obtain the skills and techniques necessary to distinguish exposed energized electrical conductors and circuit part from other parts of electrical equipment Obtain the skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts State the approach distances specified in Table 130.2(C) and the corresponding voltages to which the qualified person will be exposed Explain the decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely 	<p>Review objectives; note that these are the minimum requirements found in the OSHA standard and NFPA 70E</p>	
<p>Limitations of Class</p> <ul style="list-style-type: none"> This class is <i>Safety Training</i> required by OSHA and NFPA 70E This class is not skill training This class is not a qualification class and does not qualify you to perform any activities Your manager is responsible to ensure that you are properly qualified to perform assigned activities through <ul style="list-style-type: none"> OJT Prior skill/experience Demonstration 	<p>Emphasize that this is not a qualification class...but simply safety training. Qualification is the responsibility of the manager based on KSA's...</p> <p>Discuss purpose of student guide (training aid) – the actual requirements for energized work are found in the Electrical Safety Manual</p>	<p>Emphasize that students are to use the manual when performing energized work activities to ensure all requirements are covered.</p>

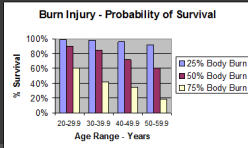


<p>Qualified Electrical Worker</p> <ul style="list-style-type: none"> • "Trained" ≠ "Qualified" • Qualified means that <ul style="list-style-type: none"> • The worker has demonstrated familiarity with relevant hazards, specific equipment, and appropriate procedures • The worker has demonstrated familiarity with relevant electrical maintenance techniques, codes, and other general knowledge • The manager has reviewed and approved the qualifications 	<p>Review slide, note that the reference for the slide is the SNL Electrical Safety Manual (ESM); Discuss role of the ESM in electrical safety at Sandia...specifically that it is the rule – and should be used whenever performing or considering the performance of energized work.</p>	
<p>Module 1</p> <p>Electrical Hazards</p>	<p>Introduce first major topic – Electrical Hazards</p> <p>Discuss personal fatality accidents from electrical contact</p>	<p>Ask if there are any questions so far...</p> <p>Ask if anyone, or anyone they know has been injured or killed by electricity.</p>
<p>Module 1 Objectives</p> <ul style="list-style-type: none"> • Upon completion of this section, the student should be able to: <ul style="list-style-type: none"> • Understand the specific hazards associated with electrical energy • Identify and understand the relationship between electrical hazards and possible injury • Describe the methods of release of victims from contact with exposed energized electrical conductors or circuit parts 	<p>Review 3 main objectives</p>	<p>Ask “What are the hazards associated with electricity?”</p>
<p>Electrical Hazards</p> <ul style="list-style-type: none"> • Two Primary Electrical Hazards <ul style="list-style-type: none"> • Shock – contact by injury with energized electrical conductors and circuit parts • Electrocution is death by electricity • Arc Flash – the passage of substantial electrical current through air 	<p>Briefly discuss the 2 hazards; note that the outcomes (injuries) vary from nothing to severe muscle damage, to fibrillation of the heart, as well as severe burns...many injuries can result in death.</p>	<p>Ask “Why are ‘falls’ listed as a secondary hazard?”</p>
<p>Shock Hazard</p> <ul style="list-style-type: none"> • Shock mechanisms <ul style="list-style-type: none"> • Muscle/nerve disruption • Internal Heating 	<p>Discuss two mechanisms of shock</p> <p>Discuss burning from electric shock, and the requirements for it to occur.</p>	<p>Show hot dog cooking video</p>


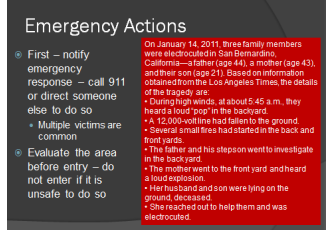
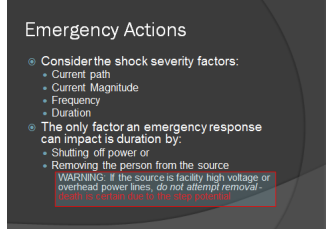
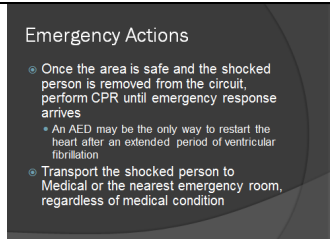
<div>Immediate Effects of Shock</div> <div><ul style="list-style-type: none">• Confusion• Amnesia• Headache• Burns• Heart stoppage</div>	Discuss immediate effects of shock																					
<div>Short and Long Term Effects</div> <div><div><ul style="list-style-type: none">• Short term effects<ul style="list-style-type: none">• Paralysis• Muscular pain• Vision abnormalities• Swelling• Headache• Cardiac irregularities</div><div><ul style="list-style-type: none">• Long term effects<ul style="list-style-type: none">• Paralysis• Speech or writing impairment• Damage to nervous system</div></div>	Discuss short and long term effects of shock																					
<div>Shock – Muscle and Nerve Impact</div> <div><p>Nerve sizes are in the micron level – general wire sizes are in the mm range. Consider the impact of sending current down this path, and the potential damage that could occur.</p></div>	Explain why muscles contract, and why there is a “no-let-go threshold” for shock.																					
<div>Levels of Concern</div> <div><table><thead><tr><th>Current Value</th><th>Effects</th></tr></thead><tbody><tr><td>1-3 ma</td><td>Barely Perceptible</td></tr><tr><td>3-5 ma</td><td>Perceptible shock, reflex actions</td></tr><tr><td>5 ma GFCI trips</td><td>Accepted as maximum harmless current</td></tr><tr><td>6-10 ma</td><td>Painful shock, victim can “let-go”</td></tr><tr><td>10-30 ma</td><td>Painful shock, victim can not let go</td></tr><tr><td>50-100 ma</td><td>Ventricular Fibrillation possible</td></tr><tr><td>100-200 ma</td><td>Ventricular Fibrillation likely</td></tr><tr><td>200 ma</td><td>Severe burns, severe muscular contractions, chest muscles clamp the heart and stop it for the duration of the shock.</td></tr><tr><td>633 ma</td><td>Current used by 100 watt light bulb</td></tr></tbody></table></div>	Current Value	Effects	1-3 ma	Barely Perceptible	3-5 ma	Perceptible shock, reflex actions	5 ma GFCI trips	Accepted as maximum harmless current	6-10 ma	Painful shock, victim can “let-go”	10-30 ma	Painful shock, victim can not let go	50-100 ma	Ventricular Fibrillation possible	100-200 ma	Ventricular Fibrillation likely	200 ma	Severe burns, severe muscular contractions, chest muscles clamp the heart and stop it for the duration of the shock.	633 ma	Current used by 100 watt light bulb	Discuss relative values; discuss history (Dalziel experimentation on “volunteers”; identified key differences between AC and DC...note that chart levels are for AC. Include information on differences in detection threshold for men and women – note that women are more sensitive to shock	Ask “So how much is 10 milliamps? In other words, how badly do I have to get into contact with electricity to get to this level?”
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<div>Electrical Theory Basic Relationships (from HS Physics)</div> <div><div><ul style="list-style-type: none">• Voltage – the potential energy (volts)• Current – the number of electrons flowing in the circuit (amps)• Resistance – opposition to current flow (ohms)• Power – total energy available in the circuit (watts or joules – 1 J = 1 watt-sec)</div><div><p>Ohms Law: $E=IR$</p><p>Power: $P=EI$</p><p>Example:</p><p>120V flowing through 1 ohm of resistance delivers 120 amps (120/1 = 120)</p></div></div>	Review basic electrical theory; identify that E = voltage and I = current																					

