

**THE CEM BODY OF KNOWLEDGE AND STUDY GUIDE**  
**Preparation for the CEM Certification Exam**



The CEM Certification Exam is a four-hour open book exam. The examination questions are based on the Body of Knowledge listed below. Because of the diversity of background and experience of Energy Managers, the examination has 15 different subject sections, all of which are included in the exam. You must bring a hand calculator to the exam as the CEM exam does not allow computers, tablets, or cell phones to be used during the test.

It is highly recommended that you review the complete Study Guide and answer the Exam Review questions included in the Study Guide to determine your readiness for the exam.

**The CEM Examination contains the following mandatory subjects:**

<b>Body of Knowledge</b>	<b>Percent of Exam</b>
Codes and Standards	3%-5%
Energy Accounting and Economics	6%-10%
Energy Audits and Instrumentation	8%-12%
Electrical Power Systems and Motors	9%-13%
HVAC Systems	9%-13%
Industrial Systems	6% -8%
Building Envelope	3%-5%
CHP Systems and Renewable Energy	4%-6%
Fuel Supply and Pricing	2%-4%
Building Automation and Control Systems	7%-11%
Thermal Energy Storage Systems	2%-4%
Lighting Systems	6%-8%
Boiler and Steam Systems	3%-5%
Maintenance and Commissioning	8%-12%
Energy Savings Performance Contracting and Measurement & Verification	3%-5%

# STUDY GUIDE

## CERTIFIED ENERGY MANAGERS (CEM® EXAM)

### Online Self-Evaluation Exam Also Available

CEM Applicants have access to an online version self-evaluation CEM exam. The 65-question multiple choice self-evaluation exam simulates half the certification test, contains a two hour time limit, and covers seventeen sections. There is a **\$50 fee** to take this online test and you may access the full details at:

Direct Link: [www.aeecenter.org/cem/selfevaluation](http://www.aeecenter.org/cem/selfevaluation)

Get a sense of how to time questions. The actual exam time allotted is 4 hours for 130 questions. You will need to complete the 65-question self-evaluation exam in 2 hours. At the end of the exam, you will receive a sections report that lets you know what sections you passed and failed. You will not be able to see the specific questions that you answered wrong/right or the answers.

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The following is a list of the subjects for the CEM exam. Each subject covers a number of topics. Following the list of topics are suggested references with chapter numbers or sections. The primary references are the Handbook of Energy Engineering, 7<sup>th</sup> by D. Paul Mehta and Albert Thumann, the Energy Management Handbook, 9<sup>th</sup> Edition by Stephen Roosa, Steve Doty and Wayne C. Turner and Guide to Energy Management, 8<sup>th</sup> Edition by Barney L. Capehart, Wayne C. Turner and William J. Kennedy. However, some other books are also referenced as appropriate.

The study guide will not lead you to answers to all of the questions, but it will certainly lead you to a very large number of correct answers. A person with the necessary experience who reviews the study guide should not have any problem passing the exam.

The exam will: be open book, last four hours, and have 130 questions to answer. Of the 130 questions, 120 are scored and 10 randomly located questions are trial questions being prepared for possible use on future exams. The 10 trial questions do not count toward the examinee's score. The trial questions are randomly located and are not identified. Therefore, all 130 questions should be answered. There are 15 sections listed below from which questions mainly are drawn.

## BODY OF KNOWLEDGE: STUDY GUIDE TOPICS & REFERENCES

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### I. CODES AND STANDARDS

\*20XX stands for current year of standard

ASHRAE/IESNA Standard 90.1-20XX	Certified, Silver, Gold, and Platinum
ASHRAE Standard 90.2-20XX	Water Efficiency
ASHRAE Standard 62.1 -20XX	Materials and Resources
ASHRAE Standard 135-20XX	ENERGY STAR Rating
ASHRAE Standard 189.1- 20XX	Energy Star Label
ASHRAE Guideline 14-20XX	LEED Certification
ASHRAE Standard 211-20XX	Energy and Atmosphere
IEEE PQ Standard 519	Indoor Environmental Quality
International Energy Conservation Code (IECC)	Portfolio Manager
ISO 50001	Green Globes
Green Buildings	ASHRAE Green Guide
Sustainable Design	

