

PRACTICE EXAM 9: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. A 240V, 2,400W resistive load is connected to a single-phase supply. The resistance of the load is?

- A. 10Ω
- B. 576Ω
- C. 100Ω
- D. 24Ω

2. When the frequency of an AC circuit is doubled, the inductive reactance of a coil will?

- A. Remain unchanged
- B. Decrease by half
- C. Increase by a factor of four
- D. Double

3. The RMS (root mean square) value of a sinusoidal AC voltage is related to its peak value by?

- A. $V_{RMS} = V_{peak} \times \pi$
- B. $V_{RMS} = V_{peak} \div \sqrt{2}$

C. $V_{RMS} = V_{peak} \times \sqrt{2}$

D. $V_{RMS} = V_{peak} \times 0.637$

4. In a parallel circuit, which quantity remains the same across all branches?

A. Current

B. Voltage

C. Resistance

D. Power

5. A 100Ω resistor, a 40Ω inductive reactance, and a 10Ω capacitive reactance are connected in series. The impedance of the circuit is approximately?

A. 150Ω

B. 104.4Ω

C. 130Ω

D. 100Ω

6. Which of the following statements correctly describes the relationship between electric field and voltage?

A. Electric field is the product of voltage and distance

B. Voltage is the work done per unit charge in moving a charge between two points in an electric field

C. Voltage and electric field are the same physical quantity

D. Electric field causes current to flow only in conductors, not in insulators

7. A $5\mu\text{F}$ capacitor is charged to 200V. The energy stored in the capacitor is?

- A. 0.05J
- B. 0.1J
- C. 1,000J
- D. 0.5J

8. In a three-phase balanced system, the sum of the three instantaneous phase voltages at any instant equals?

- A. Zero
- B. Three times the phase voltage
- C. The line voltage
- D. $\sqrt{3}$ times the phase voltage

9. Which of the following best describes impedance in an AC circuit?

- A. The opposition to current caused only by resistance
- B. The opposition to current caused only by reactance
- C. The total opposition to AC current flow, combining resistance and reactance as a vector sum
- D. The ratio of reactance to resistance in a circuit

10. A transformer rated 10 kVA, 480V primary, 120V secondary is operating at full load. The secondary current is?

- A. 20.8A
- B. 10A
- C. 48A

D. 83.3A

11. The purpose of a fuse in an electrical circuit is to?

- A. Protect the circuit conductors and equipment by opening on overcurrent conditions
- B. Regulate voltage to the connected load
- C. Improve the power factor of the circuit
- D. Provide a low-resistance ground path

12. Which type of AC motor operates at exactly synchronous speed under all load conditions?

- A. Wound rotor induction motor
- B. Squirrel cage induction motor
- C. Shaded pole motor
- D. Synchronous motor with DC field excitation

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. Which conductor insulation type is rated for use in both wet and dry locations at 75°C?

- A. TW
- B. THW
- C. THHN
- D. RHH

14. The NEC ampacity table for conductors is based on an ambient temperature of?

- A. 25°C
- B. 40°C
- C. 50°C
- D. 30°C

15. A dual-element time-delay fuse is designed to?

- A. Provide instantaneous protection for both short circuits and overloads equally
- B. Allow motor starting inrush current while still protecting against sustained overloads and short circuits
- C. Clear both AC and DC faults without de-rating
- D. Provide ground fault protection on branch circuits

16. When conductors of different systems share the same enclosure per NEC 300.3, which requirement applies?

- A. All conductors must be the same gauge
- B. Conductors from different voltage systems may never share an enclosure
- C. All conductors must be insulated for the maximum voltage present in the enclosure
- D. All circuits must originate from the same panel

17. The NEC requires that receptacles installed in dwelling unit bedrooms be protected by?

- A. GFCI breakers only
- B. Surge protection devices
- C. Ground fault circuit interrupters (GFCI)

D. Arc fault circuit interrupters (AFCI)

18. A molded case circuit breaker (MCCB) is selected for a motor branch circuit. Per NEC 430.52, the maximum rating of a non-time-delay fuse for a Design B motor is?

- A. 125% of motor FLA
- B. 300% of motor FLA
- C. 250% of motor FLA
- D. 150% of motor FLA

19. Aluminum conductors require larger sizes than copper for the same ampacity because?

- A. Aluminum is heavier and harder to install
- B. Aluminum has higher resistivity than copper, requiring greater cross-sectional area to carry the same current
- C. Aluminum oxidizes faster, requiring additional insulation thickness
- D. Aluminum has a lower melting point than copper

20. The maximum number of current-carrying conductors permitted in a conduit without derating per NEC 310.15 is?

- A. Four
- B. Two
- C. Six
- D. Three

21. Which of the following is classified as a grounding electrode under NEC Article 250?

- A. The equipment grounding conductor in the branch circuit
- B. A metal underground water pipe in contact with earth for 10 feet or more
- C. The neutral conductor of a three-phase system
- D. The metal frame of a motor

22. The purpose of a surge protective device (SPD) installed at a service entrance is to?

- A. Limit the continuous operating voltage at the panel to rated voltage
- B. Protect against overcurrent from lightning and switching transients
- C. Clamp transient overvoltages from lightning or utility switching to a safe level, protecting connected equipment
- D. Provide ground fault protection for the entire building

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. A facility's power factor is 0.72 lagging. To improve the power factor to 0.95 lagging, the facility must install?

- A. Capacitor banks to supply leading reactive power (VARs) to cancel the lagging reactive load
- B. Additional inductors to balance the reactive load
- C. A synchronous condenser operating in underexcited mode
- D. Additional resistive loads to increase real power consumption

24. In a delta-wye transformer, the secondary wye neutral point provides?

- A. A stable reference for single-phase loads and ground fault current return path

- B. A connection point for the surge arrester only
- C. The primary voltage measurement point for protection relays
- D. A tap for reduced-voltage starting of motors

25. Which of the following correctly describes the function of a current transformer (CT) with a ratio of 400:5?

- A. It steps up current from 5A to 400A for high-current loads
- B. It steps down current from 5A to 400A in the secondary
- C. It provides 400A of secondary current regardless of primary current
- D. It steps down 400A of primary current to 5A for metering and protection relays

26. Ferroresonance in a power transformer occurs when?

- A. The transformer is overloaded beyond its rated kVA
- B. The transformer primary voltage exceeds rated voltage by 10%
- C. Transformer magnetizing inductance resonates with line or cable capacitance at a specific voltage and frequency, producing overvoltage
- D. Excessive harmonic current saturates the transformer core

27. In a utility distribution system, a recloser is installed on a feeder to?

- A. Regulate feeder voltage during peak load periods
- B. Provide metering of feeder energy consumption
- C. Limit feeder short circuit current to rated values
- D. Automatically interrupt and reclose on temporary faults, restoring service without manual switching

28. A 13.8kV switchgear bus has a short circuit current rating of 25 kA symmetrical. This rating means the switchgear can?

- A. Withstand and interrupt fault currents up to 25 kA without damage or failure
- B. Carry 25 kA of continuous load current on the bus
- C. Sustain 25 kA of fault current indefinitely without tripping
- D. Develop a maximum 25 kA fault current from the connected transformer

29. The purpose of an underfrequency relay (ANSI Function 81) on a generator bus is to?

- A. Trip the generator when output frequency rises above rated
- B. Initiate load shedding or generator protection when system frequency drops below a preset threshold
- C. Monitor frequency for synchronizing purposes only
- D. Detect islanding when the generator is separated from the utility

30. Which of the following is the most common cause of transformer failure in utility and commercial service?

- A. Insulation degradation from moisture, heat, and electrical stress over time
- B. Lightning strikes directly to the transformer
- C. Overloading beyond nameplate kVA for short periods
- D. Ferroresonance during capacitor bank switching

31. A ground fault neutralizer (Petersen coil) is used in some distribution systems to?

- A. Limit fault current on the system
- B. Reduce system operating voltage during fault conditions
- C. Filter harmonic currents from the distribution bus

D. Tune the system inductance to resonate with line capacitance, canceling ground fault current and allowing faulted operation

32. Voltage flicker on a distribution feeder is most commonly caused by?

A. Harmonic current from non-linear loads

B. Rapidly fluctuating loads such as arc furnaces, welders, or large motor starts

C. Power factor below 0.85

D. Transformer inrush during energization

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. A generator's no-load voltage is 485V and its full-load voltage is 465V at rated current. The voltage regulation is?