<p>Some Basic Calculations</p> <ul style="list-style-type: none"> Assume that you are working on a power supply. Your lab is warm, and you are perspiring slightly. The table where you are working is well grounded You contact an energized point with your hand, and your opposite arm elbow is touching the metal table top 	Discuss initial conditions (reference the video)	
<p>Basic Calculations</p> <ul style="list-style-type: none"> Assume your body resistance is approximately 5000 ohms, and the voltage you contact is 120 volts. Will the breaker in the wall panel (20 A) trip? Will the power supply fuses (1 A) trip? 	Write desired outcomes (breaker trip, power supply fuse levels) on board	Ask students what they think...engage / discuss why/why not
<p>Basic Calculations</p> <p>Voltage = current times resistance ($E = IR$) We know voltage (120 VAC) and Resistance (5000 Ohms) $E/R = I \rightarrow 120/5000 = 0.024$ amps or 24 millamps – the breaker won't trip, the fuse won't blow, but you may be stuck on the circuit and receive a painful shock.</p> <p>At 277 VAC (typical light switch at Sandia), the current for a similar shock would be 55 ma.</p>	<p>Review actual calculations for 120 volts. Then ask about 277 (standard lighting supply at Sandia)</p> <p>Identify that while the breaker will not trip, both of these levels are above the no-let-go threshold, posing a significant shock hazard.</p>	Ask: Why does this pose a significant shock hazard if the energy levels are below that of defibrillation?
<p>Basic Calculations</p> <ul style="list-style-type: none"> Will it kill you? Shock severity factors include: <ul style="list-style-type: none"> Duration of the shock (longer is worse) Magnitude of the shock (higher is worse) Frequency of the shock (50-60 Hz is worse) Path of current flow (through the heart is worse) 	<p>Review shock severity factors;</p> <p>Review current flow paths to identify worse and better; relate to short term/long term damage (vision impairment, swelling, headache, etc. for paths involving the head)</p>	Review 2700 shock incident (150 kV to head but very low current) – no permanent injury or disability; describe how it could have been worse.

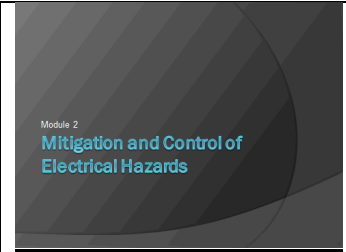
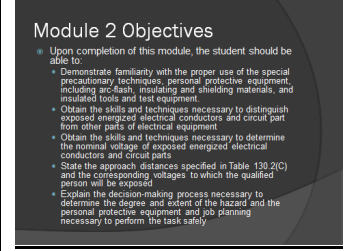
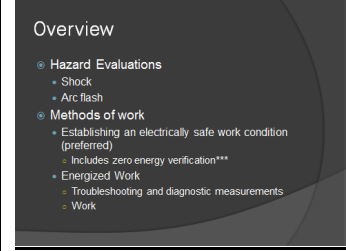
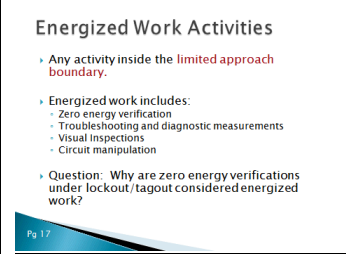
	<p>Calculations by Dalziel et.al in IEEE Std. 80 identify that time is a severity factor – above 2 seconds, fibrillation is almost always assured even at levels as low as 50 ma.</p>	<p>Ask for questions on shock hazards.</p> <p>Ask what the “other” electrical hazard is</p>
<p>Arc Flash</p> <ul style="list-style-type: none"> The passage of substantial current through ionized air. NPFA 70E says that “an arc flash hazard may exist when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. <i>Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.</i>” 	<p>Define “arc flash”</p> <p>Note that an arc flash generally occurs when the worker is interfacing with the system – operating breakers or disconnects, opening panels, etc. Rarely do they occur during normal or steady-state operation but exceptions apply</p>	<p>Show arc flash demo video</p>
<p>Why is this important?</p> <p>Electrical Arc</p>	<p>Refer to video and replay in stops to identify each of the parts of the arc flash;</p> <p>Note that noise levels can exceed 150 dB (jet engine @ 145 dB)</p>	
<p>STANFORD LINEAR ACCELERATOR FLASH INCIDENT</p>	<p>Describe event</p>	
<p>SLAC arc flash 2004</p>		

		
		
<p>Importance of FR Clothing</p> 	<p>Note that poly/cotton blends melt, rather than burn clear, aggravating any burn injuries</p>	
<p>Description of injuries</p> <p>Electrician received third degree burns on the face, chest, and legs and second degree burns on the arms, involving approximately 50% of his body. Because of the seriousness of his condition, the Board was not able to interview him.</p> <p>FROM THE TYPE A INVESTIGATION...</p>		
<p>Three Factors Affecting Arc Energy</p> <ul style="list-style-type: none"> Available short circuit current <ul style="list-style-type: none"> High may be worse – large amounts of energy released Low may be worse – longer to protective actions Duration of the arc <ul style="list-style-type: none"> Long time to protective action (fuse blow or breaker trip) is worse Distance from the arc <ul style="list-style-type: none"> Nearer to the arc is worse – the blast zone can extend to beyond 10 feet from the initiating event 	<p>Review severity factors, emphasis on available short circuit current, and how that may relate to the second severity factor;</p> <p>Describe the USN arc flash process and what was done to protect against it; relate to nature of the arc</p>	

<p>Burns From the Arc</p> <ul style="list-style-type: none">First degree: surface only. Skin is red and tenderSecond degree: blistering of the skin. Most painfulThird degree: complete destruction of the skin with charring of tissue. Most dangerous –suceptible to infection. Skin can not heal itself.		Ask if anyone has seen the “shortcuts” video– and identify the link in the manual.																				
<p>Effects of the Arc: Burns</p> <p>Arcs have ignited clothing 10' from the arc and can be fatal when within a few feet</p> <p>Burn Injury - Probability of Survival</p>  <table border="1"><caption>Burn Injury - Probability of Survival</caption><thead><tr><th>Age Range - Years</th><th>25% Body Burn</th><th>50% Body Burn</th><th>75% Body Burn</th></tr></thead><tbody><tr><td>20-29.9</td><td>~90%</td><td>~60%</td><td>~40%</td></tr><tr><td>30-39.9</td><td>~85%</td><td>~55%</td><td>~35%</td></tr><tr><td>40-49.9</td><td>~80%</td><td>~50%</td><td>~30%</td></tr><tr><td>50-59.9</td><td>~75%</td><td>~45%</td><td>~25%</td></tr></tbody></table>	Age Range - Years	25% Body Burn	50% Body Burn	75% Body Burn	20-29.9	~90%	~60%	~40%	30-39.9	~85%	~55%	~35%	40-49.9	~80%	~50%	~30%	50-59.9	~75%	~45%	~25%	Review survivability statistics	
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<p>Warning: the next few pictures are extremely graphic. If you are easily disturbed by pictures of injuries, please look away.</p>		Read warning verbatim																				
<p>Arc Flash Burns</p> 	LH – 2 nd / 3 rd degree – note the blisters on the fingers, indicative of a 2 nd degree burn Left middle – severe 1 st degree burn on back Right middle – 2 nd / 3 rd degree on hand – blackening is evidence of a 3 rd degree burn RH – 3 rd degree burn waiting skin graft	(*B) Discuss LANL capacitor shock event and energy / injuries, including path for current. Discuss hazards of closed labs and working alone																				
	Serious 3 rd degree burns																					

