South Dakota State University's

Energy Analysis Lab

"Energy Standards for Commercial Buildings"

Presentation for the
Commercial Building-Science Seminar

Speaker Introductions

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Presentation Outline

Energy Analysis Lab

Part 1: Building Energy

- Building Energy Efficiency
- Building Energy Codes
- DOE Determination

Part 2: ASHRAE 90.1-1999

- Background
- Sections 1-11
- Software Tools

Energy Analysis Lab

Overview

Group focused on energy and cost reduction
- Also deals with waste minimization/management
- Can identify productivity improvement practices

Serves industrial and commercial facilities
- Bottom line is to reduce facility costs

Located in M.E. Department at SDSU
- Utilize faculty, staff and students
- Have access to a wide variety of analysis tools

Provided by means of an ‘energy assessment’
- Otherwise known as an energy audit
- Performing assessments since 1992

Energy Analysis Lab

History

1992-93 Industrial Energy and Optimization Program (IEOP)
- Performed 20 assessments in South Dakota

1993-95 Energy Analysis and Diagnostics Center (EADC)
- Served SD, ND, MN, IA and NE

1995-96 Indian Health Services (IHS)
- Completed eight assessments in SD and ND

1995-00 Industrial Assessment Center (IAC)
- Added waste and productivity measures
- In total 175 EADC/IAC assessments

1999-00 DOE Compressed Air Special Project
- Project with two local manufacturers

2000-02 DOE Steam Bestpractices Project
- Helped develop a steam benchmarking tool

2001- Energy Analysis Lab (EAL)
- Continue to perform energy analysis

Energy Analysis Lab

History (continued)

2002-03 DDG Gasification Technology Study

- Feasibility study and energy assessment
- At local ethanol facility
- In cooperation with SD Corn Utilization Council

2003-05 Biopolymers and Other Value-Added Products

- Seeking alternative uses of DDG
- Sponsored by USDA/NRCS

2003- State Energy Program (SEP)

- Develop SD Commercial Building Energy Code

Part 1: Building Energy

Building Energy Efficiency

Energy issues in South Dakota

- An extreme climate leads to extreme heating and cooling requirements
- Limited and fixed budgets for most facilities
- Rising energy costs
- Limited information available for making better choices

Addressing these issues

- Focus on life cycle costs instead of solely on first costs
- Purchase better materials, equipment, systems that will save money
- Inform the public

Part 1: Building Energy

Building Energy Efficiency

Building energy codes provide the solution

- Set minimum standards for good practice
  - Envelope
  - Lighting
  - System/equipment efficiencies
- Disseminates energy efficiency methods and information

Part 1: Building Energy

Building Energy Codes

Model Energy Code (MEC) created in 1983

- Through DOE funding
- Contains energy efficiency criteria
- Managed by Council of American Building Officials (CABO)

Several updates

- 1986, 1989, 1992, 1993, 1995

International Code Council

- Took over in 1995

International Energy Conservation Code (IECC)

- Covers both residential and commercial buildings
- Issued in 1998
- Updated in 2000
- Updated in 2003

Part 1: Building Energy

Building Energy Codes

Standard 90 Series

- Originated with National Conference of States on Building Codes and Standards (NCS/BCS)
- Joined with National Bureau of Standards (NBS)

ASHRAE Standard 90-75 published in 1975

- Energy Conservation in New Building Design
- Several updates were made (90A-1980)

ASHRAE 90.1-1989

- Standard for all buildings except low-rise residential

ASHRAE 90.1-1999

- enhanced energy efficiency levels

ASHRAE 90.1-2001

Part 1: Building Energy

Building Energy Codes

Other codes

- Specific state code
  - Normally based on ASHRAE 90.1 series
  - Example - Minnesota

Part 1: Building Energy

DOE Determination

Federal Government specifies a minimum energy code

DOE is given this role by EPCA

- Energy Policy and Conservation Act
- Amended in 1992 by Energy Policy Act (EPACT)

Two energy codes are covered

- IECC series - residential
- ASHRAE 90.1 series - commercial

As a result of a positive determination

- States must comply within two years

Part 1: Building Energy

DOE Determination

DOE has made a positive determination Commercial Determination (July 2002)

