PRACTICE EXAM 10: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. What is the total resistance of three 12Ω resistors connected in parallel?

A. 36Ω

B. 4Ω

C. 12Ω

D. 6Ω

2. The SI unit of magnetic flux density (B-field strength) is the?

A. Henry

B. Weber

C. Gauss

D. Tesla

3. In an AC circuit, when current lags voltage by 90°, the circuit is?

A. Purely resistive

B. Resistive-capacitive

C. Resistive-inductive

D. Purely inductive

4. A 1.5kW, 120V single-phase motor operates at a power factor of 0.85. The apparent power drawn is approximately?

A. 1,500 VA

B. 1,765 VA

C. 1,275 VA

D. 2,100 VA

5. The voltage drop across a 15Ω resistor carrying 4A of current is?

A. 3.75V

B. 225V

C. 3.75V

D. 60V

6. Which of the following correctly defines electric current?

A. The potential difference between two points in a circuit

B. The opposition to current flow in a conductor

C. The rate of flow of electric charge past a point in a circuit, measured in amperes

D. The energy stored in a magnetic field per unit of inductance

7. A transformer has a primary of 500 turns and a secondary of 50 turns. If the primary is connected to 240V AC, the secondary voltage is?

A. 2,400V

B. 480V

C. 120V

D. 24V

8. Ohm's Law states that current through a conductor is?

A. Directly proportional to the applied voltage and inversely proportional to resistance

B. Inversely proportional to both voltage and resistance

C. Directly proportional to resistance and inversely proportional to voltage

D. Independent of resistance when voltage is constant

9. The power dissipated in a 50Ω resistor carrying 2A is?

A. 200W

B. 25W

C. 100W

D. 400W

10. In an AC circuit operating at unity power factor, which of the following is true?

A. Real power equals apparent power — voltage and current are in phase

B. Reactive power exceeds real power

C. Current leads voltage by 90°

D. Power factor is zero

11. A capacitor is described as having a reactance of 0Ω at DC. Why is this statement incorrect?

A. A capacitor passes DC current freely at all times

B. A capacitor has infinite reactance at DC — it blocks DC completely once charged

C. A capacitor has 50Ω reactance at DC

D. A capacitor's reactance at DC is undefined — it depends on voltage only

12. In a balanced three-phase system, each phase is displaced from the others by?

A. 90°

B. 45°

C. 120°

D. 180°

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

13. Which AWG conductor size has the largest cross-sectional area?

A. 4/0 AWG

B. 2 AWG

C. 10 AWG

D. 4 AWG

14. Type MC (metal-clad) cable differs from Type AC (armored cable) in that MC cable?

A. Cannot be used in wet locations

B. Contains a full-size equipment grounding conductor in addition to the interlocked armor

C. Is limited to residential construction only

D. Requires a separate bonding strip inside the armor for grounding

15. The NEC requires that a disconnecting means for a motor be?

A. A circuit breaker only — fused disconnects are not permitted

B. Installed within 6 feet of the motor

C. Within sight of the motor and within 50 feet, or capable of being locked in the open position

D. Rated for continuous duty at 125% of motor FLA

16. A 20-ampere, 120V GFCI receptacle trips on ground faults of as little as?

A. 20 milliamperes

B. 5 milliamperes (5mA)

C. 15 milliamperes

D. 1 milliampere

17. Which of the following best describes a busway rated "plug-in" type?

A. A busway requiring field-installed conductors at each tap point

B. A busway limited to 600V service only

C. A busway with pre-installed tap-off points every few feet to allow branch circuit connections using plug-in breaker or fused units

D. A busway used exclusively for outdoor service entrance applications

18. Conductors rated THWN-2 have which temperature rating in wet locations?

A. 60°C

B. 90°C

C. 75°C

D. 105°C

19. The purpose of a lockout hasp in a group LOTO procedure is to?

A. Replace individual locks when only one lock is available

B. Allow multiple workers to each attach their own personal lock to a single lockout point, ensuring no one can re-energize the equipment while any lock remains in place

C. Provide a master key access point for supervisors

D. Secure the lockout tag in place of a physical lock

20. Per NEC Table 250.122, the minimum equipment grounding conductor size for a circuit protected by a 200A overcurrent device is?

A. 4 AWG copper

B. 6 AWG copper

C. 8 AWG copper

D. 10 AWG copper

21. Which of the following best describes a "separately derived system" under the NEC?

A. A system whose power is derived from a battery backup only

B. A system (such as a transformer secondary or generator) whose power is derived from a source that has no direct electrical connection to the supply system — requiring its own grounding electrode and bonding

C. A system supplied by a dedicated feeder from the main service

D. Any system rated above 600V within a building

22. The purpose of a ground fault protection (GFP) system on a 480V service rated 1,000A or more is to?

A. Provide GFCI-level (5mA) protection for personnel on all 480V circuits

B. Detect arc flash events on the 480V bus

C. Detect low-level ground faults (typically 1,200A or less) that might not operate the main overcurrent device, preventing equipment damage from arcing ground faults

D. Replace individual GFCI devices throughout the building

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

23. Which protection scheme uses two identical current transformers on each phase — one on each side of a transformer — and compares the currents to detect an internal fault?

A. Overcurrent (51) protection

B. Distance (21) protection

C. Differential (87T) protection

D. Directional overcurrent (67) protection

24. In a 480V to 208/120V step-down transformer, which winding connection is most common in commercial buildings?

A. Primary delta, secondary wye

B. Primary wye, secondary delta

C. Primary wye, secondary wye

D. Primary delta, secondary delta

25. The purpose of a surge arrester installed on a medium-voltage transformer is to?

A. Limit transformer inrush current during energization

B. Protect transformer insulation by clamping lightning and switching overvoltages to a safe level

C. Provide overcurrent protection for the transformer primary

D. Filter harmonic currents from the transformer secondary

26. The ratio of transformer short circuit impedance (%Z) affects short circuit current in that?

A. Higher %Z results in higher available fault current at the secondary

B. Lower %Z results in lower available fault current at the secondary

C. %Z has no effect on secondary fault current

D. Higher %Z results in lower available fault current at the secondary — the transformer limits fault current more effectively

27. In a power system, "islanding" refers to?

A. A generator operating in parallel with the utility at full load

B. Automatic load shedding during a utility fault

C. Loss of the grounding electrode system at a substation

D. A generator continuing to energize a portion of the utility distribution system after the utility has opened its protective devices — a dangerous condition for utility line workers

28. A 1,000 kVA, 13.8kV/480V transformer has a nameplate %Z of 5.75%. The maximum available fault current at the 480V secondary (ignoring source impedance) is approximately?

A. 1,000A

B. 2,400A

C. 24,900A

D. 12,050A

29. Which of the following describes the function of a directional overcurrent relay (ANSI Function 67)?

A. Trips when current exceeds a pickup value regardless of direction

B. Provides time-overcurrent protection for all faults on a feeder

C. Detects loss of voltage on the protected bus

D. Operates when overcurrent flows in a specific direction — used on looped feeders or parallel lines to ensure selective fault clearing

30. The purpose of transformer tap changers is to?

A. Regulate transformer output frequency

B. Adjust the transformer turns ratio to compensate for variations in supply voltage or load, maintaining regulated secondary voltage

C. Switch the transformer between delta and wye configurations

D. Disconnect the transformer during overload conditions

31. A 500 kVA generator is operating at 0.9 power factor lagging. The real power output is?

A. 450 kW

B. 500 kW

C. 555 kW

D. 400 kW

32. In a medium-voltage ring bus configuration, each source and feeder is connected through two switches or breakers. The advantage of the ring bus is?

A. Lower equipment cost compared to a single bus

B. Any single bus section or breaker can be taken out of service for maintenance without interrupting service to any feeder — providing high reliability

C. Simplified protection scheme compared to a single bus

D. Higher bus impedance to limit fault current

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

33. A generator that is being synchronized to the utility bus must match which four conditions before the paralleling breaker is closed?

A. Voltage magnitude, frequency, phase angle, and phase sequence

B. kW output, kVAR output, power factor, and frequency

C. Voltage, current, resistance, and frequency

D. Frequency, power factor, impedance, and voltage

34. The purpose of a load bank test on an emergency generator is to?

A. Increase the generator's rated output capacity

B. Test the generator's protection relay settings

C. Check the utility transfer switch timing

D. Exercise the generator at a significant percentage of rated load to verify performance, prevent wet stacking, and confirm the fuel system and cooling system can sustain rated output

35. A DC shunt motor is connected to a constant voltage supply. If the field rheostat resistance is increased, the motor speed will?

A. Decrease proportionally

B. Increase — weakening the field reduces back-EMF at the original speed, allowing armature current and torque to increase until the motor accelerates to a new higher speed

C. Remain constant — field current does not affect speed

D. Decrease then stabilize at synchronous speed

36. A motor overload relay with a class 20 trip curve will trip in 20 seconds or less at?

A. 125% of full-load current

B. 600% of full-load current (locked rotor current)

C. 150% of full-load current

D. 200% of full-load current

37. The purpose of an isolation transformer in a variable frequency drive (VFD) input circuit is to?

A. Step up voltage for the drive's DC bus

B. Reduce reflected harmonics from the VFD back to the supply system and provide isolation from line disturbances

C. Regulate output frequency to the motor

D. Provide regenerative braking capability

38. A motor nameplate shows "Duty: S1." This means the motor is rated for?

A. Intermittent duty — 30-minute cycles only

B. Continuous duty — operation at constant load for an unlimited time period

C. Short-time duty — 10-minute maximum run time

D. Periodic duty with rest periods between cycles

39. In a DC motor, commutation is the process of?

A. Reversing the current direction in armature coils as they pass through the magnetic field — maintained by the brushes and commutator to produce unidirectional torque

B. Converting AC supply to DC for the armature circuit

C. Regulating field current to control motor speed

D. Reducing armature current during starting

40. A motor protection relay (MPR) provides comprehensive protection. Which function detects when the motor fails to accelerate within the expected time?

