FULL-LENGTH PRACTICE TESTS

Practice Test 22: Full-Length Simulated Exam 4 — All Systems

Questions 1–50

1. A building's chilled water system uses a two-position control valve at a small air handler instead of the specified modulating valve. What operational problem does this cause?

A. The chilled water pump will lose prime and stop circulating

B. The fire alarm system will display a supervisory signal

C. The zone alternates between overcooling and undercooling because the valve can only be fully open or fully closed, providing no intermediate capacity control

D. The emergency generator will start on false demand

2. A fire alarm system serves a building with a commercial kitchen. The designer specifies rate-of-rise heat detectors in the kitchen rather than smoke detectors. What is the reason for this substitution?

A. Heat detectors avoid nuisance alarms from normal cooking activities that produce airborne particles triggering smoke detectors, while still detecting abnormal temperature increases from actual fire conditions

B. Heat detectors provide faster response than smoke detectors in all environments

C. Heat detectors are required by NFPA 72 in all commercial kitchens regardless of conditions

D. Heat detectors cost significantly less than smoke detectors

3. A building's domestic water system includes a pressure reducing valve that was set at initial installation but has never been maintained. After five years, downstream pressure has increased to 95 psi. What has occurred?

A. The municipal water supply pressure has decreased below the PRV setting

B. The PRV's internal components have worn or failed, allowing the higher upstream pressure to pass through to the downstream system

C. The expansion tank has absorbed the excess pressure successfully

D. The hot water recirculation pump has created the additional pressure

4. During commissioning, the BAS indicates that a VAV box damper is 100 percent open but the measured airflow is significantly below design. What should be investigated?

A. The fire alarm duct smoke detector downstream of the box

B. The zone thermostat battery level

C. The chilled water supply temperature at the central plant

D. The upstream duct static pressure, potential duct obstructions, damper actuator mechanical linkage, and whether the damper blade is actually in the open position

5. What is the primary purpose of NFPA 72's requirement for secondary power on fire alarm systems?

A. Reducing the building's overall electrical energy consumption

B. Providing power for the building's emergency lighting system

C. Ensuring the fire alarm system continues operating during utility power failure, maintaining detection, notification, and monitoring capability

D. Powering the fire pump during utility outages

6. A plumbing engineer specifies a heat pump water heater for a commercial building. What is the primary energy advantage of this technology?

A. Using refrigeration cycle heat transfer to heat water at two to three times the efficiency of conventional electric resistance heaters

B. Producing water temperatures above 180 degrees for sanitizing

C. Eliminating the need for any electrical connection

D. Heating water instantaneously with no storage tank required

7. A building's emergency lighting system is tested and several battery units fail to maintain illumination for the required 90 minutes. What must be corrected?

A. The fire alarm system must be reprogrammed to extend alarm duration

B. The sprinkler system flow test must be conducted before repairs

C. The building's main electrical service must be upgraded

D. The failed battery units must be replaced immediately because the building cannot meet life safety egress illumination requirements during a power failure

8. A fire protection engineer discovers that a tenant improvement project has reduced the clearance between sprinkler deflectors and the ceiling of a new dropped ceiling to 2 inches. What is the concern?

A. The sprinkler heads are now too far from the floor to detect heat

B. The reduced clearance may prevent proper spray pattern development, creating areas below the deflector that do not receive adequate water coverage

C. The sprinkler heads will activate at a lower temperature than rated

D. The fire alarm notification appliances will be blocked by the new ceiling

9. A building's BAS energy dashboard shows that the cooling plant energy has increased 20 percent year-over-year with no change in building occupancy or weather. What should be investigated?

A. The fire alarm system's annual testing schedule

B. The plumbing system's hot water delivery temperature

C. Chiller efficiency, condenser and evaporator fouling, cooling tower performance, control sequences, and whether simultaneous heating and cooling has developed

D. The emergency generator's weekly exercise fuel consumption

10. What is the primary reason the plumbing code requires vent piping on a sanitary drainage system?

A. Maintaining atmospheric pressure in the drainage system to prevent trap seal loss from siphonage and back-pressure while allowing proper gravity drainage flow

B. Providing access points for drain cleaning equipment

C. Reducing noise transmission through drainage piping

D. Allowing sewer gas to enter the building for leak detection

11. A building's electrical distribution system has no surge protective devices. What risk does this create for building equipment?

A. The emergency generator will not start during power outages

B. Sensitive electronic equipment is vulnerable to damage from transient voltage spikes caused by lightning, utility switching, and internal motor switching events

C. The fire alarm system cannot transmit signals to the monitoring station

D. The building's power factor will decrease below acceptable levels

12. A commissioning agent tests a fire alarm system's duct smoke detector and finds it does not shut down the associated air handler. What must be investigated?

