G|PRO

ELECTRICAL SYSTEMS

TEST YOURSELF QUESTIONS: Answer Key

CHAPTER 1: Sustainability in Electrical Systems

1. **What are the benefits of sustainability in green building design?**

   The benefits of sustainability in green building design are:

   - New and better jobs.
   - Lower operating costs.
   - Improved indoor environmental quality and health of building occupants.
   - Reduction in carbon emissions linked to climate change.

   (see page 2)

2. **What is peak demand and under what circumstances is it most likely to occur?**

   Peak demand or peak load is the maximum power (measured in kW) drawn during a given time period (usually 1 month). Peak load is most likely to occur on the hottest days of the summer when the most air conditioners are in use *(see page 5)*.

3. **What is the difference between site energy and source energy, and how are they related to electricity usage?**

   The amount of energy delivered to a building is described as the site energy. The site energy is the total amount of fuel used directly in the building. However, the amount of useful electrical energy actually delivered to a building is typically about one-third of the amount of energy used to generate it! The other two-thirds are lost mostly in wasted heat at the generating plant, with a small amount of energy also lost in transmission. The amount of energy in the fuel used to generate the electricity is called the source energy. Figuring out a building's source energy use gives us a better indication of its overall environmental impact by measuring the amount of fossil fuels burned to produce the energy used at the building *(see pages 6-7)*.

4. **What are the codes and standards related to green building and what are their functions?**

   ANSI/ASHRAE/IESNA Standard 90.1–2010, Energy Standard for Buildings Except Low-Rise Residential Buildings and the *International Energy Conservation Code (IECC)* are independently prepared, widely adopted, and aimed at lowering energy consumption. Standard 90.1 has been made significantly more rigorous, aiming for extremely efficient buildings as standard construction by 2030 *(see page 10)*.

5. **What is ENERGY STAR and how does it relate to the LEED rating system?**

   The U.S. Green Building Council's Leadership in Energy and Design (LEED) rating system establishes criteria for minimizing the environmental footprint of buildings and neighborhoods. The U.S. EPA and DOE created the ENERGY STAR label, which is granted to products in the upper range of performance in their category. When incorporated into a building, ENERGY STAR equipment and products can often help the project achieve certain LEED credits. The U.S. EPA and DOE have also established the ENERGY STAR for New Homes Program, similar

to LEED for Homes, as a rating system for residential buildings of three stories or less *(see page 11)*.

CHAPTER 2: Lighting

1. **What is a lumen, what is a foot-candle, and how are they related?**
    - A lumen is the basic unit of visible light emitted from a source.
    - A foot-candle is a measure of illuminance, which is the amount of light falling on a surface.
    - A foot-candle is the illuminance on a one square foot surface on which one lumen is uniformly distributed.

    (see page 14)

2. **What is Lighting Power Density (LPD)?**

    The lighting power density (LPD) is the maximum electrical power allowed per square foot for lighting. It is specified by energy codes for different types of spaces *(see page 17)*.

3. **Lamps with a lower color temperature produce light of what color?**

    Lamps with lower color temperatures, 2700K – 3500K, produce yellower or visually "warmer" light (*see page 18)*.

4. **How are magnetic ballasts different from electronic ballasts?**

    Magnetic ballasts were used from the 1940s until the 1990s and included an iron-core transformer operating at 60 Hz and a set of resistors to limit the current once an arc was initiated. They are quite inefficient and were often made using a toxic transformer oil containing PCBs. Modern electronic ballasts are based on transistorized circuitry and create very high frequency AC current within the ballast. This allows the transformer to be smaller and lighter, and eliminates visible flicker *(see page 23)*.

5. **What type of lamps are discharge lamps and how do they work?**

    Fluorescent, metal halide and sodium vapor lamps are discharge lamps. Fluorescent lamps work by using an electric arc in mercury vapor to generate mostly blue and ultraviolet light inside the glass tube. The light is converted to a visible spectrum including reds and greens by the use of phosphors on the inside surface of the glass tube. Like fluorescent lamps, metal halide lamps utilize a high-intensity discharge in mercury vapor, but they also include argon and halide salts to provide color control. Sodium vapor lamps utilize an electrical discharge in sodium vapor to produce light *(see pages 22-24)*.