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 1.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 18 & 20.  
REF: **ASHRAE 62.1 2004 and 2007 Standard**  
REF: **United States Green Building Council**, website with **LEED v3 and LEED Rating Systems presentations**, [www.usgbc.org](http://www.usgbc.org)  
REF: **ENERGY STAR Building & Plants**, **ENERGY STAR website**, [www.energystar.gov](http://www.energystar.gov)  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 18

## II. ENERGY ACCOUNTING AND ECONOMICS

Simple Payback Period	Life Cycle Cost Method
Time Value of Money	Interest Formulas and Tables
Present Worth	Project Life
Net Present Value	Annual Cost Method
Present Worth Method	Economic Performance Measures
After Tax Cash Flow Analysis	Depreciation Methods
Internal Rate of Return	Impact of Fuel Escalation Rates
Energy Accounting	Energy Reporting
Point of Use Costs	Efficiency Measures

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 2.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 4.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 4.

## III. ENERGY AUDITS AND INSTRUMENTATION

Role of Audits	Combustion Analyzers
ASHRAE Level 1, 2, 3 Audit	Electric Metering
Audit Equipment	Temperature Measurement
Energy Management Measures	Pressure Measurement
Combustion Analysis	Humidity Measurement
Power Factor	Energy and Power Measurement
Basic Thermodynamics	HHV and LHV
Air Velocity Measurement	Energy Cost Index
Light Level Measurement	Rate Structure & Analysis
Infrared Equipment	ASHRAE Standard 211-20XX
Fuel Choices	Flow Measurement
Energy Use Index	Heat Measuremet
Load Factors	Behavioral Modification

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 3.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 3.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 2.

## IV. ELECTRICAL POWER SYSTEMS AND MOTORS

Demand and Energy	AC Induction Motors
Real Power	DC Motors
Power Factor	Load Factor and Slip
Rate Structure and Analysis	Motor Speed Control
Variable Speed Drives	Fan and Pump Laws
Power Quality	Motor Selection Criteria
Grounding	Motor Management Software
Load Factors	AC Synchronous Motors
Reactive Power	High Efficiency Motors
Three Phase Systems	Variable Frequency Drives
Peak Demand Reduction	Variable Flow Systems
Motors and Motor Drives	New vs. Rewound Motors
Affinity Laws (Pump and Fan Laws)	Electronically Commutated Motors
Harmonics	

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4.

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 11.

REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 5 & 7.

## V. HVAC SYSTEMS

Heating, Ventilating, and Air Conditioning (HVAC)	HVAC Economizers
Affinity Laws	Air Distribution Systems (Reheat, Multizone, VAV)
Psychrometric Chart	Chillers
HVAC Equipment Types	Energy Consumption Estimates
Degree Days	Absorption Cycle
Heat Transfer	Air and Water Based Heat Flow
Vapor Compression Cycle	Demand Control Ventilation
Cooling Towers	Smart Pumps
Variable Refrigerant Flow	Chilled Beam Systems
Performance Rating (COP, EER, kW/ton)	

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 7 & 8.

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 10.

REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 8.

## VI. INDUSTRIAL SYSTEMS

Waste Heat Recovery	Air Compressor Controls
Industrial Energy Management	Boilers and Thermal Systems
Steam Systems	Fuel Choices
Heat Exchangers	Steam Tables
Turbines	Compressors
Compressed Air Systems	Pumps and Pumping Systems

Air Compressors  
Air Leaks  
Prime Power options

Peaking Power options  
District Heating Systems

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 5, 6 & 12.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 5, 6 & 8.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 14.

## VII. BUILDING ENVELOPE

Thermal Resistance  
Insulation  
Solar Heat Gain  
Thermally Light Facilities  
Conduction Heat Loads  
Heat Transfer

Heat Transfer Coefficients  
Vapor Barriers  
Solar Shading  
Thermally Heavy Facilities  
Psychrometric Chart

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 7.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 9 & 15.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 13.