A. The sprinkler system's hydraulic calculation for the affected area

B. The emergency generator's transfer switch timing sequence

C. The smoke detector's sensitivity reading on the fire alarm panel

D. The relay connection between the fire alarm panel and the AHU controller, the control programming, and the physical interlock wiring

13. A building's hot water recirculation system has no balancing valves on the return branches. What operational problem does this create?

A. Short circulation loops closest to the pump receive disproportionate flow while remote branches receive inadequate flow, resulting in poor hot water delivery to distant fixtures

B. The expansion tank pressure will exceed the relief valve setting

C. The water heater will cycle more frequently than designed

D. The cold water supply pressure will fluctuate at remote fixtures

14. What determines whether a commercial building requires a standpipe system?

A. Only the type of sprinkler system installed in the building

B. Only the building's total construction cost

C. Building height, floor area, and building code requirements based on occupancy classification

D. Only the fire alarm system's notification appliance circuit type

15. A building automation system controls both HVAC and lighting. What energy benefit does integrated scheduling provide?

A. Eliminating the need for occupancy sensors in any zone

B. Coordinating HVAC setback and lighting shutoff simultaneously when zones become unoccupied, avoiding conditions where one system operates unnecessarily while the other is off

C. Reducing the fire alarm system's electrical power consumption

D. Increasing the emergency generator's exercise frequency

16. A facility manager notices that the building's water bill has increased 30 percent with no known changes in operation. What should be investigated first?

A. The fire alarm monitoring station's monthly service charges

B. The building's electrical demand during peak cooling hours

C. The HVAC system's outdoor air economizer operation

D. Sub-meter readings, cooling tower makeup, irrigation, and domestic systems for leaks, running fixtures, failed valves, or malfunctioning equipment

17. A fire alarm system's manual pull station at a building exit is mounted at 60 inches above the floor. Does this comply with code requirements?

A. No, manual pull stations must be mounted between 42 and 48 inches above the floor per ADA accessibility requirements

B. Yes, 60 inches meets the minimum mounting height requirement

C. Yes, manual pull stations have no mounting height requirements

D. No, manual pull stations must be mounted at exactly 36 inches

18. A building's cooling tower water treatment program has been neglected for six months. What risks has this created?

A. The chiller's refrigerant charge has decreased proportionally

B. The fire sprinkler system's water supply has been contaminated

C. Scale buildup reducing heat transfer, biological growth including Legionella risk, and accelerated corrosion of tower components and condenser water piping

D. The building's domestic hot water temperature has increased

19. A building's fire-rated floor assembly has a large rectangular opening for a new stairway that was cut without installing a rated enclosure. What life safety hazard does this create?

A. The stairway will not meet the minimum width requirements

B. The exit signs above the new stairway will be too bright

C. The new stairway will require additional sprinkler heads

D. An unrated opening in the fire-rated floor allows fire and smoke to spread freely between floors, completely bypassing the floor's intended fire compartmentation

20. During commissioning, an air handler's supply fan VFD is found operating in bypass mode at constant full speed. What is the energy impact?

A. No measurable impact because bypass mode provides equivalent performance

B. Significant energy waste because the fan runs at full speed regardless of duct static pressure demand, eliminating all variable-speed energy savings

C. Improved fan performance from operating at the motor's rated speed

D. Reduced noise from the supply ductwork downstream of the fan

21. A plumbing inspector tests a backflow preventer and finds that the first check valve leaks. What must occur before the device can be returned to service?

A. Only a notation in the inspection log with no corrective action

B. Only retesting the device at a later date to confirm the reading

C. Only cleaning the exterior of the device and reinstalling the caps

D. The first check valve must be repaired or replaced and the device must pass a complete retest confirming all components function correctly

22. What is the primary purpose of a fire protection system's tamper switch on a sprinkler control valve?

A. Measuring the water flow rate through the sprinkler system

B. Detecting water temperature changes in the sprinkler piping

C. Monitoring the valve position and transmitting a supervisory signal to the fire alarm panel if the valve is moved from its normal open position

D. Activating the fire pump when system pressure drops

23. A commercial building's LED lighting system uses 0-10V dimming. During commissioning, several fixtures flicker at low dim levels. What is the most likely cause?

A. The fire alarm system is interfering with the dimming signal

B. Incompatibility between the LED driver's minimum dim level and the dimming control signal, or the driver requires a minimum load that is not being met

C. The emergency lighting battery is draining the dimming circuit

D. The building's power factor is causing harmonic distortion

24. What is the primary purpose of an owner's project requirements document in the commissioning process?

A. Establishing the building owner's expectations for system performance, efficiency, comfort, and operational requirements that serve as the benchmark for verifying all commissioned systems

B. Calculating the construction project's total budget

C. Selecting the general contractor through competitive bidding

D. Establishing the building's property tax assessment value

25. A building's fire pump runs its weekly automatic exercise but the controller displays a phase reversal alarm. What does this indicate?