A. 4.1%

B. 3.1%

C. 4.3%

D. 0.41%

34. In a wound rotor induction motor (WRIM), inserting external resistance in the rotor circuit at starting?

A. Increases starting torque while reducing starting current — matching slip speed to the point of maximum torque

B. Reduces both starting torque and current simultaneously

C. Increases starting current while reducing torque

D. Has no effect on starting torque — it only limits speed

35. The purpose of a motor's thermal protector (embedded thermostat or thermistor) is to?

- A. Monitor motor speed and trip on overspeed
- B. Protect against phase loss conditions
- C. Monitor motor current and trip on overcurrent
- D. Detect excessive winding temperature and trip or alarm before insulation damage occurs

36. A two-speed motor using a Dahlander (pole-changing) winding achieves its two speeds by?

- A. Using a separate winding for each speed
- B. Reconnecting the stator winding to change the number of effective poles, changing synchronous speed
- C. Adjusting the rotor resistance for each speed
- D. Reducing supply frequency to the motor for low speed operation

37. The purpose of an anti-condensation heater (space heater) in a motor enclosure is to?

- A. Maintain motor winding temperature during operation to improve efficiency
- B. Increase motor starting torque in cold ambient conditions
- C. Provide supplemental cooling during high-load operation
- D. Maintain the motor above the dew point when idle to prevent moisture condensation on windings

38. In a motor control center (MCC), the incoming line section contains?

- A. The main disconnect, bus connections, and often the main overcurrent protection for the MCC
- B. Individual motor starters for each load
- C. Control transformers for the 120V control circuits
- D. Power factor correction capacitor banks

39. A VFD programmed with a linear V/Hz curve operates a pump motor. At 30 Hz (50% of base frequency), the output voltage is?

- A. 480V
- B. 120V
- C. 240V
- D. 360V

40. The purpose of motor winding thermistors (PTC type) connected to the motor control circuit is to?

- A. Measure motor speed for the VFD feedback
- B. Trip the motor contactor or VFD when winding temperature exceeds a threshold temperature, preventing thermal damage
- C. Control motor starting sequence
- D. Monitor motor current during operation

41. Which starting method provides the lowest starting current for a large three-phase induction motor?

- A. Star-delta (wye-delta) starting
- B. Variable frequency drive (VFD) starting
- C. Autotransformer starting
- D. Part-winding starting

42. A motor nameplate lists "460V, 3Ø, 60 Hz, 40 HP, 46A FLA, 1.15 SF." Operating this motor at service factor load requires?

- A. 40 HP maximum — the SF has no effect on operating load

B. A supply current of approximately 52.9A and adequate winding temperature margin within insulation class limits

C. Derated supply voltage to 400V

D. A different overload relay setting than the FLA rating

43. What is the purpose of the excitation system on a synchronous generator?

A. Control prime mover speed and output frequency

B. Provide cooling airflow to the stator windings

C. Regulate real power output to the bus

D. Control field current to regulate terminal voltage and reactive power output

44. In a three-phase motor circuit, a phase sequence relay (ANSI Function 47) protects against?

A. Reverse phase sequence or phase loss that would cause reverse rotation or unbalanced operation

B. Overvoltage on one phase

C. Motor overheating from excessive current

D. Loss of motor field excitation

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. A ground resistance test using the fall-of-potential method measures?

A. The resistance of the grounding electrode to remote earth

B. The resistance of the equipment grounding conductor

C. The insulation resistance of buried cable

D. The fault current available at the grounding electrode

46. When performing a contact resistance test on a circuit breaker with a micro-ohmmeter (DLRO), the acceptable maximum resistance for a properly maintained 480V breaker contact is typically?

- A. Less than 100 micro-ohms ($\mu\Omega$) per contact set
- B. Less than 1,000 $\mu\Omega$ per contact set
- C. Less than 10,000 $\mu\Omega$ per contact set
- D. No limit — any resistance is acceptable if the breaker passes its operational test

47. An oscilloscope displays a voltage waveform with a peak value of 170V. The RMS voltage of this waveform is approximately?

- A. 120V
- B. 240V
- C. 85V
- D. 170V

48. The purpose of a power factor test (Doble test or tan-delta test) on transformer insulation is to?

- A. Detect deterioration of transformer insulation by measuring the dielectric losses — increasing power factor indicates moisture, contamination, or degradation
- B. Measure transformer turns ratio
- C. Verify transformer cooling system efficiency
- D. Measure transformer core losses at no load

49. A three-phase motor is found to have 400 M Ω insulation resistance phase-to-ground after a 1-minute megger test. This result indicates?

- A. Failed insulation requiring immediate rewinding

B. Good insulation with no immediate concern — values above 100 MΩ are generally excellent for medium-voltage motors

C. Marginal insulation requiring close monitoring

D. The motor requires drying before service

50. A fault locator using time domain reflectometry (TDR) identifies a cable fault by?

A. Injecting DC high voltage and measuring leakage current

B. Applying power frequency AC and measuring insulation resistance

C. Using an infrared camera to detect heat at the fault location

D. Sending a high-frequency pulse into the cable and measuring the time for the reflection from the impedance discontinuity to return

51. A control transformer secondary is measured at 105V under no load but drops to 85V under full load. This indicates?

A. Normal voltage regulation for a control transformer

B. Correct transformer tap selection

C. Excessive load or a failing transformer with high internal impedance

D. The transformer requires replacement of the secondary fuse

52. When measuring insulation resistance on a large motor, the engineer observes that the megger needle deflects hard to zero immediately and stays there. This indicates?

A. A dead short in the motor winding — the insulation has completely failed

B. Normal megger behavior for large motors with high capacitance

C. The megger battery is discharged

D. Excellent insulation with maximum charge absorption

53. A relay technician is performing a timing test on a time-overcurrent relay at 300% of pickup. The measured time is 0.5 seconds but the TCC curve shows 0.45 seconds at that multiple. The technician should?

- A. Adjust the relay time dial upward to increase the operating time
- B. Replace the relay immediately — it has failed
- C. Accept the result — most standards allow $\pm 10\%$ timing tolerance
- D. Adjust the pickup setting to compensate for the timing error

54. Proper pre-energization checks before energizing a newly installed transformer include?

- A. Verifying correct tap position, oil level, cooling system operation, protective relay settings, and ground connections — and performing insulation resistance and turns ratio tests
- B. Performing a load bank test at full kVA only
- C. Checking the secondary voltage only under full load
- D. Energizing at 50% voltage first to verify turns ratio

MECHANICAL EQUIPMENT (Questions 55–63)

55. A centrifugal pump exhibits cavitation. The characteristic sound is described as?

- A. A steady high-pitched whine from the motor bearings
- B. A crackling or rattling noise similar to gravel or marbles passing through the pump casing
- C. A low-frequency rumble from the pump base
- D. Intermittent banging from the discharge check valve

56. The purpose of a mechanical seal flush plan API Plan 23 (closed-loop with heat exchanger) is to?

- A. Circulate process fluid from the pump discharge to the seal chamber
- B. Supply clean external barrier fluid to a dual mechanical seal
- C. Circulate seal chamber fluid through an external heat exchanger to cool the seal — used on high-temperature services
- D. Provide a gas barrier between the process and atmosphere

57. In a reciprocating air compressor, the volumetric efficiency is reduced by?

- A. Clearance volume in the cylinder — compressed gas remaining in the clearance expands on the suction stroke and reduces the volume available for new charge
- B. Increasing the compression ratio to reduce discharge pressure
- C. Lowering the ambient temperature, which densifies the intake air
- D. Using intercooling between compression stages

58. Which diesel engine component is responsible for atomizing fuel into the combustion chamber?

- A. Transfer pump
- B. Fuel filter
- C. Governor
- D. Fuel injector nozzle

59. The function of a crankcase ventilation system on a diesel engine is to?

- A. Provide fresh air for combustion to the cylinders
- B. Regulate crankcase oil temperature
- C. Remove blowby gases and oil mist from the crankcase to prevent pressure buildup and oil contamination
- D. Cool the connecting rod bearings during operation

60. A steam-driven turbine generator's speed governor droop is set at 5%. This means that?
- A. The governor allows 5% overspeed before tripping the unit
 - B. The governor allows speed to decrease by 5% from no-load to full-load — providing a stable proportional control response
 - C. The turbine output drops 5% when load is suddenly removed
 - D. The governor hunting amplitude is limited to $\pm 5\%$ of rated speed
61. The purpose of a vibration isolation mount under a motor-pump assembly is to?
- A. Protect the motor from floor-level flooding
 - B. Level the baseplate to correct shaft alignment
 - C. Provide a sacrificial connection that breaks before the pump is damaged
 - D. Prevent transmission of vibration energy from the rotating equipment to the building structure
62. A hydraulic cylinder drifts (moves slowly under load with no command signal). The most likely cause is?
- A. Excessive system pressure above the cylinder's rated pressure
 - B. Worn or damaged cylinder seals or a leaking directional control valve allowing internal leakage past the seals
 - C. Hydraulic oil too cold, increasing viscosity
 - D. Pump delivering too much flow to the cylinder
63. In a diesel generator, the purpose of the jacket water (coolant) heater is to?
- A. Maintain the engine coolant at operating temperature during standby so the engine can start and pick up load immediately without a cold-start warm-up period

