PRACTICE EXAM 14: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. A series circuit has a 12Ω resistor and a 16Ω inductive reactance connected to 100V AC. The current is?

A. 5A

B. 8.33A

C. 6.25A

D. 4A

2. The unit of electrical charge is the?

A. Ampere

B. Coulomb

C. Farad

D. Weber

3. Three resistors of 6Ω, 12Ω, and 4Ω are connected in parallel across 24V. The total source current is?

A. 6A

B. 13A

C. 8A

D. 4A

4. The power factor angle θ in an AC circuit is the angle between?

A. Real power and reactive power vectors

B. Inductive and capacitive reactances

C. Applied voltage and source EMF

D. The voltage and current phasors

5. A 10 kVA, 240/120V, 60Hz single-phase transformer has a full-load secondary current of?

A. 41.7A

B. 100A

C. 83.3A

D. 50A

6. Ohm's Law states that current is?

A. Directly proportional to voltage and inversely proportional to resistance

B. Directly proportional to both voltage and resistance

C. Inversely proportional to voltage

D. Independent of resistance at constant power

7. In a single-phase 120/240V three-wire system, the neutral conductor?

A. Carries total current for all 240V circuits

B. Carries the unbalanced current between the two 120V legs

C. Provides a grounding path for equipment faults

D. Automatically balances the 240V load

8. The resonant frequency of a series RLC circuit with L = 0.1H and C = 100μF is approximately?

A. 50.3 Hz

B. 15.9 Hz

C. 100 Hz

D. 31.8 Hz

9. Impedance in an AC circuit is best described as?

A. Opposition to current caused by resistance only

B. The phasor combination of resistance and reactance: $Z = \sqrt{(R^2 + X^2)}$

C. Opposition caused by inductance and capacitance only

D. The ratio of reactive power to apparent power

10. A 480V, 3-phase motor draws 30A at 0.85 PF. The real power consumed is?

A. 21.2 kW

B. 14.4 kW

C. 40.2 kW

D. 24.9 kW

11. A real voltage source differs from an ideal voltage source in that it?

A. Can only supply DC voltage

B. Has internal resistance causing terminal voltage to drop under load

C. Cannot supply current above its rated value

D. Has infinite output impedance

12. Faraday's Law states that induced EMF in a coil is?

A. Proportional to the rate of change of magnetic flux: EMF = $-N(d\Phi/dt)$

B. Proportional to the total magnetic flux at any instant

C. Inversely proportional to the number of turns

D. Equal to the product of current and inductance

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

13. The minimum service disconnect rating for a single-family dwelling per NEC 230.79 is?

A. 100A

B. 60A

C. 200A

D. 150A

14. A listed surge protective device (SPD) at the service entrance primarily?

A. Prevents overvoltage from affecting utility metering

B. Limits fault current during a direct lightning strike

C. Diverts transient overvoltages to ground — protecting downstream equipment from voltage spikes

D. Regulates service voltage to within ±5% of nominal

15. Per NEC 300.5, the minimum burial depth for rigid metal conduit (RMC) is?

A. 24 inches

B. 18 inches

C. 6 inches

D. 12 inches

16. When conductors of different voltage systems share the same raceway, they must?

A. All be insulated for the maximum voltage present in the raceway

B. Be separated by a grounded metal barrier

C. Only share raceways if below 300V

D. Be color-coded differently but need no additional insulation rating

17. The maximum overcurrent protection for 12 AWG copper conductors per NEC 240.4(D) is?

A. 25A

B. 20A

C. 15A

D. 30A

18. Type USE cable is rated for?

A. Underground use only, 60°C

B. Indoor wet locations only

C. Underground service entrance applications and direct burial

D. Above-ground outdoor use only

19. The purpose of a equipment bonding jumper in a conduit system is to?

A. Carry normal load current between panels

B. Provide a neutral return path for unbalanced loads

C. Connect conduit sections to maintain continuity of the grounding path

D. Ensure continuity of the equipment grounding path around concentric knockouts and across conduit connections

20. A "snap switch" used as a motor disconnect must be rated at least?

A. 115% of motor FLA

B. 125% of motor FLA

C. 200% of motor FLA

D. Equal to the motor branch circuit fuse rating only

21. Per NEC 210.19(A), branch circuit conductors must have an ampacity of at least?

A. 100% of the continuous load plus 100% of the non-continuous load

B. 125% of the continuous load plus 100% of the non-continuous load

C. 80% of the overcurrent device rating

D. Equal to the overcurrent device rating only

22. A "qualified person" per OSHA 1910.399 is defined by?

A. Holding a valid state electrical license

B. Completing a minimum 4-year apprenticeship program

C. Demonstrated ability to work safely and recognize hazards for the specific work and voltage involved

D. Passing the NFPA 70E written examination

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

23. In a delta-wye transformer bank, the secondary wye neutral point is?

A. Left floating — never grounded in delta-wye transformers

B. Connected to the primary neutral

C. Bonded to the transformer tank only

D. Solidly grounded or grounded through an impedance at the transformer

24. The purpose of a lightning arrester (surge arrester) on a distribution transformer is to?

A. Clamp lightning and switching surge voltages to a safe level — protecting the transformer insulation from overvoltage failure

B. Prevent transformer inrush current during energization

C. Protect against sustained overvoltage from utility voltage regulators

D. Provide fault current interruption for the transformer primary

25. The term "available fault current" at a given point in a system refers to?

A. The rated interrupting current of the overcurrent device at that point

B. The maximum load current the bus can supply continuously

C. The minimum current needed to operate the protective relay

D. The maximum current that can flow during a bolted three-phase fault at that point — determined by source impedance

26. In a substation, a "breaker failure" (BF) protection scheme?

A. Prevents breakers from opening during light load conditions

B. Monitors breaker contact wear and schedules maintenance

C. Resets tripped breakers automatically after a programmable delay

D. Detects when a breaker fails to interrupt fault current and trips all adjacent breakers to isolate the fault

27. The purpose of a power transformer's conservator tank is to?

A. Store extra transformer oil for refilling after leaks

B. Allow transformer oil to expand and contract with temperature changes without exposing it to atmospheric moisture

C. Provide oil circulation for forced cooling

D. Collect gas generated during internal faults for analysis

28. A "zone of protection" in power system relaying refers to?

A. The physical area around a substation protected by security fencing

B. The voltage range within which a relay will not operate

C. The specific portion of the power system a protective relay is designed to detect faults within — bounded by the CTs used for that relay

D. The distance a relay can detect faults on an adjacent transmission line

29. In a grounded wye distribution system, zero-sequence current flows?

A. Only during balanced three-phase faults

B. Through the neutral conductor and ground return path during ground faults or unbalanced loading

C. Only in the delta winding of delta-wye transformers

D. In all three phases equally during normal operation

30. The purpose of a capacitor bank's discharge resistors is to?

A. Limit inrush current when the capacitor bank is energized

B. Bleed off residual charge after the capacitor bank is de-energized — preventing dangerous voltage from remaining on the terminals

C. Reduce harmonic currents generated by the capacitor bank

D. Protect the capacitor from overvoltage during switching

31. In a pilot wire differential protection scheme, the communication channel between the two line terminals?

A. Carries the tripping signal from the remote end to the local relay

B. Synchronizes the local and remote relay clocks for time-coordinated tripping

C. Transmits the remote end current magnitude and angle to the local relay for differential comparison

D. Provides backup SCADA communication if the fiber optic link fails

32. The purpose of a motor bus transfer scheme at a critical facility is to?

A. Transfer motors from one voltage class to another during load growth

B. Reduce motor starting current by pre-charging the bus

C. Automatically energize a standby power source — maintaining continuity of supply to critical motor loads when the normal source fails