A. The fire pump impeller needs replacement

B. The fire pump's suction pressure is too low for operation

C. The fire pump's jockey pump has lost prime

D. The electrical phase sequence to the pump motor is incorrect, which would cause the pump to run backward and not deliver water

26. A building's HVAC system uses demand-controlled ventilation in a large training room. The CO2 sensor reads 350 ppm during a fully occupied session. What does this low reading suggest?

A. The room is receiving exactly the correct amount of outdoor air

B. The training session has not generated any CO2 yet

C. The CO2 sensor is likely malfunctioning because a fully occupied room should produce CO2 readings well above outdoor baseline levels of approximately 400 ppm

D. The HVAC system is providing excessive heating to the room

27. A building's fire protection closeout documentation is missing the fire alarm system's record of completion. Why is this document essential?

A. It establishes the fire alarm monitoring station's annual fee

B. It is the permanent record of the installed system configuration including all devices, circuits, software, and test results required by NFPA 72 for ongoing system management

C. It calculates the building's fire insurance premium discount

D. It establishes the fire alarm contractor's warranty start date only

28. What is the primary energy benefit of an ice thermal storage system in a commercial building?

A. Shifting chiller operation from expensive peak daytime electrical rates to lower off-peak nighttime rates, reducing both demand charges and energy costs

B. Providing emergency cooling water during fire pump testing

C. Eliminating the need for any cooling tower operation

D. Maintaining indoor temperatures during extended utility outages

29. A plumbing contractor installs a water heater without the required seismic bracing in a seismically active zone. What risk does this create?

A. The water heater warranty is voided by the manufacturer

B. The water heater could topple during an earthquake, rupturing gas and water connections, creating fire hazard, flooding, and loss of hot water service

C. The water heater will produce excessive noise during operation

D. The water heater's thermal efficiency will decrease over time

30. A building's structured cabling infrastructure uses Category 6A cable throughout. What current and future capability does this provide?

A. Only telephone service up to 100 megabits per second

B. Only wireless access point power with no data capability

C. Only security camera connections with no other applications

D. Support for 10-gigabit Ethernet and Power over Ethernet, accommodating current high-bandwidth applications and providing headroom for future technology upgrades

31. A building's fire alarm system has multiple notification appliance circuits. During testing, one NAC fails to activate any devices. What should be investigated?

A. The NAC circuit wiring, panel output module, and circuit supervision to identify the fault preventing power from reaching the notification appliances

B. The sprinkler system waterflow switch on the affected floor

C. The fire pump controller's phase rotation monitor

D. The duct smoke detector locations on the affected floor

32. A facility manager wants to reduce the building's domestic hot water energy consumption. What strategy provides the greatest savings?

A. Increasing the water heater storage temperature to 160 degrees

B. Implementing hot water recirculation scheduling, pipe insulation improvements, point-of-use heaters for remote fixtures, and low-flow fixtures to reduce both heat loss and demand

C. Removing all thermostatic mixing valves from the system

D. Increasing the recirculation pump to the maximum available speed

33. During a fire drill, the voice evacuation system delivers the evacuation message to all floors simultaneously in a high-rise building. What operational problem does this create?

A. The fire alarm panel will display a trouble condition

B. The sprinkler system will activate on all floors simultaneously

C. The emergency generator will not start due to excessive load

D. All stairwells become overcrowded simultaneously because phased evacuation was not implemented, creating a more dangerous condition than the fire itself

34. A building's electrical system uses power factor correction capacitors. What primary benefit do these provide?

A. Providing backup power during momentary utility outages

B. Increasing the voltage at remote panelboards

C. Reducing reactive power demand to lower utility charges, free distribution capacity, and improve overall system efficiency

D. Protecting sensitive equipment from transient voltage spikes

35. A plumbing engineer specifies low-impact development stormwater strategies including permeable paving and bioswales. What is the primary environmental benefit?

A. Reducing stormwater runoff volume, rate, and pollutant content while promoting groundwater recharge and reducing downstream flooding and erosion

B. Increasing the building's potable water supply capacity

C. Providing fire protection water supply from collected stormwater

D. Eliminating the need for any conventional storm drainage piping

36. A fire alarm system's beam smoke detector in a warehouse atrium intermittently produces nuisance alarms. What environmental factor is the most likely cause?

A. The warehouse HVAC system is set to heating mode

B. Dust accumulation, vibration, or structural movement causing beam misalignment between the transmitter and receiver

C. The sprinkler system waterflow switch is generating false signals

D. The fire alarm panel software requires a version update

37. A building's emergency electrical system includes both NEC Article 700 emergency and Article 701 legally required standby loads. What is the key difference in power restoration timing?

A. Article 701 loads require faster restoration than Article 700 loads

B. Both articles require identical 10-second restoration timing

C. Article 700 emergency loads require power within 10 seconds while Article 701 legally required standby loads allow up to 60 seconds for restoration

D. Neither article specifies any restoration timing requirement

38. A commissioning agent reviews BAS trend data and finds that a building's boiler operates year-round including during summer months. What should be investigated?