## VIII. CHP SYSTEMS and RENEWABLE ENERGY

Topping Cycles  
Combined Cycles  
Prime Movers  
Regulations  
Combined Heat and Power  
HHV and LHV  
Solar, Wind, Biomass, and Hydropower  
Solar Thermal and Solar Photovoltaic Systems  
Bottoming Cycles

Fuel Selection  
Operating Strategies  
Codes and Standards  
Distributed Generation  
Thermal Efficiencies  
Wind Energy Systems  
Heat Recovery Steam Generators  
Micro-Grids  
Battery Storage

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 9.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 7.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 15 & 16

## IX. FUEL SUPPLY AND PRICING

Procurement of Natural Gas  
Electricity as a Commodity  
Procurement of Oil  
Supply and Demand Impact on Pricing

Evaluating Supply Options  
Selection of Energy Supplier in a Deregulated Market  
Fuel Price Risks  
Trends in Deregulation

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 1.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 23 & 24.

## X. BUILDING AUTOMATION AND CONTROL SYSTEMS

Energy Management Strategies	PID Controls
Basic Controls	Signal Carriers
Open Protocol Systems	Direct Digital Control
Power Line Carriers	Central Control
Distributed Control	Reset Controls
Optimization Controls	Communication Protocols
Building Control Strategies	Artificial Intelligence
Expert Systems	Energy Information Systems
Self-Tuning Control Loops	Web Based Systems
TCP/IP	Impact of proprietary controls on integration
BAS Energy Management Systems	Internet Of Things (IOT)
Terminology	Cloud based Systems

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4 & 10.

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 12.

REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 11 & 17.

## XI. THERMAL ENERGY STORAGE SYSTEMS

Design Strategies	Advantages and Limitations
Storage Media	Ice Storage
Chilled Water Storage	Volume Requirements
Sizing	Partial Storage Systems
Full Storage Systems	Phase Change Materials (PCM)
Operating Strategies	Thermal Storage for Heating

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 19.

## XII. LIGHTING SYSTEMS

Light Sources	Strike and Restrike
Lamp Life	Footcandles
Lumens	Inverse Square Law
Zonal Cavity Design Method	Room Cavity Ratios
Coefficient of Utilization	Light Loss Factors
Lamp Lumen Depreciation	Lighting Controls
Dimming	Color Rendering Index
Color Temperature	Reflectors
Visual Comfort Factor	Ballast Factor
Ballasts	IES Lighting Standard
Lighting Retrofits	Luminaire Specific Lighting Controls
Efficiency and Efficacy	

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4.

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 13.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 6.

### **XIII. BOILER AND STEAM SYSTEMS**

Combustion Efficiency	Air to Fuel Ratio
Excess Air	Boiler Economizers
Steam Traps	Steam Leaks
Condensate Return	Boiler Blowdown
Waste Heat Recovery	Flash Steam
Scaling and Fouling	Turbulators
HHV and LHV	Condensing Boilers

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 6.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 5 & 6.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 9 and 10.

### **XIV. MAINTENANCE AND COMMISSIONING**

#### **MAINTENANCE**

Combustion Control	Steam Traps
Steam Leaks	Outside Air Ventilation
Insulation	Scheduled Maintenance
Group Relamping	Proactive Maintenance
Preventive Maintenance	Water Treatment
Boiler Scale	Behavioral Modification
Compressed Air Leaks	

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 11.  
REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 14.  
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 12 & 20.

#### **COMMISSIONING**

Purpose of Commissioning	Benefits of Commissioning
Need for Commissioning	Commissioning New Buildings
Retro-Commissioning	Real Time and Continuous Commissioning
Phases of Commissioning	Commissioning Agent
Commissioning Documentation	Facility Design Intent
Measurement in Support of Commissioning	Re-commissioning

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 26

### **XV. ENERGY SAVINGS PERFORMANCE CONTRACTING and MEASUREMENT AND VERIFICATION**

Measurement and Verification Protocols	Utility Financing
Energy Service Companies	Demand Side Management

Savings Determination

Risk Assessment

Loans, Stocks and Bonds

Energy Savings Performance Contracting (ESPC)

Shared Savings Contracts

Contracting and Leasing

Utility Energy Services Contract (UESC)

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 13.

REF: Roosa, Doty and Turner, **Energy Management Handbook**, Chapter 25 & 27.



