Pretest Module 29 High Voltage

1. Is a person qualified to work on high-voltage installations when this module is completed? No

2. What is the code definition of high-voltage? Greater than 750V

3. What is the IEEE definition of high-voltage? 115,000-230,000V

4. What are the typical utilization voltages? 600/347V, and 208/120V

5. What is the main problem with generating higher voltages? Cost of lines and equipment

6. What is the main problem with generating higher amperages? Heating problems and line losses

7. What is the typical transmission voltage range? 60-765kV

8. What type of cable is typically used for high-voltage transmission? Aluminum with steel core (bare)

9. What factor determines the voltage of a transmission line? Bulk power required and distance

10. What is a sub-transmission voltage line? Voltages considered below transmission but above distribution

11. What is the name given to the invisible field around a high-voltage cable? Electrostatic field

12. What determines the strength and direction of the magnetic field around a conductor? Instantaneous polarity and magnitude

13. What is the most common insulating medium between high-voltage wires and ground points? Air
14. What causes stress in the insulation on high-voltage conductors? Movement of electrons due to electrostatic stress

15. Where is the stress greatest on the insulation of a high-voltage conductor? Areas of highest flux density (Insulation layer closest to surface of conductor)

16. What is voltage gradient? Stress on insulation decreasing with distance

17. What is ionization? Air breaking down and becoming a conductor

18. What is corona? Ionized air

19. What is the term used to describe the minimum separation for high-voltage cables from towers and ground? Strike distance

20. What causes flashover? Lightening, switching and pollution

21. What is creepage? Current tracking over the insulation to ground

22. Why are insulators cleaned at regular intervals? Pollution and dust may cause a flashover

23. What are two types of voltage stress on conductor insulation? System voltage and impulse or transient voltage

24. What is a “BIL” rating of a conductor? Basic Impulse Insulation Level

25. What are the three categories of high-voltage distribution systems? Radial, ring, and network

26. What are the main advantages of a radial distribution system? Simple and cheapest

27. What is the main disadvantage of a radial distribution system? Least reliable

28. What is a ring or loop distribution system? Power supplied from two directions so if one line goes down power is not interrupted
29. What is a network distribution system and what is the most obvious advantage?
   Loop system with many interconnecting ties. Reliability

30. What is the maximum voltage of indoor service equipment? 13.8 kVA

31. What type of room is required for a high-voltage system installed indoors? Non-combustible

32. What is typically found in a substation? Line terminals, disconnects, circuit breakers, power transformers, lightening arresters, instrument transformers, metering and control equipment

33. What is a unit substation? Large industrial fed underground with medium-voltage cable to vault-type room. Factory-made modular design

34. What type of equipment is typically installed in a unit substation? Main circuit breaker, transformer, load circuit breakers

35. What are some of the rules for an electrical vault? Built of concrete, have at least one outside wall, steel door, padlocked, sloped floor and drainage for liquid-filled transformers, large enough, and located away from sewer, water and gas entry points.

36. What are two methods for lightening to affect a high-voltage line? Direct hit or induction from a neighboring strike

37. What is the difference between a lightening arrester and a surge suppressor? Same

38. How does a lightening arrester operate? Divert a high-voltage surge to ground by providing a easily conducting path
39. What is the “valve” in a lightening arrester and how does it work? Thyrite or lead pellets that vary resistance inversely with voltage magnitude and rebuild impedance after the strike.

40. How is the distance of the air gap determined in a lightening arrester? Based on normal system voltage not being able to break it down.