A. The cooling tower's water treatment chemical feed rate

B. The fire alarm system's summer testing schedule

C. The building's roof insulation R-value

D. Whether reheat coils, domestic hot water, or other loads require hot water in summer, and whether the boiler schedule should be modified to eliminate unnecessary operation

39. A building's plumbing system includes a medical gas installation. What standard governs the installation, testing, and certification of medical gas piping?

A. NFPA 99 Health Care Facilities Code, requiring specific piping materials, brazing procedures with nitrogen purge, and comprehensive testing and certification by a qualified verifier

B. The International Plumbing Code general drainage provisions

C. ASHRAE Standard 62.1 ventilation requirements

D. NFPA 13 sprinkler system installation standards

40. A building's rooftop solar PV system's inverter shuts down unexpectedly during peak production. What should be investigated?

A. The fire alarm system's rooftop detection zone

B. The building's domestic hot water temperature setpoint

C. Inverter fault codes, DC input voltage and current, AC grid connection, ground fault status, and whether the rapid shutdown system was accidentally activated

D. The sprinkler system's roof-level coverage area

41. A building's fire sprinkler system serves both an office area and a restaurant kitchen. What different suppression requirements apply to the kitchen cooking area?

A. The office sprinkler system alone provides adequate protection for all areas

B. The kitchen requires only additional sprinkler heads at closer spacing

C. The kitchen cooking area requires a dedicated wet chemical hood suppression system in addition to the building sprinkler system, with fuel shutoff interlocks

D. The kitchen requires only portable fire extinguishers near cooking equipment

42. A plumbing code inspection reveals that a commercial dishwasher is connected to the potable water supply with no backflow protection. What hazard does this create?

A. The dishwasher will not operate at the correct water temperature

B. The dishwasher uses chemicals and operates under pressure conditions that could cause contaminated water to backflow into the potable supply

D. The dishwasher's drainage connection will not function

C. The dishwasher will consume excessive water during each cycle

43. A building's lighting control system includes automatic shutoff for all non-emergency lighting. What energy code requirement does this satisfy?

A. ASHRAE 90.1's requirement that all non-emergency interior lighting be automatically shut off within 30 minutes of all occupants leaving a space

B. NFPA 72's fire alarm notification appliance scheduling requirement

C. NEC Article 700's emergency lighting power requirement

D. NFPA 101's exit sign illumination continuous operation requirement

44. A fire alarm system's addressable smoke detector reports "Dirty" on the fire alarm panel display. What maintenance action is required?

A. Replacing the fire alarm control panel immediately

B. Cleaning or replacing the detector to restore proper sensitivity before it drifts out of its listed sensitivity range and either produces nuisance alarms or fails to detect smoke

C. Increasing the detector's sensitivity through panel programming

D. Only documenting the condition in the maintenance log

45. A building's chilled water system has air trapped in the upper portions of the piping. What operational problems does this cause?

A. The fire alarm system will display a trouble signal

B. The building's electrical demand will increase proportionally

C. Reduced heat transfer at coils, noise in the piping, potential pump cavitation, and system pressure fluctuations that degrade cooling performance

D. The domestic hot water temperature will decrease

46. A building's fire protection system includes both a wet-pipe sprinkler system and a pre-action system protecting different areas. What documentation must the closeout package include for each system?

A. Only the fire marshal's acceptance letter covering both systems

B. Only the general contractor's project closeout certificate

C. Only the sprinkler contractor's business license

D. Separate as-built drawings, hydraulic calculations, acceptance test reports, and O&M procedures for each system type because they have different operating characteristics and maintenance requirements

47. What is the primary purpose of life cycle cost analysis when evaluating MEP system alternatives?

A. Evaluating total cost of ownership including initial investment, operating costs, maintenance, energy consumption, and end-of-life value over the system's full useful life

B. Calculating only the initial purchase and installation cost

C. Determining only the manufacturer's warranty duration

D. Establishing only the first-year operating budget

48. A building's smoke control system uses a combination of stairwell pressurization and floor exhaust. During commissioning, the smoke exhaust fan operates but the stairwell pressurization fan does not start. What must be investigated?

A. The sprinkler system's waterflow switch alarm delay

B. The fire alarm integration command to the pressurization fan, the fan starter or VFD, the control wiring, and whether the fan's safety interlocks are preventing startup

C. The building's domestic water pressure at the top floor

D. The cooling tower's condenser water supply temperature

49. A building owner wants to improve the building's energy performance without major capital investment. What approach typically delivers the best return?

A. Replacing all windows with high-performance glazing

B. Adding a new central chilled water plant

C. Installing a complete new building automation system

D. Retro-commissioning to identify and correct operational deficiencies including scheduling errors, setpoint drift, control sequence malfunctions, and simultaneous heating and cooling

50. A plumbing engineer designs a commercial building's sanitary drainage system using cast iron piping throughout. What are the primary advantages of this material selection?