- B. Prevent freezing of the coolant system in cold weather only
- C. Maintain coolant above 180°F during operation
- D. Pre-heat the fuel oil before injection

FLUID SYSTEMS (Questions 64–72)

64. Which type of pump is classified as a positive displacement pump?

- A. Centrifugal pump
- B. Reciprocating piston pump
- C. Axial flow pump
- D. Mixed flow pump

65. A steam system uses a thermostatic steam trap. This trap opens when?

- A. The condensate level in the trap rises above a float
- B. The trap body temperature reaches saturation temperature
- C. A magnetic float actuates the valve through a magnetic coupling
- D. The trap body temperature falls below the steam saturation temperature — condensate is cooler than steam

66. In a chilled water plant, the coefficient of performance (COP) of a chiller is defined as?

- A. The ratio of real power input to heat rejected at the condenser
- B. The ratio of heat rejected at the condenser to compressor work input
- C. The ratio of refrigeration effect (heat absorbed at the evaporator) to the compressor work input
- D. The ratio of chilled water flow to condenser water flow

67. The purpose of a waterside economizer in a chilled water plant is to?

- A. Recover heat from chiller condenser water for building heating
- B. Pre-cool chilled water supply using cooling tower water without running the chiller
- C. Improve chiller compressor efficiency at full load
- D. Provide free cooling by bypassing the chiller when outdoor wet-bulb temperature is low enough for the cooling tower to cool building water directly

68. Which type of valve is commonly used as a pressure relief valve on a steam boiler?

- A. Globe valve with a manual reset handle
- B. Spring-loaded pop safety valve that opens fully at setpoint and reseats below blowdown pressure
- C. Solenoid valve controlled by a pressure transmitter
- D. Needle valve with a calibrated pressure setting

69. In a hydronic system, a differential pressure bypass valve is used to?

- A. Prevent backflow through idle pumps
- B. Measure pump differential pressure for flow calculation
- C. Maintain minimum system differential pressure when zone control valves close, protecting the pump from deadhead conditions
- D. Regulate pump speed in response to system demand

70. The purpose of chemical oxygen scavengers (sodium sulfite or hydrazine) in boiler feedwater treatment is to?

- A. Neutralize acidic pH in the feedwater
- B. Prevent scale formation on boiler tube surfaces

- C. Kill biological organisms in the feedwater supply
- D. React with and remove dissolved oxygen before it can cause pitting corrosion of boiler tubes and steam system components

71. In a compressed air system, a refrigerated air dryer reduces the pressure dew point to approximately?

- A. 35–50°F (2–10°C) — preventing moisture condensation in the distribution system above this temperature
- B. –40°F — suitable for instrument air applications
- C. 70°F — ambient temperature only
- D. 0°F — freezing point of water at atmospheric pressure

72. Which of the following describes the purpose of a condenser water blowdown controller on a cooling tower?

- A. Drain the tower basin when the system is shut down
- B. Automatically discharge a portion of the basin water to control cycles of concentration and maintain water quality within specified limits
- C. Control the makeup water flow rate to the tower basin
- D. Discharge water when tower basin temperature exceeds a setpoint

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. The term "working load limit" (WLL) on rigging hardware is defined as?

- A. The load at which the hardware will fail structurally
- B. The maximum load the hardware is rated to carry in service — typically the breaking strength divided by the design factor
- C. The load at which permanent deformation begins

D. The maximum load during a proof test

74. When using a come-along (lever hoist) for a vertical lift, the maximum working load must not exceed?

A. 75% of the rated capacity to account for chain wear

B. The rated capacity with an additional 10% for dynamic loading

C. 50% of the rated capacity for overhead lifts only

D. The manufacturer's rated capacity under the conditions specified on the nameplate

75. Which type of sling provides the highest load capacity for a given load when used in a vertical hitch?

A. Wire rope sling — due to its high tensile strength-to-weight ratio

B. Round sling

C. Web sling

D. Chain sling

76. A conduit bender's "gain" refers to?

A. The amount of conduit length saved by the bend due to the curved path being shorter than two straight pieces meeting at the bend angle

B. The force multiplier provided by the bender handle length

C. The degree of bend accuracy achievable with the bender

D. The additional conduit length needed to account for the bend radius

77. In electrical panel wiring, control wiring (120V AC control circuits) is typically separated from power wiring because?

A. Power wiring can induce electrical noise into control wiring, causing erratic relay or PLC operation

- B. NEC requires physical separation between all voltage levels
- C. Control wiring insulation cannot withstand proximity to high-voltage conductors
- D. Separating the wiring allows easier identification of each circuit type

78. Which of the following describes the correct method for splicing two conductors in a conduit system?

- A. Tape the conductors together with electrical tape rated for the circuit voltage
- B. Make the splice in an accessible junction box using listed connectors — splices are not permitted inside conduit
- C. Use a compression sleeve and seal with silicone in the conduit
- D. Use a waterproof wire nut inside the conduit if the conduit is weatherproof

79. The purpose of a cable pulling lubricant when installing conductors in conduit is to?

- A. Protect the conductor insulation from moisture after installation
- B. Provide color coding for circuit identification
- C. Reduce pulling tension by lowering the coefficient of friction between conductor insulation and conduit wall
- D. Prevent conductor oxidation at terminations

80. Which rigging hardware is used to connect a wire rope sling to a load hook where the sling eye must be able to rotate freely?

- A. Shackle
- B. Swivel
- C. Eyebolt
- D. Turnbuckle

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Under OSHA's HazCom standard, the GHS pictogram showing an exclamation mark (!) indicates?

- A. The chemical is flammable
- B. Irritant, skin sensitizer, acute toxicity Category 4, narcotic effects, or respiratory tract irritation
- C. The chemical is explosive
- D. The chemical is acutely toxic (Categories 1–3)

82. The EPA's Clean Air Act regulates emissions from emergency generators. Generators used for demand response or peak shaving are subject to?

- A. NESHAP subpart ZZZZ for reciprocating internal combustion engines
- B. Title V major source permitting if above 100 tons per year of regulated pollutants
- C. New Source Review only during initial installation
- D. Tier 4 emission standards and hour limitations on non-emergency operation

83. A lead-acid battery spill of sulfuric acid (pH 1.0) in a maintenance shop requires?

- A. Immediate evacuation of the building and HAZMAT team response
- B. Neutralization with baking soda (sodium bicarbonate) or lime, followed by cleanup with appropriate PPE and disposal as corrosive waste
- C. Dilution with large quantities of water and discharge to the floor drain
- D. Absorption with paper towels and disposal in regular trash

84. Under RCRA, a generator of less than 100 kg of hazardous waste per month is classified as a?

- A. Large Quantity Generator (LQG)

- B. Very Small Quantity Generator (VSQG) — formerly Conditionally Exempt Small Quantity Generator
- C. Small Quantity Generator (SQG)
- D. Non-generator — no regulatory requirements apply

85. Which OSHA standard governs bloodborne pathogens exposure control for workers who may be exposed to blood or body fluids during first-aid response?

- A. 29 CFR 1910.151
- B. 29 CFR 1910.1200
- C. 29 CFR 1910.1030
- D. 29 CFR 1910.146

86. The purpose of a facility's Spill Prevention, Control, and Countermeasure (SPCC) plan under 40 CFR Part 112 is to?

- A. Respond to chemical spills inside the facility only
- B. Document emergency contacts for hazardous chemical spills
- C. Meet RCRA reporting requirements for hazardous waste spills
- D. Prevent oil discharges to navigable waters and provide countermeasures if a spill occurs

87. NYC Local Law 55 requires buildings to assess and mitigate indoor allergen hazards including?

- A. Volatile organic compounds (VOCs) from paint
- B. Mouse and cockroach allergens, mold, and other indoor allergens in residential buildings — requiring annual inspections and remediation
- C. Lead paint in all buildings built before 1978
- D. Asbestos in all commercial buildings

88. A chemical that is both a flammable liquid and acutely toxic would have which combination of GHS pictograms?

- A. Skull and crossbones and environmental hazard
- B. Exclamation mark and health hazard (silhouette)
- C. Flame and skull and crossbones
- D. Corrosion and flame

89. The purpose of an Environmental Management System (EMS) such as ISO 14001 in a facility operation is to?

- A. Provide a systematic framework for identifying, managing, and continuously improving environmental performance and compliance
- B. Replace OSHA safety programs with an integrated safety-environment system
- C. Satisfy NYC DEP permit requirements automatically upon certification
- D. Eliminate the need for environmental training by using automated compliance systems

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. An "authorized employee" under OSHA 1910.147 is defined as a worker who?