- ASHRAE Standard 90.1-1999 over 90.1-1989
- States must comply or receive an extension by July 2004 (SD applied for and received an extension)
- ASHRAE Standard 90.1-2001 determination in progress

Part 1: Building Energy

DOE Determination

ASHRAE/IESNA Standard 90.1-1999

- Written by
  - American Society of Heating Refrigerating and Air-Conditioning Engineers
  - Illuminating Engineering Society of North America
- Both societies are leading organizations in their fields
- Consensus standard
  - Professional, technical and trade organizations; environmental organizations; equipment manufacturers; utility companies; code officials; and design professionals
  - Two public reviews and resulting revisions
  - Over 70,000 comments considered
- Economically driven
  - Code based on 10 year simple payback or less
  - Most under 7 years

Part 2: ASHRAE 90.1-1999

Background

ASHRAE/IESNA Standard 90.1-1999

TECHNICAL

- Section 1 - Purpose
- Section 2 - Scope
- Section 3 - Definitions, Abbreviations and Acronyms
- Section 4 - Administration and Enforcement
- Section 5 - Building Envelope
- Section 6 - Heating, Ventilating and Air-Conditioning (HVAC)
- Section 7 - Service Water Heating (SWH)
- Section 8 - Power
- Section 9 - Lighting
- Section 10 - Other Equipment
- Section 11 - Energy Cost Budget Method (ECBM)
- Section 12 - Normative References
- Appendices

Section 1: Purpose

The purpose is to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings

Section 2: Scope

Provides minimum requirements for

- New buildings and their systems
- New portions of buildings and their systems
- New systems and equipment in existing buildings

Applies to

- Envelope when output capacity >3.4 Btu/h-ft^2 (heating) and >5 Btu/h-ft^2 (cooling)
- Virtually all mechanical and lighting systems

Does not apply to

- Single-family houses, multi-family structures 3 stories or fewer
- Buildings that do not use electricity or fossil fuel
- Equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing or commercial processes

Section 3: Definitions

Terms, abbreviations and acronyms

- 10.5 pages of definitions
- 1 page of abbreviations and acronyms
- Defined terms are italicized in text of standard

Section 4: Administration

New buildings and additions

- Shall comply with Sections 5, 6, 7, 8, 9 and 10 or
- Section 11

Alterations

- Shall comply with Sections 5, 6, 7, 8, 9 and 10
- i.e. lighting
- Exceptions apply

Section 4: Administration

Compliance Paths

BUILDING SYSTEM

- ENVELOPE
- HVAC
- SWH
- POWER
- LIGHTING
- OTHER

MANDATORY REQUIREMENTS

COMPLIANCE OPTIONS

- Prescriptive Option
- Trade-Off Option
- Energy Cost Budget
- Simplified Approach

ENERGY CODE COMPLIANT

Section 5: Envelope

Section 5.1

- General

Section 5.2

- Mandatory Provisions

Section 5.3

- Prescriptive Building Envelope Option

Section 5.4

- Building Envelope Trade-Off Option

Section 5.1: General

5.1.1 Building Envelope Scope

Applies to

a) Exterior building envelope which separates conditioned space from the exterior
b) Semi-exterior building envelope
   - Separates conditioned space from semiheated space
   - Separates conditioned space from unconditioned space
   - Separates semiheated space from unconditioned space
   - Separates semiheated space from the exterior