A. Lower material cost compared to all alternative piping materials

B. Superior sound attenuation reducing drainage noise transmission to occupied spaces, inherent fire resistance as a noncombustible material, and long service life in commercial applications

C. Lighter weight making installation faster than any alternative

D. Compatibility with solvent cement joining methods for rapid assembly

ANSWER KEY 22: DETAILED EXPLANATIONS — PRACTICE TEST 22 FULL-LENGTH SIMULATED EXAM 4 — ALL SYSTEMS

Questions 1–50

1. **C. The zone alternates between overcooling and undercooling because the valve can only be fully open or fully closed, providing no intermediate capacity control** — A two-position valve provides only full cooling or no cooling, causing the zone temperature to oscillate continuously above and below setpoint. A modulating valve proportionally adjusts chilled water flow to match the exact cooling demand, maintaining stable temperature control and occupant comfort.

2. **A. Heat detectors avoid nuisance alarms from normal cooking activities that produce airborne particles triggering smoke detectors, while still detecting abnormal temperature increases from actual fire conditions** — Commercial kitchens generate grease particles, steam, and combustion byproducts during normal cooking that routinely activate smoke detectors. Rate-of-rise heat detectors ignore these normal conditions but activate when the rate of temperature increase exceeds normal cooking levels, indicating an actual fire.

3. **B. The PRV's internal components have worn or failed, allowing the higher upstream pressure to pass through to the downstream system** — Pressure reducing valves contain internal springs, diaphragms, and seat components that degrade over time from mineral deposits, wear, and corrosion. Without periodic maintenance and testing, these components fail and the valve can no longer regulate pressure, allowing full upstream pressure to pass through to the building.

4. **D. The upstream duct static pressure, potential duct obstructions, damper actuator mechanical linkage, and whether the damper blade is actually in the open position** — When the BAS indicates full open but airflow is low, the investigation must verify whether the physical conditions match the electronic indication. The damper actuator linkage may be disconnected so the blade does not follow the actuator, duct obstructions may restrict flow upstream, or insufficient duct static pressure may limit available airflow.

5. **C. Ensuring the fire alarm system continues operating during utility power failure, maintaining detection, notification, and monitoring capability** — NFPA 72 requires secondary power to maintain fire alarm operation when primary utility power fails. Batteries must support 24

hours of supervisory operation plus alarm notification duration. Without secondary power, any utility interruption leaves the building entirely without fire detection and occupant notification.

6. **A. Using refrigeration cycle heat transfer to heat water at two to three times the efficiency of conventional electric resistance heaters** — Heat pump water heaters extract heat from surrounding air using a refrigeration cycle and transfer it to the stored water. This process moves existing heat rather than generating it from electricity, achieving coefficients of performance of 2.0 to 3.5 compared to the 1.0 COP of conventional electric resistance elements.

7. **D. The failed battery units must be replaced immediately because the building cannot meet life safety egress illumination requirements during a power failure** — Emergency lighting must provide a minimum average of 1 foot-candle along the means of egress for 90 minutes after power failure. Failed batteries cannot meet this duration, leaving portions of the egress path dark during an emergency. Replacement is required immediately to restore life safety compliance.

8. **B. The reduced clearance may prevent proper spray pattern development, creating areas below the deflector that do not receive adequate water coverage** — Sprinkler heads require specific clearance between the deflector and the ceiling to allow the spray pattern to develop fully. When a new ceiling reduces this clearance, the water spray cannot spread properly, creating shadow areas directly beneath the head that receive inadequate water coverage during a fire.

9. **C. Chiller efficiency, condenser and evaporator fouling, cooling tower performance, control sequences, and whether simultaneous heating and cooling has developed** — A 20 percent increase in cooling plant energy with unchanged occupancy and weather indicates system degradation. The investigation should examine chiller performance, heat exchanger fouling that reduces efficiency, cooling tower capability, control sequence accuracy, and whether heating and cooling systems are operating simultaneously and fighting each other.

10. **A. Maintaining atmospheric pressure in the drainage system to prevent trap seal loss from siphonage and back-pressure while allowing proper gravity drainage flow** — Vent piping connects the drainage system to the atmosphere, equalizing pressure throughout the system. Without venting, drainage flow creates pressure variations that can siphon water from trap seals, allowing sewer gas to enter occupied spaces. Vents also allow air to enter the system ahead of flowing water, maintaining smooth gravity drainage.

11. **B. Sensitive electronic equipment is vulnerable to damage from transient voltage spikes caused by lightning, utility switching, and internal motor switching events** — Transient voltage spikes from external lightning strikes, utility grid switching, and internal sources like motor starts and VFD switching can damage or degrade sensitive electronics. Surge protective devices at the main switchgear and branch panels clamp these transients to safe voltage levels before they reach equipment.

12. **D. The relay connection between the fire alarm panel and the AHU controller, the control programming, and the physical interlock wiring** — Duct smoke detector activation must trigger

AHU shutdown through an integration pathway between the fire alarm panel and the HVAC controls. When detection occurs but shutdown does not follow, the relay, control module, wiring, or programming that connects these two independent systems has failed and must be investigated and corrected.