- A. Has management approval to perform any maintenance task
- B. Has been trained on LOTO procedures for the specific equipment being serviced
- C. Locks out or tags out machines or equipment in order to perform servicing or maintenance
- D. Supervises other workers performing LOTO on complex equipment

91. NFPA 70E defines a "qualified person" as someone who?

- A. Holds a valid electrical license in the jurisdiction
- B. Has demonstrated skills and knowledge related to the construction and operation of electrical equipment and has received safety training to identify and avoid the hazards involved
- C. Has completed an OSHA 10-hour electrical safety course
- D. Has at least five years of electrical maintenance experience

92. When a permit space entry is completed or must be cancelled, the entry supervisor must?

- A. Cancel the permit, ensure all entrants have exited, and return the space to normal conditions — removing all entry equipment and informing affected personnel
- B. File the completed permit with the facility safety officer within 24 hours
- C. Retain the permit for use on the next entry into the same space
- D. Sign the permit and post it on the space entrance for 30 days

93. The minimum safe approach distance (MAD) for qualified workers near energized 13.8kV conductors in an outdoor substation is?

- A. 12 inches
- B. 6 inches
- C. 2 feet 4 inches (28 inches) — the restricted approach boundary for 13.8kV
- D. 5 feet

94. Which type of fire extinguisher must never be used on a Class D (combustible metal) fire?

- A. Water — reacts violently with burning metals such as sodium, magnesium, or lithium, intensifying the fire

- B. CO₂ — causes excessive pressure at the fire site
- C. Dry powder (Met-L-X)
- D. Dry sand

95. Under OSHA 1910.303, all electrical equipment must be installed and maintained in a?

- A. Safe condition — free from recognized hazards that could cause death or injury
- B. Listed and labeled condition per the NEC only
- C. Condition that meets the original design specifications
- D. Condition approved by the facility's insurance carrier

96. The purpose of the OSHA Process Safety Management (PSM) standard (29 CFR 1910.119) is to?

- A. Govern emergency generator testing procedures
- B. Regulate hazardous waste disposal at industrial facilities
- C. Prevent catastrophic releases of highly hazardous chemicals through management of hazards in processes involving those chemicals
- D. Regulate compressed gas cylinder storage and handling

97. A worker is found unconscious in a permit-required confined space. The trained rescue team's first action is to?

- A. Enter the space immediately to retrieve the worker
- B. Attempt a non-entry rescue using a retrieval line or mechanical device if one is available and the worker can be reached
- C. Call 911 and wait for the fire department
- D. Ventilate the space before attempting any rescue

98. The NFPA 70E requirement for establishing an electrically safe work condition includes which steps?

- A. Wearing arc-rated PPE before touching any equipment
- B. De-energizing, LOTO, verifying absence of voltage with a properly rated tester, and releasing or restraining stored energy
- C. Installing temporary protective grounds only
- D. Verifying absence of voltage with a non-contact voltage tester only

99. When using a portable ladder in an electrical work environment, which precaution is required?

- A. Ladders must be positioned on a non-conductive mat
- B. Only wooden ladders may be used near energized equipment
- C. Metal ladders must be used for stability only on concrete floors
- D. Non-conductive (fiberglass) ladders must be used when working near or on energized electrical equipment

100. The purpose of a pre-task safety briefing before starting a maintenance job is to?

- A. Satisfy union contract requirements for hazardous work classification
- B. Assign liability for any accident that occurs during the work
- C. Ensure all workers understand the hazards, the controls in place, their individual roles, and the emergency plan before work begins
- D. Document that OSHA regulations have been reviewed for the task

PRACTICE EXAM 9 — ANSWER KEY

AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: D — 24Ω

Resistance = $V^2 \div P = 240^2 \div 2,400 = 57,600 \div 2,400 = 24$ ohms. Alternatively, $I = P \div V = 2,400 \div 240 = 10$ A, then $R = V \div I = 240 \div 10 = 24\Omega$. Both methods confirm that a 2,400W, 240V resistive load has a resistance of 24 ohms.

2. Correct Answer: D — Double

Inductive reactance $X_L = 2\pi \times f \times L$. Since X_L is directly proportional to frequency, doubling the frequency doubles the inductive reactance. If a coil had $X_L = 100\Omega$ at 60 Hz, it would have $X_L = 200\Omega$ at 120 Hz — frequency and inductive reactance have a direct linear relationship.

3. Correct Answer: B — $V_{RMS} = V_{peak} \div \sqrt{2}$

The RMS value of a sinusoidal waveform equals its peak value divided by $\sqrt{2}$ (approximately 1.414). For the standard 120V RMS system: $V_{peak} = 120 \times \sqrt{2} = 169.7$ V. The RMS value represents the equivalent DC voltage that delivers the same power to a resistive load as the AC waveform.

4. Correct Answer: B — Voltage

In a parallel circuit, all branches are connected directly across the same two nodes, so voltage is identical across every branch regardless of the branch impedance. Current divides among branches (inversely proportional to impedance), but voltage remains constant — this is the defining characteristic of parallel circuit topology.

5. Correct Answer: B — 104.4Ω

Net reactance = $X_L - X_C = 40 - 10 = 30\Omega$. Impedance $Z = \sqrt{(R^2 + X^2)} = \sqrt{(100^2 + 30^2)} = \sqrt{(10,000 + 900)} = \sqrt{10,900} = 104.4\Omega$. In a series RLC circuit, inductive and capacitive reactances partially cancel — only the net reactance combines with resistance to form impedance.

6. Correct Answer: B — Voltage is the work done per unit charge in moving a charge between two points in an electric field

Voltage (potential difference) is defined as the work done per unit charge (W/q) in moving a positive test charge between two points. It is measured in volts (joules per coulomb). The electric field (V/m) is the

force per unit charge — the two quantities are related but distinct: voltage is the integral of the electric field over distance.

7. Correct Answer: B — 0.1J

Energy stored in a capacitor: $E = \frac{1}{2} \times C \times V^2 = \frac{1}{2} \times 5 \times 10^{-6} \times 200^2 = \frac{1}{2} \times 5 \times 10^{-6} \times 40,000 = \frac{1}{2} \times 0.2 = 0.1$ joules. This energy is stored in the electric field between the capacitor plates and can be recovered when the capacitor discharges.

8. Correct Answer: A — Zero

In a balanced three-phase system, the three phase voltages are equal in magnitude and displaced 120° apart. At any instant, their instantaneous values sum to exactly zero — a fundamental property of balanced three-phase systems. This is why no current flows in the neutral of a perfectly balanced three-phase wye load.

9. Correct Answer: C — The total opposition to AC current flow, combining resistance and reactance as a vector sum

Impedance $Z = \sqrt{R^2 + X^2}$ is the vector (phasor) combination of resistance and reactance. It represents the total opposition to AC current flow in a circuit. The angle of the impedance vector ($\theta = \arctan(X/R)$) determines the circuit's power factor. Impedance is measured in ohms, like resistance and reactance.

10. Correct Answer: D — 83.3A

Secondary current = $kVA \times 1,000 \div \text{Secondary voltage} = 10,000 \div 120 = 83.3$ amperes. The 10:1 voltage step-down (480V to 120V) produces a 1:10 current step-up, so the secondary current (83.3A) is approximately ten times the primary current (20.8A), maintaining the VA balance across the transformer.

11. Correct Answer: A — Protect the circuit conductors and equipment by opening on overcurrent conditions

A fuse is a one-time overcurrent protective device — its fusible element melts and opens the circuit when current exceeds its rating for a sufficient time. Fuses protect conductors from overheating and equipment from damage caused by overloads and short circuits. Unlike circuit breakers, they cannot be reset and must be replaced after operation.

12. Correct Answer: D — Synchronous motor with DC field excitation

A synchronous motor with DC field excitation rotates at exactly synchronous speed ($N_s = 120f/P$) at all loads from no-load to full load — it has zero slip by definition. Induction motors always have some slip (typically 2–5% at full load) because they require a relative motion between rotor and rotating magnetic field to produce rotor current and torque.

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. Correct Answer: B — THW

THW insulation is rated for 75°C in both wet and dry locations — the "T" indicates thermoplastic insulation, "H" indicates 75°C heat rating, and "W" indicates suitable for wet locations. TW is 60°C wet/dry; THHN is 90°C dry only (75°C wet); RHH is 90°C dry only without the "W" suffix.

14. Correct Answer: D — 30°C

NEC Table 310.15(B)(16) and similar ampacity tables are based on an ambient temperature of 30°C (86°F). When conductors are installed in locations with ambient temperatures above or below 30°C, correction factors from NEC Table 310.15(B)(2) must be applied to adjust the tabulated ampacity to the actual installation conditions.

15. Correct Answer: B — Allow motor starting inrush current while still protecting against sustained overloads and short circuits

Dual-element time-delay fuses have two separate elements: a time-delay element that tolerates motor inrush current (600–800% FLA for several seconds during starting) without blowing, and a fast-acting element that clears high-magnitude short circuit faults quickly. This dual function makes them ideal for motor branch circuit protection.