<p>Review Questions – Page 12</p> <ol style="list-style-type: none"> List three factors that increase the severity of a shock. For the following arc flash severity factors, identify which case is worse: <ol style="list-style-type: none"> Available short circuit current Distance from the arc Time for protective action to occur For the following conditions, determine if the current felt by the worker is above the no-let-go threshold: <ol style="list-style-type: none"> Applied voltage = 500 VDC Resistance to ground (through the worker) = 2500 ohms 	<p>Note that the bad pictures are finished.</p> <p>Discuss review questions. Answers:</p> <p>1: magnitude of current, path of shock, duration of shock</p> <p>2: high or low; closer; longer</p> <p>3. Above (200 ma)</p>	
		<p>Ask for questions on arc flash.</p> <p>Ask what should be done in the event of an electrical accident – class discussion</p>
	<p>Emphasize the importance of initiating the emergency response system and assessing initial conditions</p> <p>Discuss hazards and actions around high voltage</p>	<p>Review electrocution news article</p> <p>Show power line arcing video</p>
	<p>Review slide – once EMS is activated...THINK before you act;</p> <p>Discuss victim removal</p>	<p>Ask how to remove victim safely.</p>
	<p>Review slide; note that CPR may or may not be required.</p> <p>Discuss importance of AED</p>	<p>Ask how to get victim to medical. Drive self?</p>

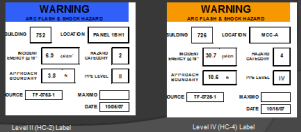
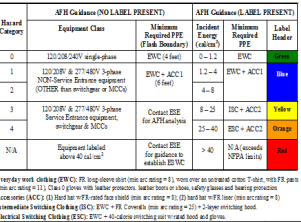
<p>Shock Actions - Summary</p> <ul style="list-style-type: none"> • Call 911 • Assess area and enter only if safe • Shut off power or remove injured from power source using available equipment • Administer CPR • Transport to medical 	<p>Summarize shock actions</p>	<p>Ask why 911 first; Ask when a victim should not be removed from an energized circuit;</p> <p>Ask about CPR and its effectiveness in treating shock Ask why an AED is critical in shock victim recovery</p> <p>Ask about when a shock victim doesn't have to be treated.</p>
<p>Shock Actions - Discussion</p> <ul style="list-style-type: none"> • ALL SHOCKS MUST BE ASSESSED BY MEDICAL <ul style="list-style-type: none"> • Symptoms may not be immediately apparent • Cardiac problems may go undetected for several hours • Electrolyte imbalances have caused death several days after contact • REPORT ALL SHOCKS <ul style="list-style-type: none"> • This ensures proper treatment • This also prevents recurrence, perhaps fatally, for the next person 	<p>Review medical assessment;</p> <p>Review reporting requirements – emphasize delayed injury response and potential for another victim</p>	<p>Ask when shocks must be reported and why</p>
<p>Review Questions – Page 15</p> <ol style="list-style-type: none"> 1. Which path of current is most dangerous? <ol style="list-style-type: none"> 1. Right hand to right elbow 2. Right hand to left hand 3. Left hand to right foot 2. What is the first thing you should do when you come upon a potential shock victim? Why? 3. In which of the following situations should the subject be assessed by medical? <ol style="list-style-type: none"> 1. A person is found unconscious and is the apparent victim of an electrical shock 2. Person receives a minor shock from a piece of equipment 3. Person feels a tingle in their hand when touching a piece of equipment 4. Person receives a static shock when touching a doorknob 	<p>Discuss Review Questions on page 16</p> <p>Answers:</p> <ol style="list-style-type: none"> 1. RH to LH or LH to RF – both paths are across the heart 2. Call 911 – ensure emergency response is activated in case you are injured in the rescue 3. All except static shock 	<p>Emphasize the importance of reporting all shocks, however minor</p>
<p>More Review Questions</p> <p>Charles Dalziel determined some interesting facts about the effects of electrical shock on people.</p> <ol style="list-style-type: none"> a. Which group of people is more sensitive to electrical shock? b. Which electrical waveform is most injurious? c. In general, electrical current below what level is not harmful? 	<p>Discuss review questions</p> <p>A – women B – AC – 60 Hz C – 5 ma</p>	

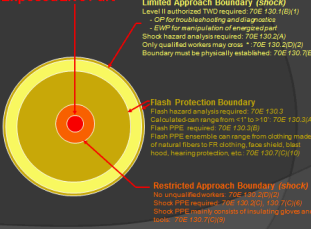
 <p>Module 2 Mitigation and Control of Electrical Hazards</p>	<p>Evaluate need for break (10-12 minutes) after 60 minutes classroom time.</p> <p>Introduce topic: In the first module, we learned about the potential hazards of electricity. In this module, we will figure out how to manage those hazards.</p>	<p>Ask what the primary and secondary hazards of shock are (shock, arc flash/blast, and falls)</p>
 <p>Module 2 Objectives</p> <ul style="list-style-type: none"> Upon completion of this module, the student should be able to: <ul style="list-style-type: none"> Demonstrate familiarity with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulated tools and test equipment. Obtain the skills and techniques necessary to distinguish exposed energized electrical conductors and circuit part from other parts of electrical equipment. Obtain the skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts. State the approach distances specified in Table 130.2(C) and the corresponding voltages to which the qualified person will be exposed. Explain the decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely. 	<p>Review specific objectives</p>	
 <p>Overview</p> <ul style="list-style-type: none"> Hazard Evaluations <ul style="list-style-type: none"> Shock Arc flash Methods of work <ul style="list-style-type: none"> Establishing an electrically safe work condition (preferred) <ul style="list-style-type: none"> Includes zero energy verification** Energized Work <ul style="list-style-type: none"> Troubleshooting and diagnostic measurements Work 	<p>Emphasize that the primary way to prevent electrical accidents/injuries is to shut off the equipment and lock it out.</p> <p>Energized work should be performed only when absolutely necessary (not out of convenience) and only then when <i>authorized and justified</i>.</p>	
 <p>Energized Work Activities</p> <ul style="list-style-type: none"> Any activity inside the limited approach boundary. Energized work includes: <ul style="list-style-type: none"> Zero energy verification Troubleshooting and diagnostic measurements Visual Inspections Circuit manipulation Question: Why are zero energy verifications under lockout/tagout considered energized work? <p>Pg 17</p>	<p>Define energized work</p> <p>Define and explain the limited approach boundary</p>	<p>Demonstrate LAB concept</p> <p>Ask “why are zero energy verifications under lockout/tagout considered energized work?”</p>

