

EEL4935/6936 – Power Plant Engineering

Homework #1: Introduction and Electrical Safety

Due: 01/26/09

#1. A combined cycle power plant utilizes two thermal cycles to drive the prime mover(s). What are the names of the two thermal cycles that are referenced by the term “combined cycle”

- A. Rankine – Carnot
- B. Rankine – Brayton
- C. Carnot – Brayton

Answer: B

#2. Using the equation on page 1.14 of the text book (slide #5 of presentation 1), if the ash content of a sample of coal is 4.2 percent on an as-determined basis and the moisture M [as determined (ad)] is 7.5 percent, what is the ash content on a dry (d) basis?

- A. 4.0 percent
- B. 4.5 percent
- C. 5.0 percent
- D. 5.5 percent

Answer: B

#3. Name at least 5 energy resources that are used to generate electrical power;

- A. _____
- B. _____
- C. _____
- D. _____
- E. _____

Answer: (five of the following)

Coal
Oil
Natural Gas
Nuclear Fuel
Hydro
Tidal
Solar
Geogthermal

Wind
Biomass
Waste

#4. What are the 4 minimum steps to establish an electrically safe work condition?

- A. _____
- B. _____
- C. _____
- D. _____

Answer:

Isolate all sources of electrical energy
Apply Lockout / Tagout device
Verify absence of voltage
Ground phase conductors where possibility of induced voltage exists

#5. What activities below constitute energized electrical work.

- A. Taking voltage readings on panel that has just been isolated from the source but not yet locked out
- B. Closed door racking out circuit breaker from energized bus.
- C. Removal of MCC bucket from energized bus.
- D. All the above.

Answer D

#6. Given the following situation, determine the flash protection boundary in feet;

The activity is racking out a 3 phase, 480V line to line, power circuit breaker with doors closed from an energized switchgear bus. The bolted fault level calculated on the switchgear bus is 50,000A and the clearing time of the next available upstream breaker is 12 cycles (0.2 seconds). Use the following equation for your calculation;

$$D_c = [2.65 \times MVA_{bf} \times t]^{\frac{1}{2}}$$

or

$$D_c = [53 \times MVA \times t]^{\frac{1}{2}}$$

where:

D_c = distance in feet from an arc source for a second-degree burn

MVA_{bf} = bolted fault capacity available at point involved (in mega volt-amperes)

MVA = capacity rating of transformer (mega volt-amperes). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25

t = time of arc exposure (in seconds)

- A. 3.5 feet
- B. 4.7 feet
- C. 18 feet
- D. 22 feet

Answer: B. 4.7 feet

#7. Given the activity in problem #6 above, can you use the table 130.7(C)(9)(a) (listed below)? Why or why not?

Table 130.7(C)(9)(a) *Continued*

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
600 V Class Switchgear (with power circuit breakers or fused switches) — Notes 5 and 6			
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V, exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	3	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	3	N	N
Opening hinged covers (to expose bare, energized parts)	2	N	N

General Notes (applicable to the entire table): [ROP 360]

(a) *Rubber Insulating Gloves* are gloves rated and tested for the maximum line-to-line voltage upon which work will be done. [ROP 309, 331, 360]

(b) *Insulated and Insulating Hand Tools* are tools rated and tested for the maximum line-to-line voltage upon which work will be done. [ROP 331, 360]
Insulated and Insulating Hand Tools are tools that are manufactured and tested in accordance with the ASTM F 1505 standard. [ROP 358]

(c) 2* designation — means that a arc flash suit hood, or alternatively a face shield used in combination with a balaclava (sock hood) is required for this task in addition to the other Hazard/Risk Category 2 requirements of Table 130.7(C)(10). These components shall have a minimum arc rating of 8 cal/cm². [ROP 356, 360]

(d) Y = yes (required), N = no (not required) [ROP 360]

(e) For systems rated less than 1000 volts, the fault currents and upstream protective device clearing times are based on an 18-inch working distance. [ROP 360]

(f) For systems rated 1 kV and greater, the Hazard/Risk Categories are based on a 36-inch working distance. [ROP 360]

(g) For equipment protected by upstream current limiting fuses with arcing fault current in their current limiting range (1/2 cycle fault clearing time or less), the hazard/risk category required may be reduced by one number. [ROP 322]

Specific Notes (as referenced in the table): [ROP 360]

1. Maximum of 25 kA short circuit current available, and maximum of 0.03 second (2 cycle) fault clearing time. [ROP 322]

2. Maximum of 65 kA short circuit current available, and maximum of 0.03 second (2 cycle) fault clearing time. [ROP 322]

3. [ROP 349]

4. Maximum of 42 kA short circuit current available, and maximum of 0.33 second (20 cycle) fault clearing time. [ROP 348]

5. Maximum of 35 kA short circuit current available, and maximum of up to 0.5 second (30 cycle) fault clearing time. [ROP 348]

6. [ROP 349]

Answer: No can not use. Reason is that bolted fault current level is 50KA and note 5 limits max bolted fault current for use of table at 35KA

#8. Given the activity in problem #6 above, using table 130.2(C) (shown below), what is the limited approach boundary, restricted approach boundary, and prohibited approach boundary in feet & inches?