Does not address moisture control

Section 5.1: General

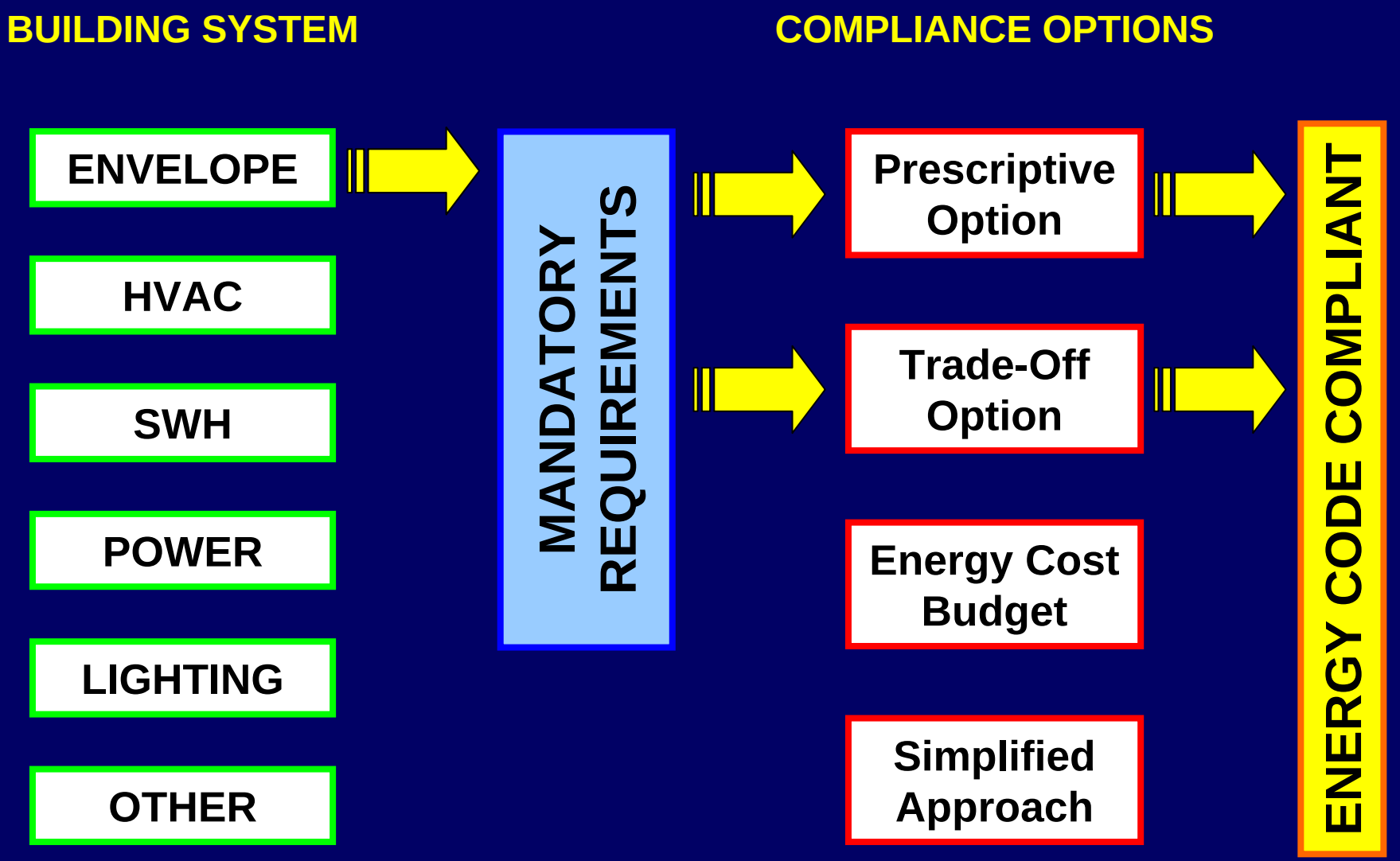
5.1.2 Compliance

The building envelope shall comply with

a) 5.1 (General)
b) 5.2 (Mandatory Provisions)
c) 5.3 (Prescriptive Building Envelope Option) or 5.4 (Building Envelope Trade-Off Option)

Section 5.1: General

5.1.2 Compliance



Section 5.1: General

5.1.3 Climate

Based on Annual CDD50 and HDD65

- CDD50 = Cooling Degree-Days, base 50°F*
- DDD65 = Heating Degree-Days, base 65°F**

* Cooling Degree-Days for a day are based on (mean daily outside temperature if over 50°F – 50°F)
South Dakota Approx. Range: 2,200-3,000 CDD50

** Heating Degree-Days for a day are based on (65°F - mean daily outside temperature if under 65°F)
South Dakota Approx. Range: 7,300-8,700 HDD65