41. Where do the two ends of a lightening arrester connect? Line and Ground.

42. How does a series reactor act as a surge suppressor? Limits the current by acting as a choke when voltage increases.

43. What is the typical rating of the secondary in a current transformer for a high-voltage system? 5A.

44. What is the typical rating of the secondary in a potential transformer for a high-voltage system? 120V.

45. What factor will determine the size of a VT for a high-voltage system? Primary voltage.

46. What percentage of the full-load amperage of a circuit is used to select a current transformer? 115-125%.

Task 3

1. How is access to the key obtained in a key interlocking high-voltage fuse enclosure? Open the disconnecting device.

2. What other purpose is key interlocking used for? Prevent non-loadbreak switches from being operated under load.

3. What are pre-switching and post-switching procedures for high-voltage systems? Rules, regulations, and sequence of events for switching.
4. What are the five steps for switching high-voltage systems? **Disconnect, lockout, test for absence of voltage, ground and short circuit, and screen off live parts when necessary**

5. What is the minimum approach limit that must be maintained for a 100 kV system? **15 ft-4.5m**

6. What are three methods of working around high-voltage systems when minimum clearances cannot be maintained? **De-energized, effectively guarded against, or displaced or rerouted from the area**

7. What is the potential voltage at a ground rod if the resistance to ground is 15 ohms and the current is 250 amps? **3,750V**

8. What is step voltage? **Voltage (potential) difference between your feet when taking a step**

9. What is touch voltage? **Voltage (potential) difference between hands and feet when touching a grounded structure**

10. What is the purpose of a metal grid mat for working on high-voltage equipment? **Eliminate step and touch voltage when working around high-voltage equipment**

11. What is the minimum size grounding conductor for a grounding mat system? **No.2/0 AWG**

12. Where in the CEC will you find special terminology for high-voltage systems? **Section 36**

13. What is the maximum voltage rise for metal parts of a high-voltage substation? **5000V**
14. What does the CEC rule 36-210 require for VTs? Disconnecting means on HV side with OC protection

**Unit 2**

1. What is the main difference between high-voltage cables and low-voltage cables?  
   Heavier insulation

2. What are liquid-filled and gas-filled cables? Cables with oil or gas (nitrogen) that flows through a channel in the center of the conductor or through the pipe that houses the cable

3. What is the first layer after the actual conductor on a medium-voltage, solid-dielectric cable? Semi-conducting shield

4. What is the outer layer on a medium-voltage, solid-dielectric cable? Polyethylene jacket

5. What is PILC cable? Paper-insulated, lead-covered

6. What term is used to describe the insulating qualities of high-voltage cables? Dielectric strength

7. What is the unit of dielectric strength? Voltage per unit thickness

8. What happens to the dielectric strength of insulation as it heats? Decrease

9. What other factors affect dielectric strength? Moisture

10. What are the two types of plastic insulation found on high-voltage cables?  
    Plastics, cross-link polyethylene, polyvinyl chloride, polyethylene, oil-treated paper, synthetic rubber

11. What type of plastic is XLPE insulation? Thermoset plastic

12. What are two types of plastic insulation? Thermoset and thermoplastic Fix
13. What is one advantage of PILC? Better protection from surge voltages

14. What is a strand shield? Thin conducting or semi-conducting material of metallic or carbon impregnated plastic which effectively bonds the outer strands

15. What is an insulation shield? Thin conducting or semi-conducting material of metallic or carbon impregnated plastic which surrounds the conductor with ground making stresses equal all around

16. What are three functions of the insulation shield? Make the flux uniform, suppress radio and tv interference, and protect life in the event of mechanical damage to cable.

17. How are most cable sheaths for high-voltage cables grounded? Both ends

18. What insulation level is typically used for cables in a high-voltage ungrounded system where fault currents are not eliminated in one minute? 133%

19. Why is steel interlocking armour not typically used on single conductor high-voltage cables? Iron loss problems

20. What is the main advantage of wire cable armour? Longitudinal strength

21. Which type of high-voltage cable has a metallic insulation shield with as much current carrying capacity as the conductor? Concentric-neutral cable

22. What is the primary purpose of concentric neutral cable? Underground residential distribution (URD)

23. Where are shielded cables used? Industrial plants, substations, refineries, and generating stations

24. Where are medium-voltage tech cables used? Mining, refineries, chemical plants, office towers, commercial buildings, and medium and heavy industry
25. What determines the current and voltage rating of high-voltage cables? Current and voltage rating is based on AWG size and insulation levels.