6. **What are some installation tips for occupancy sensors?**

    Some installation tips for occupancy sensors are:
    - Location is very important. Pay attention to placement: Avoid lights going off while a space is occupied; install PIR sensors at least 4 to 6 feet away from HVAC air diffusers and other heat sources; do not mount sensors in locations that may be blocked by door swings; be aware that the range of some ceiling mounted sensors can be diminished by up to 50% in areas with partitions/cubicles.
    - Occupancy sensors are not appropriate for metal halide lamps.
    - Well-designed installations will include sensor placement in all drawings so the installer does not have to improvise. If specifications or locations are not provided, ask for them.

- Beware of in-rush (high start-up currents) when using occupancy sensors with fluorescent lighting.
- Some devices have minimum load requirements.

(see page 29)

7. **What are vacancy sensors and how do they compare to occupancy sensors?**

   Vacancy sensors operate very much like occupancy sensors with the distinction that a person must manually turn the lights on, and the sensors will turn them off after a set period of no detected motion in the space. Vacancy sensors save more energy than occupancy in appropriate spaces *(see page 30)*.

CHAPTER 3: Heating and Cooling

1. **How is using a VFD on a motor efficient? What is an important issue to keep in mind when wiring a VFD?**
   - Variable frequency drives (VFDs) are systems that control the speed of AC induction motors. Varying the speed of your motors allows the equipment to match the actual load required for pumps, fans, and other machinery more closely.
   - Remember, VFDs are programmable and have within them a tiny computer that can remember schedules and responses to control wires. If power to the VFD is cut off, in many cases the computer will forget its program. When power is restored, it will start up with a default program or remain "always on," eliminating all efficiency benefits. The VFD's internal on/off controls should always be used – an external on/off switch should never be connected to the power supply of a VFD.

   (see pages 40-41)

2. **What are the effects of using oversized pumps, motors, or control valves?**

   Using oversized pumps, motors, or control valves leads to the installation of more expensive equipment, excessive energy consumption, a lifetime of inefficiency, and higher operational costs *(see pages 40-43)*.

3. **How do heat pumps work?**

   A heat pump moves heat from one location (the source) at a lower temperature to another location called the heat sink at a higher temperature using mechanical work, generally supplied by an electric motor. The device operates by passing refrigerant through a heat exchanger called the evaporator, where the heat required to boil it into a vapor is taken from the fluid in which the evaporator is immersed, either air or water. Cooled air or water is the result of this process *(see page 44)*.

4. **What are some of the capabilities of building management and information systems?**

   Some of the capabilities of building management and information systems are:
   - Scheduling timely operation of equipment, including start times, stop times, and the optimization of start-up sequences.
   - Controlling of parameters, including temperature, pressure, and humidity.
   - Controlling fans and pumps to regulate the flow of air and water.
   - Responding to fire alarm system operations.
   - Alarming and providing building operators with notifications.

   (see page 49)

CHAPTER 4: Distributed and Renewable Energy Generation

1. **Give examples of central, distributed, renewable energy and nonrenewable energy generation.**
    - Central: Large generation stations powered by coal, natural gas, nuclear power, or hydropower
    - Distributed: Rooftop photovoltaics, gas-fired cogeneration, and small local wind turbines
    - Renewable energy: Solar energy, tidal power
    - Nonrenewable energy: Fossil fuels

    (see pages 51-52)

2. **Why is a secure disconnect system needed for a distributed generator?**

    A secure disconnect system is needed for a distributed generator because it can be dangerous if the grid has gone down and the distributed source continues to generate electricity, as the power could electrocute workers attempting to restore power. A secure disconnect ensures that even if the building continues to generate power, none of it should feed back to the affected grid *(see page 53)*.