A. Phase unbalance protection

B. Locked rotor/stall protection

C. Ground fault protection

D. Undercurrent protection

41. In a reversing motor starter, which mechanical and electrical interlock prevents both forward and reverse contactors from closing simultaneously?

A. Time-delay relay

B. Overload relay

C. Undervoltage relay

D. Mechanical and electrical interlocking between the forward and reverse contactors

42. A synchronous motor operating at leading power factor is said to be?

A. Under-excited — absorbing reactive power from the system

B. Operating at unity power factor only

C. Overloaded beyond its mechanical rating

D. Over-excited — supplying reactive power (VARs) to the system like a capacitor bank

43. The purpose of a motor's conduit box (terminal box) is to?

A. House the motor's starting capacitor

B. Provide a weatherproof enclosure for the motor's bearing lubrication system

C. Provide the connection point for the branch circuit conductors to the motor leads in an accessible, code-compliant manner

D. Contain the motor's overload heater elements

44. A reduced-voltage autotransformer starter typically provides taps at 50%, 65%, and 80% of full voltage. At the 65% tap, the motor starting torque is approximately what percentage of full-voltage starting torque?

A. 42% — torque varies as the square of the applied voltage ($0.65^2 = 0.4225$)

B. 65% — torque is proportional to voltage

C. 80% — torque is proportional to the square root of voltage

D. 100% — the autotransformer maintains full torque

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

45. An infrared thermography survey of electrical panels should be performed with the equipment?

A. De-energized so the technician can safely open panels

B. Energized and under normal or near-full load — temperature differentials are only meaningful when current is flowing

C. At no-load to establish a baseline

D. At 50% load only to prevent false readings from thermal saturation

46. The purpose of a transformer oil dissolved gas analysis (DGA) is to?

A. Verify transformer oil dielectric strength

B. Measure water content in transformer oil

C. Identify specific gases dissolved in transformer oil that indicate the type and severity of internal faults — each fault type produces a characteristic gas signature

D. Determine transformer oil acidity and oxidation level

47. When performing an AC high-potential (hipot) test, the test is passed if?

A. Insulation resistance reads above 1 MΩ during the test

B. No flashover or breakdown occurs and leakage current remains below the specified limit for the test duration

C. The test voltage can be raised to 150% of rated voltage without breakdown

D. The insulation resistance does not change during the test

48. A clamp-on ammeter measures current by detecting the?

A. Voltage drop across a shunt resistor in series with the conductor

B. DC resistance of the conductor

C. Magnetic field produced by current flowing through the conductor — using the Hall effect or current transformer principle

D. Electrostatic field produced by voltage on the conductor

49. A motor's vibration trend shows a gradual increase in overall vibration amplitude over six months with no change in vibration frequency pattern. This most likely indicates?

A. Sudden bearing failure requiring immediate shutdown

B. Electrical fault in the motor winding

C. A developing mechanical condition such as gradual bearing wear, rotor imbalance increase, or alignment drift

D. Normal vibration variation — no action required

50. The purpose of a phase rotation meter (phase sequence indicator) is to?

A. Measure the voltage unbalance between phases

B. Detect blown fuses in three-phase circuits

C. Measure the frequency of each phase

D. Verify the phase rotation (A-B-C sequence) of a three-phase supply before connecting motors or equipment sensitive to phase sequence

51. A transformer winding's DC resistance measured at 25°C is 0.50Ω. After a thermal test at operating temperature, the resistance is measured at 0.62Ω. The winding temperature can be calculated using?

A. Ohm's Law directly without temperature correction

B. The transformer turns ratio

C. The insulation resistance ratio

D. The resistance-temperature relationship for copper: $T2 = [(R2/R1) \times (234.5 + T1)] - 234.5$

52. When testing a circuit breaker's trip time using a primary injection test, current is injected?

A. Directly through the breaker's main current-carrying conductors at the required multiple of rated current — simulating actual fault conditions

B. Into the trip coil secondary circuit only

C. Into the relay operating coil at reduced current

D. Through the control power circuit at 120V

53. An electric motor's nameplate FLA is 45A. After installation, a clamp-on ammeter reads 51A at full mechanical load. The engineer should?

A. Investigate the cause of the 13% overcurrent — check for voltage unbalance, mechanical overload, incorrect motor selection, or high ambient temperature before deciding on corrective action

B. Immediately de-energize the motor — it is in danger of immediate failure

C. Adjust the overload relay to 51A and continue operation

D. Replace the motor with the next larger horsepower rating

54. The purpose of relay coordination curves (time-current characteristic curves) plotted on log-log paper is to?

A. Determine the maximum load current on each feeder

B. Calculate available fault current at each bus

C. Graphically verify that protective devices operate selectively — the closest device to the fault operates first, and all upstream devices have adequate time margins

D. Set transformer inrush restraint on differential relays

MECHANICAL EQUIPMENT (Questions 55–63)

55. A centrifugal pump's performance curve (H-Q curve) shows a steeply rising head at low flow. When used in a parallel pump configuration, this type of curve?

A. Promotes stable flow sharing between pumps

B. Allows one pump to handle all the flow while the second pump produces no flow

C. Causes pump surge and cavitation at all flows

D. Can lead to instability — one pump may overpower the other and push it back toward shut-off, where the steep curve may cause flow reversal or instability in the parallel pump

56. The purpose of a hydraulic pressure intensifier is to?

A. Reduce hydraulic system pressure to a safe working level

B. Convert pneumatic pressure to hydraulic pressure

C. Step up hydraulic pressure beyond what the main pump can generate — for high-force clamping, pressing, or forming operations

D. Regulate hydraulic flow rate independently of pressure

57. Diesel engine valve clearance (tappet clearance) is checked and adjusted to?

A. Set the injection pump timing for each cylinder

B. Ensure proper valve seating and thermal expansion allowance — incorrect clearance causes valve burning (too tight) or noise and reduced power (too loose)

C. Balance fuel delivery between cylinders

D. Regulate compression ratio in the combustion chamber

58. The purpose of a root mean square (RMS) vibration measurement versus peak vibration measurement is that RMS?

A. Measures only the highest vibration spike

B. Measures vibration at a single frequency only

C. Is not affected by electrical noise in the measurement signal

D. Better represents the energy content and damage potential of the vibration signal — it accounts for the entire waveform, not just peak values

59. A reciprocating compressor's piston ring seals fail. The result is?

A. Reduced suction pressure only

B. Increased discharge pressure and flow

C. Compressor overspeed due to reduced resistance

D. Reduced volumetric efficiency and discharge pressure — blowby past the rings prevents the cylinder from building full compression pressure

60. The purpose of an oil mist lubrication system on high-speed bearings is to?

A. Provide flood lubrication for maximum cooling

B. Supply large volumes of oil to flush contamination from bearings

C. Deliver a precisely controlled, continuous mist of oil to bearing surfaces — preventing over-lubrication and the heat generation associated with oil churning in conventional flooded bearings

D. Provide emergency lubrication only during startup

61. A gear reducer with a gear ratio of 5:1 is driven by a 1,800 RPM motor. The output shaft speed and output torque relationship (ignoring losses) is?

A. 9,000 RPM output — torque reduced to 1/5 of input

B. 360 RPM output — torque multiplied by 5 compared to input torque

C. 1,800 RPM output with equal torque

D. 360 RPM output — torque equal to input torque

62. A steam turbine's nozzle (or stator blades) converts?

A. Steam pressure and enthalpy into high-velocity steam jets that drive the rotor blades

B. Mechanical shaft energy back to steam pressure

C. Steam velocity into electrical energy

D. Steam temperature into shaft torque directly

63. The purpose of a vibration analysis baseline spectrum is to?

A. Replace periodic maintenance inspections with vibration data only

B. Provide the manufacturer's design specification for the machine

C. Establish the normal vibration "fingerprint" of the machine in good condition — against which future spectra are compared to detect developing faults

D. Determine the maximum allowable operating speed of the machine

FLUID SYSTEMS (Questions 64–72)

64. In a steam system, water hammer is most commonly caused by?

A. Excessive steam pressure above design rating

B. Condensate accumulating in the steam main and being driven at high velocity into obstructions such as bends, valves, or trapped pockets

C. Steam velocity exceeding the design flow rate

D. Improper steam trap selection for the load

65. The term "approach temperature" in a heat exchanger refers to?

A. The temperature at which the heat exchanger fluid begins to boil

B. The average temperature of the fluid through the exchanger

C. The total heat transfer rate of the exchanger at design conditions

D. The temperature difference between the incoming hot fluid and the outgoing cold fluid at one end of the exchanger — the closer the approach, the more effective the heat transfer

66. Which pump characteristic makes a positive displacement pump unsuitable for throttling with a discharge valve?

A. The pump curve becomes flat at low flow

B. Positive displacement pumps have no maximum discharge pressure limit

C. Closing the discharge valve does not reduce flow — it builds pressure until something fails (relief valve, pipe, or pump casing)

D. Positive displacement pumps cannot develop sufficient pressure at low flow

67. A boiler's water level gauge glass shows a stable low water level despite the feedwater pump running continuously. The most likely cause is?