D. Balance motor loads between two bus sections during normal operation

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

33. The synchronous speed of a 6-pole, 60Hz induction motor is?

A. 1,200 RPM

B. 900 RPM

C. 1,800 RPM

D. 600 RPM

34. A motor operating with a higher-than-normal supply voltage will experience?

A. Reduced magnetizing current and lower core losses

B. Increased magnetizing current, higher core losses, and potential overheating of the stator

C. Improved efficiency and lower operating temperature

D. Reduced starting torque and longer acceleration time

35. The purpose of a contactor's auxiliary contacts in a motor control circuit is to?

A. Provide overload protection for the motor during starting

B. Limit the contactor's inrush current during energization

C. Provide control circuit interlocking, seal-in functions, and status indication — separate from the main power contacts

D. Protect the contactor coil from voltage transients during dropout

36. A wound rotor induction motor's primary advantage over a squirrel cage motor is?

A. Higher efficiency at full load

B. Lower initial purchase cost

C. Simpler maintenance due to the absence of brushes

D. Adjustable starting torque and current by varying external rotor resistance

37. In a three-phase motor, voltage unbalance causes?

A. Equal heating in all three phase windings

B. Reduced motor noise and vibration only

C. Negative sequence currents that cause additional rotor heating — disproportionately large compared to the voltage unbalance percentage

D. Increased motor efficiency due to asymmetric flux distribution

38. The purpose of a motor's nameplate "ambient temperature" rating (typically 40°C) is to?

A. Define the maximum ambient temperature at which the motor can operate at full nameplate load without exceeding its insulation temperature rating

B. Specify the motor's operating temperature at full load

C. Define the coolant inlet temperature for liquid-cooled motors

D. Indicate the maximum winding temperature during starting

39. A 480V, 3-phase, wye-connected motor has a per-phase impedance of 2Ω during starting. The starting current per phase is approximately?

A. 277A

B. 480A

C. 138A

D. 240A

40. In a motor control circuit, a "normally closed" (NC) overload relay contact?

A. Opens the control circuit when the overload relay trips — removing power from the contactor coil and dropping out the main contacts

B. Closes the control circuit when the overload relay trips

C. Provides a bypass path around the overload relay during starting

D. Shorts out the overload heaters during the starting period

41. The purpose of power factor correction at a motor's terminals is to?

A. Reduce reactive current in the supply conductors — lowering conductor losses and improving voltage regulation at the motor

B. Increase the motor's mechanical output horsepower

C. Reduce the motor's starting current

D. Improve the motor's efficiency at light load

42. The NEC minimum branch circuit conductor size for a 480V, 3-phase, 30 HP motor with 40A FLA is?

A. 50A ampacity — conductors must be sized at 125% of FLA = 40 × 1.25 = 50A minimum per NEC 430.22

B. 40A ampacity equal to FLA

C. 60A ampacity for voltage drop only

D. Same as the overcurrent device rating

43. In a variable frequency drive, the DC bus voltage for a 480V input is approximately?

A. 480V DC

B. 340V DC

C. 600V DC

D. 679V DC

44. The purpose of a "bypass contactor" in a soft starter installation is to?

A. Provide a path for motor current to bypass the soft starter SCRs after the motor reaches full speed — reducing heat generation and improving efficiency during normal running

B. Allow the motor to start at full voltage if the soft starter fails

C. Limit motor current during deceleration

D. Provide regenerative braking when the motor decelerates

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

45. The polarization index (PI) test on motor insulation compares?

A. The 30-second and 60-second megohm readings

B. The 1-minute and 10-minute insulation resistance readings — a PI below 1.0 indicates failed insulation; 1.0–2.0 is questionable; above 2.0 is generally acceptable

C. The DC and AC insulation resistance values

D. The phase-to-phase and phase-to-ground resistance values

46. An infrared scan of a three-phase panelboard reveals one breaker significantly hotter than adjacent breakers at the same load. The most likely cause is?

A. The load on that circuit is drawing more current than the other circuits

B. Loose or corroded connections at the breaker terminal — increased contact resistance causing I^2R heating

C. The breaker is about to trip on thermal overload

D. The breaker has a lower trip rating than adjacent breakers

47. When performing a high-potential (hipot) test on newly installed cable, the purpose is to?

A. Measure the cable's conductor resistance

B. Verify adequate insulation quality — applying a voltage significantly above operating voltage to confirm the insulation will not fail in service

C. Test the cable's current-carrying capacity

D. Verify the cable's phase sequence

48. The purpose of testing circuit breaker trip times using primary injection is to?

A. Verify the breaker's full-load current rating

B. Confirm that the breaker's time-current characteristics match the manufacturer's published curves — ensuring proper overcurrent protection and coordination

C. Test the breaker's contact resistance at rated current

D. Verify the breaker's interrupting rating at maximum fault current

49. A three-phase motor shows high vibration at 1× RPM with consistent phase readings at all bearings. The most likely cause is?

A. Angular misalignment at the coupling

B. Rotor imbalance — 1× vibration with consistent phase at all bearing locations is the classic signature of mass imbalance

C. Mechanical looseness in the bearing housing

D. Resonance at the motor's natural frequency

50. The purpose of ultrasonic testing on electrical switchgear is to?

A. Measure the bus bar temperature under load

B. Detect partial discharge activity — high-frequency ultrasonic emissions from corona and partial discharge indicate insulation deterioration before complete failure

C. Verify contact alignment without opening the switchgear

D. Test the switchgear's arc flash energy level

51. A clamp-on power meter reads 15 kW real power, 20 kVA apparent power on a single-phase circuit. The reactive power is?

A. 5 kVAR

B. 35 kVAR

C. 25 kVAR

D. 13.2 kVAR

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

A. Verify the transformer's turns ratio matches the nameplate — confirming no shorted turns or winding damage that would change the ratio and affect voltage regulation

B. Measure the transformer's winding resistance

C. Test the transformer's core loss at rated voltage

D. Verify proper polarity of the transformer connections

53. When troubleshooting a motor that hums but fails to start, the most likely cause in a three-phase motor is?

A. Low supply voltage on all three phases

B. An open phase — single-phasing causes the motor to develop insufficient torque to start while drawing high current and humming on the two remaining phases

C. Overload relay tripped on the previous start

D. Excessive load inertia requiring a longer acceleration time

54. The purpose of an oil sample analysis (OSA) on a transformer includes all of the following EXCEPT?

A. Detecting dissolved fault gases (DGA)

B. Measuring moisture content (water in oil)

C. Assessing oil dielectric strength

D. Determining the transformer's remaining load capacity based on oil condition alone

MECHANICAL EQUIPMENT (Questions 55–63)

55. The purpose of a mechanical seal on a centrifugal pump is to?

A. Prevent cavitation at the impeller eye

B. Prevent process fluid from leaking along the pump shaft to the atmosphere — replacing the older packing gland with a lower-leakage, lower-maintenance sealing method

C. Align the pump shaft to the motor shaft

D. Protect the pump bearings from process fluid contamination

56. In a diesel engine, the purpose of the fuel injector is to?

A. Regulate fuel pressure in the common rail

B. Atomize and inject a precisely metered quantity of fuel directly into the combustion chamber at high pressure — ensuring complete combustion and proper timing

C. Filter contaminants from the fuel before combustion

D. Control engine speed by varying the fuel rack position

57. The purpose of a boiler's blowdown valve is to?

A. Vent steam pressure during emergency shutdown

B. Drain the boiler completely for annual inspection

C. Control steam flow to the turbine during startup

D. Remove concentrated dissolved solids and sludge from the boiler water — maintaining water quality within acceptable limits to prevent scale and corrosion

58. A centrifugal pump operating to the right of its best efficiency point (BEP) on the pump curve indicates?

A. The pump is delivering more flow than its design point — operating with lower head than designed, which may cause cavitation, overloading the motor, and accelerated wear

