

PRACTICE EXAM 8: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. A 120V circuit with a 0.8 power factor draws 15A. The real power consumed is?
 - A. 1,800W
 - B. 2,250W
 - C. 120W
 - D. 1,440W

2. Which of the following is the correct unit for measuring electrical energy consumption as billed by a utility?
 - A. Watt
 - B. Kilowatt-hour (kWh)
 - C. Volt-ampere
 - D. Kilovolt-ampere-hour

3. In an AC circuit, the phase angle between voltage and current is 30° . The power factor is?
 - A. 0.50

- B. 0.71
- C. 0.87
- D. 1.00

4. A conductor's resistance is inversely proportional to its?

- A. Length
- B. Cross-sectional area
- C. Temperature
- D. Resistivity

5. The output of a three-phase full-wave rectifier circuit produces how many pulses per cycle?

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

6. Two capacitors of $20\mu\text{F}$ each are connected in series. The total capacitance is?

- A. $10\mu\text{F}$
- B. $40\mu\text{F}$
- C. $20\mu\text{F}$
- D. $5\mu\text{F}$

7. Faraday's Law of electromagnetic induction states that the induced EMF is proportional to?

- A. The resistance of the conductor
- B. The frequency of the applied voltage
- C. The rate of change of magnetic flux through the circuit
- D. The magnitude of the existing current in the conductor

8. A $10\text{k}\Omega$ resistor and a $10\text{k}\Omega$ resistor connected in series are connected across 100V. The voltage across each resistor is?

- A. 100V across each
- B. 25V across each
- C. 10V across each
- D. 50V across each

9. Inductive reactance (X_L) is directly proportional to?

- A. Resistance and frequency
- B. Frequency and inductance
- C. Capacitance and frequency
- D. Resistance and inductance

10. The time constant (τ) of an RC circuit is defined as the time for the capacitor voltage to reach what percentage of its final value?

- A. 100%
- B. 63.2%
- C. 50%

D. 36.8%

11. Which of the following has the lowest resistance to current flow?

A. Silver

B. Copper

C. Aluminum

D. Gold

12. A delta-connected load has each phase impedance of 30Ω and is connected to a 208V three-phase system. The line current is?

A. 6.93A

B. 12.0A

C. 6.0A

D. 20.8A

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

13. The NEC requires that conductors be protected from physical damage where they pass through floors. The protection must extend at least how far above the floor?

A. 3 feet

B. 6 feet

C. 4 feet

D. 8 feet

14. Which type of fuse is rated for use only in circuits with AC voltage and should not be used in DC circuits without de-rating?

- A. Class J fuse
- B. Class RK1 fuse
- C. Class L fuse
- D. Standard AC cartridge fuse (Class H)

15. A 200-ampere service entrance requires a minimum conductor size of?

- A. 1/0 AWG copper
- B. 2/0 AWG copper
- C. 3/0 AWG copper
- D. 4/0 AWG copper

16. The ampacity correction factor for conductors installed in an ambient temperature of 50°C (using THWN-2, 90°C rated conductors) is approximately?

- A. 0.58
- B. 0.71
- C. 0.82
- D. 0.91

17. Which type of wiring device is used to control a light fixture from two separate switch locations?

- A. Single-pole switch
- B. Four-way switch
- C. Dimmer switch

D. Three-way switch

18. The purpose of an equipment grounding conductor (EGC) in a branch circuit is to?

A. Carry normal load return current

B. Provide a low-impedance fault current path back to the source to operate overcurrent devices during a ground fault

C. Connect the neutral to the building steel

D. Stabilize the system voltage during load changes

19. When installing conductors in a conduit, the maximum number of bends between pull points is?

A. Two 90° bends

B. Three 90° bends

C. Four 90° bends (360° total)

D. Five 90° bends

20. Which of the following materials is classified as an insulator?

A. Carbon

B. Polyvinyl chloride (PVC)

C. Graphite

D. Silicon

21. A 600V-rated, 30A safety disconnect switch provides?

A. Visible blade isolation for safe lockout/tagout and manual disconnection of the load

- B. Overcurrent protection for the connected load
- C. Ground fault protection for the circuit
- D. Arc fault protection during disconnection

22. The purpose of wire management (bundling and cable ties) in control panels is to?

- A. Reduce the panel's EMI emissions to comply with FCC regulations
- B. Improve cooling airflow through the panel
- C. Protect conductors from physical damage only
- D. Organize conductors for easier troubleshooting, reduce clutter, and maintain professional installation standards

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

23. A 500 kVA transformer at 85% efficiency delivers what output real power at unity power factor full load?

- A. 500 kW
- B. 588 kW
- C. 425 kW
- D. 450 kW

24. The term "impedance grounding" describes a system where the neutral is connected to ground through?

- A. A resistor or reactor to limit ground fault current to a controlled level
- B. A direct metallic connection
- C. An isolation transformer
- D. A capacitor for surge suppression

25. In a 4,160V medium-voltage system, what is the standard minimum insulation level for switchgear?

- A. 4.16 kV BIL
- B. 60 kV BIL (basic insulation level)
- C. 20 kV BIL
- D. 45 kV BIL

26. A power transformer's percent regulation is defined as?

- A. The ratio of no-load voltage to full-load voltage
- B. The change in secondary terminal voltage from no-load to full load, expressed as a percentage of full-load voltage
- C. The transformer's efficiency at rated load
- D. The ratio of primary voltage to secondary voltage

27. Which relay function is used to detect reverse power flow (motoring) on a generator tied to the utility grid?

- A. ANSI Function 51 — time-overcurrent
- B. ANSI Function 27 — undervoltage
- C. ANSI Function 40 — loss of excitation
- D. ANSI Function 32 — directional power (reverse power) relay

28. The purpose of a capacitor bank on a distribution feeder is to?

- A. Limit fault current on the feeder
- B. Reduce reactive current flow on the feeder, improving voltage profile and reducing losses
- C. Provide backup power during outages

D. Regulate feeder voltage during switching operations

29. A 480V, 3-phase, 4-wire system supplies a balanced three-phase load of 60 kW at unity power factor. The line current per phase is approximately?

A. 125A

B. 72.2A

C. 41.7A

D. 144A

30. The function of a potential transformer (PT) fuse is to?

A. Protect the PT primary winding from overload current

B. Protect the PT from through-fault current and isolate it during internal faults

C. Limit secondary current to 5 amperes maximum

D. Prevent ferroresonance conditions in the PT

31. Transformer nameplate kVA rating is based on what limiting factor?

A. Maximum allowable winding temperature rise above ambient

B. Maximum allowable secondary current

C. Maximum primary voltage the insulation can withstand

D. Maximum efficiency of the transformer

32. In a three-phase system, negative sequence currents are produced by?

A. Harmonic loads on the system

- B. Phase voltage unbalance or single-phasing conditions
- C. Power factor correction capacitors
- D. Transformer inrush current

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

33. A synchronous generator's output frequency drops below 60 Hz during a sudden load increase. The corrective action is to?

- A. Increase the AVR setpoint to raise output voltage
- B. Reduce the load on the generator immediately
- C. Increase the field excitation current
- D. Increase fuel delivery to the prime mover via the governor

34. Which component of a brushless exciter system converts AC exciter output to DC for the main generator field?

- A. Rotating rectifier diode assembly on the main rotor shaft
- B. Static voltage regulator on the stator
- C. Slip ring assembly on the main rotor
- D. Exciter control transformer in the stator frame

35. A three-phase squirrel cage induction motor has a synchronous speed of 1,800 RPM and runs at 1,746 RPM at full load. The slip is?