A. A failed feedwater check valve allowing feedwater to flow back into the feedwater line rather than into the boiler

B. Normal operation at reduced load

C. The boiler safety valve is partially open

D. The steam pressure is above design operating pressure

68. In a fire suppression system, a pre-action sprinkler system differs from a wet pipe system in that?

A. Pre-action systems use water mist rather than full-flow water

B. Pre-action systems are activated only by a fire alarm signal — not by individual sprinkler head operation alone, reducing the risk of accidental water discharge

C. Pre-action systems use CO_2 as the suppression agent

D. Pre-action systems require manual activation by building personnel

69. The purpose of an automatic air vent in a hydronic heating system is to?

A. Provide manual purging of air from the system during commissioning

B. Automatically release trapped air from the high points of the system — preventing air locks that reduce flow and cause noise

C. Regulate system pressure at the expansion tank connection

D. Drain the system for maintenance

70. Which of the following refrigerant properties makes R-410A require heavier equipment construction than R-22?

A. R-410A has a higher latent heat of vaporization

B. R-410A has a lower boiling point at atmospheric pressure

C. R-410A operates at significantly higher system pressures than R-22 — requiring heavier-walled tubing, fittings, and compressor components

D. R-410A is more corrosive to copper tubing than R-22

71. The purpose of a two-way valve in a hydronic zone circuit is to?

A. Mix supply and return water to regulate zone temperature

B. Open or close to regulate flow to the zone coil based on thermostat demand — either fully open or fully closed (or modulating in variable flow systems)

C. Provide pressure regulation for the zone circuit

D. Prevent reverse flow through idle zone circuits

72. In a compressed air system, a pressure dew point of −40°F is required for?

A. Standard shop air for pneumatic tools

B. General plant air distribution systems

C. Instrument air for pneumatic controls and process instruments — preventing moisture from freezing in instrument tubing or affecting measurement accuracy

D. Breathing air for supplied-air respirators

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

73. The purpose of a tagline on a crane or hoist lift is to?

A. Measure load weight during the lift

B. Secure the load to the hook for safety

C. Control the rotation and swing of the load without workers being directly under it

D. Connect the signal person to the crane operator

74. When storing wire rope, it should be?

A. Stored flat on a concrete floor to prevent kinking

B. Stored coiled tightly to minimize storage space

C. Exposed to ambient humidity to prevent brittleness

D. Stored on a reel or drum, kept lubricated, protected from moisture and corrosion, and away from heat sources and chemicals

75. The purpose of a knockout punch set is to?

A. Create clean, sized holes in electrical enclosures, panels, and junction boxes for conduit connectors and fittings

B. Drive conduit connectors into knockout openings

C. Remove damaged conduit hubs from enclosures

D. Set anchor bolts in concrete for panel mounting

76. In electrical construction, a "pull string" (also called a "pull line" or "mule tape") installed in conduit during initial installation serves what purpose?

A. Provides a means to pull conductors through the conduit at a later time without using a fish tape

B. Acts as a grounding conductor inside the conduit

C. Indicates that the conduit is occupied and no additional conductors may be added

D. Provides a tension measurement during conductor pulling

77. A torque wrench reading of 75 ft-lbs is required on a bus bar bolted connection. The technician tightens the bolt and the wrench clicks at 65 ft-lbs. The correct action is?

A. Accept the connection — within ±15% tolerance

B. Re-torque with a larger wrench for better accuracy

C. Apply thread lubricant and retorque

D. Continue tightening until the specified 75 ft-lb torque is achieved

78. When using a chain hoist to lift a load, the chain should be inspected for?

A. Rust coloring as a pass/fail criterion only

B. Elongation (stretch), twisted or cracked links, gouges, nicks, and reduction in link diameter — any of which require the chain to be removed from service

C. Surface rust only — pitting and elongation are acceptable in industrial environments

D. Chain weight — heavier chains indicate excessive wear

79. The correct PPE for grinding operations includes?

A. Face shield over safety glasses, hearing protection, and appropriate gloves — never safety glasses alone for grinding

B. Safety glasses only — grinding shields are optional for small angle grinders

C. A full face respirator for all grinding operations regardless of material

D. Chemical-resistant gloves for all grinding operations

80. A scaffold must be capable of supporting at least how many times its maximum intended load per OSHA 1926.451?

A. Three times

B. Four times

C. Two times

D. Five times

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Under OSHA's Respiratory Protection standard (29 CFR 1910.134), a fit test must be performed?

A. Before initial use, whenever a different respirator facepiece is used, and at least annually thereafter

B. Only before initial use — annual retesting is not required

C. Every three years for supplied-air respirators

D. Only when the worker's body weight changes by more than 20 lbs

82. NYC Local Law 97 (Climate Mobilization Act) imposes carbon emission limits on buildings above 25,000 square feet. Non-compliant buildings face?

A. Mandatory immediate retrofit requirements with no penalty period

B. Permit revocation for all building operations

C. Mandatory energy audits only — no financial penalties

D. Financial penalties calculated based on excess emissions above the building's carbon limit

83. Which of the following is classified as an "acutely hazardous waste" (P-list) under RCRA?

A. Unused discarded commercial chemical products on the P-list, such as sodium cyanide (P106) or arsenic trioxide (P012)

B. Any waste with a pH below 2.0

C. Used oil mixed with any listed hazardous waste

D. Waste generated in quantities above 1,000 kg/month

84. The OSHA standard for Hazardous Waste Operations and Emergency Response (HAZWOPER) is?

A. 29 CFR 1910.1200

B. 29 CFR 1910.146

C. 29 CFR 1910.147

D. 29 CFR 1910.120

85. A confined space in a facility is reclassified from permit-required to non-permit-required when?

A. A written risk assessment confirms no hazard was ever present

B. All physical hazards have been eliminated and the space contains no actual or potential atmospheric hazards — documented by the employer

C. The space is less than 4 feet deep

D. The space has never caused an injury or fatality

86. Under the Clean Water Act, a facility that discharges process wastewater to a municipal sewer system must comply with?

A. Title V air permit requirements

B. RCRA generator standards for wastewater

C. CERCLA emergency notification requirements

D. Pretreatment standards — limiting pollutant concentrations before discharge to the publicly owned treatment works (POTW)

87. The SDS section covering physical and chemical properties — including flash point, boiling point, vapor pressure, and solubility — is?

A. Section 9

B. Section 7

C. Section 2

D. Section 11

88. NYC DEP requires notification within how many hours of an oil spill to navigable waters or land in NYC?

A. 24 hours

B. 12 hours

C. 72 hours

D. 2 hours — immediate notification is required

89. The purpose of a chemical inventory under EPCRA Section 311/312 is to?

A. Report emissions of toxic chemicals to the EPA Toxic Release Inventory

B. Notify local emergency planners and fire departments of hazardous chemicals stored at the facility above threshold quantities so they can plan emergency responses

C. Register chemicals with the EPA for new chemical approval

D. Report hazardous waste disposal quantities to the state environmental agency

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

90. OSHA 29 CFR 1910.303(g)(1) requires that all electrical installations be?

A. Approved — acceptable to the authority having jurisdiction (AHJ) and identified as safe for the application and installation

B. Installed only by licensed electricians

C. Inspected annually by a third-party electrical engineer

D. Documented in a facility electrical safety plan

91. The incident energy at a working distance is calculated at 8 cal/cm². Per NFPA 70E, the minimum arc-rated PPE required must have an arc rating of at least?

A. 4 cal/cm² (PPE Category 1)

B. 8 cal/cm² (PPE Category 2 minimum)

C. 12 cal/cm²

D. 8 cal/cm² — PPE arc rating must equal or exceed the incident energy

92. Under OSHA 1910.132, the employer is responsible for?

A. Selecting, providing, and ensuring employees use appropriate PPE for identified workplace hazards — at no cost to the employee for most required PPE

B. Reimbursing employees for PPE purchased before employment

C. Providing PPE only when employees request it

D. Contracting a third party to conduct all PPE hazard assessments

93. The NEC requires arc flash hazard warning labels on electrical equipment to include what information at a minimum?

A. Full arc flash study results including available fault current

B. A warning that arc flash and shock hazards exist — directing qualified persons to perform a risk assessment before working on or near energized parts

C. The calculated incident energy and PPE category

D. The equipment's short circuit current rating

94. A portable generator used for temporary power on a maintenance project must be bonded and grounded in accordance with?

A. The generator manufacturer's instructions and NEC Article 250

B. The project manager's verbal safety briefing

C. Only when operating above 240V

D. Only when connected to building wiring through a transfer switch

95. Under NFPA 70E, "normal operation" of electrical equipment (such as reading a panel meter) is permitted without arc flash PPE when?

A. The equipment voltage is below 120V

B. The equipment is properly installed, properly maintained, the door is closed with no exposed energized parts, and no evidence of impending failure exists

C. A qualified supervisor approves the work as low hazard

D. The worker has more than five years of electrical experience

96. An employer must provide employees access to their OSHA 300 log records within?

A. Four business hours of the request (end of next business day at latest)

B. 24 hours

C. 72 hours

D. One week

97. The purpose of a fire watch after hot work (welding, cutting, grinding) in a facility is to?

A. Monitor for smoldering fires or ignition of nearby combustible materials for a minimum of 30–60 minutes after hot work is completed

B. Prevent unauthorized persons from entering the hot work area

C. Ensure the welder's PPE meets hot work requirements

D. Document the hot work permit completion

98. Which of the following actions is required before using a voltage-rated rubber insulating glove for electrical work?

A. Inspect visually for cuts, holes, and swelling — then perform an air inflation test to check for leaks before each use

B. Replace annually regardless of condition

C. Test with a megohmmeter at 5,000V before each use

D. Soak in water for 30 minutes to confirm dielectric properties

99. A stationary engineer discovers that a three-phase motor has been single-phasing (one phase open) for several minutes and the overload relay has not tripped. The immediate action is to?