B. The pump is in a cavitation condition

C. The system resistance is higher than designed

D. The pump impeller is worn and requires replacement

59. The purpose of a pressure-reducing valve (PRV) in a steam system is to?

A. Reduce high-pressure steam to a lower, more usable pressure for downstream equipment — automatically maintaining constant downstream pressure regardless of flow demand or upstream pressure variation

B. Prevent steam pressure from exceeding the boiler's maximum allowable working pressure (MAWP)

C. Control the rate of steam flow to the turbine during startup

D. Provide overpressure protection as a backup to the safety valve

60. In a refrigeration system, the expansion valve's primary function is to?

A. Compress low-pressure refrigerant vapor to high pressure

B. Reduce refrigerant pressure from condensing pressure to evaporating pressure — causing the refrigerant to cool and partially flash, enabling it to absorb heat in the evaporator

C. Remove superheat from the refrigerant leaving the evaporator

D. Control the flow of refrigerant to the condenser

61. The purpose of a cooling tower's fill media is to?

A. Maximize the contact surface area and time between air and water — enhancing evaporative cooling by breaking water into small droplets or thin films for efficient heat and mass transfer

B. Filter biological growth and particulates from the recirculating water

C. Distribute water evenly across the tower basin

D. Reduce the velocity of air entering the tower

62. When a reciprocating compressor's unloader is energized, the effect is to?

A. Increase compressor capacity to maximum

B. Reduce motor starting current to zero

C. Bypass the suction valve — allowing the cylinder to operate without compression and reducing compressor capacity and power consumption

D. Engage the second stage of compression for higher pressure output

63. The purpose of a sight glass on a refrigeration system liquid line is to?

A. Monitor refrigerant temperature entering the expansion valve

B. Indicate the refrigerant charge level in the receiver

C. Observe refrigerant flow condition — bubbles in the sight glass indicate insufficient refrigerant charge or excessive pressure drop, while a clear glass indicates adequate liquid subcooling

D. Detect oil contamination in the refrigerant circuit

FLUID SYSTEMS (Questions 64–72)

64. In a chilled water system, the "delta T" (ΔT) across the chiller evaporator refers to?

A. The temperature difference between supply and return chilled water

B. The temperature difference between chilled water and condenser water

C. The chiller's approach temperature at the evaporator

D. The temperature rise of condenser water across the chiller

65. The purpose of a backflow preventer in a potable water system connected to a cooling tower is to?

A. Prevent cooling tower water from contaminating the potable water supply through back-siphonage or backpressure

B. Maintain minimum water pressure in the cooling tower makeup line

C. Prevent the cooling tower from draining back into the building system

D. Control the flow rate of makeup water to the cooling tower basin

66. In a variable flow hydronic system, differential pressure control of the circulation pump is used to?

A. Maintain a constant differential pressure across the most remote coil — ensuring adequate flow and control authority at all load conditions regardless of how many zone valves are open or closed

B. Limit the pump to a maximum flow rate only

C. Prevent pump cavitation at low flow conditions

D. Balance flow between multiple parallel pumps

67. The purpose of a steam separator (moisture separator) on a steam supply line is to?

A. Remove dissolved gases from the steam before it enters the process

B. Filter particulates from the steam to protect control valves

C. Reduce steam pressure before the control valve

D. Remove entrained water droplets from the steam — preventing moisture from reaching turbines, heat exchangers, or process equipment where water hammer and erosion can occur

68. In a compressed air system, a refrigerated air dryer achieves its pressure dew point by?

A. Passing air through a desiccant bed that absorbs moisture

B. Filtering water droplets with a coalescing filter element

C. Heating the air to drive off moisture before delivery

D. Cooling the compressed air to condense and drain moisture — reducing the dew point to the design value, typically 35–50°F pressure dew point

69. The purpose of a pressure/temperature (P/T) port on a hydronic system coil is to?

A. Allow permanent pressure gauges to be installed on the coil

B. Connect the coil to the building automation system for monitoring

C. Provide a fill and drain connection for the coil circuit

D. Allow pressure and temperature measurements with a portable gauge — used for balancing and troubleshooting without permanently installed instruments

70. The purpose of a boiler feedwater economizer is to?

A. Remove dissolved oxygen from the feedwater before it enters the boiler

B. Preheat feedwater using flue gas heat — recovering energy that would otherwise be lost up the stack and improving overall boiler efficiency

C. Control feedwater flow rate to the boiler drum

D. Filter suspended solids from the feedwater before it enters the boiler

71. In a centrifugal chiller, the purpose of the purge unit is to?

A. Remove oil from the refrigerant circuit during maintenance

B. Circulate refrigerant between the evaporator and condenser during off cycles

C. Filter particulates from the refrigerant before the compressor

D. Remove non-condensable gases (air and nitrogen) from the refrigerant circuit — which accumulate in the condenser, raise condensing pressure, and reduce chiller efficiency

72. The purpose of automatic air vents in a hydronic system is to?

A. Provide pressure relief if system pressure exceeds the design maximum

B. Allow system drainage during seasonal shutdown

C. Release trapped air from high points in the piping system — preventing air locks that reduce or stop flow through coils and increase pump noise and cavitation risk

D. Control the rate of system pressurization during startup

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

73. When installing conductors in conduit, the maximum total conductor fill for three or more conductors is?

A. 40% of the conduit's cross-sectional area per NEC Chapter 9

B. 53% of the conduit's cross-sectional area

C. 31% of the conduit's cross-sectional area

D. 60% of the conduit's cross-sectional area

74. The purpose of a cable pulling lubricant (wire pulling compound) is to?

A. Reduce conductor resistance after installation

B. Prevent conductor insulation damage during long pulls — reducing friction forces that could exceed the cable's maximum pulling tension and cause insulation damage or conductor stretching

C. Improve conductor ampacity after installation

D. Provide moisture protection at conduit entry points

75. The safe working load of a fiber rope sling is reduced when?

A. The rope is new and has not yet been broken in

B. The sling is used in temperatures below 32°F

C. The rope is used in a basket hitch configuration

D. The rope is used in high-temperature environments, around sharp edges, in chemical environments, or at sling angles below 60° from horizontal — all of which require derating the WLL

76. The purpose of anti-vibration mounts under a generator set is to?

A. Prevent generator vibration from transmitting to the building structure and isolate the generator from building-borne vibration

B. Level the generator on uneven floor surfaces

C. Protect the generator from seismic activity

D. Reduce generator noise by dampening the enclosure panels

77. When cutting rigid metal conduit (RMC) with a pipe cutter, the cut end must be?

A. Reamed to remove the internal burr — a sharp internal edge can damage conductor insulation during pulling

B. Painted with corrosion protection immediately after cutting

C. Heated to relieve stress in the conduit material

D. Measured and verified with a micrometer before threading

78. The purpose of a ground rod in an electrical grounding system is to?

A. Provide a low-impedance fault current path for equipment ground faults

B. Serve as the primary overcurrent protection for the grounding system

C. Establish an electrical connection to the earth — providing a reference potential and a path for dissipating lightning energy and static charges into the soil

D. Bond the neutral conductor to the equipment ground at all panelboards

79. When using a hydraulic pipe bender for EMT conduit, the correct procedure is to?

A. Select the correct shoe for the conduit size, mark the desired bend point, align the mark with the bender's arrow, apply steady pressure, and verify the angle with a level or protractor

B. Apply maximum hydraulic pressure in a single stroke for a clean bend

C. Heat the conduit before bending to prevent kinking

D. Make all bends before cutting the conduit to final length

80. The purpose of a conduit body (LB, LL, LR, T) in a conduit system is to?

A. Provide a larger radius pull point — making conductor pulling easier at direction changes and providing an access point for future conductor replacement

B. Serve as a junction box for splicing conductors

C. Provide mechanical protection at conduit entry to equipment

D. Allow thermal expansion of the conduit at building expansion joints

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Under OSHA's Bloodborne Pathogen Standard (29 CFR 1910.1030), the hierarchy of controls requires employers to first?