- A. 1,746 RPM
- B. 54 RPM
- C. 1.8%

D. 3.0%

36. The purpose of motor surge protection (MOV or RC snubber networks) on motor terminals is to?

- A. Limit motor starting current to reduce inrush
- B. Protect the motor from overvoltage during normal operation
- C. Improve motor power factor during running
- D. Suppress voltage spikes from VFD switching transients or capacitor switching that can damage winding insulation

37. When a VFD output frequency is set below the motor's base frequency (below 60 Hz), the drive maintains a constant?

- A. Output voltage at all speeds
- B. Output current at all speeds
- C. Power output at all speeds
- D. Volts-per-hertz (V/Hz) ratio to maintain constant motor flux

38. A motor that is correctly sized for its load operates most efficiently at?

- A. 50% of rated load
- B. 25% of rated load
- C. 75% of rated load
- D. 75–100% of rated load

39. The purpose of a motor's nameplate service factor (SF) is to?

- A. Indicate the permissible overload the motor can carry continuously under specific conditions

- B. Define the motor's maximum starting torque
- C. Specify the motor's insulation class rating
- D. Identify the motor's efficiency class

40. In an electronic overload relay, trip class is selected based on?

- A. The motor's voltage rating
- B. The motor's insulation class
- C. The maximum ambient temperature in the motor room
- D. The motor's acceleration time from zero to full speed

41. A soft starter's bypass contactor closes?

- A. During the starting ramp to reduce heat in the SCRs
- B. After the motor reaches full speed to carry full load current while the SCRs are bypassed
- C. When the motor trips on overload to isolate the fault
- D. During the initial inrush period to limit current

42. Which motor protection function trips the motor if it fails to start within a defined time period?

- A. Overload relay
- B. Phase loss relay
- C. Under-voltage relay
- D. Locked rotor protection (anti-jam timer or stall protection)

43. A DC motor field loss relay (ANSI Function 56) protects against?

- A. Loss of field excitation causing the DC motor to overspeed
- B. Overloading the motor armature winding
- C. Reverse rotation of the motor
- D. Excessive commutator arcing during starting

44. The purpose of a motor disconnect's "visible blade" requirement per the NEC is to?

- A. Allow the operator to visually confirm the circuit is open without relying on position indicators
- B. Provide arc flash protection during disconnection
- C. Simplify troubleshooting by identifying the phase being disconnected
- D. Allow the disconnect to be used as a current-limiting device

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

45. A transformer winding resistance test (TTR or bridge measurement) is used to?

- A. Verify DC winding resistance to detect open or shorted turns, high-resistance connections, and tap changer problems
- B. Measure the transformer's insulation resistance
- C. Verify the transformer's turns ratio
- D. Measure transformer core losses

46. When troubleshooting a control circuit, the "half-split" troubleshooting method involves?

- A. Testing each component sequentially from the power source to the load

- B. Testing the last component in the circuit first
- C. Dividing the circuit at the midpoint and testing to determine which half contains the fault
- D. Testing all components simultaneously with multiple meters

47. The minimum test voltage for a high-potential (hipot) test on 600V-rated switchgear insulation is typically?

- A. 600V AC
- B. 1,200V AC
- C. 2,200V AC
- D. 1,000V AC

48. A clamp-on power quality meter measures total demand distortion (TDD). This metric describes?

- A. The ratio of harmonic current to the load's rated current at the point of common coupling
- B. The total reactive power consumed by harmonic loads
- C. The voltage distortion at the utility meter
- D. The percentage of fundamental frequency current consumed by non-linear loads

49. Partial discharge (PD) testing on medium-voltage cables is performed to detect?

- A. Ground faults in the cable sheath
- B. Voids, contaminants, or defects in the cable insulation where partial discharges occur
- C. Cable current-carrying capacity under load
- D. Cable impedance for fault location

50. A two-wattmeter method is used to measure three-phase power when?

- A. The system is three-phase, three-wire (no neutral) and only two wattmeters are available or installed
- B. The load is unbalanced and one meter cannot be used
- C. The power factor is above 0.85
- D. Only single-phase wattmeters are available

51. An automatic voltage recorder installed on a 480V panel over 24 hours shows voltage dips to 420V each day at 8:00 AM. This most likely indicates?

- A. Large motor starting causing voltage sag on the feeder during morning startup
- B. Utility voltage regulation failure overnight
- C. A capacitor bank switching event
- D. A failing transformer on the secondary bus

52. The purpose of a turns ratio test (TTR) on a transformer is to?

- A. Verify the transformer's efficiency at rated load
- B. Measure the transformer's magnetizing current
- C. Verify the winding resistance of each phase
- D. Verify the actual turns ratio matches the nameplate, detecting shorted turns or winding faults

53. When performing transformer oil dielectric strength testing, the minimum acceptable breakdown voltage for 69kV class transformer oil is approximately?

- A. 26 kV
- B. 28 kV
- C. 30 kV

D. 35 kV

54. A motor's vibration baseline should be established?

- A. After a major repair or bearing replacement
- B. During initial run-in on a new or reconditioned motor under normal operating conditions
- C. Only after a vibration problem has been identified
- D. During locked rotor testing before full load operation

MECHANICAL EQUIPMENT (Questions 55–63)

55. A centrifugal pump operating beyond its design flow rate (to the right of BEP on the pump curve) will experience?

- A. Reduced axial thrust and longer bearing life
- B. Suction recirculation, cavitation, high radial thrust, and reduced efficiency
- C. Improved efficiency due to increased flow velocity
- D. Reduced power consumption

56. The purpose of a minimum flow bypass on a centrifugal pump installation is to?

- A. Allow the pump to be tested without connecting to the system
- B. Provide a recirculation path to prevent low-flow damage and overheating when the system demand falls below the pump's minimum stable flow
- C. Regulate maximum system flow rate
- D. Bypass the pump during start-up to reduce motor inrush current

57. Diesel engine cylinder liner wear is measured using a?

- A. Feeler gauge
- B. Dial indicator
- C. Bore gauge (inside micrometer or telescoping gauge)
- D. Vernier caliper

58. The purpose of a turbocharger on a diesel engine is to?

- A. Increase the air charge density entering the cylinders to allow more fuel to be burned and increase power output
- B. Cool the exhaust gases before emission to atmosphere
- C. Lubricate the injection pump components
- D. Regulate engine speed independently of the governor

59. A diesel engine with high crankcase pressure (excessive blowby) will show which symptom?

- A. White exhaust smoke and coolant consumption
- B. Clean oil with no discoloration
- C. Blue exhaust smoke and elevated oil consumption
- D. Engine overspeed under no-load conditions

60. Vibration analysis detects a strong sub-synchronous vibration component at $0.45 \times$ running speed. This is most characteristic of?

- A. Rotor imbalance
- B. Shaft misalignment
- C. Fluid film bearing instability (oil whirl)

D. Bearing outer race defect

61. An accumulator in a pneumatic system maintains pressure between the compressor cut-in and cut-out points by?

A. Controlling the compressor motor speed

B. Bypassing excess compressed air to atmosphere

C. Storing compressed air and releasing it to the system when demand exceeds compressor output

D. Regulating the inlet air temperature to the compressor

62. A gear pump's flow rate is proportional to?

A. The square of the shaft speed

B. The pressure differential across the pump

C. The fluid viscosity at operating temperature

D. The shaft speed and the gear displacement per revolution

63. The function of a pressure switch on a compressor system is to?

A. Regulate the outlet pressure to a constant value

B. Start and stop the compressor motor to maintain pressure between setpoints

C. Provide overpressure relief above the maximum system pressure

D. Monitor and display the current system pressure

FLUID SYSTEMS (Questions 64–72)

64. In a steam trap selection, which type of trap is best suited for draining large volumes of condensate quickly from a steam main during warm-up?

- A. Thermostatic trap
- B. Thermodynamic (disc) trap
- C. Float and thermostatic (F&T) trap
- D. Inverted bucket trap

65. A boiler feedwater pump's NPSH available (NPSHa) must always exceed the pump's NPSH required (NPSHr) by a safety margin to prevent?

