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

CEM®

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 17 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 36 Exam Review questions included in the Study Guide to determine your readiness for the exam.

The CEM Examination contains the following mandatory subjects:

Body of Knowledge	Percent of Exam
Codes and Standards	4 – 6 %
Energy Accounting and Economics	11 – 14 %
Energy Audits and Instrumentation	11 – 15 %
Electrical Systems	5 – 7 %
HVAC Systems	5 – 7 %
Motors and Drives	5 – 6 %
Industrial Systems	4 – 6 %
Building Envelope	4 – 5 %
CHP Systems and Renewable Energy	4 – 5 %
Fuel Supply and Pricing	4 – 5 %
Building Automation and Control Systems	4 – 6 %
High Performance Buildings	4 – 5 %
Thermal Energy Storage Systems	3 – 4 %
Lighting Systems	5 – 7 %
Boiler and Steam Systems	4 – 6 %
Maintenance and Commissioning	4 – 6 %
Energy Savings Performance Contracting and Measurement & Verification	4 – 5 %

STUDY GUIDE

CERTIFIED ENERGY MANAGERS (CEM® EXAM)
<u>Online Self-Evaluation Exam Also Available</u>

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 an **$80 fee** to take this online test and you may access the full details at:

Direct Link: 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.

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. The primary references are the <u>Handbook of Energy Engineering,</u> 7th by D. Paul Mehta and Albert Thumann, the <u>Energy Management Handbook,</u> 8th Edition by Steve Doty and Wayne C. Turner, and <u>Guide to Energy Management,</u> 8th 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 17 sections listed below from which questions mainly are drawn.

BODY OF KNOWLEDGE: STUDY GUIDE TOPICS & REFERENCES

I. CODES AND STANDARDS

> ISO 50001
> ASHRAE/IESNA Standard 90.1-2012
> IEC and IEEC Codes
> ASHRAE Standard 90.2
> ASHRAE Standard 62.1-2010
> Model Energy Code
> ASHRAE Standard 135-2008
> ASHRAE Standard 189.1-2009
>
> REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 1.
> REF: Turner, **Energy Management Handbook**, Chapter 20.
> REF: **ASHRAE 62.1 2004 and 2007 Standard**

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	Btu Reporting
Point of Use Costs	Efficiency Measures

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 2.
REF: 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	Audit Equipment
ASHRAE Type 1 Audit	ASHRAE Type 2 Audit
Energy Management Measures	Load Factors
Combustion Analysis	Combustion Analyzers
Power Factor Correction	Electric Metering Equipment
Very Basic Thermodynamics	Temperature Measurement
Air Velocity Measurement	Pressure Measurement
Light Level Measurement	Humidity Measurement
Infrared Equipment	Energy and Power Measurement
Fuel Choices	HHV and LHV
Energy Use Index	Energy Cost Index

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

IV.   ELECTRICAL SYSTEMS

Demand and Energy	Load Factors
Real Power	Reactive Power
Power Factor	Three Phase Systems
Power Factor Correction	Peak Demand Reduction
Rate Structure and Analysis	Motors and Motor Drives
Variable Speed Drives	Affinity Laws (Pump and Fan Laws)
Power Quality	Harmonics
Grounding	IEEE PQ Standard 519

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4.
REF: Turner, **Energy Management Handbook**, Chapter 11.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 5.

V. HVAC SYSTEMS

Heating, Ventilating, and Air Conditioning (HVAC)

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

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 7 & 8.
REF: Turner, **Energy Management Handbook**, Chapter 10.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 8.

VI.　MOTORS AND DRIVES

AC Induction Motors	AC Synchronous Motors
DC Motors	High Efficiency Motors
Load Factor and Slip	Power Factor and Efficiency
Motor Speed Control	Variable Frequency Drives
Fan and Pump Laws	Variable Flow Systems
Motor Selection Criteria	New vs. Rewound Motors
Motor Management Software	Power Factor Correction

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4.
REF: Turner, **Energy Management Handbook**, Chapter 11.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 7.

VII.　INDUSTRIAL SYSTEMS

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

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

VIII.　BUILDING ENVELOPE

Thermal Resistance	Heat Transfer Coefficients
Insulation	Vapor Barriers
Solar Heat Gain	Solar Shading
Thermally Light Facilities	Thermally Heavy Facilities
Conduction Heat Loads	Psychrometric Chart
Air Heat Transfer	Water Heat Transfer

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

IX.   CHP SYSTEMS and RENEWABLE ENERGY

Topping Cycles   Bottoming Cycles
Combined Cycles   Fuel Selection
Prime Movers   Operating Strategies
Regulations   Codes and Standards
Combined Heat and Power   Distributed Generation
HHV and LHV   Thermal Efficiencies
Solar, Wind, Biomass, and Hydropower   Wind Energy Systems
Solar Thermal and Solar Photovoltaic Systems

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

X. FUEL SUPPLY AND PRICING

Procurement of Natural Gas   Procurement of Oil
Supply and Demand Impact on Pricing   Evaluating Supply Options
Fuel Price Risks   Trends in Deregulation around the World
Electricity as a Commodity   Selection of Energy Supplier in a Deregulated Market

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 1.
REF: Turner, **Energy Management Handbook**, Chapter 21 & 24.