Section 5.1: General

5.1.4 Space-Conditioning Categories and Basis

Each space shall be one of the following

a) Nonresidential conditioned space
b) Residential conditioned space
c) Both nonresidential and residential semiheated space

Spaces in excess of 1800 HDD65 shall be assumed to be conditioned space

Section 5.2: Mandatory

5.2.1 Insulation General

Where required, insulation shall comply with the following

- Insulation shall be installed in accordance with manufacturer's recommendations and must achieve rated R-values
- Insulation shall be installed in substantial contact with the inside surface
- Recessed equipment shall not affect the insulation thickness
- Roof insulation shall not be installed on a suspended ceiling
- Exterior insulation shall be covered with a protective material

Section 5.2: Mandatory

5.2.2 Fenestration and Doors

Fenestration performance will be based on the following

- U-Factors in accordance with NFRC 100 (National Fenestration Rating Council)
- Solar Heat Gain Coefficient in accordance with NFRC 200
- Visible Light Transmittance in accordance with NFRC 200

Section 5.2: Mandatory

5.2.3 Air Leakage

Building Envelope Sealing

a) Joints around fenestration and door frames
b) Junction between walls and foundations/building corners/structural floors or roofs/roof or wall panels
c) Openings at penetrations of utility services
d) Site-built fenestration and doors
e) Building assemblies used as ducts or plenums
f) Joints, seams and penetrations of vapor retarders
g) All other openings in the building envelope

Section 5.2: Mandatory

5.2.3 Air Leakage (continued)

Fenestration and Doors

- Determine in accordance with NFRC 400

Loading Dock Weatherseals

- In excess of 3600 HDD65 cargo and loading dock doors shall be equipped with weatherseals

Vestibules

- Doors separating conditioned space from exterior shall be protected with an enclosed vestibule
- Exceptions do apply

Section 5.3: Prescriptive

General Notes

Exterior building envelope shall comply with Table 5.3

Section 5.3: Prescriptive

5.3.1 Opaque Areas

Compliance shall be demonstrated by one of the following

a) Minimum rated R-values of insulation
b) Maximum U-factor, C-factor or F-factor for the entire assembly
c) Area-weighted average for multiple assemblies

Section 5.3: Prescriptive

5.3.1.1 Roof Insulation

Shall have rated R-value not less than specified.

Applies to:

a) Roofs with insulation entirely above deck
b) Metal building roofs
c) Attics and other roofs

Section 5.3: Prescriptive

5.3.1.2 Above-Grade Wall Insulation

Shall have rated R-value not less than specified.

Applies to:

a) Mass walls
b) Metal building walls
c) Steel-framed walls
d) Wood-framed and other walls

Section 5.3: Prescriptive

5.3.1.3 Below-Grade Wall Insulation

Shall have rated R-value not less than specified.

Section 5.3: Prescriptive

5.3.1.4 Floor Insulation

Shall have rated R-value not less than specified.

Applies to:

a) Mass floors
b) Steel joist floors
c) Wood-framed and other floors

Section 5.3: Prescriptive

5.3.1.5 Slab-on-Grade Floor Insulation

Shall have rated R-value not less than specified in Table 5-3.

Section 5.3: Prescriptive

5.3.1.6 Opaque Doors

Shall have U-value not greater than specified in Table 5-3.

Section 5.3: Prescriptive

5.3.2 Fenestration

U-factor and SHGC compliance shall be demonstrated by 5.2.2

Section 5.3: Prescriptive

5.3.2.1 Fenestration Area

Fixed and operable vertical fenestration

- Shall be less than 50% of the gross wall area

Skylight area

- Shall be less than 5% of gross roof area

Section 5.3: Prescriptive

5.3.2.2 Fenestration U-Factor

Shall have a U-factor not greater than specified in Table 5.3

Section 5.3: Prescriptive

5.3.2.3 Fenestration Solar Heat Gain Coefficient (SHGC)

Fenestration shall have an SHGC not greater than specified

- No requirements for semiheated spaces or buildings in climates with >10800 HDD65

Exceptions to 5.3.2.3

a) North-oriented vertical fenestration in latitudes >10°
b) Multipliers for shading with projections
c) Vertical fenestration located on the street side

Section 5.3: Prescriptive

5.3.2.4 Visible Light Transmittance (VLT)

No minimum visible light transmittance criteria

Section 5.4: Trade-Off

Building envelope complies with the standard if

- Satisfies 5.1 (General)
- Satisfies 5.2 (Mandatory) and
- Envelope performance factor of proposed building is less than or equal to that of the budget building.