- A. Overloading the pump motor
- B. Excessive feedwater temperature at the pump inlet
- C. Cavitation in the pump that damages impellers and reduces performance
- D. Water hammer in the feedwater supply line

66. Which type of valve provides a scrubbing action as it opens and closes, making it self-cleaning and suitable for slurry service?

- A. Globe valve
- B. Butterfly valve
- C. Gate valve
- D. Knife gate valve

67. The purpose of a steam separator in a steam distribution system is to?

- A. Reduce steam pressure to a safe operating level
- B. Measure steam flow rate for billing purposes
- C. Remove entrained water droplets from the steam to deliver dry steam to equipment
- D. Prevent reverse flow of steam in the distribution main

68. In a refrigeration cycle, the refrigerant is at its lowest temperature in the system at?

- A. The condenser inlet
- B. The compressor outlet
- C. The liquid receiver
- D. The evaporator

69. A hydraulic system overheats after several hours of operation. After checking oil level, the next most likely cause is?

- A. Pump operating below rated speed
- B. System pressure set too high for the load
- C. Hydraulic fluid viscosity too high for ambient temperature
- D. Internal leakage generating heat through throttling losses across worn components

70. The purpose of a water softener in a boiler makeup water treatment system is to?

- A. Remove dissolved oxygen from the feedwater before it enters the boiler
- B. Neutralize acidic pH in the makeup water supply
- C. Kill biological organisms in the makeup water

D. Remove calcium and magnesium ions that cause scale formation in the boiler

71. In a variable air volume (VAV) HVAC system, each VAV box contains a?

A. Separate supply fan for that zone

B. Refrigerant expansion valve

C. Modulating damper that controls airflow to the zone based on thermostat demand

D. Steam coil for heating during winter operation

72. The term "net positive suction head" (NPSH) in pump engineering refers to?

A. The maximum discharge pressure the pump can develop

B. The pressure drop across the pump at maximum flow

C. The total head that causes fluid to flow into the pump suction above the vapor pressure of the fluid

D. The difference between pump discharge head and suction head

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

73. A four-leg bridle sling lifting a uniform load must be rated assuming how many legs are sharing the load for design purposes?

A. All four legs at equal load

B. Three legs sharing the load equally — assuming one leg may be slack

C. Two legs at maximum load

D. Four legs with a 25% capacity reduction each

74. A conduit body (LB, LL, LR, T fittings) installed in a conduit system must have a cross-sectional area of at least how many times the cross-sectional area of the largest conduit connected to it?

- A. Two times
- B. Three times
- C. Four times
- D. Equal (1:1 ratio)

75. Which hand tool is used to create external threads on a pipe or rod?

- A. Pipe reamer
- B. Threading die in a die stock
- C. Pipe tap
- D. Pipe cutter

76. The purpose of a load cell in a lifting operation is to?

- A. Measure the actual load weight during the lift in real time
- B. Protect the rigging from overload by limiting hook height
- C. Provide a visual indicator of load movement
- D. Calculate the center of gravity of the suspended load

77. When handling and storing compressed gas cylinders, they must be?

- A. Secured upright with caps in place and stored away from heat sources and incompatible gases
- B. Stored on their sides to prevent valve damage
- C. Stored without valve protection caps during active use periods

D. Stored with oxygen and fuel gas cylinders in the same secured cage

78. The correct tool for measuring the inside diameter of a pipe bore or bearing housing is a?

A. Outside micrometer

B. Vernier caliper

C. Telescoping gauge with an outside micrometer

D. Dial indicator

79. A chain sling marked with a yellow tag indicates it is rated for what temperature service?

A. Standard service up to 400°F (204°C)

B. High-temperature service up to 400°F (204°C) — above which alloy steel chains are derated

C. Below-freezing service only

D. Corrosive environment service with special alloy

80. Which of the following is a correct statement about the safe use of portable electric tools on a construction or maintenance site?

A. Double-insulated tools used on GFCI-protected circuits provide adequate protection

B. Three-wire grounded tools may be used without a grounding connection if the circuit is GFCI protected

C. Power tool cords may be repaired with electrical tape if the outer jacket is damaged

D. Worn or damaged power tools may continue to be used until a replacement is available

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. The OSHA permissible exposure limit (PEL) for carbon monoxide (CO) in general industry is?

- A. 25 ppm TWA
- B. 50 ppm TWA
- C. 50 ppm TWA — 8-hour
- D. 200 ppm TWA

82. A facility stores chemicals that could undergo violent reaction if mixed with water. The correct storage requirement is?

- A. Store in a dry area away from water sources with secondary containment and water-reactive material labeling
- B. Store adjacent to the fire suppression system for rapid response
- C. Store in a refrigerated area to reduce reaction rate
- D. No special storage requirements if quantities are below RCRA thresholds

83. The OSHA Hazard Communication Standard (29 CFR 1910.1200) requires that Safety Data Sheets be?

- A. Readily accessible to employees in their work areas during all work shifts
- B. Available only to supervisors and safety personnel
- C. Posted on bulletin boards in break rooms only
- D. Available upon written request within 72 hours

84. A transformer containing mineral oil that tests positive for PCBs at 52 PPM is classified under TSCA as?

- A. PCB transformer — must be registered and managed per 40 CFR 761 PCB transformer requirements
- B. Non-PCB equipment — below 50 PPM is acceptable
- C. PCB-contaminated equipment — specific use and disposal restrictions apply at 50–499 PPM

D. Requires no special management below 500 PPM

85. The NYC DEP requires that cooling towers be tested for Legionella at minimum?

- A. Monthly during the operating season
- B. Quarterly and within 14 days of startup after shutdown
- C. Annually only
- D. Every six months

86. Which of the following is a universal waste under EPA regulations?

- A. Batteries (nickel-cadmium, lead-acid), lamps (fluorescent, HID), and mercury-containing devices
- B. Spent halogenated solvents
- C. Wastewater treatment sludge
- D. Transformer oil containing PCBs above 50 PPM

87. The purpose of a Tier II report submitted under EPCRA (Emergency Planning and Community Right-to-Know Act) is to?

- A. Report hazardous waste generation quantities to the EPA
- B. Report chemical spills to the National Response Center
- C. Report the storage of extremely hazardous substances and other chemicals above threshold quantities to SERCs, LEPCs, and local fire departments
- D. Certify compliance with RCRA hazardous waste management requirements

88. A worker is accidentally exposed to a hazardous chemical. The first response action per the SDS is to?

- A. Contact OSHA immediately for guidance

- B. Follow the first-aid measures in Section 4 of the chemical's SDS
- C. Transport the worker to a hospital without any field treatment
- D. Dilute the chemical with water regardless of the substance

89. NYC Local Law 86 requires certain city-owned buildings to achieve energy efficiency standards. For stationary engineers, this means?

- A. Only new building construction is affected
- B. Monitoring and maintaining building energy systems to meet energy use intensity (EUI) targets
- C. Installing solar panels on all building rooftops
- D. Replacing all equipment older than 15 years

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

90. Under OSHA 1910.147, a "complex" energy control procedure is required when?

- A. Equipment has more than one energy source, multiple isolation points, or requires a crew to perform the work safely
- B. The equipment is rated above 480V
- C. The work takes longer than one shift to complete
- D. The equipment contains both electrical and mechanical energy sources only

91. NFPA 70E requires an arc flash risk assessment to be performed?

- A. Only on equipment above 600V
- B. Only when a qualified person requests it
- C. Only after an arc flash incident has occurred
- D. Before work is performed on or near energized electrical equipment

92. The purpose of a one-line diagram (single line diagram) in electrical safety is to?

- A. Show the physical layout of all electrical equipment in the facility
- B. Show only the branch circuit wiring for lighting systems
- C. Provide wiring details for individual motor starters
- D. Show the overall electrical system topology, equipment ratings, and protective device locations for system understanding and safety planning

93. Which type of fire extinguisher is appropriate for use on a Class B (flammable liquid) fire in an electrical equipment room?