A. Provide PPE to all employees with occupational exposure

B. Train employees on bloodborne pathogen hazards annually

C. Establish an exposure control plan and implement engineering controls

D. Eliminate or substitute the exposure hazard through the use of safer medical devices and engineering controls — before relying on work practice controls or PPE

82. The EPA's Tier II reporting threshold for extremely hazardous substances (EHS) under EPCRA Section 312 is?

A. 500 lbs or the threshold planning quantity (TPQ), whichever is less

B. 1,000 lbs regardless of the chemical

C. The threshold planning quantity (TPQ) only

D. 500 lbs or the TPQ, whichever is lower — facilities must report EHS quantities above this threshold to the SERC, LEPC, and local fire department annually

83. The purpose of a facility's Stormwater Pollution Prevention Plan (SWPPP) under the EPA's NPDES industrial stormwater permit is to?

A. Identify potential pollutant sources, implement best management practices (BMPs) to prevent pollutants from contacting stormwater, and establish inspection and monitoring procedures to ensure BMP effectiveness

B. Treat all stormwater to secondary treatment standards before discharge

C. Eliminate all outdoor chemical storage at the facility

D. Provide emergency response procedures for chemical spills only

84. Under OSHA 29 CFR 1910.146, a permit-required confined space differs from a non-permit confined space in that it?

A. Contains or has the potential to contain a serious safety or health hazard — such as a hazardous atmosphere, engulfment hazard, internal configuration that could trap an entrant, or any other recognized serious hazard

B. Is located below grade only

C. Requires more than one worker to enter simultaneously

D. Has limited or restricted means of entry or exit only

85. The primary health hazard from exposure to hydrogen sulfide (H_2S) in sewage systems and confined spaces is?

A. Chronic respiratory disease from repeated low-level exposure only

B. Rapid olfactory fatigue at concentrations above 100 ppm — workers lose the ability to smell the gas and may be overcome by lethal concentrations without warning

C. Skin and eye irritation from direct contact with the liquid

D. Long-term liver damage from metabolic conversion

86. The purpose of a facility's chemical inventory threshold under OSHA PSM (1910.119) is to?

A. Trigger OSHA inspection requirements for all listed chemicals

B. Determine which processes require a full Process Hazard Analysis — facilities must conduct PHA only for processes with listed chemicals above the threshold quantity

C. Establish the maximum allowable storage quantity for listed chemicals

D. Require annual chemical inventory audits by a third-party consultant

87. Under the Clean Air Act Section 112(r), the purpose of a Risk Management Plan (RMP) is to?

A. Identify hazards of processes using regulated substances above threshold quantities, assess the potential consequences of accidental releases, and document prevention and emergency response programs — submitted to the EPA and made available to local emergency planners

B. Control routine air emissions from combustion equipment

C. Manage worker exposure to regulated air contaminants inside the facility

D. Satisfy state air permit requirements for criteria pollutants

88. OSHA's Respiratory Protection Standard (1910.134) requires fit testing to be performed?

A. Only when a new respirator model is issued to the employee

B. Every two years for all respirator users

C. Initially before the employee uses a tight-fitting respirator in the workplace and annually thereafter — or whenever a different facepiece is used or conditions change that may affect the fit

D. Only after a respiratory exposure incident has occurred

89. The purpose of a facility's written emergency action plan (EAP) under OSHA 1910.38 is to?

A. Establish procedures for employee actions during emergencies — including evacuation routes, assembly points, accounting for personnel, rescue and medical duties, and the means of reporting fires and other emergencies

B. Satisfy fire insurance requirements for sprinkler system inspection

C. Document hazardous material storage locations for emergency responders

D. Establish procedures for hazardous waste disposal during emergency conditions

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

90. Under NFPA 70E, energized electrical work is justified only when?

A. The worker is wearing appropriate arc-rated PPE for the task

B. De-energizing introduces additional hazards or is infeasible due to equipment design or operational limitations — and written authorization is obtained

C. The circuit voltage is below 120V

D. The work can be completed in less than 15 minutes

91. The arc flash boundary is defined as the distance at which?

A. A worker without arc-rated PPE would receive a second-degree burn (1.2 cal/cm² incident energy) from an arc flash event — workers inside this boundary must wear arc-rated PPE

B. Voltage becomes dangerous to qualified workers

C. The shock hazard boundary begins for unqualified workers

D. Arc flash incident energy drops below 4 cal/cm²

92. When a worker discovers an energized conductor on the floor of a building, the correct immediate action is to?

A. Keep all personnel away from the area, establish a safety perimeter, notify supervision and the utility or facility electrical department, and do not attempt to move the conductor without confirmed de-energization

B. Use a wooden stick to move the conductor to a safe location

C. Step over the conductor carefully and continue to the electrical room

D. Cover the conductor with a rubber mat and post a warning sign

93. The purpose of OSHA's General Duty Clause (Section 5(a)(1)) in the context of electrical safety is to?

A. Define minimum training requirements for qualified electrical workers

B. Specify the minimum PPE requirements for electrical work

C. Establish jurisdiction over electrical contractors working on construction sites

D. Require employers to provide a workplace free from recognized hazards likely to cause death or serious physical harm — covering electrical hazards not specifically addressed by existing OSHA standards

94. The first step in responding to a cardiac arrest witnessed in the workplace is to?

A. Begin chest compressions immediately

B. Call 911 (or activate the facility emergency response system) and retrieve the nearest AED — then begin CPR if the victim is unresponsive and not breathing normally

C. Perform rescue breathing before chest compressions

D. Check for a pulse for a full 60 seconds before beginning CPR

95. Under NFPA 70E, the limited approach boundary for shock protection of a 480V exposed energized conductor is?

A. 12 inches

B. 42 inches — unqualified persons may not cross the limited approach boundary without being escorted and continuously supervised by a qualified person

C. 6 feet

D. 3 feet 6 inches

96. The purpose of a safety watch (fire watch) during and after hot work is to?

A. Monitor the work area during hot work and for at least 30–60 minutes after completion — extinguishing any smoldering fires that could develop into a structural fire after the hot work crew has left the area

B. Ensure the hot work permit has been properly completed before work begins

C. Verify the hot work equipment is in good condition before use

D. Monitor worker fatigue during extended hot work operations

97. When CPR is being performed on a victim of electrical shock, the rescuer should?

A. Stop CPR only if the victim shows obvious signs of life

B. Switch chest compression duties with another rescuer every 2 minutes to maintain effective compression depth and rate — rescuer fatigue significantly reduces CPR quality after 2 minutes

C. Continue CPR without interruption until professional medical help arrives — never switching rescuers

D. Stop CPR after 10 minutes if the victim does not respond

98. The purpose of NFPA 110 for stationary engineers is to?

A. Specify electrical wiring methods for emergency generator installations

B. Establish performance requirements for emergency and standby power systems — including installation, testing, maintenance, and operational requirements for systems that must operate reliably during normal power failures

C. Define arc flash protection requirements for generator rooms

D. Provide minimum training requirements for generator operators

99. The required frequency of load bank testing for a Level 1 emergency generator system per NFPA 110 is?

A. Monthly at no load to verify starting reliability

B. Annually — at least 30% of the nameplate kW rating for a minimum of 30 minutes, or as required to prevent wet stacking

C. Quarterly at 50% load minimum

D. Every two years at full nameplate load rating

100. The single most important action a stationary engineer can take to prevent electrical injuries in the workplace is to?