Section 6: HVAC

Section 6.1

- General

Section 6.2

- Mandatory Provisions

Section 6.3

- Prescriptive Path

Section 6.1: General

6.1.1 HVAC Scope

Applies to

- All mechanical equipment and systems serving the building's heating, cooling, or ventilating needs

Does not apply to manufacturing processes

Section 6.1: General

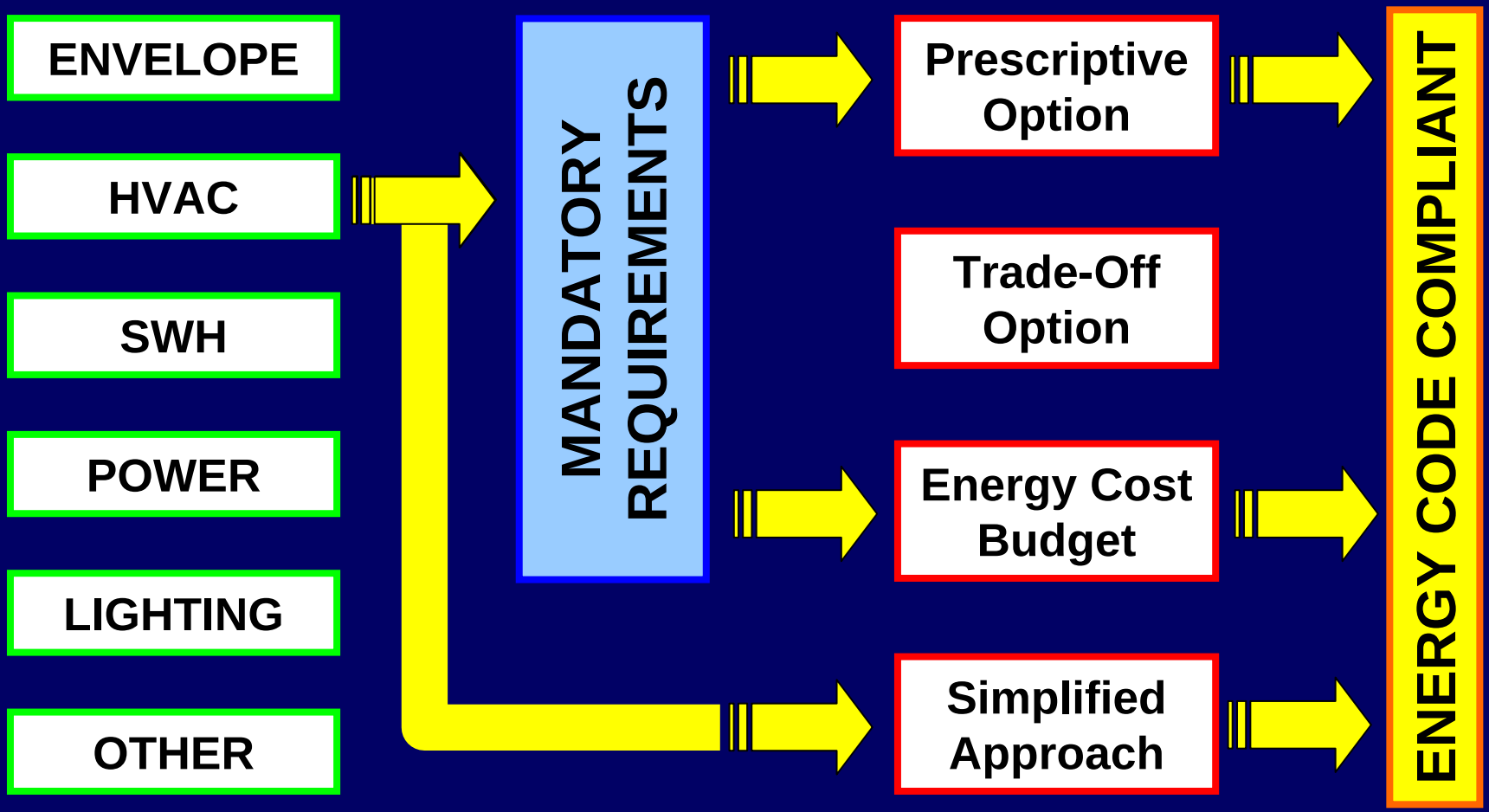
6.1.2 Compliance

Compliance is met by meeting

- 6.1.3 (Simplified Approach Option for HVAC Systems) or
- 6.2 (Mandatory Provisions) and 6.3 (Prescriptive Path) or
- 6.2 (Mandatory Provisions) along with Section 11 (Energy Cost Budget Method)

Section 6.1: General

6.1.2 Compliance



Section 6.1: General

6.1.3 Simplified Approach Option for HVAC Systems

Applies to smaller buildings

- Two stories or less
- Less than 25,000 ft^2 or less gross floor area

Must meet following criteria (a-o)

a) System serves a single zone

b) Cooling provided by unitary packaged or split-system air conditioner either air cooled or evaporatively cooled
   - Must meet minimum efficiencies
   - Air Conditioners (Table 6.2.1A)
   - Heat Pumps (Table 6.2.1B)
   - Packaged terminal and room air conditioners and heat pumps (Table 6.2.1D)

Section 6.1: General

6.1.3 Simplified Approach Option for HVAC Systems

Must meet following criteria (continued)

c) System shall utilize an economizer
- Where indicated (Table 6.3.1)
- With controls (Tables 6.3.1.1.3A and 6.3.1.1.3B)
- Either barometric or powered relief to prevent overpressurization
- No economizer required if cooling system meets or exceeds efficiency levels (Table 6.1.3)

Section 6.1: General

6.1.3 Simplified Approach Option for HVAC Systems

Must meet following criteria (continued)

d) Heating system must meet minimum efficiencies