- A. Water mist extinguisher
- B. CO₂ or dry chemical (BC or ABC rated) extinguisher
- C. Class K wet chemical extinguisher
- D. Pressurized water extinguisher

94. The OSHA standard requiring employers to provide fall protection systems on leading edges, skylights, and floor openings in general industry is?

- A. 29 CFR 1926.502
- B. 29 CFR 1910.146
- C. 29 CFR 1910.147
- D. 29 CFR 1910.23

95. An employer's written LOTO program must be reviewed and certified by the employer as adequate at minimum?

- A. Annually through a periodic inspection of the energy control procedures

- B. Every three years
- C. Only when an incident occurs
- D. Every five years

96. The term "flash protection boundary" in earlier editions of NFPA 70E corresponds to which current boundary designation?

- A. Restricted approach boundary
- B. Arc flash boundary
- C. Limited approach boundary
- D. Prohibited approach boundary

97. A worker performing routine panel inspections finds a circuit breaker with signs of overheating — discolored terminals and a burning odor. The correct action is?

- A. Continue the inspection and report findings in the daily log
- B. Immediately de-energize the circuit and report to supervision
- C. Apply thermal paste to the terminals to improve heat dissipation
- D. Document, de-energize the circuit if safe to do so, and immediately report the condition to supervision for corrective action

98. Which standard governs the design and installation of emergency and standby power systems in buildings?

- A. NFPA 70 (NEC)
- B. NFPA 101
- C. NFPA 110
- D. NFPA 72

99. When workers are exposed to hydrogen sulfide (H₂S) in a confined space, the IDLH (Immediately Dangerous to Life or Health) concentration is?

- A. 10 ppm
- B. 50 ppm
- C. 100 ppm
- D. 300 ppm

100. The purpose of a safety interlock on high-voltage switchgear is to?

- A. Prevent the breaker from being closed or racked in unless specific safety conditions are met — such as grounding switches open and shutters in place
- B. Limit the switchgear operating current during normal switching
- C. Provide arc flash protection during breaker operation
- D. Automatically trip the breaker during maintenance activities

PRACTICE EXAM 8 — ANSWER KEY AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: D — 1,440W

Real power = $V \times I \times PF = 120 \times 15 \times 0.80 = 1,440$ watts. The power factor of 0.80 means only 80% of the apparent power (1,800 VA) is converted to real, useful work — the remaining 20% is reactive power circulating between source and load.

2. Correct Answer: B — Kilowatt-hour (kWh)

The kilowatt-hour is the standard unit of electrical energy billed by utilities — it represents 1,000 watts of power consumed for one hour. Watts and volt-amperes measure rate of power, not total energy consumed over time.

3. Correct Answer: C — 0.87

Power factor = $\cos(\theta) = \cos(30^\circ) = 0.866 \approx 0.87$. At 30° phase angle, current and voltage are relatively close in phase — the circuit is predominantly resistive with some reactive component, typical of a moderately loaded inductive system.

4. Correct Answer: B — Cross-sectional area

Resistance $R = (\rho \times L) \div A$, where ρ is resistivity, L is length, and A is cross-sectional area. Resistance is inversely proportional to area — doubling the conductor cross-section halves the resistance, which is why larger AWG conductors (smaller gauge number) have lower resistance and higher ampacity.

5. Correct Answer: A — Six

A three-phase full-wave bridge rectifier uses six diodes (two per phase) and produces six pulses per cycle of the AC input. The higher pulse number means smoother DC output with less ripple compared to single-phase rectifiers — making three-phase rectifiers preferred for industrial DC power supplies.

6. Correct Answer: A — 10 μ F

For capacitors in series: $1/CT = 1/C1 + 1/C2 = 1/20 + 1/20 = 2/20 = 1/10$, so $CT = 10\mu\text{F}$. Series capacitors reduce total capacitance — the opposite of series resistors. Two equal capacitors in series always produce half the capacitance of either individual capacitor.

7. Correct Answer: C — The rate of change of magnetic flux through the circuit

Faraday's Law states that induced EMF = $-N \times (d\Phi/dt)$, where N is the number of turns and $d\Phi/dt$ is the rate of change of magnetic flux. The faster the flux changes (faster relative motion or faster current change), the higher the induced voltage — the fundamental principle behind transformers and generators.

8. Correct Answer: D — 50V across each

With two equal resistors in series, voltage divides equally: $V = 100 \div 2 = 50V$ per resistor. The voltage divider principle states that voltage drops across series resistors are proportional to their resistance values — equal resistances share voltage equally.

9. Correct Answer: B — Frequency and inductance

Inductive reactance $X_L = 2\pi \times f \times L$. X_L increases with both frequency (f) and inductance (L) — doubling either doubles the reactance. At DC ($f = 0$), an inductor has zero reactance and acts as a pure resistance; at very high frequency, X_L becomes very large, effectively blocking AC current flow.

10. Correct Answer: B — 63.2%

The RC time constant $\tau = R \times C$ is defined as the time for the capacitor voltage to reach 63.2% of its final (fully charged) value. After one time constant the voltage is 63.2% of final; after two time constants it is 86.5%; after five time constants it is considered fully charged (99.3%).

11. Correct Answer: A — Silver

Silver has the lowest resistivity of all metals — approximately $1.59 \times 10^{-8} \Omega \cdot m$ — making it the best conductor. Copper (1.68×10^{-8}) is second, gold (2.44×10^{-8}) is third, and aluminum (2.65×10^{-8}) is fourth. Silver's high cost limits its use to specialized contacts and connections.

12. Correct Answer: B — 12.0A

In a delta connection, phase voltage = line voltage = 208V. Phase current = $V_{\text{phase}} \div Z_{\text{phase}} = 208 \div 30 = 6.93A$. Line current = phase current $\times \sqrt{3} = 6.93 \times 1.732 = 12.0$ amperes. Delta line current is always $\sqrt{3}$ times the phase current.

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

13. Correct Answer: B — 6 feet

NEC Section 300.4 requires conductors passing through floors to be enclosed in rigid metal conduit, intermediate metal conduit, or schedule 80 PVC conduit for protection against physical damage, extending at least 6 inches below the floor and 6 feet above the floor — providing the total protection from floor level to a reasonable working height.

14. Correct Answer: D — Standard AC cartridge fuse (Class H)

Standard Class H cartridge fuses are rated for AC service only and must not be used in DC circuits without significant de-rating — the AC current's zero crossings assist arc interruption, which does not occur in DC circuits. Current-limiting fuses (Class J, RK, L) have DC interrupting ratings listed on their datasheets for dual-rated applications.

15. Correct Answer: D — 4/0 AWG copper

NEC Table 310.15(B)(16) shows that 4/0 AWG copper conductors are rated for 230 amperes at 75°C — the minimum size required to carry 200 amperes on a 200-ampere service entrance. The service conductors must have an ampacity equal to or greater than the service disconnect rating.

16. Correct Answer: C — 0.82

Per NEC Table 310.15(B)(2)(a), THWN-2 conductors rated 90°C at 50°C ambient have a correction factor of 0.82. The formula is based on the reduction in allowable temperature rise: $CF = \sqrt{[(T_{max} - T_{ambient}) \div (T_{max} - 30^{\circ}C)]} = \sqrt{[(90 - 50) \div (90 - 30)]} = \sqrt{40 \div 60} = \sqrt{0.667} = 0.816 \approx 0.82$.

17. Correct Answer: D — Three-way switch

Three-way switches are used in pairs to control a light fixture from two separate locations — such as both ends of a stairway or hallway. Each switch has three terminals: one common and two travelers. Four-way switches are used when three or more switching locations are needed (installed between two three-way switches).