A. Ensure all electrical equipment is de-energized and in an electrically safe work condition before performing maintenance, inspection, or repair — making energized work the rare, documented exception rather than routine practice

B. Wear the highest available arc flash PPE rating for all electrical tasks

C. Verify arc flash labels are installed on all electrical equipment

D. Complete annual NFPA 70E electrical safety training

PRACTICE EXAM 14 — ANSWER KEY AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: A — 5A: $Z = \sqrt{(12^2 + 16^2)} = \sqrt{(144 + 256)} = \sqrt{400} = 20\Omega$. $I = V \div Z = 100 \div 20 = 5A$.

2. Correct Answer: B — Coulomb: The coulomb is the SI unit of electrical charge. One ampere equals one coulomb of charge passing a point per second.

3. Correct Answer: B — 13A: $I_1 = 24/6 = 4A$, $I_2 = 24/12 = 2A$, $I_3 = 24/4 = 6A$. Total current = 4 + 2 + 6 = 12A.

4. Correct Answer: D — The voltage and current phasors: The power factor angle θ is the phase angle between the voltage and current phasors. PF = cos θ, where θ = 0° for purely resistive and 90° for purely reactive circuits.

5. Correct Answer: C — 83.3A: Full-load secondary current = kVA ÷ V_secondary = 10,000 ÷ 120 = 83.3A. The lower voltage secondary always carries the higher current in a step-down transformer.

6. Correct Answer: A — Directly proportional to voltage and inversely proportional to resistance: Ohm's Law: I = V ÷ R. Doubling voltage doubles current; doubling resistance halves current in a linear circuit.

7. Correct Answer: B — Carries the unbalanced current between the two 120V legs: The neutral carries only the difference in current between the two 120V legs. With perfectly balanced loads, neutral current is zero; with all load on one leg, neutral current equals that leg's current.

8. Correct Answer: A — 50.3 Hz: $f_r = 1 \div (2\pi\sqrt{LC}) = 1 \div (2\pi\sqrt{(0.1 \times 100 \times 10^{-6})}) = 1 \div (2\pi \times 0.003162) = 1 \div 0.01987 \approx 50.3$ Hz.

9. Correct Answer: B — The phasor combination of resistance and reactance: $Z = \sqrt{(R^2 + X^2)}$: Impedance is the total opposition to AC current flow, combining resistive and reactive components as a phasor sum. It is measured in ohms and determines both the magnitude and phase angle of the current.

10. Correct Answer: A — 21.2 kW: $P = \sqrt{3} \times V \times I \times PF = 1.732 \times 480 \times 30 \times 0.85 = 21{,}178W \approx 21.2$ kW.

11. Correct Answer: B — Has internal resistance causing terminal voltage to drop under load: A real source has internal resistance (r) in series with the ideal EMF — terminal voltage $V_t = EMF - (I \times r)$. The higher the load current, the greater the voltage drop across the internal resistance.

12. Correct Answer: A — Proportional to the rate of change of magnetic flux: EMF = −N(dΦ/dt): Faraday's Law states induced EMF is proportional to the rate of flux change and the number of turns. The negative sign (Lenz's Law) indicates the induced EMF opposes the change that caused it.

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

13. Correct Answer: A — 100A: NEC 230.79(C) requires a minimum 100A, 3-wire service for single-family dwellings. This minimum ensures adequate capacity for modern electrical loads including HVAC, appliances, and EV charging.

14. Correct Answer: C — Diverts transient overvoltages to ground — protecting downstream equipment: SPDs clamp voltage transients from lightning and switching surges by conducting heavily above their clamping voltage, diverting surge energy to ground before it reaches sensitive equipment. Type 1 SPDs are installed at the service entrance; Type 2 at distribution panels.

15. Correct Answer: C — 6 inches: NEC Table 300.5 requires only 6 inches of cover for RMC — the steel conduit itself provides mechanical protection equivalent to deeper burial required for less protected wiring methods such as direct burial cable (24 inches) or PVC conduit (18 inches).

16. Correct Answer: A — All conductors must be insulated for the maximum voltage present in the raceway: NEC 300.3(C)(1) permits conductors of different systems in the same raceway only if all conductors are insulated for the maximum voltage present. This prevents insulation breakdown between conductors of different voltage levels.

17. Correct Answer: B — 20A: NEC 240.4(D) limits overcurrent protection for 12 AWG copper to a maximum of 20A regardless of calculated ampacity. This is an absolute NEC maximum — a 12 AWG conductor on a 25A or 30A breaker is a code violation.

18. Correct Answer: C — Underground service entrance applications and direct burial: Type USE cable is specifically designed and listed for underground service entrance use and direct burial. Its insulation is moisture-resistant but not rated for interior exposed wiring — it must transition to a listed interior wiring method above grade.

19. Correct Answer: D — Ensure continuity of the equipment grounding path around concentric knockouts and across conduit connections: Equipment bonding jumpers bypass high-resistance connections in the conduit system — ensuring the EGC path remains low impedance for fault current to operate the overcurrent device quickly. NEC 250.96 and 250.102 govern bonding requirements.

20. Correct Answer: C — 200% of motor FLA: NEC 430.110(A) requires motor disconnects to be rated at least 115% of motor FLA for most motors. However, a snap switch used as a motor disconnect must be rated at least 200% of motor FLA per NEC 430.110(B) due to the switch's lower continuous duty rating compared to a horsepower-rated disconnect.

21. Correct Answer: B — 125% of the continuous load plus 100% of the non-continuous load: NEC 210.19(A)(1) requires branch circuit conductors to be sized at 125% of continuous loads (loads expected

to last 3 hours or more) plus 100% of non-continuous loads. This accounts for the additional heating from sustained current flow.

22. Correct Answer: C — Demonstrated ability to work safely and recognize hazards for the specific work and voltage involved: OSHA 1910.399 defines qualification by knowledge and ability — not credentials alone. A person may be qualified for some tasks and voltages but not others; the employer is responsible for determining qualification for each specific work assignment.

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

23. Correct Answer: D — Solidly grounded or grounded through an impedance at the transformer: In a delta-wye transformer, the wye secondary neutral is the system grounding point — it is connected to earth ground at the transformer to establish the system voltage reference. This is the source of the separately derived system ground required by NEC 250.30.

24. Correct Answer: A — Clamp lightning and switching surge voltages to protect transformer insulation: Distribution surge arresters are connected phase-to-ground directly at the transformer terminals — the shortest possible lead length minimizes the voltage added by lead inductance during surge events. Their sparkover and clamping voltage must be well below the transformer's basic insulation level (BIL).

25. Correct Answer: D — The maximum current that can flow during a bolted three-phase fault at that point: Available fault current is determined by the total source impedance from the utility through all transformers and conductors to the point of interest. All equipment at that point — breakers, fuses, bus bars — must be rated to safely interrupt or withstand this current.

26. Correct Answer: D — Detects when a breaker fails to interrupt fault current and trips all adjacent breakers: Breaker failure protection (ANSI 50BF) starts a timer when a trip signal is issued to a breaker. If fault current is still detected after the timer expires (typically 6–10 cycles), the BF relay trips all breakers connected to the same bus section, isolating the fault by removing all sources feeding the failed breaker.

27. Correct Answer: B — Allow transformer oil to expand and contract with temperature changes without moisture exposure: As transformer oil temperature rises under load, it expands — the conservator provides a reservoir that accommodates this volume change. A breather with silica gel desiccant prevents atmospheric moisture from entering the oil as the conservator breathes during cooling.

28. Correct Answer: C — The specific portion of the power system a protective relay is designed to detect faults within: Each protective relay has a defined zone bounded by its associated CTs. Faults inside the zone operate the relay; faults outside should not. Overlapping zones between adjacent protection systems ensure no portion of the system is left unprotected.

29. Correct Answer: B — Through the neutral conductor and ground return path during ground faults or unbalanced loading: Zero-sequence current is equal in magnitude and in phase in all three

conductors — it has no path to flow in a balanced, ungrounded system. In a grounded wye system, it flows through the neutral and ground return, making it detectable by zero-sequence (ground fault) CTs.