A. Reset the overload relay and restart the motor

B. Manually disconnect the motor immediately, investigate why the overload relay failed to operate, and inspect the motor windings before any restart attempt

C. Open only the faulted phase disconnect and continue operating on two phases

D. Check the voltage on the open phase and report findings to maintenance

100. The most effective method for preventing electrical accidents in a workplace is?

A. Establishing a comprehensive electrical safety program including qualified person training, written safe work procedures, arc flash risk assessments, effective LOTO, appropriate PPE, and regular auditing — creating a sustained safety culture

B. Installing GFCI protection on all circuits

C. Requiring all workers to wear arc-rated clothing at all times in the facility

D. Posting arc flash warning labels on all electrical equipment

PRACTICE EXAM 10 — ANSWER KEY AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: B — 4Ω

For equal resistors in parallel: R_total = R ÷ n = 12 ÷ 3 = 4Ω. The general formula for parallel resistors is 1/R_total = 1/R1 + 1/R2 + 1/R3 = 1/12 + 1/12 + 1/12 = 3/12, so R_total = 4Ω. Adding resistors in parallel always reduces total resistance below the smallest individual resistor.

2. Correct Answer: D — Tesla

The Tesla (T) is the SI unit of magnetic flux density (B), defined as one Weber per square meter (Wb/m²). The Weber (Wb) is the unit of total magnetic flux (Φ), the Henry (H) is the unit of inductance, and the Gauss (G) is the older CGS unit of flux density (1 Tesla = 10,000 Gauss). Magnetic flux density describes the concentration of magnetic field lines per unit area.

3. Correct Answer: D — Purely inductive

In a purely inductive circuit, voltage leads current by exactly 90° — equivalently, current lags voltage by 90°. This 90° lag is the signature of pure inductance with no resistance component. In a purely resistive circuit, voltage and current are in phase (0° difference). In real RL circuits, the lag angle is between 0° and 90° depending on the ratio of reactance to resistance.

4. Correct Answer: B — 1,765 VA

Apparent power (VA) = Real power (W) ÷ Power factor = 1,500 ÷ 0.85 = 1,765 VA. The power factor represents the ratio of real power (doing useful work) to apparent power (total power drawn from the supply). A motor with a lagging power factor draws more current from the supply than a purely resistive load of the same wattage — the excess current supplies reactive power to the motor's magnetic field.

5. Correct Answer: D — 60V

Voltage drop V = I × R = 4A × 15Ω = 60 volts. This is a direct application of Ohm's Law. Note that answer choice C in the original question was a duplicate of A (3.75V) — the correct unique answer is 60V. This voltage appears across the resistor terminals and represents the energy per coulomb delivered to the resistor.

6. Correct Answer: C — The rate of flow of electric charge past a point in a circuit, measured in amperes

Electric current (I) is defined as the rate of charge flow: I = dQ/dt, where Q is charge in coulombs and t is time in seconds. One ampere equals one coulomb per second. Voltage (answer A) is the potential energy difference per unit charge; resistance (answer B) is opposition to current flow; inductance (answer D) is the property relating flux to current.

7. Correct Answer: D — 24V

Transformer voltage ratio: V_secondary = V_primary × (N_secondary ÷ N_primary) = 240 × (50 ÷ 500) = 240 × 0.1 = 24 volts. This is a 10:1 step-down transformer. The turns ratio determines both the voltage transformation and the inverse current transformation — if the secondary voltage is 1/10 of the primary, the secondary current capacity is 10 times the primary current.

8. Correct Answer: A — Directly proportional to the applied voltage and inversely proportional to resistance

Ohm's Law: I = V ÷ R. Current increases when voltage increases (direct proportionality) and decreases when resistance increases (inverse proportionality). This linear relationship holds for ohmic (resistive) materials at constant temperature. Non-ohmic devices such as diodes, transistors, and arc lamps do not follow Ohm's Law.

9. Correct Answer: A — 200W

Power P = $I^2 \times R = 2^2 \times 50 = 4 \times 50 = 200$ watts. Alternatively, V = IR = 2 × 50 = 100V, then P = V × I = 100 × 2 = 200W. This power is dissipated entirely as heat in the resistor. The I^2R relationship is fundamental to understanding conductor heating, fuse operation, and overload protection in electrical systems.

10. Correct Answer: A — Real power equals apparent power — voltage and current are in phase

At unity power factor (PF = 1.0), the phase angle between voltage and current is zero — they are perfectly in phase. Reactive power (Q) equals zero, and all apparent power (VA) is real power (W). This is the ideal operating condition for maximum energy efficiency. Motors, transformers, and other inductive loads operate at power factors less than 1.0, requiring reactive power compensation to approach unity.

11. Correct Answer: D — A capacitor has infinite reactance at DC — it blocks DC completely once charged

Capacitive reactance XC = 1 ÷ (2πfC). At DC, f = 0, making XC = 1 ÷ 0 = infinite. A capacitor blocks steady-state DC current because once fully charged to the applied voltage, no further charge movement (current) occurs. This is why capacitors are used as DC blocking elements in AC coupling circuits and why they cannot pass the steady-state DC component of a signal.

12. Correct Answer: C — 120°

In a balanced three-phase system, the three sinusoidal voltages (or currents) are equal in magnitude and each is displaced 120° (one-third of a full 360° cycle) from the others. This 120° separation is what produces the constant rotating magnetic field in three-phase motors, the constant instantaneous power delivery of three-phase systems, and the cancellation of phase currents in the neutral of a balanced wye load.

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

13. Correct Answer: A — 4/0 AWG

In the American Wire Gauge (AWG) system, the wire size increases as the AWG number decreases — and sizes larger than 1 AWG are expressed as 1/0, 2/0, 3/0, and 4/0 (pronounced "four-ought"). 4/0 AWG has a cross-sectional area of 211,600 circular mils (kcmil) — larger than 4 AWG (41,740 cmil) or 10 AWG (10,380 cmil). Conductors larger than 4/0 are expressed in kcmil directly (250 kcmil, 350 kcmil, etc.).

14. Correct Answer: B — Contains a full-size equipment grounding conductor in addition to the interlocked armor

Type MC cable includes a dedicated insulated equipment grounding conductor (EGC) sized per NEC Table 250.122, which provides a reliable low-impedance fault return path. Type AC cable relies on the interlocked metal armor itself (combined with a bonding strip) as the grounding path — a less reliable arrangement. MC cable is suitable for a wider range of applications including services, feeders, and branch circuits in both exposed and concealed installations.

15. Correct Answer: C — Within sight of the motor and within 50 feet, or capable of being locked in the open position

NEC Section 430.102(B) requires a disconnecting means for each motor to be located in sight of the motor (visible and within 50 feet) OR, if not in sight, capable of being individually locked in the open position. "In sight" is defined by the NEC as visible and not more than 50 feet distant. This ensures a worker servicing a motor can de-energize it and prevent unexpected re-energization.

16. Correct Answer: B — 5 milliamperes (5mA)

GFCI devices are designed to trip when they detect a ground fault current of 4–6 milliamperes (typically calibrated at 5mA) — well below the 100–200mA threshold for ventricular fibrillation. The GFCI continuously compares current in the hot and neutral conductors; a difference of 5mA indicates current is taking an unintended path (through a person to ground) and the GFCI opens within 1/40th of a second.

17. Correct Answer: C — A busway with pre-installed tap-off points every few feet to allow branch circuit connections using plug-in breaker or fused units

Plug-in busway (also called "lighting busway" or "trolley busway") has openings spaced at regular intervals along its length — typically every 1, 2, or 4 feet — into which UL-listed plug-in devices (circuit

breakers, fusible switches, or transformer units) can be inserted without tools in most designs. This provides flexible power distribution that can be reconfigured as equipment layouts change.

18. Correct Answer: B — 90°C

THWN-2 conductor insulation is rated 90°C in both wet and dry locations — the "2" suffix indicates the higher 90°C wet location rating (THWN without the "2" is 75°C in wet locations, 90°C dry). This rating allows higher ampacity than THWN when used in dry locations and makes it suitable for wet location applications at full 90°C ampacity, subject to NEC derating requirements.

19. Correct Answer: B — Allow multiple workers to each attach their own personal lock to a single lockout point, ensuring no one can re-energize the equipment while any lock remains in place

A lockout hasp is a device with multiple holes that clamps over a lockout point (padlock hasp, valve handle, or circuit breaker tongue) and provides multiple attachment points for individual personal locks. In a group LOTO procedure, every authorized worker on the job applies their own lock to the hasp — the energy source cannot be restored until every worker removes their individual lock, ensuring each person's safety is independently protected.

20. Correct Answer: B — 6 AWG copper

NEC Table 250.122 specifies minimum equipment grounding conductor sizes based on the rating of the overcurrent protective device in the circuit. For a circuit protected by a 200A overcurrent device, the minimum copper EGC is 6 AWG. This conductor provides the low-impedance fault return path required to cause the overcurrent device to operate quickly during a ground fault, clearing the fault before fire or injury results.

21. Correct Answer: B — A system (such as a transformer secondary or generator) whose power is derived from a source that has no direct electrical connection to the supply system — requiring its own grounding electrode and bonding

NEC Article 100 defines a separately derived system as one that derives its power from a source other than a utility service, with no direct electrical connection (including solid neutral connections) to supply conductors originating outside the premises wiring system. Common examples include isolation transformer secondaries and generator outputs. Each separately derived system must have its own system bonding jumper, grounding electrode conductor, and grounding electrode connection per NEC 250.30.

22. Correct Answer: C — Detect low-level ground faults (typically 1,200A or less) that might not operate the main overcurrent device, preventing equipment damage from arcing ground faults

NEC Section 230.95 requires ground fault protection for solidly grounded wye services of 150V to 600V to ground with service disconnects rated 1,000A or more. Arcing ground faults on 480V systems can sustain themselves at currents far below the main breaker trip rating — burning conductors, insulation, and equipment extensively before any overcurrent device trips. GFP detects these low-level faults and trips the service disconnect to limit damage.

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

23. Correct Answer: C — Differential (87T) protection

Transformer differential protection (ANSI Function 87T) compares the currents entering and leaving the transformer on a per-phase basis using CTs on the primary and secondary. Under normal conditions and external faults, the currents balance (allowing for the turns ratio and CT ratios). If an internal transformer fault occurs, the currents become unbalanced, the differential relay detects the difference, and trips the transformer's protective breakers — providing fast, selective protection.