XI.   BUILDING AUTOMATION AND CONTROL SYSTEMS

Energy Management Strategies   Terminology
Basic Controls   PID Controls
BACnet & LON   Signal Carriers
Power Line Carriers   Direct Digital Control
Distributed Control   Central Control
Optimization Controls   Reset Controls
Building Control Strategies   Communication Protocols
Expert Systems   Artificial Intelligence
Self-Tuning Control Loops   Energy Information Systems
TCP/IP   Internet, Intranets and WWW
BAS Systems   Web Based Systems

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 4 & 10.
REF: Turner, **Energy Management Handbook**, Chapter 12 & 22.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 11 & 17.

XII. HIGH PERFORMANCE BUILDINGS

Green Buildings	USGBC
Sustainable Design	LEED Certification
ASHRAE 90.1 Energy Cost Budget Method	LEED O&M
Certified, Silver, Gold, and Platinum	LEED NC
LEED CI	LEED CS
Water Efficiency	Energy and Atmosphere
Materials and Resources	Indoor Environmental Quality
ENERGY STAR Rating	Portfolio Manager
Energy Star Label	Green Globes
ASHRAE Standard 189	ASHRAE Green Guide

REF: **United States Green Building Council, website with LEED v3 and LEED Rating Systems presentations, www.usgbc.org**
REF: **ENERGY STAR Building & Plants, ENERGY STAR website, www.energystar.gov**
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 18

XIII. THERMAL ENERGY STORAGE SYSTEMS

Design Strategies	Operating Strategies
Storage Media	Advantages and Limitations
Chilled Water Storage	Ice Storage
Sizing	Volume Requirements
Full Storage Systems	Partial Storage Systems

REF: Turner, **Energy Management Handbook**, Chapter 19.

XIV. LIGHTING SYSTEMS

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

REF: Mehta and Thumann**, Handbook of Energy Engineering**, Chapter 4.
REF: Turner, **Energy Management Handbook**, Chapter 13.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 6.

XV. 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: Turner, **Energy Management Handbook**, Chapter 5 & 6.
REF: Capehart, Turner and Kennedy, **Guide to Energy Management**, Chapter 9 and 10.

XVI. MAINTENANCE AND COMMISSIONING

MAINTENANCE

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

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

COMMISSIONING

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

REF: Turner, **Energy Management Handbook**, Chapter 26

XVII. ENERGY SAVINGS PERFORMANCE CONTRACTING and MEASUREMENT AND VERIFICATION

Measurement and Verification Protocols	Energy Service Companies
Energy Savings Performance Contracting	Utility Financing
Shared Savings Contracts	Demand Side Management
Contracting and Leasing	Savings Determination
Risk Assessment	Loans, Stocks and Bonds

REF: Mehta and Thumann, **Handbook of Energy Engineering**, Chapter 13.
REF: Turner, **Energy Management Handbook**, Chapter 25.

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 = qout/qin.
    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 x 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^2
    B. $0.040/yr/ft^2
    C. $0.0312/yr/ft^2
    D. $0.0201/yr/ft^2

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. $0.010/ft^2$-yr
    B. $0.025/ft^2$-yr
    C. $0.040/ft^2$-yr
    D. $0.195/ft^2$-yr
    E. $0.202/ft^2$-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)

For a listing of AEE Certification Programs: Visit www.aeecenter.org/certification

For a listing of Training Providers: Visit www.aeecenter.org/CEM/training

For a listing of Remote Testing Centers: Visit www.aeecenter.org/certification/cem

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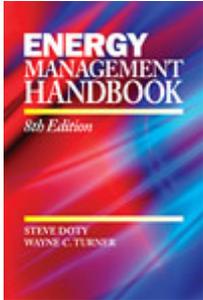
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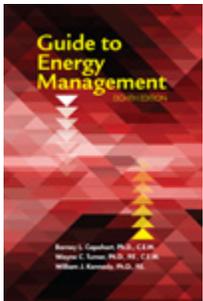
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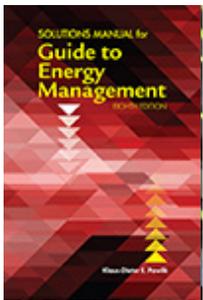
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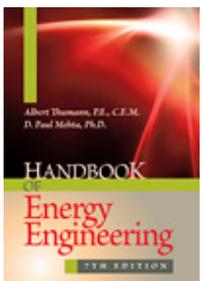
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