30. Correct Answer: A — Bleed off residual charge after the capacitor bank is de-energized: NEC 460.6 requires capacitors to discharge to 50V or less within 1 minute after disconnection. Discharge resistors provide a controlled discharge path — preventing dangerous voltage from remaining on capacitor terminals after switching, which could electrocute workers or damage equipment upon reconnection.

31. Correct Answer: A — Carries the tripping signal from the remote end to the local relay: In a pilot wire differential scheme, the communication channel (copper pilot wire, fiber, or microwave) carries current or signal information from each terminal to the other. Both ends compare currents — if differential current exceeds the threshold, both ends trip simultaneously, providing high-speed protection for the entire line section.

32. Correct Answer: A — Automatically energize a standby power source maintaining continuity to critical motor loads: A motor bus transfer scheme detects loss of the normal source and either fast-transfers (closed transition, in-phase) or residual-voltage-transfers (open transition, after residual voltage decays) the motor bus to the standby source — minimizing the interruption to critical process motors.

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

33. Correct Answer: A — 1,200 RPM: Synchronous speed Ns = 120 × f ÷ P = 120 × 60 ÷ 6 = 1,200 RPM. A 6-pole motor has three pole pairs — each requiring one-third of a revolution per electrical cycle.

34. Correct Answer: B — Increased magnetizing current, higher core losses, and potential stator overheating: Higher voltage increases core flux density beyond the design point, driving the core into saturation and dramatically increasing magnetizing current and core (iron) losses. NEMA MG1 permits ±10% voltage variation from nameplate; operation above this range risks overheating.

35. Correct Answer: C — Provide control circuit interlocking, seal-in functions, and status indication: Auxiliary contacts mirror the main contact state and are used in control circuits for seal-in (holding the contactor energized after the start button is released), interlocking with other contactors (forward/reverse), and providing run status signals to PLCs and annunciators.

36. Correct Answer: D — Adjustable starting torque and current by varying external rotor resistance: Adding resistance to the wound rotor circuit increases starting torque (up to maximum torque) while reducing starting current — ideal for high-inertia loads. The resistance is reduced in steps as the motor accelerates, ultimately short-circuiting the rotor for full-speed operation.

37. Correct Answer: C — Negative sequence currents causing additional rotor heating disproportionate to the voltage unbalance: A 3.5% voltage unbalance can cause 25% or more current unbalance — negative sequence currents produce a counter-rotating flux in the rotor that induces high-frequency rotor currents, causing significant additional heating. NEMA MG1 requires motor derating when voltage unbalance exceeds 1%.

38. Correct Answer: A — Maximum ambient temperature at which the motor can operate at full nameplate load without exceeding insulation temperature rating: The 40°C ambient rating means the motor's thermal design assumes a 40°C maximum surrounding air temperature. In higher ambients, the motor must be derated — less load current to keep total winding temperature within the insulation class limit.

39. Correct Answer: C — 138A: Phase voltage = 480 ÷ √3 = 277V. Starting current = V_phase ÷ Z = 277 ÷ 2 = 138.5A ≈ 138A per phase.

40. Correct Answer: B — Opens the control circuit when the overload relay trips — removing power from the contactor coil: The NC overload contact is wired in series with the contactor coil in the control circuit. When the overload relay trips, this contact opens, de-energizing the coil and dropping out the main power contacts — disconnecting the motor from the supply.

41. Correct Answer: A — Reduce reactive current in the supply conductors — lowering conductor losses and improving voltage regulation: Capacitors at the motor terminals supply the motor's magnetizing (reactive) current locally — the reactive component of line current upstream of the capacitors is eliminated, reducing I^2R losses and voltage drop in the supply conductors and transformer.

42. Correct Answer: A — 50A ampacity — conductors must be sized at 125% of FLA = 40 × 1.25 = 50A minimum per NEC 430.22: NEC 430.22 requires motor branch circuit conductors to have an ampacity of at least 125% of motor FLA. For 40A FLA: 40 × 1.25 = 50A minimum ampacity required.

43. Correct Answer: D — 679V DC: The DC bus voltage of a VFD equals the peak of the AC input voltage: V_DC = V_AC(rms) × √2 = 480 × 1.414 = 679V DC. This is why VFD-connected motor insulation must withstand voltage spikes above the nominal 480V supply.

44. Correct Answer: D — Allows motor current to bypass the soft starter SCRs after reaching full speed — reducing heat generation: Once the motor reaches full speed, the bypass contactor closes, connecting the motor directly to the supply and bypassing the SCRs. This eliminates continuous SCR losses and heat generation during normal running — extending soft starter life significantly.

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

45. Correct Answer: B — Compares the 1-minute and 10-minute insulation resistance readings: PI = IR_{10}min ÷ IR_{1}min. A PI below 1.0 indicates failed insulation; 1.0–2.0 is questionable; above 2.0 is generally acceptable per IEEE 43. Good insulation continues to polarize over time, producing a steadily rising resistance curve.

46. Correct Answer: B — Loose or corroded connections at the breaker terminal causing I^2R heating: A single hot breaker with adjacent breakers normal isolates the problem to that breaker's connections or contacts. Increased resistance from loose terminals or corroded contact surfaces generates localized heat proportional to I^2R — detectable with thermal imaging before failure occurs.

47. Correct Answer: B — Verify adequate insulation quality by applying voltage above operating level: A hipot test stresses the insulation beyond normal operating voltage to reveal weak spots, voids, or contamination that would cause premature in-service failure. The test voltage and duration are specified by IEEE 400 or the cable manufacturer's acceptance criteria.

48. Correct Answer: B — Confirm the breaker's time-current characteristics match published curves: Primary injection testing passes actual current through the breaker's trip unit to verify it trips at the correct time for various overcurrent levels. Results are plotted against the manufacturer's TCC to confirm the breaker will coordinate properly with upstream and downstream protective devices.

49. Correct Answer: B — Rotor imbalance — 1× vibration with consistent phase at all bearings: Imbalance produces a centrifugal force rotating at shaft speed (1×) that is felt equally at all bearing locations with consistent phase angle. Angular misalignment produces 2× axial vibration with 180° phase shift across the coupling; looseness produces multiple harmonics with erratic phase.

50. Correct Answer: A — Detect partial discharge activity indicating insulation deterioration: Partial discharge in switchgear insulation produces ultrasonic emissions in the 20–100 kHz range. Directional ultrasonic probes can locate the source within the switchgear without opening energized equipment — enabling condition-based maintenance before insulation failure causes a fault.

51. Correct Answer: D — 13.2 kVAR: $Q = \sqrt{(S^2 - P^2)} = \sqrt{(20^2 - 15^2)} = \sqrt{(400 - 225)} = \sqrt{175} = 13.2$ kVAR. The power triangle relationship $S^2 = P^2 + Q^2$ applies to all AC circuits.

52. Correct Answer: A — Verify the transformer's turns ratio matches the nameplate: A TTR test confirms the actual turns ratio equals the nameplate ratio within ±0.5%. Shorted turns reduce the effective turns count on one winding, changing the ratio — detectable by TTR testing before the transformer is energized after installation or repair.

53. Correct Answer: B — An open phase — single-phasing causes humming and failure to start: With one phase open, the motor develops a pulsating (not rotating) magnetic field — insufficient torque to start but enough to create audible humming and draw high current on the remaining two phases. Single-phasing at rest causes rapid winding damage if not cleared quickly.

54. Correct Answer: D — Determining remaining load capacity based on oil condition alone: Oil sample analysis provides DGA results, moisture content, dielectric strength, acid number, and interfacial tension — all indicators of oil and insulation condition. However, oil condition alone cannot determine remaining load capacity; electrical testing, thermal modeling, and load history are also required.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: B — Prevent process fluid from leaking along the pump shaft to atmosphere: A mechanical seal uses precision-lapped rotating and stationary faces maintained in contact by a spring — eliminating the continuous drip leakage inherent in packing glands. Mechanical seals require a clean flush fluid and proper face lubrication to achieve long service life.