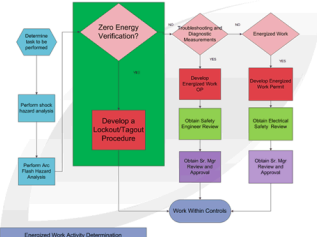
	<p>Describe flow chart – used to determine what is being done, as well as defining the need for the various hazard analyses. Inform students that the flowchart is in the back of the student guide.</p>	
<p>Electrical Hazards</p> <ul style="list-style-type: none"> • Shock • Arc Flash • BOTH hazards must be evaluated 	<p>Identify that both hazards have to be assessed.</p>	<p>Ask “What are the two primary hazards associated with energized electrical components / circuit parts?”</p> <p>Show slide</p>
<p>Shock and Arc Flash Hazard Analyses</p> <ul style="list-style-type: none"> • Required regardless of your activity <ul style="list-style-type: none"> • Zero energy verification requires protection at the same level as if the device was energized • Part of the LOTO Procedure (Step 6c) 	<p>Discuss when (and why) the 2 analyses must be performed</p>	<p>Ask how this is implemented in the LOTO procedure</p>
<p>Shock Hazard Evaluation</p>	<p>Introduce the Shock Hazard Analysis</p>	<p>Ask what people think the analysis consists of.</p>

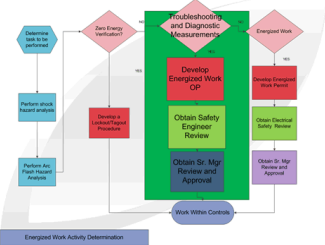
<p>Shock Hazard Analysis</p> <ul style="list-style-type: none"> • The shock hazard analysis shall determine: <ul style="list-style-type: none"> • The voltage the worker will be exposed to • The boundary requirements • PPE 	<p>Identify that the analysis must contain three requirements:</p> <ul style="list-style-type: none"> -Voltage (and type) -Boundaries (based on voltage / type) -PPE for exposure level 	<p>Note that both electrical hazard analyses first determine the magnitude of the hazard, then the boundaries (based on the magnitude) and then appropriate compensatory measures.</p>
<p>Shock Hazard Analysis: Voltage</p> <ul style="list-style-type: none"> • Must assess all exposed voltages within the limited approach boundary for type (AC, DC, RF etc.) and quantity (frequency and voltage) • The highest voltage determines the boundary limits 	<p>Discuss / reemphasize the differences between AC and DC; Briefly discuss RF hazards and exposure / damage (IEEE C95.1)</p>	<p>Ask: Which is more dangerous: AC or DC?</p>
<p>Shock Hazard Analysis: Boundaries</p> <ul style="list-style-type: none"> • Three boundaries of concern: <ul style="list-style-type: none"> • Prohibited Approach Boundary → Same as contact • Restricted Approach Boundary → Identifies an increased risk of shock due to arc-over when working in close proximity to energized conductor or circuit part • Limited Approach Boundary → Limit for unqualified personnel where a shock hazard exists 	<p>Discuss / Explain electrical boundary concept</p>	<p>Ask which boundary identifies the need for PPE</p> <p>Ask at which boundary do we consider energized work taking place?</p>
<p>Boundaries</p> <ul style="list-style-type: none"> • Restricted Approach Boundary: <ul style="list-style-type: none"> • Entry by unqualified personnel is not allowed • Entry requires PPE • Limited Approach Boundary: <ul style="list-style-type: none"> • Unqualified personnel must be escorted • Requires authorization to enter • Must be physically posted 	<p>Emphasize the requirements for entry into each boundary</p> <ul style="list-style-type: none"> -LAB – authorization -RAB - PPE 	<p>Ask – what determines the qualification of a worker?</p>


<p>Approach Boundaries for AC Systems</p> <table border="1"> <thead> <tr> <th>Nominal System Voltage Phase-to-Phase</th> <th>Limited Approach Boundary</th> <th>Restricted Approach Boundary</th> </tr> </thead> <tbody> <tr><td>< 50 V</td><td>Not Specified</td><td>Not Specified</td></tr> <tr><td>50 – 300 V</td><td>3 ft 6 in</td><td>Avoid Contact</td></tr> <tr><td>301–750 V</td><td>3 ft 6 in</td><td>1 ft</td></tr> <tr><td>751 – 15,000 V</td><td>5 ft</td><td>2 ft 2 in</td></tr> <tr><td>15.1 – 36 kV</td><td>6 ft</td><td>2 ft 7 in</td></tr> <tr><td>36.1 – 46 kV</td><td>8 ft</td><td>2 ft 9 in</td></tr> <tr><td>46.1 – 72.5 kV</td><td>8 ft</td><td>3 ft 3 in</td></tr> <tr><td>72.6 – 121 kV</td><td>8 ft</td><td>3 ft 4 in</td></tr> <tr><td>121 – 145 kV</td><td>10 ft</td><td>3 ft 10 in</td></tr> <tr><td>145.1–169 kV</td><td>11 ft 8 in</td><td>4 ft 3 in</td></tr> <tr><td>230 – 242 kV</td><td>13 ft</td><td>5 ft 8 in</td></tr> <tr><td>345 – 362 kV</td><td>15 ft 4 in</td><td>9 ft 2 in</td></tr> <tr><td>500 – 550 kV</td><td>19 ft</td><td>11 ft 10 in</td></tr> <tr><td>765–800 kV</td><td>23 ft 9 in</td><td>15 ft 11 in</td></tr> </tbody> </table>	Nominal System Voltage Phase-to-Phase	Limited Approach Boundary	Restricted Approach Boundary	< 50 V	Not Specified	Not Specified	50 – 300 V	3 ft 6 in	Avoid Contact	301–750 V	3 ft 6 in	1 ft	751 – 15,000 V	5 ft	2 ft 2 in	15.1 – 36 kV	6 ft	2 ft 7 in	36.1 – 46 kV	8 ft	2 ft 9 in	46.1 – 72.5 kV	8 ft	3 ft 3 in	72.6 – 121 kV	8 ft	3 ft 4 in	121 – 145 kV	10 ft	3 ft 10 in	145.1–169 kV	11 ft 8 in	4 ft 3 in	230 – 242 kV	13 ft	5 ft 8 in	345 – 362 kV	15 ft 4 in	9 ft 2 in	500 – 550 kV	19 ft	11 ft 10 in	765–800 kV	23 ft 9 in	15 ft 11 in	<p>Emphasize chart is for AC voltages</p>	<p>Ask: How close can an unqualified worker get to 48,000 VAC?</p> <p>Ask: What distance will a worker need to don PPE before working on 12,470 VAC?</p>
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<p>Examples</p> <ul style="list-style-type: none"> A worker has to take voltage measurements of a high voltage power supply. Inside the power supply is 120 VAC, line current, and intermediate step-up transformer raising the line voltage to 500 VAC, a DC power supply that rectifies the AC and steps it up to 800 VDC, and a pulsed power network that is capable of outputting a short (microsecond) pulse of 40,000 volts. A facility electrician is replacing the batteries inside an Uninterruptible Power Supply (UPS). The batteries are installed in series, and total approximately 550 VDC, and the unit puts out 480 VAC. A pulsed power technologist is evaluating the hazards associated with a device. The output is a 120,000 volt pulse that exists inside a large high bay. Following the pulse, the worker needs to apply shorting straps to the device. <p>Pg 20</p>	<p>Refer students to tables; Use board to identify voltages, then appropriate table to identify boundary</p>	<p>Ex 1: 120 VAC LAB is 3’6”, RAB is avoid contact 500 VAC – LAB is still 3’6”, but RAB is now 1’ 40 kv dc – LAB is 8 ft, and RAB is 2’9” Ex. 2 550 VDC and 480 VAC LAB is 3’6” and RAB is 1’ Ex.3 120 kv dc LAB is 10’, RAB is 4’</p> <p>Ask for questions; Ask for def on energized work</p>																																													
<p>Arc Flash Hazard Analysis</p> <ul style="list-style-type: none"> Analysis must determine: <ul style="list-style-type: none"> The arc flash boundary The incident energy at the working distance The appropriate PPE required inside the arc flash boundary Determination of information may require assistance from Facilities (requires panel and equipment-specific information to be properly calculated) 	<p>Review terms – Incident energy – the amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event (cal/cm²)</p>																																														