- Heat pumps (Table 6.2.1B)
- PTAC (Table 6.2.1D)
- Furnace (Table 6.2.1E)
- Electric Resistance (6.2.1F)

e) Outside air
- <3000 cfm and
- <70% of supply air
- Unless energy recovery is provided

f) Controlled by
- Manual change-over or
- Dual set-point thermostat

Section 6.1: General

6.1.3 Simplified Approach Option for HVAC Systems

Must meet following criteria (continued)

g) When heat pump equipped, auxiliary electric resistance should be used only when necessary

h) System controls shall not permit simultaneous heating and cooling

i) Timeclock control capable of

1) Start and stop for seven different day-types per week
2) Capable of retaining programming during loss of power
3) Includes manual override
4) Setback down to 55°F
5) Setup to 90°F

Section 6.1: General

6.1.3 Simplified Approach Option for HVAC Systems

Must meet following criteria (continued)

j) Piping shall be insulated according to Table 6.2.4.5
k) Ductwork and plenums shall be insulated according to
   - Table 6.2.4.2A and 6.2.4.2B
l) Ducted system must be air balanced within 10%
m) Thermostats to be interlocked to prevent simultaneous heating and cooling
n) Exhausts shall be equipped with dampers that will automatically shut when the systems are not in use
o) Systems with a supply air capacity >10,000 cfm shall have optimum start controls

Section 6.2: Mandatory

6.2.1 Mechanical Equipment Efficiency

Shall have minimum performance

- Air Conditioners and Condensing Units (Table 6.2.1A)
- Heat Pumps (Table 6.2.1B)
- Water Chilling Packages (Table 6.2.1C)
- Packaged Terminal and Room Air Conditioners and Heat Pumps (Table 6.2.1D)
- Furnaces, Duct Furnaces and Unit Heaters (Table 6.2.1E)
- Boilers (Table 6.2.1F)
- Heat Rejection Equipment (Table 6.2.1G)