16. Correct Answer: C — All conductors must be insulated for the maximum voltage present in the enclosure

NEC Section 300.3(C)(1) permits conductors of different voltage systems to share an enclosure only when all conductors are insulated for the maximum voltage present. This prevents the insulation of lower-voltage conductors from being overstressed by proximity to higher-voltage conductors in the same raceway or enclosure.

17. Correct Answer: D — Arc fault circuit interrupters (AFCI)

NEC Section 210.12 requires AFCI protection for all 120V, 15A and 20A branch circuits supplying outlets and devices in dwelling unit bedrooms — and in current editions, throughout most of the dwelling unit. AFCI breakers detect the unique electrical signature of arcing faults that can ignite fires but may not trip standard overcurrent devices.

18. Correct Answer: B — 300% of motor FLA

NEC Table 430.52 specifies the maximum overcurrent protective device ratings for motor branch circuit protection. For a non-time-delay fuse protecting a Design B squirrel cage motor, the maximum permitted rating is 300% of motor full-load amperes. Time-delay fuses are permitted up to 175% FLA — the higher rating for non-time-delay fuses accounts for motor inrush.

19. Correct Answer: B — Aluminum has higher resistivity than copper, requiring greater cross-sectional area to carry the same current

Aluminum's resistivity is approximately 1.6 times that of copper (2.65 vs. $1.68 \times 10^{-8} \Omega \cdot \text{m}$). To achieve the same resistance (and thus the same ampacity) as a copper conductor, an aluminum conductor must have a proportionally larger cross-sectional area — typically two AWG sizes larger for equivalent ampacity.

20. Correct Answer: D — Three

NEC Section 310.15(C) permits up to three current-carrying conductors in a conduit without applying derating factors. When four or more current-carrying conductors share a raceway, the ampacity of each must be derated — 80% for 4–6 conductors, 70% for 7–9 conductors, etc. — because the conductors cannot dissipate heat as effectively when bundled together.

21. Correct Answer: B — A metal underground water pipe in contact with earth for 10 feet or more

NEC Section 250.52 lists the approved grounding electrodes: metal underground water pipe (10 ft or more), metal frame of a building, concrete-encased electrode (Ufer ground), ground ring, rod and pipe electrodes, and plate electrodes. The EGC (answer A) and neutral conductor (answer C) are system conductors — not grounding electrodes.

22. Correct Answer: C — Clamp transient overvoltages from lightning or utility switching to a safe level, protecting connected equipment

Service entrance SPDs (Type 1 or Type 2) connect between the line conductors and ground at the main panel. When a transient overvoltage occurs (from a lightning strike or utility switching), the SPD's metal oxide varistors (MOVs) conduct and clamp the voltage spike to a safe level, diverting the transient energy to ground before it reaches sensitive equipment.

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. Correct Answer: A — Capacitor banks to supply leading reactive power (VARs) to cancel the lagging reactive load

Inductive loads (motors, transformers) draw lagging reactive current that reduces power factor below 1.0. Capacitors draw leading reactive current that cancels the lagging reactive current. Installing capacitor banks sized to supply the difference in reactive power between the existing and target power factor shifts the overall system power factor toward unity.

24. Correct Answer: A — A stable reference for single-phase loads and ground fault current return path

The wye neutral point in a delta-wye transformer provides the physical neutral conductor that establishes the voltage midpoint for single-phase loads (120V or 277V from phase to neutral). It also provides the

fault current return path for ground faults, enabling overcurrent devices to operate and clear faults — the key safety advantage over ungrounded delta systems.

25. Correct Answer: D — It steps down 400A of primary current to 5A for metering and protection relays

A CT with ratio 400:5 produces 5 amperes of secondary current when 400 amperes flows in the primary. This proportional reduction allows standard 5A metering instruments and relay inputs to measure and protect circuits carrying hundreds or thousands of amperes safely. CT secondary circuits must never be open-circuited while the primary is energized — this produces dangerously high voltages.

26. Correct Answer: C — Transformer magnetizing inductance resonates with line or cable capacitance at a specific voltage and frequency, producing overvoltage

Ferroresonance is a nonlinear resonance phenomenon occurring when a transformer's nonlinear magnetizing inductance resonates with line or cable capacitance under specific switching conditions — such as single-phase switching of an unloaded transformer fed through a capacitive cable. The resulting overvoltages can be several times normal and damage transformer insulation and connected equipment.

27. Correct Answer: D — Automatically interrupt and reclose on temporary faults, restoring service without manual switching

Distribution feeder reclosers are automatic circuit breakers with programmable reclose sequences (typically instantaneous trip, then one or more timed reclosures). Most distribution faults (80–85%) are temporary — caused by lightning, tree contact, or animal contact — and clear themselves if the line is momentarily de-energized. Reclosers restore service automatically after temporary faults.

28. Correct Answer: A — Withstand and interrupt fault currents up to 25 kA without damage or failure

The symmetrical short circuit current rating of switchgear defines the maximum fault current the equipment can safely interrupt (break) and the maximum fault current the bus can withstand momentarily without mechanical or thermal damage. Equipment with a 25 kA rating must not be installed where available fault current exceeds 25 kA.

29. Correct Answer: C — Monitor frequency for synchronizing purposes only

ANSI Function 81U (underfrequency) initiates protective action when system frequency drops below a preset threshold — it triggers load shedding schemes to restore frequency balance on an overloaded system, or initiates generator protection against sustained underfrequency operation that damages turbine blades and motor loads.

30. Correct Answer: A — Insulation degradation from moisture, heat, and electrical stress over time

The majority of transformer failures are insulation failures caused by the cumulative effects of thermal aging (Arrhenius law — insulation life halves with every 8–10°C temperature increase above rating),

moisture absorption, oxidation of insulating oil, and electrical stress. Lightning, overloading, and ferroresonance are less common failure causes in well-maintained systems.

31. Correct Answer: D — Tune the system inductance to resonate with line capacitance, canceling ground fault current and allowing faulted operation

A Petersen coil (ground fault neutralizer) is an adjustable iron-core reactor connected between the system neutral and ground. It is tuned to resonate with the system's distributed line-to-ground capacitance at power frequency, so that during a single-phase ground fault, the inductive current from the coil and the capacitive charging current from the unfaulted phases cancel — reducing fault current to near zero and allowing continued operation.

32. Correct Answer: B — Rapidly fluctuating loads such as arc furnaces, welders, or large motor starts

Voltage flicker (rapid, repetitive voltage variations perceived as light flicker) is caused by loads that draw rapidly varying current — arc furnaces, electric welders, and large motor starts are the classic sources. The fluctuating current through the feeder impedance causes corresponding fluctuations in feeder voltage that modulate lamp brightness at a rate perceptible to the human eye (2–30 Hz is most perceptible).

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. Correct Answer: C — 4.3%

Voltage regulation = $[(V_{NL} - V_{FL}) \div V_{FL}] \times 100 = [(485 - 465) \div 465] \times 100 = (20 \div 465) \times 100 = 4.3\%$. Note that regulation is calculated as a percentage of full-load voltage (not no-load voltage) — this is the standard definition. Lower regulation means more stable output voltage across the load range.

34. Correct Answer: A — Increases starting torque while reducing starting current — matching slip speed to the point of maximum torque

Adding external rotor resistance in a WRIM shifts the torque-speed curve so that maximum torque occurs at a higher slip value — ideally at starting (zero speed). This simultaneously increases starting torque toward the breakdown torque value and reduces starting current, providing superior starting performance for high-inertia loads compared to squirrel cage motors.

35. Correct Answer: D — Detect excessive winding temperature and trip or alarm before insulation damage occurs

Embedded thermostats (bimetallic discs) or PTC thermistors placed directly in the motor windings respond to the actual winding temperature rather than ambient or current — providing protection against overheating from any cause: overload, blocked ventilation, high ambient temperature, or voltage unbalance. They trip or alarm before the insulation reaches its rated maximum temperature.

36. Correct Answer: B — Reconnecting the stator winding to change the number of effective poles, changing synchronous speed

A Dahlander winding uses a single winding that can be reconnected externally to create either 2P or 4P (or 4P/8P, etc.) pole configurations — typically in a 2:1 speed ratio. The reconnection changes from series delta (high-speed, fewer poles) to parallel wye (low-speed, more poles), changing the synchronous speed without requiring a separate winding set.

37. Correct Answer: D — Maintain the motor above the dew point when idle to prevent moisture condensation on windings

When a motor is shut down, especially in humid environments or after warm operation, the windings can cool below the dew point and moisture condenses on the winding insulation. Space heaters energized during motor standby maintain the winding temperature 5–10°C above ambient dew point, preventing moisture accumulation that reduces insulation resistance and causes insulation failure.

38. Correct Answer: A — The main disconnect, bus connections, and often the main overcurrent protection for the MCC

The incoming line section of an MCC contains the main lugs or main circuit breaker/fused disconnect that serves as the principal disconnect means for the entire MCC, along with the horizontal bus bars that distribute power to all the individual starter buckets. It is the power entry point for the entire motor control center assembly.