3. **What should you consider when determining the most cost-effective size of a building's cogeneration system?**

    When determining the most cost-effective size of a building's cogeneration system, you should consider:
    - The difference in cost between gas and electricity (the so-called "spark spread") – the more expensive electricity is relative to gas, the more cost-effective cogen is.
    - Annual operating hours – the more hours a system is in operation, the more cost-effective cogen is.
    - System output vs. system capacity – the more the system operates at or near full capacity, especially on the waste heat side, the more cost-effective cogen is.
    - Initial cost – the more difficult (and thus costly) the installation, the less cost-effective cogen is.

    (see page 55)

4. **What does a fuel cell produce?**

    A fuel cell produces electricity, heat, and water by an electrochemical reaction (not combustion) of hydrogen and oxygen *(see page 59)*.

5. **What is the relationship between maximum voltage and maximum power in photovoltaic panels?**

    A typical PV cell or panel will generate the highest voltage when no current is being drawn. Conversely, it will produce the largest current when the output terminals are connected to each other through a zero-resistance ammeter, a device used to measure the electric current *(see page 61)*.

6. **What type of power is generated in a PV cell and how is it used in a building?**

    The power generated in a PV cell is DC, but the power used in most buildings is AC. This means that the panels have to be connected to an inverter to convert the DC power to AC power *(see page 62)*.

7. **What are some factors to consider when determining the most effective location of a wind turbine?**

   Some factors to consider when determining the most effective location of a wind turbine are:

   - It makes sense to put a wind generator where wind speeds are highest in order to maximize generated energy, and placement makes a big difference in output.
   - Wind turbines are substantially less cost-effective in cities, even though the wind on top of buildings is higher than at street level. There are concerns about the impact of accidental machine failure in dense areas.
   - The impact of additional stresses on existing buildings is an important consideration.

   (see page 67)

CHAPTER 5: Assuring Building Performance

1. **What are the responsibilities of the CxA?**

   Commissioning is a process needed to ensure the different systems within a building do not interfere with each other and that all controls operate correctly. The CxA is responsible for the process from beginning to end. The CxA creates a detailed Cx plan, inspects and tests all key areas of installation, and confirms all systems work together properly *(see page 73)*.

2. **Name 2 steps that should be taken prior to the start of field testing.**

   Prior to the start of field testing:

   - For the success of a test program, the test data needs to be complete, organized, and readily available. Forms will be provided by the CxA that detail the test procedure, sequence, instrument, required data, and most importantly, acceptable test values for each result.
   - It is recommended that the construction team set up a meeting to review these forms with the CxA prior to the start of testing. During this meeting, a review of the general chronological list of what will happen on the test day should occur.

   (see pages 73-74)

3. **Why would a CxA plan for deferred testing?**

   There will be some building systems that cannot be tested until the building is actually occupied and being used under design conditions. In this case, the CxA will plan deferred testing, which will be completed during the post-occupancy period *(see page 77)*.

4. **What is a proper comparison to estimate the energy and water consumption savings in a new building?**

   The approach generally taken for new construction is to compare the energy and water consumption of the new building to what the consumption would have been had the building been constructed using standard techniques, without any efficient devices or fixtures *(see page 78)*.

CHAPTER 6: Job Management

1. **Describe some scenarios where inter-trade coordination is critical for building performance.**

   Some scenarios where inter-trade coordination is critical for building performance include:

   - Floor penetrations.

- Underfloor distribution of HVAC and wiring.
- Start-up, troubleshooting, and commissioning of building management systems (BMS).
- Collaboration in finding acceptable low VOC materials.

(see page 85)

2. What should every worker on a green building job understand?

Every worker on a green building job should understand the following:

- Safety should never be compromised. All OSHA regulations must be enforced.
- This is a green and sustainable building project. Special conditions will apply.
- Applicable rating systems, such as LEED and ENERGY STAR.
- Strategies for conservation of important resources such as water, energy, and materials.
- The importance of good indoor air quality.
- Everyone on the team needs to work together.

(see page 87)