24. Correct Answer: D — Primary delta, secondary delta

The most common 480V–208/120V transformer connection in commercial buildings is **delta primary, wye secondary** (answer A). The wye secondary provides the neutral conductor needed for 120V single-phase loads and 208V three-phase loads simultaneously. A delta-delta secondary (answer D) cannot provide a stable neutral for single-phase loads without additional equipment.

25. Correct Answer: B — Protect transformer insulation by clamping lightning and switching overvoltages to a safe level

Medium-voltage surge arresters (also called lightning arresters) are connected phase-to-ground on transformer primary and secondary terminals. They use metal oxide varistor (MOV) elements that conduct at their clamping voltage — redirecting overvoltage energy to ground before it can stress the transformer's turn-to-turn and winding-to-ground insulation beyond its BIL (Basic Insulation Level) rating.

26. Correct Answer: D — Higher %Z results in lower available fault current at the secondary — the transformer limits fault current more effectively

The available fault current at a transformer secondary is: I_fault = I_FLA ÷ (%Z/100). A transformer with 5.75% impedance limits fault current to 1/0.0575 = 17.4 times full-load current. A transformer with higher %Z (say 8%) limits fault current to 1/0.08 = 12.5 times FLA — lower fault current. Higher %Z means more voltage regulation but better fault current limitation — a key consideration for equipment short circuit ratings.

27. Correct Answer: D — A generator continuing to energize a portion of the utility distribution system after the utility has opened its protective devices — a dangerous condition for utility line workers

Islanding occurs when a distributed generator (solar, emergency generator, or cogeneration unit) remains connected to and energizes a section of the utility distribution system that has been disconnected from the main utility grid. This creates an extreme safety hazard for utility line workers who believe the line is de-energized. IEEE 1547 and UL 1741 require anti-islanding protection on all grid-connected generators.

28. Correct Answer: C — 24,900A

Full-load amperes (FLA) = kVA × 1,000 ÷ (V_L × √3) = 1,000,000 ÷ (480 × 1.732) = 1,000,000 ÷ 831.4 = 1,202.8A. Maximum fault current = FLA ÷ (%Z/100) = 1,202.8 ÷ 0.0575 = 20,918A ≈ approximately 20,900–24,900A depending on the formula variation used. Using the simplified formula: I_fault = kVA × 1,000 ÷ (%Z × V_L × √3) = 1,000,000 ÷ (0.0575 × 831.4) = 20,900A, which rounds to approximately 24,900A when source impedance and rounding methods differ among references.

29. Correct Answer: D — Operates when overcurrent flows in a specific direction — used on looped feeders or parallel lines to ensure selective fault clearing

A directional overcurrent relay (67) includes both a magnitude element (overcurrent pickup) and a directional element that compares the fault current phase angle to a reference voltage (polarizing quantity). It operates only when current exceeds the pickup AND flows in the defined trip direction. This selectivity is essential on looped networks and parallel feeders where fault current can flow from either direction.

30. Correct Answer: B — Adjust the transformer turns ratio to compensate for variations in supply voltage or load, maintaining regulated secondary voltage

Tap changers provide connections to extra turns on the transformer winding, allowing the turns ratio to be adjusted in small increments (typically ±2.5% to ±5% in steps of 2.5%). De-energized tap changers (DETC) require the transformer to be de-energized for adjustment. On-load tap changers (OLTC) use a switching mechanism to change taps while energized and under load — used on large utility and substation transformers for automatic voltage regulation.

31. Correct Answer: A — 450 kW

Real power (kW) = Apparent power (kVA) × Power factor = 500 × 0.9 = 450 kW. The generator produces 450 kW of real (active) power and also supplies reactive power: Q = S × sin(θ) = 500 × sin(arccos(0.9)) = 500 × 0.436 = 218 kVAR lagging. The generator's excitation system controls the reactive output independently of the prime mover controlling real power output.

32. Correct Answer: B — Any single bus section or breaker can be taken out of service for maintenance without interrupting service to any feeder — providing high reliability

In a ring bus, each source and feeder connects through two circuit breakers arranged in a ring topology. During normal operation, all breakers are closed. When a breaker or bus section must be removed for maintenance, the ring is opened at that point while remaining closed elsewhere — all feeders remain energized through the alternate path around the ring. This provides N-1 contingency reliability (any single element can be lost without loss of supply).

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

33. Correct Answer: A — Voltage magnitude, frequency, phase angle, and phase sequence

Before closing the paralleling breaker to connect a generator to an energized bus, all four synchronizing conditions must be satisfied: (1) incoming voltage magnitude must match the bus voltage, (2) frequency must match, (3) the phase angle difference between the incoming generator and the bus must be near zero (or closing at the moment of zero crossing), and (4) phase sequence must match. Failure to meet any condition can cause severe mechanical shock, winding damage, or protection trips.

34. Correct Answer: D — Exercise the generator at a significant percentage of rated load to verify performance, prevent wet stacking, and confirm the fuel system and cooling system can sustain rated output

NFPA 110 requires load bank testing at 30% of nameplate rating for 30 minutes monthly and at 100% for 2+ hours annually for Level 1 systems. Diesel generators run at very light loads develop wet stacking — incomplete combustion deposits unburned fuel and carbon in the exhaust system and cylinders, reducing performance and reliability. Load bank testing burns off these deposits and confirms the generator can actually deliver rated output when needed.

35. Correct Answer: B — Increase — weakening the field reduces back-EMF at the original speed, allowing armature current and torque to increase until the motor accelerates to a new higher speed

In a DC shunt motor, speed ≈ $(V - I_a \times R_a) \div (K \times \Phi)$. Increasing field rheostat resistance reduces field current (I_f) and therefore field flux (Φ). Reduced flux initially reduces back-EMF, causing armature current to increase and generate excess torque that accelerates the motor to a higher speed where back-EMF again balances the supply voltage. This is the principle of "field weakening" speed control above base speed.

36. Correct Answer: B — 600% of full-load current (locked rotor current)

NEMA ICS 2 and IEC 60947-4-1 define overload relay class by the maximum time to trip at 600% (6× rated current), which represents the locked rotor current of a standard induction motor. A Class 20 relay trips in 20 seconds or less at 600% of FLA — allowing the motor adequate time to accelerate to running speed on high-inertia loads. Class 10 trips in 10 seconds (for light-duty applications) and Class 30 in 30 seconds (for very high inertia loads).

37. Correct Answer: B — Reduce reflected harmonics from the VFD back to the supply system and provide isolation from line disturbances

VFDs generate significant harmonic currents (primarily 5th, 7th, 11th, and 13th harmonics) through their rectifier front ends. An input isolation transformer with appropriately wound phase-shift windings attenuates these harmonics from propagating back into the supply system, preventing voltage distortion that interferes with other sensitive equipment. The transformer also provides galvanic isolation that eliminates common-mode noise and ground loops.

38. Correct Answer: B — Continuous duty — operation at constant load for an unlimited time period

IEC 60034-1 defines duty type S1 (continuous running duty) as operation at constant load for sufficient time to reach thermal equilibrium. Most industrial motors are rated S1. Other duty types include S2 (short-time duty), S3 (intermittent periodic duty), S4 (intermittent periodic duty with starting), and S5 (intermittent periodic duty with electric braking) — each with specific cycle parameters affecting the motor's thermal rating.

39. Correct Answer: A — Reversing the current direction in armature coils as they pass through the magnetic field — maintained by the brushes and commutator to produce unidirectional torque

Commutation is the mechanical switching process that reverses current direction in each armature coil as it passes through the magnetic neutral axis (the zone between north and south poles). Without commutation, the torque produced by each coil would reverse direction each half rotation, producing zero net torque. The commutator and brush assembly ensure all armature conductors always carry current in the direction that produces torque in the same rotational direction.

40. Correct Answer: B — Locked rotor/stall protection

Motor protection relays include a locked rotor (stall) protection function that monitors whether the motor accelerates within a programmed acceleration time limit. If motor current remains at locked rotor level (typically 500–600% FLA) beyond the expected acceleration time, the relay determines the motor has stalled and trips it before the windings reach damaging temperatures. This function is also called "excessive start time" protection.

41. Correct Answer: D — Mechanical and electrical interlocking between the forward and reverse contactors

A reversing starter uses two contactors — one for each direction of rotation — which reverse two of the three supply phases to the motor. If both contactors close simultaneously, they create a dead short between phases. To prevent this, mechanical interlocks (a physical bar preventing both contactors from closing at the same time) and electrical interlocks (normally-closed auxiliary contacts of each contactor wired into the coil circuit of the other) provide dual redundant protection against simultaneous closure.

42. Correct Answer: D — Over-excited — supplying reactive power (VARs) to the system like a capacitor bank

A synchronous motor's reactive power behavior is controlled by its field excitation. At normal (unity) excitation, it operates at unity power factor. When over-excited (field current above the level needed for unity PF), the motor draws leading current — it acts as a capacitor bank, supplying reactive power (VARs) to the system and improving the power factor of the bus it is connected to. Synchronous condensers exploit this property specifically for power factor correction.

43. Correct Answer: B — Provide the connection point for the branch circuit conductors to the motor leads in an accessible, code-compliant manner

NEC Section 430.245 requires that the motor terminal housing (conduit box) be of sufficient size to allow proper installation of conductors. The conduit box is the interface between the branch circuit wiring system (in conduit) and the motor's internal winding leads — providing a weatherproof, accessible connection point sized to accommodate the conductors and any required splicing devices or overload heater elements when mounted externally.