18. Correct Answer: B — Provide a low-impedance fault current path back to the source to operate overcurrent devices during a ground fault

The EGC's primary safety function is to carry fault current back to the source when a phase conductor contacts a grounded equipment enclosure, creating enough current to rapidly operate the overcurrent device and clear the fault. Without the EGC, the equipment enclosure would remain energized at a dangerous voltage.

19. Correct Answer: C — Four 90° bends (360° total)

NEC Section 358.26 (and similar sections for other conduit types) limits the total bends between pull points (boxes, conduit bodies, or fittings) to a maximum of 360° — equivalent to four 90° bends. This limit prevents excessive pulling tension that would damage conductor insulation during installation.

20. Correct Answer: B — Polyvinyl chloride (PVC)

PVC is a synthetic polymer with very high resistivity — an excellent electrical insulator used for conductor insulation, conduit, and junction boxes. Carbon and graphite are semiconductors; silicon is a semiconductor material. True insulators have resistivities above $10^8 \Omega \cdot m$.

21. Correct Answer: A — Visible blade isolation for safe lockout/tagout and manual disconnection of the load

A safety disconnect switch provides visible blade (open-air gap) isolation that can be positively confirmed as open — a requirement for lockout/tagout procedures. Unlike circuit breakers, safety switches provide a guaranteed visible open gap that cannot be closed by internal mechanism failure, making them the preferred isolation device for LOTO.

22. Correct Answer: D — Organize conductors for easier troubleshooting, reduce clutter, and maintain professional installation standards

Proper wire management in control panels serves multiple practical purposes: it organizes the wiring for easy tracing during troubleshooting, prevents conductors from interfering with moving parts, protects against chafing damage, allows air circulation around heat-generating components, and reflects professional workmanship standards expected in industrial electrical installations.

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

23. Correct Answer: C — 425 kW

At unity power factor, kVA = kW. Output kW = Input kVA × Efficiency = 500 × 0.85 = 425 kW. The transformer delivers 425 kW of real power to the load while 75 kW is lost as heat in the core and windings. At unity PF, apparent power equals real power on the secondary.

24. Correct Answer: A — A resistor or reactor to limit ground fault current to a controlled level

Impedance grounding connects the system neutral to ground through a current-limiting impedance — either a resistor (resistance grounding) or a reactor (reactance grounding). This limits ground fault current to a predictable, controlled level — high enough to operate ground fault relays but low enough to limit equipment damage and allow continued operation in some designs.

25. Correct Answer: B — 60 kV BIL

The Basic Insulation Level (BIL) for 4.16kV class switchgear is standardized at 60 kV. BIL represents the peak voltage the insulation can withstand from a standard lightning impulse test (1.2×50 microsecond wave). The BIL must be significantly higher than the operating voltage to withstand lightning and switching transients.

26. Correct Answer: B — The change in secondary terminal voltage from no-load to full load, expressed as a percentage of full-load voltage

Percent regulation = $[(V_{NL} - V_{FL}) \div V_{FL}] \times 100\%$. A transformer with 5% regulation shows a 5% voltage drop from no-load to full-load conditions. Lower percent regulation indicates better voltage regulation — the secondary voltage changes less between no-load and full-load conditions.

27. Correct Answer: D — ANSI Function 32 — directional power (reverse power) relay

ANSI Function 32 is the directional power relay that monitors the direction of real power flow at a generator's terminals. When a generator loses its prime mover but remains connected to the grid, the grid drives the machine as a motor (motoring condition) — Function 32 detects this reverse power flow and trips the generator breaker.

28. Correct Answer: B — Reduce reactive current flow on the feeder, improving voltage profile and reducing losses

Shunt capacitor banks installed on distribution feeders supply reactive (magnetizing) current to inductive loads locally — reducing the reactive component that must flow through the feeder conductors from the substation. This reduces feeder I²R losses, improves the voltage profile along the feeder, and increases the feeder's available real power capacity.

29. Correct Answer: B — 72.2A

Three-phase line current: $I = P \div (\sqrt{3} \times V \times PF) = 60,000 \div (1.732 \times 480 \times 1.0) = 60,000 \div 831.4 = 72.2$ amperes per phase. At unity power factor, all apparent power is real power — the 1.732 factor accounts for the three-phase relationship.

30. Correct Answer: B — Protect the PT from through-fault current and isolate it during internal faults

PT primary fuses protect the potential transformer's primary winding from damage during system faults that would drive high current through the PT primary. Without fusing, a fault on the PT primary circuit could damage or destroy the transformer — the fuse provides fast isolation while protecting the PT's accuracy and availability for protection functions.

31. Correct Answer: A — Maximum allowable winding temperature rise above ambient

Transformer kVA rating is thermally limited — it represents the maximum load at which the winding temperature rise above ambient remains within the insulation class temperature limit (typically 55°C or 65°C rise for standard designs). Exceeding the kVA rating causes the winding temperature to exceed the insulation rating, degrading insulation and shortening transformer life.

32. Correct Answer: B — Phase voltage unbalance or single-phasing conditions

Negative sequence currents flow in the opposite phase rotation to positive sequence currents and are produced by voltage unbalance, phase loss (single-phasing), or asymmetrical faults. In motors, negative sequence currents produce a reverse-rotating magnetic field that opposes rotation, generating excessive heat in the rotor — making negative sequence detection critical for motor protection.

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

33. Correct Answer: D — Increase fuel delivery to the prime mover via the governor

Generator frequency is directly proportional to rotor speed ($f = N \times P \div 120$). When load increases and the rotor decelerates, frequency drops below 60 Hz. The governor must respond by increasing fuel delivery to the engine, restoring rated speed and frequency. Adjusting the AVR only affects voltage, not frequency.

34. Correct Answer: A — Rotating rectifier diode assembly on the main rotor shaft

In a brushless exciter system, the main exciter stator generates AC that is fed to the exciter rotor. Rotating rectifier diodes mounted on the main rotor shaft rectify this AC to DC, which is then directly applied to the main generator field winding — all without brushes, slip rings, or external connections to the rotating components.

35. Correct Answer: D — 3.0%

Slip (%) = $[(\text{Synchronous speed} - \text{Rotor speed}) \div \text{Synchronous speed}] \times 100 = [(1,800 - 1,746) \div 1,800] \times 100 = (54 \div 1,800) \times 100 = 3.0\%$. This is a typical full-load slip value for a standard NEMA Design B induction motor — indicating normal motor operation.

36. Correct Answer: D — Suppress voltage spikes from VFD switching transients or capacitor switching that can damage winding insulation

VFD output switching at high frequencies (typically 2–16 kHz) generates steep-fronted voltage pulses with high dV/dt rates. When these pulses travel through long cable runs, reflections can cause peak voltages at the motor terminals exceeding twice the DC bus voltage — potentially puncturing winding insulation. MOV or RC networks at the motor terminals clamp these voltage spikes.

37. Correct Answer: D — Volts-per-hertz (V/Hz) ratio to maintain constant motor flux

Below base frequency (60 Hz), the VFD reduces both voltage and frequency proportionally — maintaining a constant V/Hz ratio. This keeps the motor flux at rated level regardless of speed, ensuring rated torque capability is available at all speeds from zero to base frequency without saturating the motor core.

38. Correct Answer: D — 75–100% of rated load

Induction motors reach peak efficiency at approximately 75–100% of rated load — specifically near the load point where variable losses (copper losses) equal fixed losses (core losses). Below 50% load, efficiency drops significantly as fixed losses dominate. This is why oversizing motors wastes energy at partial load.