39. Correct Answer: C — 240V

At 30 Hz (50% of 60 Hz base), a linear V/Hz drive outputs 50% of base voltage: $480 \times (30/60) = 480 \times 0.5 = 240$ volts. The constant V/Hz ratio ($480\text{V}/60\text{Hz} = 8 \text{ V/Hz}$) is maintained at all speeds below base frequency to keep motor flux constant — at 30 Hz: $8 \times 30 = 240\text{V}$.

40. Correct Answer: B — Trip the motor contactor or VFD when winding temperature exceeds a threshold temperature, preventing thermal damage

PTC (positive temperature coefficient) thermistors embedded in motor windings have a resistance that increases sharply at a specific threshold temperature (the Curie point). When the winding reaches this temperature, the PTC resistance jumps from a few hundred ohms to many kilohms — this change is detected by the monitoring relay which trips the contactor or drive, protecting the motor from thermal damage.

41. Correct Answer: B — Variable frequency drive (VFD) starting

A VFD provides the lowest starting current of all motor starting methods by ramping the output frequency from zero to rated frequency at a controlled rate, keeping the motor flux and torque constant while current remains at or near full-load amperes throughout acceleration. Starting current is typically 100–150% FLA — far below the 300–600% of star-delta, autotransformer, or across-the-line starting methods.

42. Correct Answer: B — A supply current of approximately 52.9A and adequate winding temperature margin within insulation class limits

Service factor load = FLA × SF = 46 × 1.15 = 52.9 amperes. The motor can carry this load continuously provided the supply voltage, frequency, and ambient temperature are within nameplate limits. Operating at SF load uses the motor's thermal margin — the insulation class must have sufficient temperature budget to accommodate the additional winding heat generated at SF load.

43. Correct Answer: D — Control field current to regulate terminal voltage and reactive power output

The excitation system (comprising the exciter, automatic voltage regulator, and field winding circuit) controls the DC field current in the rotor, which determines the strength of the rotor's magnetic field. Increasing field current raises terminal voltage and causes the generator to supply more reactive power (VARs) to the system; reducing field current lowers voltage and causes the generator to absorb reactive power.

44. Correct Answer: B — Reverse phase sequence or phase loss that would cause reverse rotation or unbalanced operation

A phase sequence relay monitors the relative phase rotation of the three-phase supply. It detects both reversed phase sequence (A-C-B instead of A-B-C) — which would cause a three-phase motor to run backwards — and phase loss (single-phasing), which causes severe current unbalance and rapid overheating. It prevents motor starting or trips a running motor under either condition.

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. Correct Answer: B — The resistance of the grounding electrode to remote earth

The fall-of-potential method measures the resistance between a grounding electrode and true earth (remote earth) by driving two auxiliary test stakes at specific distances from the electrode under test and measuring the voltage drop with a known test current injected between the test electrode and the outer auxiliary stake. IEEE 81 and NFPA 70 specify maximum acceptable ground resistance values.

46. Correct Answer: A — Less than 100 micro-ohms ($\mu\Omega$) per contact set

Contact resistance measurements on properly maintained circuit breaker contacts should be below 100 $\mu\Omega$ per contact set for 480V-class equipment — NETA MTS and manufacturer specifications typically cite 50–100 $\mu\Omega$ as acceptable. Values above this threshold indicate pitting, oxidation, or loose connections that will generate heat under load current and eventually cause failure.

47. Correct Answer: A — 120V

$V_{RMS} = V_{peak} \div \sqrt{2} = 170 \div 1.414 = 120.2V \approx 120V$. The 120V RMS standard power system voltage has a peak value of approximately 169.7V — this is the standard relationship between RMS and peak for a sinusoidal waveform, confirming that this waveform is a standard 120V AC supply.

48. Correct Answer: A — Detect deterioration of transformer insulation by measuring the dielectric losses — increasing power factor indicates moisture, contamination, or degradation

The power factor (tan delta) test applies AC voltage to the transformer insulation and measures the dielectric loss angle. Healthy, dry transformer insulation has a very low power factor (0.1–0.5%). As insulation absorbs moisture or degrades chemically, its dielectric losses increase — the power factor rises to 1–5% or higher, indicating the need for drying or further investigation.

49. Correct Answer: B — Good insulation with no immediate concern — values above 100 MΩ are generally excellent for medium-voltage motors

IEEE 43 provides guidelines for minimum acceptable insulation resistance values. For motors rated above 1kV, a minimum of (kV rating + 1) MΩ is recommended — a 4.16kV motor requires at least 5.16 MΩ minimum. A reading of 400 MΩ is far above this threshold, indicating excellent insulation condition with no moisture, contamination, or significant degradation.

50. Correct Answer: D — Sending a high-frequency pulse into the cable and measuring the time for the reflection from the impedance discontinuity to return

TDR fault location works on the same principle as radar — a high-frequency pulse travels down the cable at a known propagation velocity. When it reaches an impedance discontinuity (fault, open, short, or splice), a portion of the pulse energy is reflected back. By measuring the round-trip travel time and knowing the cable's velocity of propagation, the distance to the fault is calculated.

51. Correct Answer: D — The transformer requires replacement of the secondary fuse

A 20V drop (105V to 85V) from no-load to full-load in a control transformer represents very poor voltage regulation — far worse than the normal 3–5% expected. This large drop indicates either excessive load current exceeding the transformer rating, or internal transformer failure causing high series impedance. The secondary fuse should be checked, but the primary cause is transformer overload or failure.

52. Correct Answer: A — A dead short in the motor winding — the insulation has completely failed

When a megohmmeter needle immediately deflects to zero (0 Ω) and stays there, the insulation has completely broken down — there is a direct short circuit between the winding conductor and ground. No insulation resistance exists. The motor requires immediate rewinding or replacement. This must be distinguished from a large motor's initial capacitive response, which shows a temporary dip before recovering.

53. Correct Answer: D — Adjust the pickup setting to compensate for the timing error

A timing error of 0.05 seconds at 300% pickup represents approximately 11% deviation — slightly outside the typical ±10% tolerance specified by IEEE C37.112 and most relay manufacturers. The technician should first verify test equipment calibration, then determine if relay adjustment or replacement is warranted. Most standards allow ±10% or ±0.05s (whichever is greater), making this result borderline.

54. Correct Answer: A — Verifying correct tap position, oil level, cooling system operation, protective relay settings, and ground connections — and performing insulation resistance and turns ratio tests

Pre-energization checks for a new transformer must comprehensively verify: correct primary tap setting matches the supply voltage, oil level and condition, all cooling equipment operational, all protective relays properly set and tested, ground connections complete, turns ratio matches nameplate, and insulation resistance is acceptable — before the transformer is placed in service.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: B — A crackling or rattling noise similar to gravel or marbles passing through the pump casing

Cavitation produces a characteristic crackling, rattling, or popping noise caused by the violent implosion of vapor bubbles collapsing against the impeller and casing surfaces. This sound — often described as "pumping gravel" — is accompanied by vibration, reduced performance, and visible pitting erosion on the impeller vanes when the pump is opened for inspection.

56. Correct Answer: C — Circulate seal chamber fluid through an external heat exchanger to cool the seal — used on high-temperature services

API Plan 23 uses a pumping ring to circulate fluid from the seal chamber through a cooler (shell-and-tube or plate heat exchanger) and back to the seal chamber in a closed loop. This significantly reduces the temperature at the seal faces compared to using hot process fluid — critical for extending seal life on high-temperature pump applications such as hot water, condensate, and thermal oil services.

57. Correct Answer: A — Clearance volume in the cylinder — compressed gas remaining in the clearance expands on the suction stroke and reduces the volume available for new charge

Clearance volume is the dead space above the piston at top dead center that cannot be swept by the piston. The compressed gas trapped in this space must re-expand before the inlet valve can open on the suction stroke. This re-expansion consumes part of the piston stroke, reducing the effective displacement available for drawing in a new charge of gas — lowering volumetric efficiency.

58. Correct Answer: D — Fuel injector nozzle

The fuel injector nozzle atomizes fuel into the combustion chamber at extremely high pressure (typically 2,000–30,000 PSI in modern common-rail systems) through precisely calibrated orifices. The high-pressure injection creates a fine fuel spray with a large surface area, enabling rapid vaporization and mixing with the compressed air — essential for efficient combustion and emissions control.

59. Correct Answer: C — Remove blowby gases and oil mist from the crankcase to prevent pressure buildup and oil contamination

The crankcase ventilation system (breather or PCV system) removes combustion gases that blow past the piston rings into the crankcase. Without ventilation, these gases would pressurize the crankcase, forcing oil past seals and gaskets. The system also removes oil mist to prevent dilution and acidification of the crankcase oil by combustion byproducts.