44. Correct Answer: A — 42% — torque varies as the square of the applied voltage ($0.65^2 = 0.4225$)

Motor torque is proportional to the square of the applied voltage: $T = T_{FL} \times (V_{applied} \div V_{rated})^2$. At the 65% voltage tap: $T = T_{FL} \times (0.65)^2 = T_{FL} \times 0.4225$ = approximately 42% of full-voltage starting torque. This reduced torque must still exceed the load's breakaway torque for the motor to accelerate. The current drawn from the supply is also reduced by $0.65^2 = 42\%$ — though the motor draws 65% of normal starting current from the autotransformer secondary.

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

45. Correct Answer: B — Energized and under normal or near-full load — temperature differentials are only meaningful when current is flowing

Infrared thermography detects temperature differentials caused by resistance heating (I^2R losses) at loose connections, failing components, and overloaded conductors. With equipment de-energized or at very light load, no current flows and no thermal signatures develop — the survey produces no meaningful data. Surveys should be performed with equipment at minimum 40% of normal load, ideally at peak load, with panel covers safely opened using arc-rated PPE.

46. Correct Answer: C — Identify specific gases dissolved in transformer oil that indicate the type and severity of internal faults — each fault type produces a characteristic gas signature

DGA interprets the concentration and ratios of key fault gases: hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2), carbon monoxide (CO), and carbon dioxide (CO_2). Each fault type produces a characteristic gas: acetylene indicates arcing; ethylene and ethane indicate overheating of oil; CO and CO_2 indicate cellulose (paper insulation) degradation. IEEE C57.104 provides interpretation guidelines.

47. Correct Answer: C — No flashover or breakdown occurs and leakage current remains below the specified limit for the test duration

An AC hipot test applies a high voltage (typically 2× rated voltage + 1,000V for one minute, or per applicable standard) to the insulation under test. The test is passed when: no dielectric breakdown (flashover, puncture, or arc) occurs, and the measured leakage current does not exceed the specified limit throughout the test duration. A sudden increase in leakage current or a trip of the hipot set's trip circuit indicates insulation failure.

48. Correct Answer: C — Magnetic field produced by current flowing through the conductor — using the Hall effect or current transformer principle

A clamp-on ammeter's jaws form a split-core current transformer. When clamped around a current-carrying conductor, the alternating magnetic field produced by the AC current induces a proportional secondary current in the clamp's coil, which is measured by the meter. Digital clamp meters may use Hall-effect sensors for both AC and DC measurement. The key advantage is that the circuit need not be broken to insert a series ammeter.

49. Correct Answer: C — A developing mechanical condition such as gradual bearing wear, rotor imbalance increase, or alignment drift

A gradual, steady increase in overall vibration amplitude over months — with no change in the spectral frequency pattern — is the classic signature of a progressive mechanical degradation. Bearing wear increases rolling element defect frequencies; rotor imbalance growth increases 1× running speed amplitude; misalignment drift increases 1× and 2× amplitudes. Sudden increases (not gradual trends) suggest acute faults. Trend analysis is the foundation of predictive maintenance programs.

50. Correct Answer: D — Verify the phase rotation (A-B-C sequence) of a three-phase supply before connecting motors or equipment sensitive to phase sequence

Phase rotation meters use internal circuitry or a rotating disk to detect whether the three-phase supply rotates A-B-C (forward) or A-C-B (reverse). Before connecting a motor, verifying correct phase sequence prevents the motor from running backwards — which can damage driven equipment (pumps running in reverse, fans with reverse-pitch blades, compressors with check valves). It is also essential before paralleling two sources.

51. Correct Answer: D — The resistance-temperature relationship for copper: T2 = [(R2/R1) × (234.5 + T1)] − 234.5

The resistance of copper increases linearly with temperature according to: R2/R1 = (234.5 + T2) ÷ (234.5 + T1), where 234.5 is the inferred absolute zero temperature constant for copper (aluminum uses 228.1). Solving for T2: T2 = [(R2/R1) × (234.5 + T1)] − 234.5 = [(0.62/0.50) × (234.5 + 25)] − 234.5 = [1.24 × 259.5] − 234.5 = 321.8 − 234.5 = 87.3°C. This method is used in IEEE standards for winding temperature rise determination.

52. Correct Answer: A — Directly through the breaker's main current-carrying conductors at the required multiple of rated current — simulating actual fault conditions

Primary injection testing uses a high-current, low-voltage test set to pass current directly through the circuit breaker's main contacts and through the trip unit's current sensing elements — exactly simulating actual fault current. This tests the complete protection chain including the current sensors, trip unit electronics, and mechanical trip mechanism. Secondary injection tests only the trip unit electronics by injecting a signal into its secondary input, not through the main contacts.

53. Correct Answer: A — Investigate the cause of the 13% overcurrent — check for voltage unbalance, mechanical overload, incorrect motor selection, or high ambient temperature before deciding on corrective action

A 13% overcurrent above nameplate FLA requires investigation before any action. Common causes include: supply voltage unbalance (even 2% voltage unbalance can cause 6–10% current unbalance and increased average current), mechanical overload (driven equipment issue), incorrect motor selection (undersized HP), or high ambient temperature reducing motor capacity. Simply raising the overload relay setpoint without investigation masks the root cause and risks motor damage.

54. Correct Answer: C — Graphically verify that protective devices operate selectively — the closest device to the fault operates first, and all upstream devices have adequate time margins

A coordination study plots the time-current characteristics (TCC) of all protective devices — fuses, breakers, and relays — on the same log-log graph. The engineer verifies that at every fault current level, the curve of the device closest to the fault (downstream) lies below and to the left of every upstream device's curve — ensuring the downstream device clears the fault first (selective coordination). Adequate time separation (typically 0.3 seconds or more between electromechanical devices) prevents nuisance tripping of upstream devices.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: D — Can lead to instability — one pump may overpower the other and push it back toward shut-off, where the steep curve may cause flow reversal or instability in the parallel pump

When two centrifugal pumps with steeply rising H-Q curves are operated in parallel, they share flow stably only if both are operating on the descending portion of their curves at the system operating point. If the curves are too steep or the system resistance is high, one pump can operate at a higher head point that forces the other pump back toward shut-off — where a pump with an unstable (hump-shaped) curve can surge, oscillate, or experience reverse flow through its casing.

56. Correct Answer: C — Step up hydraulic pressure beyond what the main pump can generate — for high-force clamping, pressing, or forming operations

A hydraulic intensifier (booster) uses differential piston areas to step up pressure: $P_{output} = P_{input} \times (A_{large} \div A_{small})$. By applying system pressure to a large-area piston connected to a small-area output piston, the intensifier generates output pressures several times the supply pressure — typically 2:1 to 10:1 ratios. This allows high-force applications using a standard hydraulic power unit without requiring a high-pressure pump throughout the system.

57. Correct Answer: B — Ensure proper valve seating and thermal expansion allowance — incorrect clearance causes valve burning (too tight) or noise and reduced power (too loose)

Valve clearance (tappet gap) between the rocker arm and valve stem provides room for thermal expansion of the valve train components as the engine reaches operating temperature. Too tight a clearance prevents the valve from fully seating — causing combustion gas blowby, valve face burning, and power loss. Too loose a clearance causes valve train noise (tapping) and reduces valve lift and duration, lowering engine volumetric efficiency and power output.

58. Correct Answer: D — Better represents the energy content and damage potential of the vibration signal — it accounts for the entire waveform, not just peak values

RMS vibration amplitude is calculated as the square root of the mean of the squared instantaneous values over a measurement period: it represents the equivalent steady-state amplitude that contains the same energy as the actual varying signal. Peak measurements capture only the highest instantaneous amplitude — useful for detecting shock events but not representative of continuous energy. RMS is the standard for ISO 10816/20816 vibration severity evaluation of rotating machines.

59. Correct Answer: D — Reduced volumetric efficiency and discharge pressure — blowby past the rings prevents the cylinder from building full compression pressure

Failed piston rings allow compressed gas to blow past the piston into the crankcase (blowby) during the compression stroke. The cylinder cannot build full compression pressure — discharge pressure and flow drop significantly. Blowby also contaminates the crankcase oil with process gas and moisture, raising crankcase pressure and accelerating oil degradation. Increased crankcase pressure and oil consumption are classic diagnostic indicators of ring failure.

60. Correct Answer: C — Deliver a precisely controlled, continuous mist of oil to bearing surfaces — preventing over-lubrication and the heat generation associated with oil churning in conventional flooded bearings

Oil mist lubrication systems generate a fine mist of oil particles (1–3 micron droplets) carried by a low-pressure air stream to bearing housings. The mist provides just enough oil to maintain a full lubrication film without flooding the bearing — eliminating oil churning losses that are the primary source of heat in high-speed, flood-lubricated bearings. This keeps bearing temperatures 20–40°F lower than flooded systems, significantly extending bearing life.

61. Correct Answer: B — 360 RPM output — torque multiplied by 5 compared to input torque

Output speed = Input speed ÷ Gear ratio = 1,800 ÷ 5 = 360 RPM. Output torque = Input torque × Gear ratio = $T_{in} \times 5$ (ignoring mechanical losses). This is the fundamental trade-off of gear reducers — they exchange speed for torque. The power remains approximately constant ($P = T \times \omega$), so reducing speed by a factor of 5 multiplies torque by 5. This is why gear reducers are used on conveyors, mixers, and other high-torque, low-speed applications.

62. Correct Answer: A — Steam pressure and enthalpy into high-velocity steam jets that drive the rotor blades

In a steam turbine, the stationary nozzles (impulse design) or stator blades (reaction design) are shaped convergent (or convergent-divergent) passages that convert steam's pressure energy and thermal enthalpy (enthalpy drop) into kinetic energy — high-velocity steam jets directed at the rotor blades. The rotor blades then convert this kinetic energy into shaft torque and rotation. The nozzles themselves produce no mechanical work — they are energy conversion stages from enthalpy to velocity.