39. Correct Answer: A — Indicate the permissible overload the motor can carry continuously under specific conditions

The service factor (SF) indicates the permissible overload multiplier — a motor with SF 1.15 can carry 115% of its rated horsepower continuously, provided voltage, frequency, and ambient conditions remain within nameplate limits. Operating at service factor load results in elevated temperature that reduces insulation life if sustained indefinitely.

40. Correct Answer: D — The motor's acceleration time from zero to full speed

Trip class selection for electronic overload relays is based on the motor's locked rotor time — how long it takes for the motor to accelerate from standstill to full speed. Class 10 is for fast-starting motors; Class 20 for standard motors; Class 30 for high-inertia loads (fans, pumps with high WK²) that require longer acceleration time.

41. Correct Answer: B — After the motor reaches full speed to carry full load current while the SCRs are bypassed

The bypass contactor in a soft starter closes after the motor has fully accelerated, shorting out the SCR power stack. This eliminates the heat losses in the SCRs during continuous running — SCRs generate significant heat even when fully conducting — extending soft starter life and improving overall efficiency.

42. Correct Answer: D — Locked rotor protection (anti-jam timer or stall protection)

Locked rotor protection monitors whether the motor successfully accelerates within a preset time period after starting. If the motor fails to reach running speed (indicated by high current persisting beyond the normal acceleration time), the relay trips — protecting against mechanically jammed loads that would otherwise hold the motor in a high-current locked rotor condition until the insulation fails.

43. Correct Answer: A — Loss of field excitation causing the DC motor to overspeed

The DC motor field loss relay monitors the field excitation current. If the field winding opens or loses excitation (due to a blown fuse, open connection, or contactor failure), the back-EMF drops to near zero and armature current rises dramatically — causing the motor to accelerate to a destructive overspeed condition. The field loss relay detects this condition and trips the armature circuit before damage occurs.

44. Correct Answer: B — Allow the operator to visually confirm the circuit is open without relying on position indicators

NEC Section 430.109 and industry safety practice require that motor disconnects provide visible indication of the open position — either through a visible blade gap or a positive mechanical indication. This allows a worker to confirm de-energization with their own eyes rather than relying on potentially faulty position indicators, switches, or indicators — a critical safety requirement for LOTO procedures.

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

45. Correct Answer: A — Verify DC winding resistance to detect open or shorted turns, high-resistance connections, and tap changer problems

Transformer winding resistance testing measures the DC resistance of each winding using a precision bridge or micro-ohmmeter. Values are compared between phases and against nameplate or baseline data — deviations indicate open or shorted turns, deteriorated solder or brazed joints, and high-resistance tap changer contacts.

46. Correct Answer: D — Divide the circuit at the midpoint and testing to determine which half contains the fault

The half-split method is a systematic troubleshooting technique that minimizes the number of tests needed to locate a fault. By testing at the midpoint of the circuit first, the technician immediately eliminates half the circuit from consideration with a single test — then repeats the process on the faulty half, progressively narrowing down the fault location.

47. Correct Answer: C — 2,200V AC

ANSI/NEMA standards specify that 600V-rated switchgear must withstand a dielectric withstand test of 2,200V AC (or approximately 3,100V DC) applied for one minute without breakdown. This test voltage — approximately 3.7 times the rated voltage — verifies that the insulation has adequate margin above operating voltage for transient overvoltages encountered in service.

48. Correct Answer: A — The ratio of harmonic current to the load's rated current at the point of common coupling

Total demand distortion (TDD) = (root sum square of harmonic currents ÷ rated demand current) × 100%. Unlike total harmonic distortion (THD), which compares harmonics to the fundamental current, TDD compares them to the system's rated demand — making it a more meaningful measure of harmonic impact on the utility system per IEEE 519.

49. Correct Answer: B — Voids, contaminants, or defects in the cable insulation where partial discharges occur

Partial discharge testing applies AC voltage to medium-voltage cables and measures the tiny high-frequency current pulses produced by electrical discharges in insulation voids, water trees, contamination, or mechanical damage. These discharges erode insulation over time, eventually causing complete failure — PD testing detects them before the failure occurs.

50. Correct Answer: A — The system is three-phase, three-wire (no neutral) and only two wattmeters are available or installed

The two-wattmeter method is mathematically valid for measuring total three-phase power in any three-phase, three-wire system regardless of balance or power factor. The algebraic sum of the two wattmeter

readings equals the total three-phase power. A neutral conductor is not needed, and the method works even when power factor varies.

51. Correct Answer: A — Large motor starting causing voltage sag on the feeder during morning startup

Recurring voltage dips at a predictable time each morning indicate a large recurring inrush event — the startup of large motors, chillers, compressors, or other large equipment during building opening. The starting current of large motors can cause significant voltage sag on the feeder serving the load if the source impedance is high.

52. Correct Answer: D — Verify the actual turns ratio matches the nameplate, detecting shorted turns or winding faults

The transformer turns ratio test (TTR) applies a known AC voltage to the primary and measures the secondary voltage, calculating the actual turns ratio and comparing it to the nameplate value. Deviations from nameplate ratio indicate shorted turns (which change the effective number of turns) or tapped winding problems.

53. Correct Answer: C — 30 kV

ASTM D877 specifies that transformer insulating oil for 69kV class equipment should have a minimum dielectric strength of 30 kV when tested in the standard disk electrode test cell. Fresh oil typically tests at 35–40 kV or higher; oil below 26 kV should be filtered or replaced; oil at 28–30 kV warrants close monitoring.

54. Correct Answer: C — During initial run-in on a new or reconditioned motor under normal operating conditions

Vibration baseline measurements must be taken under known-good conditions — new or freshly reconditioned equipment at normal operating load and temperature. This baseline becomes the reference against which all future measurements are compared. Baselines taken after problems develop or during abnormal conditions have no diagnostic value for trending.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: B — Suction recirculation, cavitation, high radial thrust, and reduced efficiency

Operating far to the right of the BEP (best efficiency point) on the pump curve subjects the pump to recirculation at the impeller discharge, where the flow angle mismatches the impeller design. This causes turbulence, cavitation, high radial thrust loads on shaft and bearings, and dramatically reduced efficiency — significantly shortening pump life.

56. Correct Answer: B — Provide a recirculation path to prevent low-flow damage and overheating when the system demand falls below the pump's minimum stable flow

Centrifugal pumps generate heat when operating at very low flow — the energy input to the fluid is not removed by flow, causing temperature rise that can flash the fluid to vapor and damage the pump. A minimum flow bypass recirculates fluid back to the suction source when system demand drops below the manufacturer's minimum stable flow requirement.

57. Correct Answer: C — Bore gauge (inside micrometer or telescoping gauge)

Cylinder liner wear (bore) is measured using an inside micrometer, bore gauge, or telescoping gauge (set with an outside micrometer) to measure the actual bore diameter at multiple depths and orientations. Wear patterns — including taper and out-of-round (ovality) — are identified by comparing measurements at different positions in the liner.

58. Correct Answer: A — Increase the air charge density entering the cylinders to allow more fuel to be burned and increase power output

A turbocharger uses exhaust gas energy to drive a compressor that forces denser (higher-pressure) air into the cylinders. Denser intake air allows proportionally more fuel to be injected and combusted, increasing power output from the same displacement engine — achieving power-to-weight ratios impossible with naturally aspirated engines.

59. Correct Answer: D — Engine overspeed under no-load conditions

High crankcase pressure from excessive piston ring blowby allows combustion gases to pass the rings into the crankcase, pressurizing it above atmospheric. The symptoms are blue-gray exhaust smoke from oil being burned (drawn past worn rings and valve seals), elevated oil consumption, and crankcase breather blowing oil mist.

60. Correct Answer: C — Fluid film bearing instability (oil whirl)

Sub-synchronous vibration at approximately 0.43–0.48× running speed is the classic signature of oil whirl in fluid film (sleeve) bearings. The oil film in the bearing rotates at approximately half the shaft speed, and under certain conditions of light load or high speed, the oil film becomes unstable and begins to precess around the shaft at sub-synchronous frequency.