Table 130.2(C) Approach Boundaries to Live Parts for Shock Protection. (All dimensions are distance from live part to employee.)

(1) Nominal System Voltage Range, Phase to Phase	(2) Exposed Movable Conductor	(3) Exposed Fixed Circuit Part	(4) Restricted Approach Boundary ¹ ; Includes Inadvertent Movement Adder	(5) Prohibited Approach Boundary ¹
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 to 750	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1 ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5 ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	965.2 mm (3 ft 2 in.)	635 mm (2 ft 1 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	991 mm (3 ft 3 in.)	812.8 mm (2 ft 8 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.093 m (3 ft 7 in.)	939.8 mm (3 ft 1 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.22 m (4 ft 0 in.)	1.07 m (3 ft 6 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.6 m (5 ft 3 in.)	1.45 m (4 ft 9 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.59 m (8 ft 6 in.)	2.44 m (8 ft 0 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.43 m (11 ft 3 in.)	3.28 m (10 ft 9 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.55 m (14 ft 11 in.)	4.4 m (14 ft 5 in.)

Note: For Flash Protection Boundary, see 130.3(A).

¹See definition in Article 100 and text in 130.2(D)(2) and Annex C for elaboration.

Limited Approach Boundary _____
 Restricted Approach Boundary _____
 Prohibited Approach Boundary _____

Answer:

Limited Approach Boundary = 3 Ft, 6 in.

Restricted Approach Boundary = 1 Ft, 0 in.

Prohibited Approach Boundary = 0 Ft, 1 in.

#9. If the situation identified in problem #6 is modified so that now the incident energy level is 25KA, using table 130.7(C)(9)(a) (listed below problem 6), are Voltage rated gloves and tools required to rack out the breaker?

Answer: Gloves and Tools do NOT need to be voltage rated with doors closed.

#10. An area where flammable gases or vapors can exist under normal operating conditions is an example of;

- A. Class I, Division 1 location
- B. Class I, Division 2 location
- C. Class II, Division 1 location
- D. Class II, Division 2 location
- E. Class III, Division 1 location
- F. Class III, Division 2 location

ANSWER: A

#11. Using the table below, for a situation where there is a 480V MCC assembly across from concrete wall on opposite side of switchgear, what is the minimum working space required between assemblies?

Table 400.15(A)(1) Working Spaces

Nominal Voltage to Ground	Minimum Clear Distance					
	Condition 1		Condition 2		Condition 3	
0–150	900 mm	(3 ft)	900 mm	(3 ft)	900 mm	(3 ft)
151–600	900 mm	(3 ft)	1 m	(3½ ft)	1.2 m	(4 ft)

Note: Where the conditions are as follows:

Condition 1 — Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.

Condition 2 — Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls shall be considered as grounded surfaces.

Condition 3 — Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

- A. 3 feet
- B. 3 ½ feet
- C. 4 feet

ANSWER: B

#12, An energized electrical work permit is required to perform energized work. What are some of the items that should be listed in the energized electrical work permit? (Name at least 5)

Answer: at least 5 of below.

(1) A description of the circuit and equipment to be worked on and their location

- (2) Justification for why the work must be performed in an energized condition (130.1)
- (3) A description of the safe work practices to be employed [110.8(B)]
- (4) Results of the shock hazard analysis [110.8(B)(1)(a)]
- (5) Determination of shock protection boundaries [130.2(B) and Table 130.2(C)]
- (6) Results of the flash hazard analysis (130.3)
- (7) The Flash Protection Boundary [130.3(A)]
- (8) The necessary personal protective equipment to safely perform the assigned task [130.3(B), 130.7(C)(9), and Table 130.7(C)(9)(a)]
- (9) Means employed to restrict the access of unqualified persons from the work area [110.8(A)(2)]
- (10) Evidence of completion of a job briefing, including a discussion of any job-specific hazards [110.7(G)]
- (11) Energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s)