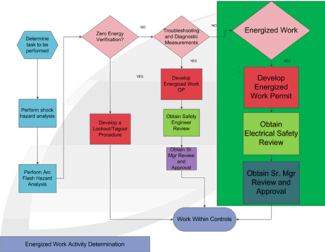
<p>Arc Flash Hazard Analysis</p> <ul style="list-style-type: none"> Information may reside on electrical panel (FMOE OP-304) 	<p>Typical panel warning labels at Sandia. Identify the components of the warning label</p>	<p>Ask “why is 18” selected as working distance?” Ask, “what if you are working closer?”</p>
	<p>FMOE arc flash PPE requirements. Note that for most lab workers, arc flash hazards seldom exceed HRC 2 (8 cal/cm²) due to system design characteristics. There are exceptions, however (WETL, 820, etc.)</p>	<p>Demonstrate videos with</p>
<p>Arc Flash Hazard Analysis</p> <ul style="list-style-type: none"> If single piece of equipment: <ul style="list-style-type: none"> 120 VAC – arc flash hazard is negligible Follow the guidelines for switching if the equipment supply disconnect is <ul style="list-style-type: none"> 0-60 amps and < 600 V: HC 0 > 60 – 200 amps and < 600 V: HC 2 All others – contact electrical safety for additional guidance 	<p>Review guidelines, note that they are only guidelines. If a certain activity is impaired by guidance PPE, contact building manager or electrical safety for additional analysis. (\$\$)</p>	
<p>Arc Flash PPE</p> <ul style="list-style-type: none"> Specially rated protective clothing to reduce or eliminate potential for clothing Generally measured in Cal/cm² Must protect against the incident energy at 18” <ul style="list-style-type: none"> If calculated, cannot use FMOE table or HRC Tables in NFPA 70E have specific limitations associated with them before use 	<p>NFPA 70E allows two methods of determination of the appropriate clothing – tables in the standard and calculation – but the two methods cannot be mixed...if calculated at 8.3 cal / cm², that level of PPE must be worn – but if identified from the tables as HRC 2, then an HRC 2 ensemble must be worn.</p>	<p>Show video of arc flash wear (and non-arc flash wear)</p> <p>Display actual arc flash PPE, if available</p>

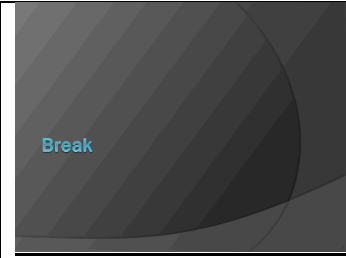
	<p>Review Table – emphasize the requirements for each boundary (LAB, RAB, AFB)</p>	<p>Ask for questions on boundaries.</p> <p><BLANK SCREEN> Review boundary requirements q&a</p>
<p>The Energized Work Decision Tool</p> <ul style="list-style-type: none"> Provides a tool to aid in performing shock and arc flash hazard analysis Available on Electrical Safety home page (http://zap.sandia.gov) 	<p>The EWDT is a tool to help you perform activities inside the LAB.</p> <p>Discuss EWDT limitations (20 kV, arc flash analysis)</p>	<p>Walk through using the EWDT</p>
<p>Types of energized work activities</p> <ul style="list-style-type: none"> Zero Energy Verification <ul style="list-style-type: none"> Part of Establishing an Electrically Safe Work Condition Troubleshooting and Diagnostics (meter usage, visual inspections) Live circuit manipulations (connecting / disconnecting leads, use of tools) <p>Pg 28</p>	<p>Now we know what constitutes energized work, and how to protect ourselves from it. We still have to figure out how to justify and authorize the work.</p>	<p>Refer to manual chart on Energized work activity determination. Ask “What are the three types of energized work activities at Sandia?”</p>
<p>Review Questions – Page 28</p> <ol style="list-style-type: none"> Which boundary must be physically posted? Crossing which boundary constitutes energized work at Sandia? What are the types of energized work activities performed at Sandia? What is Sandia's definition of energized work? 	<p>Discuss Review Questions on page 29</p> <ol style="list-style-type: none"> LAB LAB LOTO zero energy verification; troubleshooting and diagnostic measurements, live circuit manipulation Any activity inside the LAB of exposed and energized conductors and circuit parts 	

	<p>Once we've performed our analysis, we have to decide if we are working energized, or working de-energized.</p> <p>Of course, the preferred method is always to lock out the equipment</p>	<p>Ask "which do you think is preferred? Energized or locked out?" Why?</p>
<p>Establishing an Electrically Safe Work Condition</p> <ul style="list-style-type: none"> Generally requires lockout/tagout (LTO210) with an associated LOTO procedure Zero energy verification is energized work – the equipment is hazardous until positively proven otherwise Same analyses (shock and arc flash) must be performed and documented in LOTO procedure (step 6c) 	<p>Emphasize second bullet – this is a form of energized work...the equipment is energized until positively proven otherwise</p>	<p>Emphasize that the application of LOTO can be a hazardous operation – everything is energized until positively proven otherwise</p>
<p>Zero Energy Verification</p> <ul style="list-style-type: none"> Every time, the qualified electrical worker must: <ul style="list-style-type: none"> Attempt to start the equipment Don PPE as if equipment was energized (shock/arc flash hazard analyses) Test the meter on a known source Installed panel meters cannot be used because they cannot be independently tested Test all exposed circuit parts phase to phase and phase to ground (with the work area) Retest the meter on a known source 	<p>Review zero energy verification process (ref NFPA 70E Art. 120)</p>	
<p>Zero Energy Verification</p> <ul style="list-style-type: none"> Meter must be a contact-type meter (not induced/proximity) to verify zero energy Proximity testers confirm the <i>presence</i> of voltage, not the absence Limited conditions of use for proximity testers 	<p>Discuss when use of proximity tester is appropriate, and limiting conditions</p>	<p>Demonstrate two types of meters – show shortfall with non-contact type detectors</p> <p>Review recent occurrences where zero energy verification was not effectively performed (SNL/Complex/NIOSH FACE)</p>