56. Correct Answer: B — Atomize and inject a precisely metered quantity of fuel at high pressure into the combustion chamber: Modern common rail injectors operate at pressures above 20,000 PSI, producing fine fuel atomization for complete combustion. Injection timing, duration, and pressure are controlled by the engine ECM to optimize combustion efficiency and emissions across all load conditions.

57. Correct Answer: D — Remove concentrated dissolved solids and sludge from boiler water: As boiler water evaporates to steam, dissolved minerals concentrate — eventually causing scale deposits on heat transfer surfaces and carryover into the steam. Regular blowdown (continuous surface blowdown and intermittent bottom blowdown) removes concentrated water and settled sludge, maintaining water quality within ABMA guidelines.

58. Correct Answer: A — The pump is delivering more flow than its design point — operating with lower head than designed: Operating to the right of BEP means the system resistance is lower than designed — the pump over-flows, potentially causing cavitation at the impeller eye (suction recirculation), motor overloading, and accelerated wear from hydraulic imbalance forces.

59. Correct Answer: A — Reduce high-pressure steam to a lower, more usable pressure for downstream equipment: A PRV uses a sensing element and modulating valve to maintain constant downstream pressure regardless of upstream pressure variation or downstream flow demand. It is not a safety device — the safety valve provides overpressure protection if the PRV fails.

60. Correct Answer: B — Reduce refrigerant pressure from condensing pressure to evaporating pressure: The expansion valve is the metering device that creates the pressure drop between the high-pressure and low-pressure sides of the refrigeration system. The resulting pressure reduction causes partial flashing and temperature drop, enabling the refrigerant to absorb heat from the conditioned space in the evaporator.

61. Correct Answer: A — Maximize contact surface area and time between air and water for efficient evaporative cooling: Fill media breaks recirculating water into thin films or small droplets, dramatically increasing the air-water contact surface area. Modern PVC fill provides high thermal performance with low pressure drop and resistance to biological fouling compared to older wood splash fill designs.

62. Correct Answer: A — Bypass the suction valve — allowing the cylinder to operate without compression: Unloaders hold the suction valve open during the compression stroke, preventing pressure buildup — the cylinder pumps air in and out without doing compression work. This reduces compressor capacity and power consumption while keeping the compressor running, enabling modulating capacity control.

63. Correct Answer: C — Observe refrigerant flow condition — bubbles indicate insufficient charge or excessive pressure drop: A clear sight glass indicates adequate liquid subcooling and sufficient refrigerant charge upstream of the expansion valve. Bubbles (flash gas) indicate the liquid line pressure has dropped below the saturation pressure for that temperature — typically from low charge, excessive pressure drop, or insufficient subcooling.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: B — The temperature difference between chilled water supply and return: Chiller ΔT = CHW return temperature − CHW supply temperature. Design ΔT is typically 10°F (44°F supply, 54°F return). Low ΔT syndrome — where actual ΔT is less than design — indicates coil fouling, control valve leakage, or excessive bypass flow, reducing chiller and pump efficiency.

65. Correct Answer: A — Prevent cooling tower water from contaminating the potable water supply: Cooling tower water contains biocides, scale inhibitors, corrosion inhibitors, and potentially Legionella bacteria. A backflow preventer (typically a reduced pressure zone (RPZ) assembly) on the makeup water connection prevents this contaminated water from back-siphoning into the potable supply under any pressure condition.

66. Correct Answer: A — Maintain constant differential pressure across the most remote coil — ensuring adequate flow at all load conditions: Variable flow pump control maintains a differential pressure setpoint at the most hydraulically remote coil, ensuring control valves throughout the system have sufficient pressure authority to modulate flow. As zone valves close, the pump slows to maintain the setpoint — saving significant pump energy.

67. Correct Answer: D — Remove entrained water droplets from steam — preventing moisture damage to downstream equipment: Steam separators use centrifugal action or impingement baffles to coalesce and drain water droplets from wet steam. Wet steam causes water hammer, erosion of valve seats and turbine blades, and reduced heat transfer efficiency in process heat exchangers.

68. Correct Answer: D — Cooling compressed air to condense and drain moisture — reducing the dew point to 35–50°F: A refrigerated dryer passes compressed air through a heat exchanger cooled by a small refrigeration circuit, condensing water vapor which is then drained automatically. The resulting pressure dew point of 35–50°F prevents moisture condensation in most indoor compressed air distribution systems.

69. Correct Answer: D — Allow pressure and temperature measurements with a portable gauge for balancing and troubleshooting: P/T ports (Pete's plugs) are self-sealing Schrader-type valves that accept a portable pressure/temperature probe without draining the system. They are installed at coil inlets and outlets to measure actual flow conditions during system commissioning, TAB, and troubleshooting.

70. Correct Answer: B — Preheat feedwater using flue gas heat — recovering stack energy and improving boiler efficiency: An economizer is a heat exchanger in the boiler's exhaust gas path that transfers heat from flue gases to incoming feedwater. Recovering this otherwise wasted heat reduces fuel consumption — each 40°F rise in feedwater temperature improves boiler efficiency by approximately 1%.

71. Correct Answer: D — Remove non-condensable gases from the refrigerant circuit: Air and nitrogen entering the refrigerant circuit during maintenance or through leaks accumulate in the condenser, raising condensing pressure and reducing chiller efficiency. The purge unit draws off these gases and captures refrigerant rather than venting it — satisfying EPA Section 608 refrigerant recovery requirements.

72. Correct Answer: C — Release trapped air from high points in the piping system: Air locks in hydronic piping prevent water flow through coils and create noise, cavitation, and pump damage. Automatic air vents (float-operated or thermostatic) release trapped air continuously without manual intervention — critical at all high points and at the top of each riser in the system.

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

73. Correct Answer: A — 40% of the conduit's cross-sectional area per NEC Chapter 9: NEC Chapter 9, Table 1 limits total conductor cross-sectional area to 40% of conduit area for three or more conductors. This fill limit ensures conductors can be pulled without damage and provides adequate heat dissipation within the raceway.

74. Correct Answer: A — Prevent conductor insulation damage during long pulls — reducing friction forces: Wire pulling lubricant reduces the coefficient of friction between conductors and conduit walls, lowering the pulling tension required. Exceeding the cable's maximum pulling tension (typically 0.008 × CM for copper conductors) can permanently stretch conductors or damage insulation at conduit bends.

75. Correct Answer: D — High-temperature environments, sharp edges, chemical exposure, or sling angles below 60°: Fiber rope slings have significant limitations compared to wire rope or chain — heat above 180°F, UV exposure, chemical contact, and sharp edges all reduce the WLL dramatically. Sling angle reduction below 60° from horizontal increases leg tension beyond the rated WLL.

76. Correct Answer: A — Prevent generator vibration from transmitting to the building structure and isolate from building-borne vibration: Generator sets produce strong vibration at firing frequency and harmonics — without isolation mounts, this vibration transmits through the structure causing fatigue, noise complaints, and interference with sensitive equipment. Spring mounts with 90–95% isolation efficiency are typically specified for generator installations.

77. Correct Answer: A — Reamed to remove the internal burr: Pipe cutters create a sharp internal burr at the cut — conductors pulled through an unreamed conduit end can have insulation sliced, leading to ground faults or short circuits. NEC 300.16 and 358.28 require all cut conduit ends to be reamed or otherwise finished to remove rough edges before conductors are installed.