60. Correct Answer: B — The governor allows speed to decrease by 5% from no-load to full-load — providing a stable proportional control response

Governor droop is the intentional speed decrease from no-load to full-load expressed as a percentage of rated speed. A 5% droop means the engine/turbine speed decreases from 105% at no load to 100% at full load (or from 100% to 95% depending on the reference). Droop provides stability for parallel operation — multiple generators automatically share load proportionally without hunting.

61. Correct Answer: D — Prevent transmission of vibration energy from the rotating equipment to the building structure

Vibration isolation mounts (spring isolators, elastomeric pads, or inertia bases with isolators) break the rigid connection between rotating equipment and the building structure. Without isolation, vibration energy travels through the structure, causing noise complaints, fatigue cracks in building components, and interference with vibration-sensitive equipment elsewhere in the building.

62. Correct Answer: B — Worn or damaged cylinder seals or a leaking directional control valve allowing internal leakage past the seals

Hydraulic cylinder drift under load indicates internal leakage — fluid bypassing from the high-pressure side to the low-pressure side of the cylinder piston through worn seal lips or across a worn directional control valve spool. This leakage flow slowly moves the piston in the direction of the load force. External leakage (past the rod seal) is visible; internal leakage requires seal replacement.

63. Correct Answer: A — Maintain the engine coolant at operating temperature during standby so the engine can start and pick up load immediately without a cold-start warm-up period

Emergency diesel generators must be capable of picking up full load within 10 seconds of a utility failure (per NFPA 110). A cold engine cannot achieve this — it requires warm-up time before accepting full load. The jacket water heater maintains coolant at approximately 90–120°F during standby, ensuring the engine is thermally ready to accept load immediately upon starting.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: B — Reciprocating piston pump

Positive displacement pumps deliver a fixed volume of fluid per revolution or stroke regardless of system pressure (within the pump's pressure rating). Reciprocating piston pumps, gear pumps, vane pumps, and

diaphragm pumps are all positive displacement types. Centrifugal, axial, and mixed flow pumps are dynamic (kinetic) pumps whose flow varies with system pressure.

65. Correct Answer: D — The trap body temperature falls below the steam saturation temperature — condensate is cooler than steam

Thermostatic traps contain a temperature-sensitive bellows or bimetallic element. The trap closes when exposed to steam (at saturation temperature) — blocking steam from escaping — and opens when cooled condensate contacts the element and contracts it, allowing condensate to discharge. The element responds to the temperature difference between steam and subcooled condensate.

66. Correct Answer: C — The ratio of refrigeration effect (heat absorbed at the evaporator) to the compressor work input

$COP = Q_{\text{evaporator}} \div W_{\text{compressor}} = \text{Heat removed from the chilled water} \div \text{Electrical energy input to the compressor}$. A COP of 6.0 means the chiller removes 6 kW of heat from the building for every 1 kW of electricity consumed. Higher COP indicates more efficient chiller operation — COP is the fundamental measure of refrigeration system efficiency.

67. Correct Answer: D — Provide free cooling by bypassing the chiller when outdoor wet-bulb temperature is low enough for the cooling tower to cool building water directly

A waterside economizer (fluid cooler or heat exchanger) allows the cooling tower to cool the building's chilled water directly when outdoor wet-bulb temperature is sufficiently low — without running the refrigerant compressor. Since the compressor accounts for 70–80% of chiller energy consumption, economizer operation during cool weather produces dramatic energy savings.

68. Correct Answer: B — Spring-loaded pop safety valve that opens fully at setpoint and reseats below blowdown pressure

Boiler safety valves are spring-loaded, full-lift pop-action valves designed to open quickly and fully (pop open) when pressure reaches the setpoint, rapidly relieving pressure. They reseal (close) at a slightly lower pressure (the blowdown pressure — typically 4% below setpoint). Full-lift action prevents the valve from partially opening and wire-drawing (eroding) the seating surfaces.

69. Correct Answer: C — Maintain minimum system differential pressure when zone control valves close, protecting the pump from deadhead conditions

When zone control valves in a variable flow hydronic system close, the pump's flow is throttled toward zero. Running a centrifugal pump at very low or zero flow (deadhead) causes the pump to overheat the recirculating fluid and subjects the pump to high radial thrust and vibration. The differential pressure bypass valve opens to maintain minimum flow, protecting the pump.

70. Correct Answer: D — React with and remove dissolved oxygen before it can cause pitting corrosion of boiler tubes and steam system components

Dissolved oxygen in boiler feedwater is extremely corrosive — even parts per billion concentrations cause pitting corrosion (oxygen pitting) that creates deep pits in boiler tubes, eventually causing tube failures. Chemical oxygen scavengers (sodium sulfite: $\text{Na}_2\text{SO}_3 + \frac{1}{2}\text{O}_2 \rightarrow \text{Na}_2\text{SO}_4$, or hydrazine: $\text{N}_2\text{H}_4 + \text{O}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$) react with dissolved oxygen to eliminate it chemically, supplementing the mechanical deaeration already performed by the deaerator.

71. Correct Answer: A — 35–50°F (2–10°C) — preventing moisture condensation in the distribution system above this temperature

Refrigerated air dryers cool compressed air to approximately 35–50°F using a refrigeration circuit, causing moisture to condense and drain out. The resulting pressure dew point of 35–50°F means moisture will not condense in distribution piping as long as ambient temperature remains above this range — suitable for plant air systems but not for instrument air requiring lower dew points.

72. Correct Answer: B — Automatically discharge a portion of the basin water to control cycles of concentration and maintain water quality within specified limits

As cooling tower water evaporates, dissolved minerals concentrate in the remaining water. A blowdown controller measures conductivity (proportional to dissolved solids concentration) and automatically opens a blowdown valve to discharge concentrated water when conductivity exceeds the setpoint — maintaining cycles of concentration within the water treatment program's specified limits to prevent scale and corrosion.

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. Correct Answer: B — The maximum load the hardware is rated to carry in service — typically the breaking strength divided by the design factor

Working Load Limit (WLL) is the maximum mass or force the hardware is designed to support in a particular service condition, determined by dividing the minimum breaking force by the appropriate design factor (typically 4:1 or 5:1 for rigging hardware). WLL is less than the proof load test value and far less than the breaking strength — it represents the maximum safe working load.

74. Correct Answer: D — The manufacturer's rated capacity under the conditions specified on the nameplate

A come-along (lever hoist) must never be loaded beyond its nameplate rated capacity — the design safety factor is already built into the WLL rating. Additional derating for overhead lifts is not required by standard rigging practice as long as the hoist is properly maintained and inspected. Operating above rated capacity risks catastrophic chain or housing failure.

75. Correct Answer: A — Wire rope sling — due to its high tensile strength-to-weight ratio

Wire rope slings have the highest strength-to-weight ratio and provide the highest absolute load capacity among sling types for a given diameter. A 1-inch diameter wire rope sling in a vertical hitch can typically

carry 10+ tons. Chain slings have similar capacity but are heavier; synthetic slings (web and round) have lower capacity but are gentler on finished surfaces.

76. Correct Answer: A — The amount of conduit length saved by the bend due to the curved path being shorter than two straight pieces meeting at the bend angle

Gain (or shrink) is the difference between the sum of two straight runs meeting at the bend angle and the actual developed length of conduit used by the bend. When making a 90° stub-up, the gain is subtracted from the measurement to place the mark correctly on the conduit — typically about 5 inches for ½" conduit and up to 8 inches for larger conduit sizes.

77. Correct Answer: A — Power wiring can induce electrical noise into control wiring, causing erratic relay or PLC operation

High-current power conductors generate electromagnetic fields proportional to the current magnitude. When control wiring runs parallel to power wiring at close proximity, these fields induce voltages in the control conductors (inductive coupling) and through capacitive coupling. This induced noise can cause false triggering of relay coils, PLC input cards, or analog signal errors — separation prevents interference.

78. Correct Answer: B — Make the splice in an accessible junction box using listed connectors — splices are not permitted inside conduit

NEC Section 300.13 and 300.15 prohibit splices inside conduit — all splices and taps must be made in accessible junction boxes, pull boxes, conduit bodies, or other listed enclosures. This requirement ensures that all connections are accessible for inspection, maintenance, and replacement without having to pull the conductors from the conduit.

79. Correct Answer: C — Reduce pulling tension by lowering the coefficient of friction between conductor insulation and conduit wall

Cable pulling lubricants (UL-listed, compatible with conductor insulation) are applied to conductors before pulling to reduce the friction coefficient between the insulation jacket and conduit wall. This reduces the pulling tension required, preventing insulation damage from excessive tension and allowing longer pulls through bends than would otherwise be possible.