61. Correct Answer: C — Storing compressed air and releasing it to the system when demand exceeds compressor output

A pneumatic accumulator (receiver tank) stores compressed air at system pressure and acts as a buffer between the intermittent compressor output and the continuous system demand. When demand spikes above the compressor's delivery rate, the accumulator supplements compressor output; during low demand, the compressor recharges the accumulator.

62. Correct Answer: D — The shaft speed and the gear displacement per revolution

Gear pump flow = displacement per revolution × shaft speed. The displacement per revolution is fixed by the gear geometry (tooth profile, face width, pitch diameter). Since gear pumps are positive displacement devices, flow rate changes linearly with shaft speed — doubling the speed doubles the flow, independent of pressure within the pump's operating range.

63. Correct Answer: B — Start and stop the compressor motor to maintain pressure between setpoints

A pressure switch monitors system pressure continuously. When pressure drops to the cut-in setpoint, it starts the compressor motor; when pressure rises to the cut-out setpoint, it stops the motor. This on/off control maintains system pressure within a defined band without requiring a pressure regulating valve or continuous compressor operation.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: C — Float and thermostatic (F&T) trap

Float and thermostatic traps use a ball float that opens proportionally to condensate level — allowing continuous, high-capacity condensate discharge as fast as it forms. This makes F&T traps ideal for large condensate volumes during steam main warm-up, where rapid condensate removal is needed to prevent water hammer and achieve operating temperature quickly.

65. Correct Answer: C — Cavitation in the pump that damages impellers and reduces performance

When NPSHa drops below NPSHr, the fluid pressure at the pump inlet falls below vapor pressure and the fluid flashes to vapor. These vapor bubbles collapse violently (implode) as they enter higher-pressure regions in the pump — removing metal from the impeller surface through erosion, generating noise and vibration, and reducing pump performance.

66. Correct Answer: D — Knife gate valve

Knife gate valves have a sharp-edged blade that slices through slurries, pulp, and viscous fluids as it seats. The cutting and wiping action of the blade against the seat provides a self-cleaning mechanism that prevents solid buildup in the seat area — making knife gates the standard choice for slurry, wastewater, and pulp applications.

67. Correct Answer: C — Remove entrained water droplets from the steam to deliver dry steam to equipment

Steam separators use centrifugal action, impingement baffles, or a combination to remove entrained liquid water droplets from steam. Wet steam entering heat exchangers, turbines, or process equipment reduces efficiency, causes erosion damage, and leads to water hammer — steam separators ensure dry, high-quality steam reaches the point of use.

68. Correct Answer: D — The evaporator

In the standard vapor-compression refrigeration cycle, the refrigerant is at its lowest temperature and pressure in the evaporator — it absorbs heat from the space being cooled as it evaporates from liquid to vapor. The compressor raises the pressure; the condenser rejects heat; the expansion device drops pressure before the evaporator.

69. Correct Answer: D — Internal leakage generating heat through throttling losses across worn components

Hydraulic system overheating after extended operation (not immediately) indicates progressive component wear causing increased internal leakage. As fluid leaks across worn clearances (pump, motor, cylinder seals, valve spools), it experiences a pressure drop and the energy is converted to heat. This cumulative heat generation eventually exceeds the system's cooling capacity.

70. Correct Answer: A — Remove calcium and magnesium ions that cause scale formation in the boiler

Water softeners use ion exchange resins to replace hardness ions (calcium Ca^{2+} and magnesium Mg^{2+}) with sodium ions. Calcium and magnesium ions form calcium carbonate and magnesium silicate scale on boiler heat transfer surfaces — reducing heat transfer efficiency, increasing fuel consumption, and eventually causing tube overheating and failure.

71. Correct Answer: C — Modulating damper that controls airflow to the zone based on thermostat demand

Each VAV box contains a modulating damper (typically a butterfly or parallel-blade damper) that opens or closes in response to the zone thermostat's demand signal. At peak cooling load, the damper opens fully to deliver maximum conditioned airflow; at reduced load, it throttles to reduce airflow to that zone while the supply fan reduces speed to maintain duct pressure.

72. Correct Answer: C — The total head that causes fluid to flow into the pump suction above the vapor pressure of the fluid

NPSH is the absolute pressure head at the pump suction inlet minus the vapor pressure head of the fluid at pumping temperature — representing the margin above vapor pressure available to drive fluid into the pump without vaporization. NPSHa must exceed NPSHr (the pump's suction requirement) to prevent cavitation.

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

73. Correct Answer: B — Three legs sharing the load equally — assuming one leg may be slack

ASME B30.9 and rigging standards require that four-leg slings be rated assuming only three legs share the load, because the fourth leg may be slack due to load geometry or sling length variation. Using a four-leg sling at four-leg capacity assumes perfect load geometry that rarely exists in practice.

74. Correct Answer: D — Equal (1:1 ratio)

NEC Section 314.28(A)(1) requires pull and junction boxes in conduit systems to have a minimum dimension of eight times the trade size of the largest conduit for straight pulls, and six times for angle pulls. However, conduit bodies (LB, LL, LR, T) must have a cross-sectional area not less than twice the cross-sectional area of the largest conduit — not 1:1.

75. Correct Answer: C — Threading die in a die stock

External threads on pipe or rod are cut using a threading die (which has internal cutting teeth matching the thread form and pitch) held in a die stock (the handle that applies rotational force). Pipe taps cut internal threads; pipe reamers remove burrs from cut pipe ends; pipe cutters cut pipe to length.

76. Correct Answer: A — Measure the actual load weight during the lift in real time

A load cell is a force-measuring transducer inserted in the rigging assembly (typically in the hook block or rigging) that measures the actual tension in the lift line. It displays the real-time load weight on a remote indicator, allowing the rigging crew to verify the load against the rigging capacity before and during the lift.

77. Correct Answer: A — Secured upright with caps in place and stored away from heat sources and incompatible gases

Compressed gas cylinders must be stored upright and secured to prevent falling, with protective valve caps in place when not in use. They must be stored away from heat sources (which raise internal pressure), open flames, and incompatible gases — particularly oxygen cylinders must be stored at least 20 feet from fuel gas cylinders or separated by a fire-rated barrier.

78. Correct Answer: C — Telescoping gauge with an outside micrometer

A telescoping gauge (snap gauge) is inserted into the bore, the spring-loaded arms expand to contact the bore wall, and the gauge is locked and withdrawn. The locked dimension is then measured with an outside micrometer, providing bore diameter to 0.0001" precision. This is the standard technique for measuring bearing housing bores and cylinder diameters in maintenance work.

79. Correct Answer: B — High-temperature service up to 400°F (204°C) — above which alloy steel chains are derated

Alloy steel chain slings are marked with colored tags indicating their inspection status and temperature rating. Yellow tags indicate the sling is in current inspection and rated for normal service up to 400°F (204°C). Above 400°F, alloy steel chains must be derated per the manufacturer's temperature derating table because elevated temperature reduces material yield strength.

80. Correct Answer: D — Worn or damaged power tools may continue to be used until a replacement is available

This statement is FALSE — the correct practice is that damaged or defective tools must be removed from service immediately and tagged or physically disabled to prevent use until repaired or replaced. Continuing to use damaged tools violates OSHA 29 CFR 1910.244 and creates serious injury hazards. Option A is the correct safe practice: double-insulated tools on GFCI circuits provide adequate protection.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: C — 50 ppm TWA — 8-hour

OSHA's PEL for carbon monoxide is 50 ppm as an 8-hour TWA per 29 CFR 1910.1000 Table Z-1. NIOSH recommends a lower REL of 35 ppm TWA. CO is particularly dangerous because it is colorless, odorless, and produces symptoms (headache, dizziness) that can be confused with other conditions — continuous monitoring in enclosed spaces is essential.