## EXAM REVIEW QUESTIONS (Sample Only)

*Some of these review questions may be more complex or difficult than the exam but will be good practice problems.*

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1. What is the basis for Commercial Building Codes by most states?
  - A. ASHRAE 90.2
  - B. ASHRAE 90.1
  - C. ASHRAE 62.2
  - D. ASHRAE 60.1
  
2. ASHRAE Standard 55 has rules for:
  - A. Ventilation for acceptable indoor air quality
  - B. Energy standard for buildings except low rise residential buildings
  - C. Thermal environmental conditions for human occupancy
  - D. All the above
  
3. If electricity is selling for \$0.06 per kilowatt-hour and is used for electric heating with an efficiency of 90%, what is the equivalent price of natural gas per therm if it can be burned with an efficiency of 80%?
  - A. \$1.33/therm
  - B. \$1.47/therm
  - C. \$1.56/therm
  - D. \$1.65/therm
  - E. \$1.780/therm
  
4. An energy saving device will save \$25,000 per year for 8 years. How much can a company pay for this device if the interest rate (discount rate) is 15%?
  - A. \$10,000
  - B. \$77,000
  - C. \$112,000
  - D. \$173,000
  
5. What would be used to find hot spots or phase imbalances in an AC circuit?
  - A. Ohmmeter
  - B. Infrared Camera
  - C. Wattmeter
  - D. All of the above
  
6. An audit for one firm showed that the power factor is almost always 70% and that the demand is 1000kW. What capacitor size is needed to correct power factor to 90%?
  - A. 266 kVAR
  - B. 536 kVAR
  - C. 618 kVAR
  - D. 1000 kVAR

7. The amount of reactive power that must be supplied by capacitors to correct a power factor of 84% to 95% in a 400 HP motor at 75% load and 98% efficiency is
- A. 72.4 kVAR
  - B. 82.5 kVAR
  - C. 90.04 kVAR
  - D. 92.4 kVAR
  - E. 123.5 kVAR
8. Power factor correcting capacitors may be located
- A. At the inductive load
  - B. At load control centers
  - C. At the customer side of the service transformer
  - D. All of the above
9. You find that you can replace a 50 HP motor with a 5 HP motor by cutting the total air flow requirements. Both motors operate at full load. Calculate the total dollar savings, given the information below: {Hint: savings of 45 HP}
- |                       |                   |
|-----------------------|-------------------|
| Runtime:              | 8,760 hours/year  |
| Motor Efficiency:     | 90% (both motors) |
| Electrical Rate:      | \$9.00/kW/mo      |
|                       | \$0.05/kWh        |
| Fuel Cost Adjustment: | \$0.005/kWh       |
- A. \$22,000
  - B. \$18,798
  - C. \$15,650
  - D. \$12,710
  - E. \$9,874
10. An absorption system with a COP of 0.8 is powered by hot water that enters at 200 F and exits at 180 F at a rate of 25 gpm. The chilled water operates on a 10 F temperature difference. Calculate the Chilled water flow. You do not need to know how an absorption chiller works to solve this problem. Use  $COP = q_{out}/q_{in}$ .
- A. 10 gpm
  - B. 20 gpm
  - C. 40 gpm
  - D. 45 gpm
  - E. 50 gpm
11. 10,000 cfm of air leaves an air handler at 50 F; it is delivered to a room at 65 F. No air was lost in the duct. No water was added or taken away from the air in the duct. How many BTU/hr was lost in the ductwork due to conduction?
- A. 162,000 BTU/hr
  - B. 126,550 BTU/hr
  - C. 75,000 BTU/hr
  - D. 42,550 BTU/hr
  - E. 10,000 BTU/hr