80. Correct Answer: B — Swivel

A swivel is inserted between the wire rope sling eye and the load hook to allow the load to rotate freely without imparting torque to the sling or hoist chain. Without a swivel, a rotating load would twist and kink the wire rope, reducing its working load limit and eventually causing wire breaks. Swivels are essential when loads can spin during the lift.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: B — Irritant, skin sensitizer, acute toxicity Category 4, narcotic effects, or respiratory tract irritation

The GHS exclamation mark pictogram indicates less severe health hazards than the skull and crossbones: acute toxicity Category 4 (harmful if swallowed, inhaled, or in contact with skin), skin/eye irritation, skin sensitization, respiratory tract irritation, and narcotic effects. The skull and crossbones is reserved for acute toxicity Categories 1–3 (more severe, potentially fatal exposures).

82. Correct Answer: D — Tier 4 emission standards and hour limitations on non-emergency operation

EPA 40 CFR Part 60 Subpart IIII establishes Tier 4 emission standards for new diesel emergency generators. Generators used for demand response, peak shaving, or non-emergency purposes are subject to strict hour limitations (up to 100 hours per year for emergency generators used for demand response) and must comply with the applicable Tier emission standards based on engine manufacture date and power rating.

83. Correct Answer: B — Neutralization with baking soda (sodium bicarbonate) or lime, followed by cleanup with appropriate PPE and disposal as corrosive waste

Sulfuric acid spills require neutralization before cleanup — baking soda (NaHCO_3) or lime (Ca(OH)_2) raises the pH to a safe level, stopping the corrosive action and generating CO_2 gas (visible foaming confirms neutralization reaction). Workers must wear acid-resistant PPE (gloves, face shield, apron). The neutralized material must be disposed of as corrosive hazardous waste — not in regular trash or floor drains.

84. Correct Answer: B — Very Small Quantity Generator (VSQG) — formerly Conditionally Exempt Small Quantity Generator

EPA's 2016 RCRA generator improvements rule renamed the CESQG category to Very Small Quantity Generator (VSQG). VSQGs generate no more than 100 kg/month of hazardous waste and no more than 1 kg/month of acutely hazardous waste. VSQGs have significantly reduced regulatory requirements compared to SQGs (100–1,000 kg/month) and LQGs (>1,000 kg/month).

85. Correct Answer: C — 29 CFR 1910.1030

OSHA's Bloodborne Pathogens standard (29 CFR 1910.1030) requires employers to protect workers who may be reasonably anticipated to have occupational exposure to blood or other potentially infectious materials — including workers designated as first-aid responders. Requirements include an exposure control plan, hepatitis B vaccination, PPE, training, and post-exposure follow-up.

86. Correct Answer: D — Prevent oil discharges to navigable waters and provide countermeasures if a spill occurs

EPA's SPCC rule (40 CFR Part 112) requires facilities that store oil above threshold quantities (1,320 gallons aboveground or 42,000 gallons underground) and that could reasonably be expected to discharge

to navigable waters to prepare and implement a Spill Prevention, Control, and Countermeasure Plan. The plan documents containment measures, inspection procedures, and response actions.

87. Correct Answer: B — Mouse and cockroach allergens, mold, and other indoor allergens in residential buildings — requiring annual inspections and remediation

NYC Local Law 55 of 2018 requires owners of multiple dwellings to annually investigate and remediate indoor allergen hazards — specifically mouse and cockroach allergens, mold, and other pests — in all dwelling units and common areas. This law expanded allergen hazard requirements beyond the previous lead-only focus, addressing major contributors to asthma and respiratory disease in NYC residential buildings.

88. Correct Answer: C — Flame and skull and crossbones

A chemical that is both flammable (Class 3 flammable liquid) and acutely toxic (Category 1–3) would display both the GHS flame pictogram (indicating flammability hazard) and the skull and crossbones pictogram (indicating acute toxicity). GHS allows multiple pictograms on a single label to communicate all relevant hazards — the combination immediately communicates both the fire hazard and the severe toxicity to workers.

89. Correct Answer: A — Provide a systematic framework for identifying, managing, and continuously improving environmental performance and compliance

ISO 14001 is an internationally recognized Environmental Management System standard that provides a Plan-Do-Check-Act framework for organizations to identify their environmental aspects and impacts, establish objectives and targets, implement controls, monitor performance, and continuously improve. Certification demonstrates commitment to environmental management but does not automatically satisfy regulatory requirements — it complements, rather than replaces, regulatory compliance programs.

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. Correct Answer: C — Locks out or tags out machines or equipment in order to perform servicing or maintenance

OSHA 1910.147 defines an authorized employee as a person who locks out or tags out machines or equipment to perform servicing or maintenance. This is distinct from an "affected employee" (one who operates the machine being locked out) or "other employee" (all others in the area). Only authorized employees may apply personal locks and perform work under the energy control procedure.

91. Correct Answer: B — Has demonstrated skills and knowledge related to the construction and operation of electrical equipment and has received safety training to identify and avoid the hazards involved

NFPA 70E defines a qualified person based on demonstrated knowledge and safety training — not solely on years of experience, licensing, or completion of a specific course. Qualification is task-specific and

equipment-specific: a person qualified to work on 480V motor control circuits may not be qualified to work on 13.8kV switchgear without additional training and demonstrated competency.

92. Correct Answer: A — Cancel the permit, ensure all entrants have exited, and return the space to normal conditions — removing all entry equipment and informing affected personnel

OSHA 1910.146(e)(5) requires that when a permit entry is completed or cancelled, the entry supervisor cancels the permit, verifies all entrants have exited the space, and returns the space to its normal (pre-entry) condition. All equipment is removed, openings are re-secured, and affected personnel are notified. Completed permits must be retained for at least one year for review.

93. Correct Answer: C — 2 feet 4 inches (28 inches) — the restricted approach boundary for 13.8kV

NFPA 70E Table 130.4(D)(a) specifies approach boundaries for AC systems. For 13.8kV (phase-to-phase voltage), the restricted approach boundary is 2 feet 4 inches (28 inches) — the distance within which qualified workers must use appropriate shock protection (voltage-rated tools and PPE). The limited approach boundary (for unqualified persons) is further away at 5 feet 0 inches.

94. Correct Answer: A — Water — reacts violently with burning metals such as sodium, magnesium, or lithium, intensifying the fire

Water must never be used on Class D fires — alkali metals (sodium, potassium, lithium) react violently and exothermically with water, generating hydrogen gas and intense heat that intensifies the fire. CO₂ can also react with some burning metals. Only approved dry powder agents (Met-L-X, graphite, dry sand) designed for the specific metal involved can safely extinguish Class D fires.

95. Correct Answer: A — Safe condition — free from recognized hazards that could cause death or injury

OSHA 29 CFR 1910.303(b)(1) states that electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees — the electrical version of the General Duty Clause. This broad requirement means that even if specific NEC or OSHA rule violations are not cited, equipment that presents a recognized hazard must be corrected.

96. Correct Answer: C — Prevent catastrophic releases of highly hazardous chemicals through management of hazards in processes involving those chemicals

OSHA PSM (29 CFR 1910.119) applies to processes using highly hazardous chemicals above threshold quantities and requires a comprehensive management system: process hazard analysis, written procedures, training, mechanical integrity programs, management of change, incident investigation, and emergency planning. PSM is specifically designed to prevent incidents like the Bhopal disaster through systematic process hazard management.

97. Correct Answer: B — Attempt a non-entry rescue using a retrieval line or mechanical device if one is available and the worker can be reached

OSHA 1910.146 requires that non-entry rescue be attempted first whenever feasible — the retrieval line attached to the entrant's body harness allows the attendant or rescue team to pull the unconscious worker out of the space without entering. Entering a space with an unconscious occupant without proper rescue procedures and SCBA risks creating additional casualties — the most common confined space fatality scenario involves rescuers who enter without proper protection.

98. Correct Answer: D — Verifying absence of voltage with a non-contact voltage tester only

NFPA 70E Section 120.5 requires all of the following steps to establish an electrically safe work condition: (1) determine all sources of supply, (2) interrupt the load, (3) open the disconnecting means, (4) visually verify the open position, (5) apply LOTO, (6) release or restrain stored energy, and (7) verify absence of voltage with a properly rated tester. Non-contact testers alone are insufficient — a rated voltage tester with test-before-touch verification is required.

99. Correct Answer: D — Non-conductive (fiberglass) ladders must be used when working near or on energized electrical equipment

OSHA 29 CFR 1910.333(c)(7) and NFPA 70E require that non-conductive ladders be used when there is a possibility of contact with exposed energized electrical conductors or parts. Fiberglass ladders provide insulation against electric shock — metal ladders conduct electricity and could complete a circuit if they contact an energized conductor, fatally electrocuting the user.

100. Correct Answer: C — Ensure all workers understand the hazards, the controls in place, their individual roles, and the emergency plan before work begins

A pre-task safety briefing (also called a toolbox talk, job safety analysis review, or tailboard meeting) ensures every member of the work crew understands the specific hazards of the planned task, the protective measures being used, their individual responsibilities, and what to do in an emergency. It promotes a safety culture, catches overlooked hazards through team discussion, and confirms readiness before the first tool is picked up.