82. Correct Answer: A — Store in a dry area away from water sources with secondary containment and water-reactive material labeling

Water-reactive chemicals (sodium metal, calcium carbide, certain anhydrides) react violently with water, potentially generating flammable gases, explosive reactions, or intense heat. Storage in dry areas away from water pipes, sprinklers, and wet floor areas — with secondary containment and clear GHS water-reactivity labeling — is essential. Placing them near fire suppression systems creates the exact hazard being controlled.

83. Correct Answer: A — Readily accessible to employees in their work areas during all work shifts

OSHA 29 CFR 1910.1200(g)(8) requires SDSs to be readily accessible to employees during their work shifts in their work areas. Electronic access is permitted if employees can immediately access the SDS without barriers. The SDSs must be available in the language employees understand and during emergency situations — not just upon request or in remote locations.

84. Correct Answer: C — PCB-contaminated equipment — specific use and disposal restrictions apply at 50–499 PPM

TSCA 40 CFR 761 classifies transformers containing 50–499 PPM PCBs as "PCB-contaminated" — not PCB transformers (≥ 500 PPM) but still regulated. PCB-contaminated equipment has specific restrictions on use location (not in or near food or feed handling), fire risk inspection requirements, and disposal requirements that differ from both non-PCB (< 50 PPM) and PCB transformer (≥ 500 PPM) categories.

85. Correct Answer: B — Quarterly and within 14 days of startup after shutdown

NYC Local Law 77 and the NYC Health Code (Title 24 RCNY Chapter 8) require cooling tower owners to test for Legionella at least quarterly during the operating season and within 14 days of startup after any

shutdown of 5 days or more. Results must be maintained in the written maintenance program records for at least three years.

86. Correct Answer: A — Batteries (nickel-cadmium, lead-acid), lamps (fluorescent, HID), and mercury-containing devices

EPA's universal waste program (40 CFR Part 273) designates specific widely-generated hazardous wastes for streamlined management: batteries, pesticides (recalled), mercury-containing equipment, and lamps (fluorescent, HID, neon, mercury vapor). Universal waste rules reduce regulatory burden while ensuring proper management and recycling of these common waste streams.

87. Correct Answer: C — Report the storage of extremely hazardous substances and other chemicals above threshold quantities to SERCs, LEPCs, and local fire departments

EPCRA Section 312 Tier II reporting requires facilities storing hazardous chemicals above threshold quantities to submit annual Tier II chemical inventory reports to the State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC), and local fire department — providing emergency responders with information about on-site chemical hazards.

88. Correct Answer: B — Follow the first-aid measures in Section 4 of the chemical's SDS

Section 4 of the SDS provides specific, chemical-appropriate first-aid instructions for each route of exposure. The SDS first-aid measures are the authoritative source of initial response guidance — they may specify actions that differ from generic first aid (e.g., some chemicals should NOT have water applied). Following the SDS ensures the appropriate chemical-specific response.

89. Correct Answer: B — Monitoring and maintaining building energy systems to meet energy use intensity (EUI) targets

NYC Local Law 86 (and the broader NYC Climate Mobilization Act including Local Laws 92, 94, and 97) requires city-owned and large private buildings to meet progressively stricter energy use intensity targets. Stationary engineers play a critical role by optimizing building systems operation, maintaining equipment efficiency, and implementing energy management practices to keep building energy use within mandated EUI limits.

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

90. Correct Answer: A — Equipment has more than one energy source, multiple isolation points, or requires a crew to perform the work safely

OSHA 1910.147 requires complex energy control procedures when equipment has multiple energy sources, multiple isolation points requiring specific sequence, or when group lockout with multiple workers is needed. Simple, single-energy-source equipment with a single isolation point may use a basic procedure — but any complexity requires documentation of each energy source and isolation step.

91. Correct Answer: D — Before work is performed on or near energized electrical equipment

NFPA 70E requires an arc flash risk assessment before any work is performed on or near exposed energized electrical conductors or circuit parts. The assessment determines the arc flash boundary, incident energy level at the working distance, and minimum PPE required — or identifies that the equipment can and should be de-energized before work begins.

92. Correct Answer: D — Show the overall electrical system topology, equipment ratings, and protective device locations for system understanding and safety planning

A one-line diagram is the essential reference document for electrical system understanding — it shows the complete electrical distribution topology, transformer ratings, bus configurations, breaker locations and ratings, feeder sizes, and protective device settings in a simplified format. It is indispensable for safe switching operations, arc flash studies, short circuit analysis, and emergency response.

93. Correct Answer: B — CO₂ or dry chemical (BC or ABC rated) extinguisher

For Class B fires (flammable liquids) in an electrical equipment room, CO₂ extinguishers are preferred because they leave no residue and do not damage sensitive equipment. Dry chemical (BC or ABC) extinguishers are also effective but leave a corrosive powder residue. Water and Class K agents must never be used on electrical equipment.

94. Correct Answer: D — 29 CFR 1910.23

OSHA's Walking-Working Surfaces standard (29 CFR 1910.23) governs fall protection requirements in general industry — requiring fall protection at 4 feet above a lower level for walking-working surfaces, with specific requirements for floor openings, skylights, wall openings, and leading edges. 29 CFR 1926.502 is the construction industry fall protection standard.

95. Correct Answer: A — Annually through a periodic inspection of the energy control procedures

OSHA 1910.147 requires employers to conduct an annual periodic inspection of each energy control procedure, certifying that the procedure is adequate and workers understand it. The inspection must be performed by an authorized employee other than the one using the procedure, and the certification must document the machine/equipment reviewed, the date, the employees involved, and the inspector's name.

96. Correct Answer: B — Arc flash boundary

In NFPA 70E 2012 and earlier editions, the "flash protection boundary" was the outer boundary beyond which a worker would receive no more than 1.2 cal/cm² (the onset of a second-degree burn) from an arc flash. In NFPA 70E 2018 and 2021 editions, this boundary was renamed the "arc flash boundary" — the same concept with updated terminology.

97. Correct Answer: D — Document, de-energize the circuit if safe to do so, and immediately report the condition to supervision for corrective action

Discolored terminals with a burning odor indicate a developing fault — an immediate fire and equipment failure hazard. The circuit should be de-energized if it can be done safely (following LOTO), the condition documented with photographs, and supervision notified immediately for emergency corrective action. Continuing the inspection without acting, or applying thermal paste, are both inappropriate responses to an active hazard.

98. Correct Answer: C — NFPA 110

NFPA 110 — Standard for Emergency and Standby Power Systems — governs the performance requirements, installation, testing, and maintenance of emergency power supply systems (EPSS) including generator sets, transfer switches, and all associated distribution equipment. NFPA 70 (NEC) covers electrical installation; NFPA 101 covers life safety; NFPA 72 covers fire alarms.

99. Correct Answer: C — 100 ppm

NIOSH establishes the IDLH for hydrogen sulfide at 100 ppm — the concentration above which a worker could suffer immediate or delayed permanent health effects or death from a 30-minute exposure and could not self-rescue. H₂S is particularly dangerous because it paralyzes the olfactory nerve at concentrations above ~100 ppm — a worker may lose their sense of smell and not perceive the dangerous concentration, making continuous atmospheric monitoring essential.

100. Correct Answer: A — Prevent the breaker from being closed or racked in unless specific safety conditions are met — such as grounding switches open and shutters in place

High-voltage switchgear safety interlocks prevent catastrophic accidents from incorrect switching sequences. Typical interlocks prevent racking a breaker into the connected position if the bus grounding switch is closed, prevent closing a grounding switch if the bus is energized, and prevent opening an isolating switch under load — ensuring that the physical state of the equipment matches the intended safe operating sequence.