12. An investment tax credit of 10% for a **single project** (Not the company) at a large company:
- A. Reduces the company's overall taxes by 10%
  - B. Increases depreciation rate by 10%
  - C. Effectively reduces first cost of the project by 10%
  - D. A and C
13. Air at 69 F dry bulb and 50% relative humidity flows at 6750 cubic feet per minute and is heated to 90 F dry bulb. How many BTU/hr is required in this process?
- A. 50,000 BTU/hr
  - B. 75,000 BTU/hr
  - C. 152,000 BTU/hr
  - D. 310,000 BTU/hr
14. Estimate the seasonal energy consumption for a building if its design-heating load has been determined to be 350,000 BTU/hr for a design temperature difference of 70 F. This means that the Building Load Coefficient,  $U \times A$ , equals 5000. The heating season has 3,500-degree days. The heating unit efficiency is 80%. Assume 1 MCF =  $10^6$  BTU.
- A. 625 MCF/year
  - B. 525 MCF/year
  - C. 420 MCF/year
  - D. 356 MCF/year
  - E. 225 MCF/year
15. A wall has a total R-value of 15. Determine the annual cost of the heat loss per square foot in a climate having 5,000 heating degree-days. The heating unit efficiency is 70% and the fuel cost is \$5.00/million BTUs.
- A. \$0.057/yr/ft<sup>2</sup>
  - B. \$0.040/yr/ft<sup>2</sup>
  - C. \$0.0312/yr/ft<sup>2</sup>
  - D. \$0.0201/yr/ft<sup>2</sup>
16. A 10,000 square foot building consumed the following amounts of energy last year. What is the Energy Use Index of the building in BTU per square foot per year?
- Natural Gas 5,000 therms/year
  - Electricity 60,000 kWh/year
- A. 7,500 BTU/square foot/yr
  - B. 18,000 BTU/square foot/yr
  - C. 31,500 BTU/square foot/yr
  - D. 70,500 BTU/square foot/yr
  - E. 700,000 BTU/square foot/yr

17. Assuming that adding 2 inches of fiberglass insulation drops the U-value of a building from 0.24 to 0.098, calculate the annual cooling savings per square foot from the data given below:
- 2,000 cooling degree days; Cooling COP = 2.5; Electrical cost \$0.05/kWh
- A. \$0.010/ft<sup>2</sup>-yr
  - B. \$0.025/ft<sup>2</sup>-yr
  - C. \$0.040/ft<sup>2</sup>-yr
  - D. \$0.195/ft<sup>2</sup>-yr
  - E. \$0.202/ft<sup>2</sup>-yr
18. How much fuel is wasted if 100 pounds per hour of condensate at 30 psia saturated liquid is drained to the sewer and is made up with water at 60 F. Assume the boiler is 80% efficient and ignore blowdown effects.
- A. 12,090 BTU/hr
  - B. 15,200 BTU/hr
  - C. 18,000 BTU/hr
  - D. 23,850 BTU/hr
  - E. 29,800 BTU/hr
19. Select the equipment best suited to efficient **air-to-air heat exchange and humidity** control in the HVAC system of a large office building:
- A. Heat pipe
  - B. Radiation recuperator
  - C. Rotary sensible heat wheel
  - D. Shell and tube heat exchanger
  - E. Run around heat exchanger loop
20. Chilled water reset increases chiller efficiency and succeeds because it \_\_\_\_\_ .
- A. Restarts the system.
  - B. Raises the water temperature leaving the chiller.
  - C. Lowers the water flowrate through the chiller.
  - D. Stops water flow to zones with no occupancy.
21. The difference between the setting at which the controller operates to one position and the setting at which it changes to the other is known as the:
- A. Throttling range
  - B. Offset
  - C. Differential
  - D. Control Point
22. An all-electric facility pays \$100,000 annually for energy. The compressed air system has energy costs of \$20,000 per year. The system air pressure can be lowered by 10 psi. Approximately how much will be saved annually?
- A. \$20,000
  - B. \$10,000
  - C. \$5,000
  - D. \$2,000
  - E. \$1,000

23. With a load leveling TES strategy, a building manager will
- A. Not operate the chiller during peak hours
  - B. Essentially base load the chiller (i.e., operate at high load most of the time)
  - C. Operate only during the peaking times
  - D. Operate in the “off” season
24. In retrofitting a large commercial building with a TES, which of these considerations would be least important?
- A. System efficiency
  - B. Space issues
  - C. Demand cost
  - D. Equipment cost
25. A building presently has the following lighting system:
- Present System*
- Type: 196 mercury vapor light fixtures  
Size: 250 watt/lamp (285 watt/fixture, including ballast)
- You have chosen to replace the existing system with the following:
- Proposed System*
- Type: 140 high pressure sodium fixtures  
Size: 150 watt/lamp (185 watt/fixture)
- The facility operates 24 hours/day. Approximate the **heating effect** if the heating system efficiency is 80%, fuel costs \$5.00 per million BTUs and there are 200 heating days (not heating degree days) per year. That is, find the increased heating cost for the heating system when the lights are more efficient, and produce less heat.
- A. \$6,986/year
  - B. \$5,289/year
  - C. \$4,485/year
  - D. \$3,070/year
  - E. \$2,548/year
26. A program available at no-cost from a US Department of Energy website that displays cost and efficiency data on electric motors is:
- A. Freeware
  - B. Building Life Cycle Cost
  - C. MotorMaster
  - D. 3EPlus
  - E. QuickPEP
27. Given the same amount of excess air and the same flue gas stack temperature rise (look at 50% excess air and 500 degrees F stack temperature rise, for example), which fuel provides the highest boiler combustion efficiency?
- A. Natural Gas
  - B. No. 2 Fuel Oil
  - C. No. 6 Fuel Oil