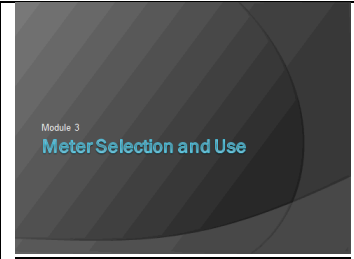
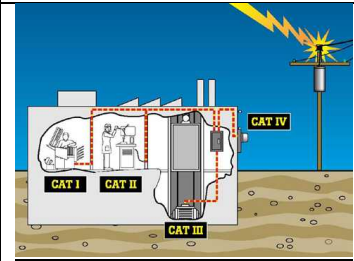
 <p>The flowchart 'Energized Work Activity Determination' starts with a decision diamond 'Determine if work is energized'. If 'No', it leads to 'Perform safety hazard analysis' and 'Perform the work safely'. If 'Yes', it leads to 'Develop a Lockout/Tagout Procedure', then 'Obtain Safety Engineer Review', and 'Obtain Sr. Mgr Review and Approval'. This leads to a central green box 'Troubleshooting and Diagnostic Measurements' and 'Develop Energized Work OP'. From there, it goes to 'Obtain Sr. Mgr Review and Approval', then 'Perform the work safely', and finally 'Work Within Controls'. There are also side paths for 'Energized Work' and 'Deenergized Work'.</p>	Review General Process for troubleshooting	
<p>Energized Work Justification</p> <ul style="list-style-type: none"> All energized work (except zero energy verifications) must be justified Only two valid justifications for performing energized work: <ul style="list-style-type: none"> The employer can demonstrate that deenergizing introduces additional hazards or increased risk The employer can demonstrate that the task to be performed is infeasible in a deenergized state due to equipment design or operational limitations 	<p>Discuss justification requirements with examples of acceptable and unacceptable energized work. Emphasize that convenience and cost savings are not operational limitations.</p> <p>Note that energized work , other than zero energy verification, is always high rigor.</p> <p>Review Canada’s permit requirements for requestor to sign on permit</p>	Ask why energized work is always high rigor (emphasize the risk)
<p>Troubleshooting and Diagnostic Measurements</p> <ul style="list-style-type: none"> Includes the following activities: <ul style="list-style-type: none"> Testing Troubleshooting Voltage Measurement Visual Inspections If the circuit must be manipulated to perform these activities (lead lifting, for example) then follow the requirements for energized work 	Review requirements	Provide examples (in book) of activities that are troubleshooting and diagnostic measurements, and ones that are not.
<p>Troubleshooting and Diagnostic Measurements</p> <ul style="list-style-type: none"> OP is required to document the shock and arc flash hazard analyses, including boundaries and PPE Safety Engineering review of OP is required OP must be approved by a Senior Manager 	Discuss review and authorization (remind on justification)	

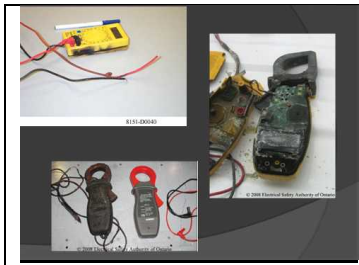
<p>Examples of troubleshooting and diagnostic measurements</p> <ul style="list-style-type: none"> A thermal chamber is not heating properly. A power off test for circuit continuity and heater functionality did not identify any problems. It is infeasible to determine if the correct voltage is applied to the heaters while the circuit was deenergized, so the senior manager approved voltage testing inside the thermal chamber.  <p>Pg 32</p>	<p>Review the reasoning for each example</p>	<p>Refer student to page 33 in manual</p>
<p>Examples of troubleshooting and diagnostic measurements</p> <ul style="list-style-type: none"> Facilities maintenance received a trouble call that a receptacle in an office wasn't working. It was not immediately apparent where the outlet was powered from, so the facility electrician traced the wires back to a junction box. The box provided circuit information, and the worker confirmed that power was, and other receptacles on the circuit were functioning. The facility worker, under OP-304, is allowed to open the junction box cover to determine if voltage is present. He discovered that a wire for the receptacle had come loose from the wire nut. He would have to lock out the circuit to perform repairs. <i>If the worker had to install the wire into a live circuit, this is considered a circuit manipulation, not troubleshooting and diagnostic measurement, and would require additional authorization.</i> <p>Pg 32</p>		
<p>Examples of troubleshooting and diagnostic measurements</p> <ul style="list-style-type: none"> A test procedure to certify a piece of equipment requires voltage and current measurements to be taken periodically, in multiple places, during the equipment startup and operation. The worker set up a series of meters to allow the readings to be performed, but due to the construction of the device, had to enter the limited approach boundary to read some of the meters. An OP approved by the senior manager would be required when the limited approach boundary was entered. The meter installation was performed under lockout/tagout. <p>Pg 33</p>		
<p>Examples of troubleshooting and diagnostic measurements</p> <ul style="list-style-type: none"> As part of a troubleshooting operation, the technical representative from the vendor of a programmable logic controller requested information on controller sequencing. This required the observation of several lights and recording of the light sequence. The lights were positioned on the inside of a 480 VAC control unit, and could only be seen from approximately 18" away. An OP approved by the senior manager would be required in this case, although it is only a visual inspection, because the limited approach boundary was crossed. No PPE would be required, however, because the restricted approach boundary was never breached (1 foot at 480 VAC). <p>Pg 33</p>		

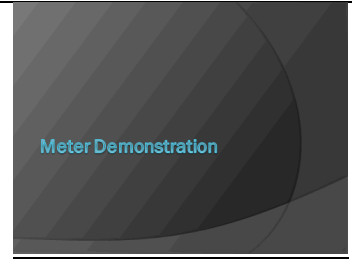

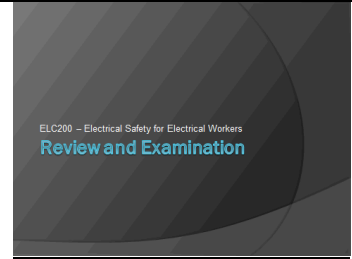
	<p>Discuss differences between OP and Permit</p> <p>Discuss similarities between OP and Permit</p>	<p>Ask – Can the general format for an EWP be used for an energized work OP for troubleshooting and voltage measurements?</p> <p>What’s different (refer to EWP on page xx)</p>
<p>Live Circuit Manipulation</p> <ul style="list-style-type: none"> › Covers everything else › Requires an Energized Work Permit › Authorized by Electrical Safety and Senior Manager › When used with multiple organization, all senior managers must concur <p>Pg 35</p>	<p>Review requirements – note differences...permits must be approved by Electrical Safety</p> <p>Most hazardous operations, requires additional backup to ensure activity is performed safely</p>	
<p>Examples of justified live circuit manipulation</p> <ul style="list-style-type: none"> › An organization needed to some testing using a large storage battery assembly rated at approximately 250 VDC. The assembly and disassembly of the battery intercell connectors required an EWP because tools were required to bolt the connectors together. › Facility electricians are required to replace batteries in lighting inverters that supply emergency lighting power to most buildings at Sandia. The removal and replacement of batteries is performed under an EWP due to the hazardous voltages present in the activity. <p>Pg 34</p>	<p>Review examples – discuss problems inherent with batteries</p>	
<p>Additional Requirements (for all types of energized work)</p> <ul style="list-style-type: none"> • Pre-brief <ul style="list-style-type: none"> • Based on activity and skill level of workers <ul style="list-style-type: none"> • Lesser brief for routine, repetitive work • More extensive as hazard increases • Must be documented • Boundaries – Limited Approach Boundary MUST be posted • Follow additional activity or site-specific requirements found in general OP’s, Electrical Safety manual, or NFPA 70E (WP&C) 	<p>Review additional requirements</p> <p>Note that the LAB must be physically posted anytime energized work (including zero energy verifications) is performed</p>	<p>Review – what does entry into the LAB require?</p> <p>What does entry into the RAB require?</p> <p>When is energized work, other than zero energy verifications, allowed to be performed?</p>