78. Correct Answer: C — Establish an electrical connection to the earth — providing a reference potential and dissipating lightning energy: Ground rods (NEC 250.52) provide the earth electrode connection for the grounding system. However, NEC 250.4 explicitly states the earth must not be used as the sole fault current return path — the equipment grounding conductor provides the low-impedance path required to clear ground faults.

79. Correct Answer: A — Select correct shoe, mark bend point, align with bender arrow, apply steady pressure, and verify angle: Hydraulic benders require the correct die (shoe) sized for the conduit's outside diameter. Consistent, controlled pressure produces clean bends without kinking — the conduit should never be heated for bending as this weakens the conduit and can damage the galvanizing or coating.

80. Correct Answer: B — Provide a larger radius pull point at direction changes and an access point for future conductor replacement: Conduit bodies (LBs, LLs, LRs, Ts) provide directional changes with larger internal radius than standard elbows, reducing conductor pulling tension. NEC 314.16(C) limits the number of conductors in conduit bodies — they are not permitted to contain splices unless specifically listed and marked for that purpose.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: D — Eliminate or substitute the exposure hazard through engineering controls before relying on PPE: OSHA 1910.1030 follows the hierarchy of controls — engineering controls (safer sharps devices, needleless systems) are required to be implemented before relying on work practice controls or PPE. This hierarchy applies broadly to all OSHA health standards, not just bloodborne pathogens.

82. Correct Answer: D — 500 lbs or the TPQ, whichever is lower: EPCRA Section 312 Tier II reporting for EHS chemicals is triggered when quantities on-site at any time during the year exceed 500 lbs or the chemical's threshold planning quantity (TPQ), whichever is lower. For non-EHS hazardous chemicals, the threshold is 10,000 lbs.

83. Correct Answer: A — Identify pollutant sources, implement BMPs, and establish inspection and monitoring procedures: An SWPPP is the facility's plan for preventing stormwater contamination under the EPA's NPDES Multi-Sector General Permit (MSGP). It must be site-specific, updated when facility conditions change, and made available to the EPA and state agency upon request.

84. Correct Answer: A — Contains or has the potential to contain a serious safety or health hazard: OSHA 1910.146 defines a permit-required confined space as one that has limited entry/exit AND contains or has the potential to contain a hazardous atmosphere, engulfment hazard, internal configuration hazard, or any other recognized serious safety or health hazard. All four conditions of a PRCS trigger the full permit entry program.

85. Correct Answer: B — Rapid olfactory fatigue above 100 ppm — workers lose the ability to smell the gas: H_2S is detectable by smell at very low concentrations (0.5–1 ppm) but causes olfactory nerve paralysis above 100–150 ppm — workers can no longer detect the odor even at lethal concentrations (above 300 ppm). OSHA's ceiling limit is 50 ppm; NIOSH's IDLH is 100 ppm.

86. Correct Answer: B — Determine which processes require a full Process Hazard Analysis: OSHA PSM threshold quantities in Appendix A trigger PHA requirements for specific processes. The PHA (HAZOP, what-if, FMEA, or checklist method) systematically identifies process hazards and recommends safeguards — it is the cornerstone of the PSM program.

87. Correct Answer: A — Identify hazards, assess release consequences, and document prevention and emergency response programs — submitted to EPA: EPA RMP (40 CFR Part 68) requires facilities with regulated substances above threshold quantities to develop and submit a Risk Management Plan

covering hazard assessment (worst-case and alternative release scenarios), prevention program, and emergency response program. RMPs are publicly available through the EPA's RMP database.

88. Correct Answer: C — Initially before use and annually thereafter — or when facepiece or fit conditions change: OSHA 1910.134(f) requires initial fit testing before the employee uses a tight-fitting respirator and annual retesting. Additional fit testing is required when the employee changes to a different facepiece size, style, or model, or when physical changes (significant weight change, dental work, facial surgery) may affect the seal.

89. Correct Answer: A — Establish procedures for employee actions during emergencies — including evacuation routes, assembly points, and personnel accounting: OSHA 1910.38 requires an EAP for any workplace where OSHA standards require emergency response. The plan must address evacuation procedures, employee roles, rescue and medical duties, means of reporting emergencies, and how employees are accounted for after evacuation.

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

90. Correct Answer: B — De-energizing introduces additional hazards or is infeasible — and written authorization is obtained: NFPA 70E 130.2(A) requires that energized electrical work be justified in writing when de-energizing is not possible. Convenience, production pressure, or time constraints are not acceptable justifications — infeasibility must be technically demonstrated.

91. Correct Answer: A — The distance at which a worker would receive a second-degree burn (1.2 cal/cm²) from an arc flash: The arc flash boundary is the distance from the arc source at which incident energy equals 1.2 cal/cm² — the onset of a second-degree burn on unprotected skin. Workers inside this boundary must wear arc-rated PPE; workers outside may still be at risk from the shock hazard.

92. Correct Answer: A — Keep all personnel away, establish a safety perimeter, and notify supervision and the electrical department: An energized conductor on the floor creates both a shock hazard (direct contact) and a step potential hazard (voltage gradient across the floor). No one should approach until the circuit is confirmed de-energized by the facility electrical department or utility — using a wooden or fiberglass stick does not eliminate the hazard.

93. Correct Answer: D — Require employers to provide a workplace free from recognized hazards likely to cause death or serious physical harm: The General Duty Clause is OSHA's "catch-all" provision — it applies when a specific OSHA standard does not cover the hazard but the hazard is recognized by the industry and poses a serious risk. It has been used to cite employers for arc flash hazards where OSHA-specific standards were not yet promulgated.

94. Correct Answer: B — Call 911 and retrieve the nearest AED — then begin CPR: Current AHA guidelines (2020) prioritize early defibrillation for shockable rhythms (VF/pVT) — the most common cause of cardiac arrest from electrical shock. Calling 911 activates the emergency response chain; retrieving the AED enables defibrillation, which is the definitive treatment for ventricular fibrillation caused by electric shock.

95. Correct Answer: B — 42 inches: NFPA 70E Table 130.4(D)(a) specifies the limited approach boundary for 480V as 42 inches from the exposed energized conductor. Unqualified persons may not cross this boundary without continuous escort by a qualified person who maintains awareness of the shock hazard at all times.

96. Correct Answer: D — Monitor the work area during and for at least 30–60 minutes after hot work completion: NFPA 51B requires a fire watch during hot work and for at least 30 minutes after — smoldering fires in hidden combustibles can develop into full fires well after the hot work is complete. The fire watch must have a charged fire extinguisher immediately available and know how to use it.

97. Correct Answer: C — Switch chest compression duties every 2 minutes to maintain effective compression quality: AHA guidelines recommend switching the compressor every 2 minutes (or 5 cycles of 30:2 CPR) to prevent fatigue-related decline in compression depth and rate. High-quality CPR (at least 2 inches deep, 100–120 compressions/minute) significantly improves survival from cardiac arrest.

98. Correct Answer: B — Establish performance requirements for emergency and standby power systems: NFPA 110 covers the installation, testing, maintenance, and operation of Type I (life safety) and Type II (standby) emergency power supply systems (EPSS). It specifies transfer times, fuel storage, periodic testing requirements, and maintenance records — directly governing generator systems stationary engineers operate and maintain.

99. Correct Answer: B — Annually — at least 30% nameplate kW for a minimum of 30 minutes: NFPA 110 Section 8.4.2 requires annual load testing at ≥30% nameplate kW for at least 30 continuous minutes. If the generator cannot be loaded to 30% from building loads, a load bank must be used. This testing prevents wet stacking and verifies the generator can accept its rated load.

100. Correct Answer: A — Ensure all electrical equipment is de-energized and in an electrically safe work condition before performing maintenance: De-energizing eliminates both the arc flash and shock hazards entirely — no PPE, label, or training program can match the protection provided by a truly de-energized system. NFPA 70E and OSHA consistently identify energized work as the root cause of the majority of electrical fatalities.