26. What is the ambient temperature used for the amperage ratings of shielded and non-shielded cables? Non-shielded 30, Shielded 40.

27. What determines how far the cable shield is removed back from the live conductor at terminations? Voltage rating.


29. What are the two most common types of stress relief for medium-voltage cables? Geometric and capacitive.

30. What type of material is used for capacitive stress relief insulation? Hi-K.

31. What is a Class 1, 2, and 3 termination? Class 3 is indoor, clean, and stress relief only. Class 2 is stress relief and anti-tracking. (Dust or salt) Class 1 is stress relief, anti-tracking, and seal to the environment.

32. What are skirted terminations? When creepage distance is maintained with shorter physical distance.

33. At what point is the stress greatest on the insulation in a high-voltage termination? Where the insulation shield is discontinued.

34. What are the CEC rules for high-voltage cables inside buildings? Enclosed in metal or be in a vault.

35. Are high-voltage cables in concrete or masonry to be identified? Yup!

36. Is it permissible to run high-voltage and low-voltage cables in the same cable tray? With a sheet steel barrier, yes.
37. What is the result of bending high-voltage cables too sharp? Creates air pockets between conductor and insulation leading to corona problems

38. Generally, what cables require shielding? All cables above 5000V and thermoset above 2000V with some exceptions

39. Which cables require a stress relief device? Any with an insulation shield

40. Where are pothead terminations typically used? PILC cables

41. Which type of stress relief is a pothead termination? Geometric stress relief

42. What are the advantages and disadvantages of pothead terminations? Excellent electrical and mechanical properties but is slow and expensive and requires trained installers

43. What are the three steps for making a stress cone termination? Prepare cable, install stress cone, grounding

44. How long is the pencil taper on a stress cone termination? (See Diagram) 6mm

45. What precautions must be taken when sanding knife cuts out of the insulation? Do not sand the semicon. Do not sand any of the semicon onto the insulation. Do not trap any of the sanded material between the semicon shield and the insulation

46. What is the purpose of the silicone grease in a stress cone termination kit? Lubrication for the stress cone

47. Why are the skirting diameters varied on a high-k stress cone? Avoid establishing a continuous pattern of water along the skirting

48. What is the most common cause of failure in high-voltage cables? Mechanical damage due to careless handling and installation methods
49. What is the definition of a good splice in an electrical cable? As mechanically and electrically sound as a continuous piece of cable

Unit 3

1. What are the two main classifications of high-voltage switches? Loadbreak and non-loadbreak

2. What is metal-clad switchgear? Everything required to control the individual circuit is enclosed in a metal cabinet and can be readily removed from the cubicle

3. What is metal-enclosed switchgear? Metal-enclosed but the circuit breaker is stationary. Does not have the drawout feature of the metal-clad switchgear

4. Which rating of a high-voltage switch will be several multiples of the nominal switch rating? Basic Impulse Level (BIL)

5. How is a spring loaded or charged in a high-voltage, load-break switch? Electric motor

6. How are contacts opened fast in a non load-break switch? Not necessary (no arc)

7. What is a “hot stick”? Long fiberglass pole for operating switches from a distance

8. What are the four main types of high-voltage switches? Isolating, horn-gap, load-break, distribution

9. What are the main characteristics of an isolating switch? Designed for operation with no load. Visible isolation. Typically single or multi-pole knife switch

10. How does a horn-gap switch operate? Has a main and auxiliary arcing-horn gap contact attachment

11. What is the maximum interrupting capacity of a horn-gap switch? 15A
12. Which type of high-voltage switch interrupts current similar to a circuit breaker?
   Load-break switch

13. Can a load-break switch interrupt and close short-circuit current? Close only

14. Which high-voltage switch has an auxiliary parallel blade located in the arc chute? Load-break switch

15. Why does the arc in a load-break switch not extinguish in the main contact? Main contacts open just ahead of the auxiliary