13. **A. Short circulation loops closest to the pump receive disproportionate flow while remote branches receive inadequate flow, resulting in poor hot water delivery to distant fixtures** — Without balancing valves, hot water follows the path of least resistance, circulating primarily through the shortest loops near the pump. Remote branches receive minimal flow, causing water in those sections to cool below acceptable temperatures and creating long wait times and Legionella risk at distant fixtures.

14. **C. Building height, floor area, and building code requirements based on occupancy classification** — The IBC requires standpipe systems in buildings exceeding specific height thresholds, in buildings with large floor areas, and in certain occupancies such as stages and underground structures. The code establishes which class of standpipe service is required based on the building's characteristics and the intended users.

15. **B. Coordinating HVAC setback and lighting shutoff simultaneously when zones become unoccupied, avoiding conditions where one system operates unnecessarily while the other is off** — Integrated scheduling ensures both HVAC and lighting respond to occupancy changes together. Without integration, HVAC may continue conditioning unoccupied spaces after lights have been turned off, or lights may remain on in spaces where HVAC has already entered setback mode, wasting energy in both cases.

16. **D. Sub-meter readings, cooling tower makeup, irrigation, and domestic systems for leaks, running fixtures, failed valves, or malfunctioning equipment** — A 30 percent water consumption increase without operational changes indicates an unplanned source of water use. Sub-meters on major systems identify which system is responsible. Common causes include cooling tower overflow from failed fill valves, irrigation system leaks, running toilet flapper valves, or failed equipment producing continuous water flow.

17. **A. No, manual pull stations must be mounted between 42 and 48 inches above the floor per ADA accessibility requirements** — ADA and NFPA 72 require manual pull stations to be accessible to all building occupants, including those in wheelchairs. Mounting at 60 inches exceeds the accessible reach range. The station must be lowered to between 42 and 48 inches to comply with accessibility requirements.

18. **C. Scale buildup reducing heat transfer, biological growth including Legionella risk, and accelerated corrosion of tower components and condenser water piping** — Cooling tower water treatment prevents three critical problems: mineral scale that insulates heat transfer surfaces and reduces tower capacity, biological growth including Legionella bacteria that pose health

hazards from aerosolized water droplets, and corrosion that degrades tower components and condenser water piping.

19. **D. An unrated opening in the fire-rated floor allows fire and smoke to spread freely between floors, completely bypassing the floor's intended fire compartmentation** — Fire-rated floor assemblies prevent vertical fire and smoke spread between floors. Cutting a stairway opening without installing a rated stairwell enclosure creates a direct path for fire and smoke to travel from floor to floor, negating the protection the floor assembly was designed to provide.

20. **B. Significant energy waste because the fan runs at full speed regardless of duct static pressure demand, eliminating all variable-speed energy savings** — VFD bypass mode operates the fan motor at full speed by connecting it directly to the electrical supply, bypassing the variable frequency drive. Since fan energy varies with the cube of speed, even modest speed reductions provide substantial savings. Full-speed operation eliminates all part-load savings the VFD was designed to capture.

21. **D. The first check valve must be repaired or replaced and the device must pass a complete retest confirming all components function correctly** — A leaking check valve means the backflow preventer cannot reliably prevent contaminated water from flowing backward into the municipal supply. The failed component must be repaired or replaced and the entire assembly must pass a complete retest by a certified tester before returning to service.

22. **C. Monitoring the valve position and transmitting a supervisory signal to the fire alarm panel if the valve is moved from its normal open position** — Tamper switches detect any movement of the valve handle from its normal fully open position. Even a partially closed valve can significantly reduce sprinkler system performance. The supervisory signal alerts building personnel to investigate and restore the valve to its correct position immediately.

23. **B. Incompatibility between the LED driver's minimum dim level and the dimming control signal, or the driver requires a minimum load that is not being met** — LED drivers have specific minimum dim levels below which they cannot maintain stable light output. When the 0-10V control signal drops below the driver's minimum threshold, the driver oscillates between on and off states, producing visible flicker. Selecting compatible drivers or adjusting the minimum control signal resolves the issue.

24. **A. Establishing the building owner's expectations for system performance, efficiency, comfort, and operational requirements that serve as the benchmark for verifying all commissioned systems** — The OPR defines what the owner expects from building systems and serves as the standard against which all commissioning testing is measured. Without a documented OPR, the commissioning team has no defined benchmark for evaluating whether systems meet the owner's actual requirements.

25. **D. The electrical phase sequence to the pump motor is incorrect, which would cause the pump to run backward and not deliver water** — Three-phase motors require the correct phase

sequence to rotate in the designed direction. Reversed phase sequence causes the pump impeller to spin backward, producing no useful water flow. The phase reversal alarm alerts personnel that the electrical connection must be corrected before the pump can perform its fire protection function.