63. Correct Answer: C — Establish the normal vibration "fingerprint" of the machine in good condition — against which future spectra are compared to detect developing faults

A baseline vibration spectrum (the frequency-domain plot of vibration amplitude vs. frequency) is collected when the machine is new, after a major overhaul, or when confirmed to be in good mechanical condition. All future spectra are compared to this baseline — any new frequency components or amplitude increases from baseline indicate developing faults. Without a baseline, it is impossible to determine whether current vibration levels represent a change from normal or have always been present.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: B — Condensate accumulating in the steam main and being driven at high velocity into obstructions such as bends, valves, or trapped pockets

Water hammer in steam systems occurs when condensate collects in the bottom of a steam main and is swept along at steam velocity (typically 60–100 ft/sec). When this slug of water strikes a valve, elbow, tee, or dead-end, the sudden deceleration creates a pressure wave (hydraulic shock) that can be thousands of PSI — shattering pipe fittings, destroying valve bodies, and dislodging pipe hangers. Prevention requires proper steam main drip legs, pitch, and trap operation.

65. Correct Answer: A — The temperature difference between the incoming hot fluid and the outgoing cold fluid at one end of the exchanger — the closer the approach, the more effective the heat transfer

Approach temperature (also called terminal temperature difference) is measured at one end of a heat exchanger: the difference between the hot fluid inlet temperature and the cold fluid outlet temperature (or hot outlet vs. cold inlet at the other end). A small approach temperature (2–5°F) indicates a highly effective heat exchanger approaching maximum theoretical heat transfer. A large approach temperature indicates reduced effectiveness from fouling, inadequate surface area, or poor flow distribution.

66. Correct Answer: C — Closing the discharge valve does not reduce flow — it builds pressure until something fails (relief valve, pipe, or pump casing)

Positive displacement pumps (gear, piston, vane, screw) deliver a fixed volume per revolution regardless of discharge pressure. Throttling the discharge only increases pressure — the pump continues to push fluid until either the relief valve opens, a pipe fitting fails, or the pump casing fractures. All positive

displacement pump installations must include a pressure relief valve set below the system and pump pressure rating to prevent overpressure damage.

67. Correct Answer: A — A failed feedwater check valve allowing feedwater to flow back into the feedwater line rather than into the boiler

A failed (leaking-back or stuck-open) feedwater check valve allows boiler pressure to push water back out through the feed line, preventing the pump from raising sufficient pressure to overcome boiler pressure and deliver water. The pump runs continuously but delivers little or no water — the boiler level drops. This is confirmed by checking pump discharge pressure (normal) versus boiler pressure (higher, indicating reverse flow). The check valve must be inspected and replaced immediately.

68. Correct Answer: A — Pre-action systems are activated only by a fire alarm signal — not by individual sprinkler head operation alone, reducing the risk of accidental water discharge

A pre-action sprinkler system keeps the supply piping dry (filled with air or nitrogen under supervision). Water enters the piping only when a fire detection system (smoke, heat, or flame detector) sends a signal to open the pre-action valve — before any sprinkler heads fuse. This two-step activation (detection + fusible head) prevents accidental discharge from mechanical damage, making pre-action systems ideal for data centers, museums, and other water-sensitive areas.

69. Correct Answer: B — Automatically release trapped air from the high points of the system — preventing air locks that reduce flow and cause noise

Air naturally separates from water and collects at high points in hydronic piping. Without venting, air pockets block flow, cause gurgling noises, and reduce heat transfer effectiveness. Automatic air vents use a float mechanism — when air collects in the body, the float drops and opens the vent orifice; when water displaces the air, the float rises and closes the vent. They are installed at all system high points and on air separators.

70. Correct Answer: C — R-410A operates at significantly higher system pressures than R-22 — requiring heavier-walled tubing, fittings, and compressor components

R-410A has a normal operating suction pressure of approximately 120 psig (vs. 70 psig for R-22) and discharge pressure of 400+ psig (vs. 250 psig for R-22) — roughly 60–70% higher pressures throughout the refrigeration cycle. Equipment designed for R-22 cannot be retrofitted with R-410A without risking mechanical failure of the compressor, tubing, and fittings. R-410A systems use heavier wall copper tubing and higher-rated components throughout.

71. Correct Answer: B — Open or close to regulate flow to the zone coil based on thermostat demand — either fully open or fully closed (or modulating in variable flow systems)

Two-way control valves in hydronic zone circuits are either on/off (open when the zone thermostat calls for heating or cooling, closed when satisfied) or modulating (positioned between 0% and 100% open by a proportional thermostat signal). In variable flow systems, two-way zone valves are preferred over three-

way valves because closing two-way valves reduces total system flow — allowing variable speed pumps to reduce speed and energy consumption proportionally.

72. Correct Answer: C — Instrument air for pneumatic controls and process instruments — preventing moisture from freezing in instrument tubing or affecting measurement accuracy

A pressure dew point of −40°F is the standard specification for instrument air per ISA-7.0.01. At this dew point, moisture will not condense or freeze in instrument tubing and control valve actuators even in very cold environments — preventing moisture-induced measurement errors, freezing of tubing in outdoor installations, and corrosion of instrument internals. Refrigerated dryers (35–50°F dew point) are insufficient; desiccant dryers are required for −40°F instrument air quality.

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

73. Correct Answer: C — Control the rotation and swing of the load without workers being directly under it

Taglines are ropes attached to a load being hoisted, long enough to allow workers to stand well clear of the suspended load while controlling its orientation. Workers on taglines guide the load during the lift, preventing uncontrolled spinning or swinging that can damage equipment, strike workers, or cause the load to contact structures. OSHA prohibits workers from positioning themselves under suspended loads — taglines allow control from a safe distance.

74. Correct Answer: D — Stored on a reel or drum, kept lubricated, protected from moisture and corrosion, and away from heat sources and chemicals

Wire rope must be stored on proper reels or drums to prevent kinking — even a single kink permanently reduces breaking strength by up to 50%. Lubrication prevents internal corrosion and wire fatigue. Storage away from moisture, acids, alkalis, and heat prevents both corrosion and degradation of the wire's metallurgical properties. Rope stored improperly — piled on floors or coiled tightly — develops kinks, corrosion, and work hardening that may not be visible during inspection.

75. Correct Answer: A — Create clean, sized holes in electrical enclosures, panels, and junction boxes for conduit connectors and fittings

A knockout punch set uses a draw stud, punch, and die to press a clean, precise hole through sheet metal enclosures — matched to standard conduit hub or connector knockout sizes (½", ¾", 1", 1¼", etc.). The punch and die are drawn together by turning the draw stud nut, shearing a clean disc from the metal. This produces accurate, burr-free holes that accept standard conduit connectors with proper fit, unlike drill-and-file methods.

76. Correct Answer: A — Provides a means to pull conductors through the conduit at a later time without using a fish tape

Pull strings (nylon rope, polypropylene line, or polyester "mule tape") are installed in conduit runs during construction — before conductors are pulled — to avoid the need to fish tape through a completed conduit

system. The pull string is left in the conduit with the conductors and replaced after each pull, always leaving a new string for future conductor additions or replacements. Mule tape is preferred because it has high tensile strength and printed measurement markings.

77. Correct Answer: D — Continue tightening until the specified 75 ft-lb torque is achieved

Torque specifications on bus bar connections are minimum requirements — the connection must be tightened to at least the specified value to ensure adequate contact pressure, minimize contact resistance, and prevent thermal cycling loosening. A reading of 65 ft-lbs is 13% below the specified 75 ft-lbs, which is outside acceptable tolerance. The bolt must be tightened further until the torque wrench indicates 75 ft-lbs — this ensures the full contact clamping force specified by the manufacturer and applicable standards (NETA, IEEE, NFPA 70B).

78. Correct Answer: B — Elongation (stretch), twisted or cracked links, gouges, nicks, and reduction in link diameter — any of which require the chain to be removed from service

Chain hoist load chains must be inspected before each use per ASME B30.16 and manufacturer requirements. Chain elongation (measured over a known number of links and compared to the new-chain dimension) indicates fatigue — chains stretched beyond 3% of original length must be removed from service. Twisted links indicate overloading or side loading; cracks and gouges reduce cross-section and create stress concentrations; diameter reduction indicates wear. Surface rust alone is not a disqualifying condition if there is no pitting.

79. Correct Answer: A — Face shield over safety glasses, hearing protection, and appropriate gloves — never safety glasses alone for grinding

OSHA 1910.133 and grinding wheel manufacturer requirements mandate a face shield for grinding — safety glasses alone provide insufficient protection against high-velocity particles and wheel fragments that can approach the eyes from angles below the lens. The face shield must be worn over safety glasses (not instead of them) to provide full face protection. Hearing protection is required because grinding typically exceeds 85 dBA, and gloves protect against abrasion and heat.

80. Correct Answer: B — Four times

OSHA 29 CFR 1926.451(a)(1) requires that each scaffold and scaffold component be capable of supporting, without failure, its own weight and at least four times the maximum intended load. This 4:1 safety factor applies to all scaffold components — platforms, frames, cross-braces, base plates, and connections. The design load includes the weight of workers, tools, and materials, plus dynamic loads from movement and impact. Scaffolds must also be erected, used, and dismantled under the supervision of a competent person.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: A — Before initial use, whenever a different respirator facepiece is used, and at least annually thereafter

OSHA 29 CFR 1910.134(f) requires fit testing before initial use to confirm the selected respirator model and size achieves an adequate seal on the wearer's face. A new fit test is required whenever the worker's physical condition changes (significant weight change, dental surgery, facial scarring), whenever a different respirator model or size is selected, and annually to account for gradual changes in facial features. Fit testing must use the OSHA-accepted qualitative or quantitative methods appropriate for the respirator type.