28. A boiler is rated at 30 boiler horsepower and 80% efficient. What is the input rating?
- A. 1,255,000 BTU/hr
  - B. 1,005,000 BTU/hr
  - C. 2,502, 500 BTU/hr
  - D. 3,628,750 BTU/hr
  - E. 13,400,000 BTU/hr
29. In a steam system, several things can happen to the condensate. Which of these is the best from the standpoint of energy expense?
- A. Drain condensate to sewer
  - B. Recover condensate in an insulated system at atmospheric pressure
  - C. Recover condensate in an un-insulated system at boiler pressure
  - D. Recover condensate in an insulated system at or near boiler pressure
30. Which of the following projects, or ECOs, would likely reduce boiler and steam system costs?
- A. Adding boiler endplate insulation
  - B. Installing condensate return system
  - C. Repairing steam leaks
  - D. Installing combustion air preheater
  - E. All the above
31. Estimate the waste heat available in Btu/minute from a refinery flare gas leaving a process unit at 800 deg F if it is flowing at 1,000 cfm and weighs 0.08 lb/cubic foot. Its specific heat or heat content over the temperature range is 0.3 Btu/lb·°F and you should assume the waste gas could be reduced in temperature to 250 deg F.
- A. 178,000 Btu/min
  - B. 165,000 Btu/min
  - C. 44,000 Btu/min
  - D. 19,200 Btu/min
  - E. 13,200 Btu/min
32. Water at 70 deg F is supplied to a 100 psia boiler. 1000 lb/hr of steam from the boiler is supplied to a process. How much heat was required to be added in the boiler to create the 1000 lb/hr of steam?
- A. 1000 Btu/hr
  - B. 234,500 Btu/hr
  - C. 729,250 Btu/hr
  - D. 1,150,000 Btu/hr
  - E. 3,759,000 Btu/hr
33. A 100 HP rotary screw air-compressor generates heat equivalent to about:
- A. 1000 Btu/hr
  - B. 12,000 Btu/hr
  - C. 100,000 Btu/hr
  - D. 250,000 Btu/hr

34. An optimum start is a control function that:
- A. shuts off the outside ventilation air during start up of the building
  - B. shuts off equipment for duty cycling purpose
  - C. senses outdoor and indoor temperatures to determine the start time needed to heat or cool down a building to desired temperatures
  - D. starts randomly
35. Which of the following could be used to detect failed steam traps?
- A. Ultrasonic equipment to listen to the steam trap operation
  - B. Infrared camera to detect the change in temperature
  - C. Real time MMS using conductance probes
  - D. All of the above
36. Calculate the group re-lamping interval for T8 lamp fixtures with instant start ballasts that annually operate for 4,160 hrs with rated life of 15,000 hrs (assuming replacements at 70% of rated life)
- A. 1.0 year
  - B. 2.5 years
  - C. 3.5 years
  - D. 4.5 years

## CEM Exam questions Key

Questions	Answers
1	(B)
2	(C)
3	(C)
4	(C)
5	(B)
6	(B)
7	(A)
8	(D)
9	(A)
10	(C)
11	(A)
12	(C)
13	(C)
14	(B)
15	(A)
16	(D)
17	(C)
18	(D)

Questions	Answers
19	(A)
20	(B)
21	(C)
22	(E)
23	(B)
24	(A)
25	(D)
26	(C)
27	(C)
28	(A)
29	(D)
30	(E)
31	(E)
32	(D)
33	(D)
34	(C)
35	(D)
36	(B)

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For a listing of Training Providers: Visit <https://www.aeecenter.org/trainingproviders>

For a listing of Remote Testing Centers: Visit [www.aeecenter.org/cem](http://www.aeecenter.org/cem)

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