16. Under what conditions can a high-voltage disconnect switch open and close a load? Negligible current (approx .5A) being switched and no significant voltage difference between the switch terminals

17. What is the main characteristic of a high-voltage disconnect switch? Visible proof of isolation

18. Do high-voltage fuses have inverse-time characteristic? Yes

19. What are the two general categories of high-voltage fuses? Distribution cutouts and power fuses

20. Which type of high-voltage fuse is typically used by supply authority, at the pole, to protect the transformer and lines? Distribution cutout

21. What are the three typical ratings on a fuse? Amperage, voltage, fault (interrupting) current

22. What are the characteristics of current-limiting fuses? Non-expulsion. Opens extremely fast under short circuit conditions limiting fault currents

23. How long does it take for a current-limiting fuse to open a circuit under short circuit? One quarter of a cycle (1/240 sec)
24. What happens when heat from an arc reacts with boric acid powder in a solid-materials fuse? Produces de-ionizing vapor that assists in extinguishing the arc

25. Which high-voltage fuses are considered expulsion fuses? Solid-materials and distribution cutout

26. What are the two styles of solid-materials fuses? Disposable and replacement-cartridge

27. What is the purpose of the spring in a solid-materials, replacement-cartridge type fuse? Elongate the arc when it blows

28. What material is used for the body of solid-materials, replacement-cartridge type fuses? Fiberglass or epoxy material

29. How is the arc quenched in a liquid fuse? Oil and the action of a spring to elongate the arc

30. Which type of high-voltage fuse is called a “drop-out” type? Distribution cutout

31. What are the two useful functions of the fuse tube swinging down 180 degrees? Visible indication of blowing and separation to prevent re-strike

32. How is the fuse link replaced in a distribution cutout? Typically with a hotstick

33. What type of material lines the fuse tube in a distribution cutout? Material that reacts with the arc in a high current interruption to produce a de-ionizing gas

34. How can high-voltage circuit breakers be physically distinguished from medium-voltage and low-voltage circuit breakers? Higher voltage CBs typically have each pole mounted on an individual support structure and having it’s own operating mechanism
35. How are high-voltage circuit breakers identified? Medium in which the contacts separate (oil, air, vacuum, sulphur hexafluoride)

36. How are high-voltage circuit breakers operated? Spring and latching mechanism most common (Hydraulic and pneumatic less common)

37. How does the BIL kV rating compare to the design rating for circuit breakers? Several multiples of design rating

38. How does the continuous-current rating compare to the interrupting-current for high-voltage circuit breakers? Typically the same

39. Where is the energy to close the main contacts stored in most circuit breakers? Spring and latching mechanism

40. What are the most common types of high-voltage circuit breakers? Air-magnetic, Vacuum, Oil, Air-blast, and Sulphur hexafluoride

41. What is a blow-out coil? Series-connected, low impedance coil

42. How is the spring charged in an air-magnetic CB? Motor or manually charged

43. What is the purpose of the puffer in an air-magnetic CB? Blows air into the arc to help extinguish it

44. What is the main advantage of a vacuum CB? Small physical size

45. Why does a vacuum CB extinguish an arc faster and with a smaller gap? Vacuum has a very high dielectric strength with no gasses to support arcing

46. Which type of oil CB is used more today? Minimum oil

47. What are the main disadvantages of bulk oil CBs? Large and bulky, oil is flammable, and environmental concerns about leaks
48. How does the minimum – oil CB operate? A small amount of oil is forced across the contacts at high pressure.

49. What are three functions of the air in an air-blast CB? Insulating, arc-quenching, and actuating force.

50. Which type of high-voltage CB is more costly and more elaborate? Sulphur hexafluoride.

51. What are the two properties of sulfur hexafluoride gas that make it acceptable for use in CBs? Non-toxic and non-combustible.