	<p>Allow 10 minutes</p>	
<p>Review Questions – Page 36–37</p> <ol style="list-style-type: none"> 1. What are the three types of energized work? 2. How does Sandia define energized work? 3. What are the two types of hazard analyses that must be performed before any energized work activities may be performed? 4. What should the required hazard analysis identify? 5. For the items in Q1, which of those require senior manager authorization? 6. What are the only 2 valid justifications for energized work? <p>Pg 36–37</p>	<p>Discuss review questions on pp 37-38</p> <ol style="list-style-type: none"> 1. ZEV, TS&D, Live ckt manip; 2. Any activity inside the LAB 3. Shock and arc flash 4. Magnitude of hazard, boundaries, PPE 5. TS&D, Live ckt manip 6. Greater hazard, infeasible 	<p>Discuss answers – allow students to provide answers (go around the room)</p>
<p>Review Questions (cont.)</p> <ul style="list-style-type: none"> For each of the scenarios below, identify if the activity is energized work, what authorizing document is required, and what the limited approach boundary is, if applicable: <ul style="list-style-type: none"> A worker is taking voltage measurements on an 800 VDC power supply. A facility worker is performing zero energy verification of an electrical panel during a planned outage. Facilities maintenance is replacing fuses in a switch. The upstream side cannot be shut down due to operational limitations, and the fuses have to be installed to restore power to a critical location. The voltage is 12,470. A manager is performing a visual inspection of a 100 kV Marx bank. The bank is attached to the system and has not been discharged. The manager is within 5 feet of the exposed capacitor bank. <p>Pg 36–37</p>	<p>1: YES, OP, 3'6"</p> <p>2: YES, ESLP, 3'6"</p> <p>3: YES</p>	
<p>Summary</p> <ul style="list-style-type: none"> All activities involving work on or around electrical circuits or part require <ul style="list-style-type: none"> Shock hazard analysis Arc Flash hazard analysis Three types of work <ul style="list-style-type: none"> Zero energy verification (LOTO) <ul style="list-style-type: none"> Troubleshooting and diagnostic measurements (no circuit manipulation) (Use of meters) Live Circuit Manipulation (Use of Tools) <p>Pg 36</p>	<p>Review Summary</p>	

<div>Summary</div> <div><ul style="list-style-type: none">⦿ Except for zero energy verification (may require a LOTO, all energized work activities require senior manager authorization:<ul style="list-style-type: none">• In an OP for troubleshooting and diagnostic measurements after safety engineer review• In an EWP for everything else, along with concurrence by the Electrical Safety SME⦿ All activities require a pre-brief</div>	Review Summary													
<div>Summary</div> <div><ul style="list-style-type: none">⦿ All energized work activities (except for zero energy verification) must be justified:<ul style="list-style-type: none">• The employer can demonstrate that deenergizing introduces additional hazards or increased risk• The employer can demonstrate that the task to be performed is infeasible in a deenergized state due to equipment design or operational limitations</div>	Review Summary	<div>Direct Students to questions in book on page xx – go around the room to answer the questions.</div> <div>Ask for any additional questions.</div>												
<div>Boundary Requirements</div> <table><tr><th>Boundary</th><th>Requirements</th></tr><tr><td>Arc Flash Boundary</td><td>Wear arc flash PPE when entering</td></tr><tr><td>Limited Approach Boundary</td><td><ul style="list-style-type: none">-Requires and OP or EWP when entering-Entry must be justified and authorized-Unqualified may not enter unless briefed and escorted by a qualified worker</td></tr><tr><td>Restricted Approach Boundary</td><td><ul style="list-style-type: none">-Wear shock PPE when entering-No unqualified persons may enter</td></tr></table> <div>Pg 36</div>	Boundary	Requirements	Arc Flash Boundary	Wear arc flash PPE when entering	Limited Approach Boundary	<ul style="list-style-type: none">-Requires and OP or EWP when entering-Entry must be justified and authorized-Unqualified may not enter unless briefed and escorted by a qualified worker	Restricted Approach Boundary	<ul style="list-style-type: none">-Wear shock PPE when entering-No unqualified persons may enter	Review Boundary Requirements. Emphasize difference between shock boundaries and arc flash boundaries					
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<div>Activity Requirements and Authorization</div> <table><tr><th>Activity</th><th>Requirements</th><th>Authorization</th></tr><tr><td>Electrical Zero Energy Verification</td><td>LOTO Procedure</td><td>Person approving the LOTO procedure</td></tr><tr><td>Troubleshooting and diagnostic measurements</td><td>Energized Work OP</td><td>Senior Manager</td></tr><tr><td>Manipulation of live parts</td><td>Energized Work Permit</td><td>All affected Senior Managers and Electrical Safety Program Manager</td></tr></table> <div>Pg 36</div>	Activity	Requirements	Authorization	Electrical Zero Energy Verification	LOTO Procedure	Person approving the LOTO procedure	Troubleshooting and diagnostic measurements	Energized Work OP	Senior Manager	Manipulation of live parts	Energized Work Permit	All affected Senior Managers and Electrical Safety Program Manager	Review Activity Requirements and Authorization; emphasize that the safe work condition (LOTO) is the first choice – intentional activities on live circuits should always be the last resort.	
Activity	Requirements	Authorization												
Electrical Zero Energy Verification	LOTO Procedure	Person approving the LOTO procedure												
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 <p>Module 3 Meter Selection and Use</p>	<p>Introduce new topic</p>	
<p>Module 3 Objective</p> <ul style="list-style-type: none"> • Upon completion of this module, the student should be able to: <ul style="list-style-type: none"> • Select an appropriate voltage detector and demonstrate how to use a device to verify the absence of voltage, including interpreting indications provided by the device. • Understand all limitations of each specific voltage detector that may be used. 	<p>Review objective</p>	
<p>Electrical Meters</p> <ul style="list-style-type: none"> • Rated by Category and Voltage • Must be listed by an NRTL • Calibration may be required to maintain the listing of the meter 	<p>Review requirements for listing – remind that this applies to <i>all</i> electrical equipment, not just meters</p> <p>Refer meter cal questions to cal lab – direct students to follow calibration CPR</p>	
	<p>Describe the four categories of meters and general ranges (0-600, 0-1000)</p> <p>Describe results of improper meter use</p>	<p>Show additional file pics of damaged meters</p>