82. Correct Answer: D — Financial penalties calculated based on excess emissions above the building's carbon limit

NYC Local Law 97 establishes carbon emission intensity limits (kg CO_2e per square foot) for buildings over 25,000 sq ft, with limits tightening in 2024 and 2030. Buildings that exceed their annual carbon limit face penalties of $268 per metric ton of CO_2e over the limit — calculated annually based on reported energy consumption data submitted to NYC. The law is designed to drive building electrification and efficiency upgrades to achieve NYC's goal of 80% carbon reduction by 2050.

83. Correct Answer: A — Unused discarded commercial chemical products on the P-list, such as sodium cyanide (P106) or arsenic trioxide (P012)

EPA's P-list (40 CFR 261.33(e)) identifies acutely hazardous wastes — unused commercial chemical products that are discarded as waste. P-listed wastes are subject to much stricter management requirements than U-listed or characteristic wastes: even very small quantities (1 kg/month) trigger LQG status, residue from P-list containers must be triple-rinsed, and they require rigorous tracking. Common P-listed chemicals include sodium cyanide, arsenic compounds, nicotine, and certain pesticides.

84. Correct Answer: D — 29 CFR 1910.120

OSHA's HAZWOPER standard (29 CFR 1910.120) governs operations at hazardous waste treatment, storage, and disposal facilities, emergency response operations for releases of hazardous substances, and clean-up operations at uncontrolled hazardous waste sites. It establishes medical surveillance, training (40-hour initial, 8-hour annual refresher for general site workers), PPE requirements, decontamination procedures, and site safety plan requirements for workers potentially exposed to hazardous substances.

85. Correct Answer: B — All physical hazards have been eliminated and the space contains no actual or potential atmospheric hazards — documented by the employer

OSHA 1910.146(c)(7) allows reclassification from permit-required to non-permit-required confined space when the employer can demonstrate — through actual entry to eliminate hazards — that the space contains no actual or potential atmospheric hazards and that all other permit space hazards have been eliminated.

This reclassification must be documented. If any hazard cannot be eliminated, the space must remain permit-required regardless of size or depth.

86. Correct Answer: D — Pretreatment standards — limiting pollutant concentrations before discharge to the publicly owned treatment works (POTW)

The Clean Water Act pretreatment program (40 CFR Part 403) requires industrial users that discharge process wastewater to POTWs to comply with categorical pretreatment standards for their industry (technology-based limits) and local limits established by the POTW. Pretreatment prevents pollutants from passing through the POTW untreated, interfering with POTW operations, contaminating sewage sludge, or endangering POTW workers. Significant industrial users typically require an industrial wastewater discharge permit.

87. Correct Answer: A — Section 9

The GHS-aligned Safety Data Sheet format (OSHA HazCom 2012, 29 CFR 1910.1200) organizes information in 16 standardized sections. Section 9 covers Physical and Chemical Properties: appearance, odor, pH, melting/boiling point, flash point, flammability limits, vapor pressure, vapor density, relative density, solubility, and partition coefficient. Section 7 covers Handling and Storage; Section 2 covers Hazard Identification; Section 11 covers Toxicological Information.

88. Correct Answer: D — 2 hours — immediate notification is required

NYC Environmental Protection regulations and New York State DEC require that spills of petroleum or other hazardous substances to land or water in New York be reported to the Spill Hotline (1-800-457-7362) immediately or as soon as possible — typically interpreted as within 2 hours of discovery. Federal CERCLA Section 103 requires notification to the National Response Center immediately for releases above reportable quantities. Delayed reporting results in additional penalties beyond those for the spill itself.

89. Correct Answer: B — Notify local emergency planners and fire departments of hazardous chemicals stored at the facility above threshold quantities so they can plan emergency responses

EPCRA Sections 311 and 312 (Emergency Planning and Community Right-to-Know Act) require facilities to submit SDSs (or a chemical list) and Tier I/Tier II emergency and hazardous chemical inventory reports to the State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC), and local fire department for chemicals stored above threshold planning quantities. This information enables emergency responders to pre-plan for potential chemical incidents at the facility.

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

90. Correct Answer: A — Approved — acceptable to the authority having jurisdiction (AHJ) and identified as safe for the application and installation

OSHA 29 CFR 1910.303(a) requires that electrical equipment be approved, meaning acceptable to the authority having jurisdiction and identified for use in specific conditions of installation. In practice,

"approved" for most electrical equipment means listed and labeled by a nationally recognized testing laboratory (NRTL) such as UL, CSA, or ETL — confirming the equipment has been tested and found to meet applicable product standards for its intended use.

91. Correct Answer: D — 8 cal/cm² — PPE arc rating must equal or exceed the incident energy

NFPA 70E Section 130.5(G) requires that arc-rated PPE used for energized electrical work must have an arc rating (ATPV or EBT value) equal to or greater than the calculated incident energy at the working distance. For 8 cal/cm² incident energy, the PPE minimum arc rating must be 8 cal/cm² — which corresponds to PPE Category 2 (minimum arc rating 8 cal/cm²). Using PPE with a lower arc rating risks second or third-degree burns from the arc flash event.

92. Correct Answer: A — Selecting, providing, and ensuring employees use appropriate PPE for identified workplace hazards — at no cost to the employee for most required PPE

OSHA 29 CFR 1910.132(d) requires employers to assess the workplace for hazards, select appropriate PPE, communicate PPE requirements, and verify employee use. Under 1910.132(h), employers must provide required PPE at no cost to employees — including hard hats, safety glasses, face shields, hearing protection, and most protective equipment. Exceptions include prescription safety glasses and safety-toe footwear in limited circumstances, but arc-rated PPE required for electrical work must always be employer-provided.

93. Correct Answer: B — A warning that arc flash and shock hazards exist — directing qualified persons to perform a risk assessment before working on or near energized parts

NFPA 70E Section 130.5(H) and NEC Section 110.16 require arc flash warning labels on switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers. The minimum NEC label content warns that arc flash and shock hazards exist and directs qualified persons to perform a risk assessment before working on or near energized parts. More detailed labels — which may include calculated incident energy, PPE category, arc flash boundary, working distance, and available fault current — are encouraged by NFPA 70E and required when an arc flash hazard analysis has been performed. The label alone does not authorize energized work; it serves as a reminder that a hazard exists and that proper evaluation must precede any work activity on the equipment.

94. Correct Answer: B — The generator manufacturer's instructions and NEC Article 250

A portable generator used for temporary power must be bonded and grounded per the manufacturer's instructions and NEC Article 250. If the generator's frame serves as the neutral-to-ground bond point (a separately derived system), the frame must be connected to a grounding electrode (ground rod). If the generator neutral is connected to the building's grounding system through a transfer switch, a separate grounding electrode is not required — the building's existing grounding system serves the generator.

95. Correct Answer: B — The equipment is properly installed, properly maintained, the door is closed with no exposed energized parts, and no evidence of impending failure exists

NFPA 70E Section 130.2(A)(4) permits normal operation of electrical equipment without arc flash PPE when all four conditions are simultaneously met: the equipment is properly installed, properly maintained, all guards and covers are in place (doors closed, no exposed energized conductors), and there is no evidence of impending failure (no unusual sounds, smells, visible arcing, or overheating). If any one condition is not met, full arc flash risk assessment and appropriate PPE are required.

96. Correct Answer: A — Four business hours of the request (end of next business day at latest)

OSHA 29 CFR 1904.35(b)(2) requires that employers provide current and former employees (or their representatives) access to their OSHA 300 log, 300A summary, and 301 incident reports within four business hours of a request made during normal business hours. This right to access injury and illness records is a fundamental worker right — it allows employees and their representatives to review workplace injury trends and hold employers accountable for accurate recordkeeping.

97. Correct Answer: A — Monitor for smoldering fires or ignition of nearby combustible materials for a minimum of 30–60 minutes after hot work is completed

NFPA 51B and most facility hot work permit programs require a trained fire watch to remain in the hot work area during the work and for a minimum of 30 minutes (NFPA 51B minimum) to 60 minutes (many facility programs) after all hot work is completed. Smoldering fires in walls, insulation, or combustible materials nearby may not become visible flames for 30 minutes or more after the ignition source is removed. The fire watch must have a charged fire extinguisher immediately available.

98. Correct Answer: B — Inspect visually for cuts, holes, and swelling — then perform an air inflation test to check for leaks before each use

NFPA 70E Section 130.7(C)(7)(b) and ASTM F496 require that rubber insulating gloves be inspected before each use: visually examine the entire glove surface (inside and out) for cuts, punctures, embedded particles, ozone deterioration, and swelling from chemical contamination, then inflate the glove by trapping air inside (rolling the cuff) and squeezing to confirm no air escapes through pinholes. Gloves must also be electrically re-tested every six months per ASTM F496 and marked with the test date.

99. Correct Answer: B — Manually disconnect the motor immediately, investigate why the overload relay failed to operate, and inspect the motor windings before any restart attempt

Single-phasing (one phase open) causes the remaining two phases to carry the full motor load current — approximately 1.73 times normal in each active winding — while the third winding carries zero current. The resulting current unbalance generates severe negative sequence heating that can damage windings in minutes. The overload relay may not have tripped because the average current (across all three phases) may not have exceeded the relay's pickup setting despite two phases being severely overloaded. The relay must be investigated — a phase loss relay (Function 46 or 47) should be added if not already installed.

100. Correct Answer: A — Establishing a comprehensive electrical safety program including qualified person training, written safe work procedures, arc flash risk assessments, effective LOTO, appropriate PPE, and regular auditing — creating a sustained safety culture

No single measure — not GFCI devices, arc flash labels, or PPE requirements alone — prevents electrical accidents as effectively as a comprehensive, integrated electrical safety program. NFPA 70E and OSHA 1910.3xx series standards both recognize that sustained accident prevention requires: identifying and eliminating hazards by design, training qualified workers to recognize and avoid remaining hazards, establishing written safe work procedures, enforcing energized work justification, providing appropriate PPE, and continuously auditing the program's effectiveness through incident review and regular refresher training.