26. **C. The CO2 sensor is likely malfunctioning because a fully occupied room should produce CO2 readings well above outdoor baseline levels of approximately 400 ppm** — Outdoor ambient CO2 concentration is approximately 400 ppm. A reading of 350 ppm in a fully occupied room is physically impossible unless the sensor is malfunctioning. The sensor requires recalibration or replacement to accurately measure occupancy-generated CO2 for proper ventilation control.

27. **B. It is the permanent record of the installed system configuration including all devices, circuits, software, and test results required by NFPA 72** — The record of completion is NFPA 72's required permanent documentation of the entire fire alarm system installation. It records every device address, circuit configuration, software version, and acceptance test result. Without this document, future system modifications, troubleshooting, and maintenance lack the baseline reference needed for proper system management.

28. **A. Shifting chiller operation from expensive peak daytime electrical rates to lower off-peak nighttime rates, reducing both demand charges and energy costs** — Ice thermal storage produces ice during off-peak nighttime hours when electricity rates are lowest. The stored ice provides cooling during peak afternoon hours, reducing or eliminating the need to run chillers during the most expensive electrical rate periods and significantly lowering the building's measured peak demand.

29. **B. The water heater could topple during an earthquake, rupturing gas and water connections, creating fire hazard, flooding, and loss of hot water service** — Seismic bracing prevents water heaters from toppling during seismic events. An unsecured water heater can shift or fall, rupturing gas connections that create fire and explosion hazards, breaking water connections that cause flooding, and eliminating hot water service when the building needs it most for recovery operations.

30. **D. Support for 10-gigabit Ethernet and Power over Ethernet, accommodating current high-bandwidth applications and providing headroom for future technology upgrades** — Category 6A cable supports 10-gigabit Ethernet speeds over the full 100-meter horizontal distance and provides the power delivery capability needed for PoE devices. This infrastructure supports current high-bandwidth applications and provides capacity for emerging technologies without requiring recabling.

31. **A. The NAC circuit wiring, panel output module, and circuit supervision to identify the fault preventing power from reaching the notification appliances** — When an entire notification appliance circuit fails to activate, the fault lies in the circuit's power delivery path. The

investigation should trace the circuit from the panel's NAC output module through the circuit wiring to the first and subsequent devices, identifying open circuits, failed modules, or supervision faults.

32. **B. Implementing hot water recirculation scheduling, pipe insulation improvements, point-of-use heaters for remote fixtures, and low-flow fixtures** — A comprehensive approach addresses multiple sources of hot water energy waste. Recirculation scheduling eliminates overnight circulation losses. Improved insulation reduces distribution heat loss. Point-of-use heaters eliminate long pipe runs. Low-flow fixtures reduce the total volume of hot water consumed, lowering both heating and pumping energy.

33. **D. All stairwells become overcrowded simultaneously because phased evacuation was not implemented, creating a more dangerous condition than the fire itself** — High-rise phased evacuation prioritizes the fire floor and adjacent floors for immediate evacuation while other floors stand by. Simultaneous full-building evacuation overcrowds stairwells, slows evacuation to a crawl, creates panic and potential injuries, and may take longer to clear the fire floor than a properly phased approach.

34. **C. Reducing reactive power demand to lower utility charges, free distribution capacity, and improve overall system efficiency** — Inductive loads such as motors and transformers draw reactive power that increases apparent power demand without performing useful work. Power factor correction capacitors supply reactive power locally, reducing the total current flowing from the utility, lowering demand charges, and freeing distribution system capacity for productive loads.

35. **A. Reducing stormwater runoff volume, rate, and pollutant content while promoting groundwater recharge and reducing downstream flooding and erosion** — Low-impact development techniques manage stormwater at the source by infiltrating, filtering, and detaining runoff on site. Permeable paving allows water to infiltrate into the ground. Bioswales filter pollutants and slow flow velocity. Together they reduce the environmental impact of development on downstream waterways.

36. **B. Dust accumulation, vibration, or structural movement causing beam misalignment between the transmitter and receiver** — Beam smoke detectors project a light beam across large open spaces between a transmitter and receiver. Dust accumulation on the optics, building vibration from mechanical equipment, or structural movement from thermal expansion can cause gradual misalignment, reducing the received signal strength to levels that falsely indicate smoke obstruction.

37. **C. Article 700 emergency loads require power within 10 seconds while Article 701 legally required standby loads allow up to 60 seconds for restoration** — The NEC distinguishes between emergency loads that are immediately critical for life safety requiring 10-second restoration, and legally required standby loads where a brief interruption is acceptable with 60-second restoration. This distinction allows the electrical system to prioritize the most critical loads.

38. **D. Whether reheat coils, domestic hot water, or other loads require hot water in summer, and whether the boiler schedule should be modified to eliminate unnecessary operation** — Year-round boiler operation may be legitimate if the building has hot water reheat coils, domestic hot water generation from the boiler, or process loads requiring heated water in summer. The investigation should determine whether these loads exist and whether the boiler schedule can be optimized to minimize summer operation.