	<p>Discuss event summaries and outcomes</p> <ul style="list-style-type: none"> -injuries -death 																
<p>Over-voltage categories</p> <table border="1"> <thead> <tr> <th>Category</th> <th>In brief</th> <th>Examples</th> </tr> </thead> <tbody> <tr> <td>CAT IV</td> <td>Three-phase at utility connections, any conductors</td> <td> <ul style="list-style-type: none"> • Entries to the "region of installation" i.e. where low-voltage connections is made to utility person • Electricity meters, primary over-current protection equipment • Outside and service entrance, service drop from pole to building, riser between meter and panel • Overhead line to detached building, underground line to well pump </td> </tr> <tr> <td>CAT III</td> <td>Three-phase in building single-phase commercial lighting</td> <td> <ul style="list-style-type: none"> • Equipment in fixed installations, such as switchgear and polyphase motors • Bus and feeder in industrial plants • Feeders and short branch circuits, distribution panel devices • Lighting systems in larger buildings • Appliance outlets with short connections to service entrance </td> </tr> <tr> <td>CAT II</td> <td>Single-phase receptacle connected loads</td> <td> <ul style="list-style-type: none"> • Appliances, portable tools, and other household and similar loads • Outlet and long branch circuits • Outlets at more than 10 metres (30 feet) from CAT III source • Outlets at more than 20 metres (60 feet) from CAT IV source </td> </tr> <tr> <td>CAT I</td> <td>Electronic</td> <td> <ul style="list-style-type: none"> • Protected electronic equipment • Equipment connected to (contact) circuits in which measures are taken to limit transient over-voltage's to an appreciably low level • Any high-voltage, low-energy source derived from a high-voltage electronic transformer, such as the high-voltage section of a copier </td> </tr> </tbody> </table>	Category	In brief	Examples	CAT IV	Three-phase at utility connections, any conductors	<ul style="list-style-type: none"> • Entries to the "region of installation" i.e. where low-voltage connections is made to utility person • Electricity meters, primary over-current protection equipment • Outside and service entrance, service drop from pole to building, riser between meter and panel • Overhead line to detached building, underground line to well pump 	CAT III	Three-phase in building single-phase commercial lighting	<ul style="list-style-type: none"> • Equipment in fixed installations, such as switchgear and polyphase motors • Bus and feeder in industrial plants • Feeders and short branch circuits, distribution panel devices • Lighting systems in larger buildings • Appliance outlets with short connections to service entrance 	CAT II	Single-phase receptacle connected loads	<ul style="list-style-type: none"> • Appliances, portable tools, and other household and similar loads • Outlet and long branch circuits • Outlets at more than 10 metres (30 feet) from CAT III source • Outlets at more than 20 metres (60 feet) from CAT IV source 	CAT I	Electronic	<ul style="list-style-type: none"> • Protected electronic equipment • Equipment connected to (contact) circuits in which measures are taken to limit transient over-voltage's to an appreciably low level • Any high-voltage, low-energy source derived from a high-voltage electronic transformer, such as the high-voltage section of a copier 	<p>Review Chart</p>	<p>Direct students to full chart on page xx</p>
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<p>Selection and Use of meters</p> <ul style="list-style-type: none"> • Contact vs. Proximity → Purpose <ul style="list-style-type: none"> • Zero energy verification – must include a contact meter • Other uses – proximity tester is ok • Ensure meters are rated for circuit • TEST the meter before and after zero energy verification on known source to ensure safety 	<p>Review difference between contact and proximity testers, and potential uses</p> <p>Emphasize ratings of meter, and testing meter before/after use on known live source</p>	<p>Why test meter?</p>															
<p>General Precautions</p> <ul style="list-style-type: none"> • Start on highest scale (when not auto-ranging) • Ensure appropriate scale for multimeters – leaving on Ω scale for voltage measurement will blow fuses • Understand other restrictions of meter <ul style="list-style-type: none"> • Operating manual • Current measurement? • Other functions? 	<p>Review meter testing precautions</p> <p>Relate testing concerns => safety and reliability</p>																

	<p>For the final objective, you have the opportunity to demonstrate that you can actually use a meter.</p>	
	<p>Walk through circuit descriptions, noting code violations (multiple power sources, incorrect wire colors, etc.) Note that there is a 120 VAC cord and plug that provides alternate power to the 120 VAC heater (SCR) control in addition to the xfmr that is not visible from the front of the equipment. Additionally, the fuses to the left provide power to heaters, and this device is one of six identical heater controllers. Emphasize that backfeed from other units is possible in the event of miswiring, which is why 70E mandates testing “all exposed points phase to phase and phase ground”.</p>	
<p>Meter Selection and Usage Activity</p> <ul style="list-style-type: none"> • Pair up • Review requirement • Select meter • Perform test with partner observing and recording on supplied form • Switch observer/performer and repeat • Send forms to front <i>with names</i> when complete (part of final exam) 	<p>Describe meter test process</p>	<p>At no time is any worker authorized to connect the meter with actual hazardous voltage as a part of this class. Qualification for energized work activities is a responsibility of your manager, not the electrical safety program.</p> <p>Perform meter testing exercise</p>
		

<p>Objectives</p> <ul style="list-style-type: none"> Understand the specific hazards associated with electrical energy Identify and understand the relationship between electrical hazards and possible injury Describe the methods of release of victims from contact with exposed energized electrical conductors or circuit parts Be familiar with the proper use of the special precautionary techniques, personal protective equipment, including arc-flash, insulating and shielding materials, and insulated tools and test equipment Select an appropriate voltage detector and demonstrate how to use a device to verify the absence of voltage, including interpreting indications provided by the device Understand all limitations of each specific voltage detector that may be used Obtain the skills and techniques necessary to distinguish exposed energized electrical conductors and circuit part from other parts of electrical equipment Obtain the skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts State the approach distances specified in Table 130.2(C) and the corresponding voltages to which the qualified person will be exposed Explain the decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely 	<p>Review objectives</p>	
<p>Review of Key Topics</p> <ul style="list-style-type: none"> Electrical hazards Energized work definition Energized work requirements Boundaries Justification Authorization Meter Usage 	<p>Review key issues – safety, energized work definition / requirements, boundaries, justification, authorization, and meter usage; Remind students of differences in shock and arc flash boundaries, and what they are.</p>	
<p>Questions???</p>	<p>Ask for questions</p>	
<p>Examination</p> <p><small>NOTE: Both parts of the exam must be passed to receive credit for the class</small></p> <ul style="list-style-type: none"> Written Exam <ul style="list-style-type: none"> Closed book 25 Questions 80% minimum passing When finished, please leave your exam with the instructor Questions marked with an asterisk are "critical" questions. These questions must be passed to pass the course. Performance Exam (already complete) <ul style="list-style-type: none"> You will be contacted if you did not pass. Completions will be recorded in TEDS within 2 days. 	<p>Introduce examination – note that it is closed book. Ask if you don't understand the exam. Remind students that Q1, Q2, and Q3 must be correct or they will have to retake the class.</p> <p>Review passing criteria – note that the exams will not be graded until after all exams are turned in, and TEDS completions will be recorded within 2 days.</p>	