52. As interrupting rating and voltage rating increase, what is done with the sulfur hexafluoride gas? Pressure and density of gas are increased.

53. What is one disadvantage and several advantages of a sulfur hexafluoride CB? Expensive but reliable (low maintenance) and small size.

54. What is a recloser and how does it operate? A circuit breaker that will automatically reclose after an interruption.

55. What are the four steps in a safety lockout procedure? Disconnect, lockout/tagout, test for absence of voltage, and ground and short circuit.

56. What precaution should be taken with a tester after verifying voltage is off in a circuit? Check on known live circuit to verify operation of tester.

57. What is a “shotgun” in relation to high-voltage systems? A fiberglass pole similar to hotstick but with attachments for voltage testers.

58. Who is required to test line-live tools and equipment? Approved agency.

59. How will you know the last time a tool or piece of equipment was tested? Dates stamped on tool.
60. What is the purpose of the rubber or fiber ring in the handle of high-voltage tools?

Safety zone warning marker to keep hands below that point

61. How does a capacitive-coupled HV tester measure voltage? Bringing it close to a voltage source (Can be mounted on a pole to maintain safe distance)

62. What must be done to consider a HV circuit not energized? Test for proper operation of tester with a live source or verifier, verify no voltage present, then repeat the first step

63. List three precautions that should be taken before working on de-energized HV equipment? Check for physical separation on disconnect switches, Check locks and tags are in place, Check for proper grounding, Check for feedback, Ensure area is roped off and danger signs in place, Ensure all but essential people are removed from the area

64. How are horn-gap switches to be mounted? Horizontally

65. What are the rules for HV fuses installed indoors? Acceptable enclosure or in a room of non-combustible construction

66. What is the maximum current rating for fuses protecting VTs? 3A

67. What is the maximum percentage of the primary rated current when selecting overload protection for dielectric-filled HV transformers? 150%

Unit 4

1. What values are monitored by HV protective relays? Current, power, voltage, frequency, and power direction

2. What are the three types of HV relay movements? Fulcrum, electromagnetic, and solenoid types
3. What is the most common type of overcurrent relay? **Shaded-pole relay**

4. What are three of the most common methods of providing time delay in high-voltage relays? **Shaded-pole induction disc, oil-dashpot, and clock-escapement**

5. What is “shunt tripping”? **Tripping a breaker with a signal from a remote sensor or device**

6. How does an inverse-time overcurrent relay operate? **Spring holds a disc in place until a sufficient magnetic field overcomes the spring and rotates the disc closing a set of points**

7. How is the current limit adjusted in the instant-trip portion of an inverse-time overcurrent relay? **Adjustable contact travel distance**

8. How does a differential relay operate? **Measures current in two different locations in a system and if there is a difference in value then current flows in the relay and initiates an action**

9. What are two possible causes of unequal readings on the CTs in a differential relay? **Phase-to-ground or Phase-to-phase faults**

10. What is the basic difference between a voltage relay and an overcurrent relay? **Coil supplied from a voltage transformer instead of a current transformer**

11. Why would an induction disc relay be used with a voltage relay? **Time delay to allow for bumps and dips in the system voltage**

12. How are solid state relays supplied? **CTs and VTs**

13. What is the main advantage of solid state relays? **Features (Accuracy, reliability, etc.)**
14. What is “fault memory”? Records circuit conditions before and at the time of faults.

15. What is the main disadvantage of solid state relays? Price.

16. What other types of relays are associated with the trip circuit of load-break switches and circuit breakers? Overcurrent relays, voltage relays, frequency relays, power relays, etc.

17. What is required to test, calibrate and set up protective relays? Specialized test equipment, properly trained personnel, and manufacturers data.

18. What is relay coordination? Having a system designed so a relay tripping only disconnects necessary equipment.

19. How are most protective relays tested? Qualified technicians test relays in place as part of regular maintenance.

20. What precautions must be taken when removing a protective relay from the case? Sliding contacts are energized and can short out.