39. **A. NFPA 99 Health Care Facilities Code, requiring specific piping materials, brazing procedures with nitrogen purge, and comprehensive testing and certification** — Medical gas systems including oxygen, nitrous oxide, nitrogen, and vacuum require strict compliance with NFPA 99. The standard specifies Type K or L copper piping, brazing with nitrogen purge to prevent internal oxidation, and comprehensive testing including initial purity testing and final verification by a qualified medical gas verifier.

40. **C. Inverter fault codes, DC input voltage and current, AC grid connection, ground fault status, and whether the rapid shutdown system was accidentally activated** — Solar inverter shutdown can result from multiple causes including internal faults, DC input voltage outside operating range, AC grid anomalies, ground fault detection, or inadvertent rapid shutdown activation. The inverter's fault code display provides the first diagnostic information identifying the specific cause.

41. **C. The kitchen cooking area requires a dedicated wet chemical hood suppression system in addition to the building sprinkler system, with fuel shutoff interlocks** — Commercial kitchen cooking equipment presents unique fire hazards from cooking oils and grease that require wet chemical suppression specifically designed for these fire types. The building's standard sprinkler system provides general area protection, but the hood suppression system provides targeted protection at the cooking surfaces with automatic fuel and electrical shutoff.

42. **B. The dishwasher uses chemicals and operates under pressure conditions that could cause contaminated water to backflow into the potable supply** — Commercial dishwashers use cleaning chemicals and sanitizing agents that would contaminate the potable supply if backflow occurred. The pressurized fill cycle and potential cross-connection with chemical injection systems create conditions where contaminated water could be forced backward into the potable piping without proper backflow protection.

43. **A. ASHRAE 90.1's requirement that all non-emergency interior lighting be automatically shut off within 30 minutes of all occupants leaving a space** — ASHRAE 90.1 requires automatic shutoff controls for all non-emergency interior lighting to prevent lights from remaining on in unoccupied spaces. This control can be accomplished through occupancy sensors, scheduling systems, or a combination of both, ensuring lighting energy is not wasted when spaces are unoccupied.

44. **B. Cleaning or replacing the detector to restore proper sensitivity before it drifts out of its listed sensitivity range** — Addressable smoke detectors that report dirty status have accumulated contamination on their sensing chambers that is affecting sensitivity. The detector must be cleaned per the manufacturer's instructions or replaced to restore proper sensitivity before it drifts far enough to produce nuisance alarms or fail to detect actual smoke conditions.

45. **C. Reduced heat transfer at coils, noise in the piping, potential pump cavitation, and system pressure fluctuations that degrade cooling performance** — Trapped air in chilled water piping creates air pockets that insulate coil surfaces and reduce heat transfer, produce gurgling and banging noises, cause pump cavitation as air bubbles collapse at the impeller, and create pressure fluctuations that destabilize control valve operation.

46. **D. Separate as-built drawings, hydraulic calculations, acceptance test reports, and O&M procedures for each system type** — Wet-pipe and pre-action systems have fundamentally different operating characteristics, maintenance requirements, and testing procedures. Each system requires its own complete documentation set so the operations team can properly manage, test, and maintain each system according to its specific requirements.

47. **A. Evaluating total cost of ownership including initial investment, operating costs, maintenance, energy consumption, and end-of-life value over the system's full useful life** — Life cycle cost analysis provides a comprehensive financial comparison that considers all costs and benefits over the equipment's entire service life. This methodology frequently reveals that higher-efficiency options with greater initial cost deliver lower total ownership cost through energy savings and reduced maintenance.

48. **B. The fire alarm integration command to the pressurization fan, the fan starter or VFD, the control wiring, and whether the fan's safety interlocks are preventing startup** — When one smoke control fan operates but another does not, the investigation must trace the complete activation pathway for the non-functioning fan. The fire alarm integration command, relay or control module, fan starter, VFD, control wiring, and safety interlocks such as duct pressure switches or motor overloads should all be verified.

49. **D. Retro-commissioning to identify and correct operational deficiencies including scheduling errors, setpoint drift, control sequence malfunctions, and simultaneous heating and cooling** — Retro-commissioning delivers the highest return on investment for energy improvement because it corrects operational deficiencies using existing equipment. Typical findings include equipment running on incorrect schedules, setpoints that have drifted from design values, and control sequences that have been overridden, all correctable at minimal cost.

50. **B. Superior sound attenuation reducing drainage noise transmission to occupied spaces, inherent fire resistance as a noncombustible material, and long service life in commercial applications** — Cast iron's dense material mass significantly reduces drainage noise compared to plastic piping, an important consideration in commercial buildings with occupied spaces below or

adjacent to drainage piping. Its noncombustible nature provides inherent fire resistance, and its proven durability delivers decades of reliable service in commercial applications.