Equipment not listed or used for other than standard operating conditions have no minimum performance requirements

Section 6.2: Mandatory

6.2.2 Load Calculations

Heating and cooling system design loads for the purpose of sizing systems and equipment

- Determined in accordance with generally accepted engineering standards and handbooks (example - ASHRAE Fundamentals)

Section 6.2: Mandatory

6.2.3.1 Thermostatic Controls

Supply of heating and cooling to each zone

- Individually controlled by thermostatic controls
- Incorporates the application of control error reduction

Section 6.2: Mandatory

6.2.3.1.2 Dead Band

Dead band of at least 5°F is required (if controlling both heating and cooling)

Exceptions include:

a) Thermostats requiring manual changeover
b) Special occupancy (retirement homes, hospitals, etc…)

Section 6.2: Mandatory

6.2.3.1.3 Set Point Overlap Restriction

Heating set point shall not exceed the cooling set point minus any applicable proportional band

Section 6.2: Mandatory

6.2.3.2 Off-Hour Controls

HVAC systems with capacity >65,000 Btu/h and fan power >3/4 hp shall have:

- Automatic Shutdown
- Setback Controls
- Optimum Start Controls
- Shutoff Damper Controls
- Zone Isolation

Exceptions include:

- Hotel/motel guest rooms
- Systems intended to operate continuously

Section 6.2: Mandatory

6.2.3.2.1 Automatic Shutdown

HVAC systems shall have one of the following:

a) Controls to start/stop the system
b) Occupancy sensor to shut of system when unoccupied
c) Manually operated timer
d) Interlock with security system

Section 6.2: Mandatory

6.2.3.2.2 Setback Controls

Setback controls are required when:

- Design temperatures are 40°F or less (heating) or 100°F or greater (cooling)
- Heating setback temperatures should be adjustable to 55°F or lower
- Cooling setback temperatures should be adjustable to 90°F or higher

Exceptions include radiant heating systems

Section 6.2: Mandatory

6.2.3.2.3 Optimum Start Controls

Systems >10,000 cfm shall have optimum start controls

- Algorithm shall be a function of difference between space temperature and occupied setpoint
- Algorithm shall be a function of the amount of time prior to scheduled occupancy

Section 6.2: Mandatory

6.2.3.2.4 Shutoff Damper Control

Motorized dampers are required to:

- Close outdoor air and exhaust systems when systems or spaces served are not in use
- Shut ventilation system during building warmup, cooldown and setback

Can remain open for night purge

Section 6.2: Mandatory

6.2.3.2.5 Zone Isolation

For zones operating nonsimultaneously

- Must be divided into isolation areas
- Each isolation area no larger than 25,000 ft^2
- Each area equipped with isolation device and independently controlled

Exceptions Apply

Section 6.2: Mandatory

6.2.3.3 Gravity Vent Controls

Stair and shaft vents

- Automatic motorized dampers that are capable of being automatically closed during normal building operation and interlocked with fire and smoke detection systems

Gravity hoods, vents and ventilators

- Automatic motorized dampers shut when spaces served are not in use

Section 6.2: Mandatory

6.2.3.4 Heat Pump Auxiliary Heat Control

Heat pumps with internal electric resistance

- Controls must prevent supplemental heat when heating load could be met by the heat pump alone

Section 6.2: Mandatory

6.2.3.5 Enclosed Parking Garage Ventilation

Garage fan systems >30,000 cfm shall have one of the following:

- Automatic control to maintain CO levels prescribed by ASHRAE Standard 62
- Automatic control to shut off or reduce fan volume when garage is not in use

Section 6.2: Mandatory

6.2.3.6 Humidifier Preheat

Humidifiers with preheat shall be provided with:

- An automatic valve to shut off preheat when humidification is not required

Section 6.2: Mandatory

6.2.3.7 Humidification and Dehumidification

Controls shall prevent simultaneous humidification and dehumidification

Section 6.2: Mandatory

6.2.3.8 Freeze Protection and Snow/Ice Melting Systems

Freeze protection systems shall include:

- Automatic shutoff when outside air temperatures are above 40°F

Snow and ice melting systems shall include:

- Automatic shutoff when pavement temperature is above 50°F

Section 6.2: Mandatory

6.2.3.9 Ventilation Controls for High-Occupancy Areas

Outside air intake shall be reduced when partially occupied according to ASHRAE Standard 62 when:

- Outside air capacity is >3,000 cfm and
- Design occupancy density exceeds 100 people/1,000 ft^2

Section 6.2: Mandatory

6.2.4 HVAC System Construction and Insulation

Insulation installed as per industry standards

Duct and plenum insulation

- Insulated according to Table 6.2.4.2A and 6.2.4.2B

Duct sealing

- As require to meet duct leakage test

Duct leakage tests

- For systems operating >3 in. w.c.

Piping insulation

- According to Table 6.2.4.5

Exceptions apply

Section 6.2: Mandatory

6.2.5 Completion Requirements

Drawings

- Construction documents of actual installation required within 90 days of system acceptance

Manuals

- Operating and maintenance manual be provided within 90 days of system acceptance

System Balancing

- All HVAC systems must be balanced according to generally accepted engineering standards
- Within 10% of design rates

System Commissioning

- HVAC control systems shall be tested
- Projects >50,000 ft^2 commissioning instructions provided by designer

Section 6.3: Prescriptive

6.3.1 Economizers

Cooling system economizers required by Table 6.3.1 and includes specifics on:

- Air economizers
- Water economizers
- Integrated economizer control
- Economizer heating system impact

Exceptions apply

Section 6.3: Prescriptive

6.3.2 Simultaneous Heating and Cooling Limitation

Zone Controls

- Controls shall prevent reheating, recooling, mixing of hot and cold air streams or other means of simultaneous heating and cooling

Hydronic System Controls

- Heating/cooling previously cooled/heated fluid shall be limited

Dehumidification

- Controls shall prevent reheating, mixing of hot and cold air streams or other means of simultaneous heating and cooling

Humidification

- Water economizer may be required

Exceptions apply

Section 6.3: Prescriptive

6.3.3 Air System Design and Control

When total fan system power >5 hp

- Fan power limitation (hp/cfm ratio)
- Variable Air Volume (VAV) Fan Control

Section 6.3: Prescriptive

6.3.4 Hydronic System Design and Control

When total pump system power >10 hp

- Hydronic Variable Flow Systems
- Pump Isolation
  - flow reduction with capacity reduction
- Chilled and Hot Water Temperature Reset Controls
  - modulate as a function of the load
  - for systems over 300,000 Btu/h

Section 6.3: Prescriptive

6.3.5 Heat Rejection Equipment

Heat rejection equipment for comfort cooling systems

- Air-cooled condensers
- Open cooling towers
- Closed-circuit cooling towers
- Evaporative condensers

Fan Speed Control

- For fans >7.5 hp

Section 6.3: Prescriptive

6.3.6 Energy Recovery

Exhaust Air Energy Recovery

- Supply air >5,000 cfm and minimum OA >70%
- Energy recovery system with minimum 50% effectiveness

Heat Recover for Service Water Heating

- Condenser heat recovery systems may apply

Exceptions Apply

Section 6.3: Prescriptive

6.3.7 Exhaust Hoods

Kitchen Hoods

- Larger than 5,000 cfm shall have make-up air for at least 50% of exhaust air volume
- Exceptions apply

Fume Hoods

- Total exhaust >15,000 cfm will need additional features

Section 6.3: Prescriptive

6.3.8 Radiant Heating Systems

Heating Unenclosed Spaces

- Radiant heating shall be used
- Exceptions apply

Heating Enclosed Spaces

- Radiant heating shall conform with governing provisions

Section 6.3: Prescriptive

6.3.9 Hot Gas Bypass Limitation

Cooling systems shall not use hot gas bypass unless

- System is designed with capacity modulation

Exceptions Apply

Section 7: SWH

Section 7.1

- General

Section 7.2

- Mandatory Provisions

Section 7.3

- Prescriptive Path

Section 7.1: General

7.1.1 Service Water Heating Scope

Applies to

- All service water heating systems and equipment

Section 7.1: General

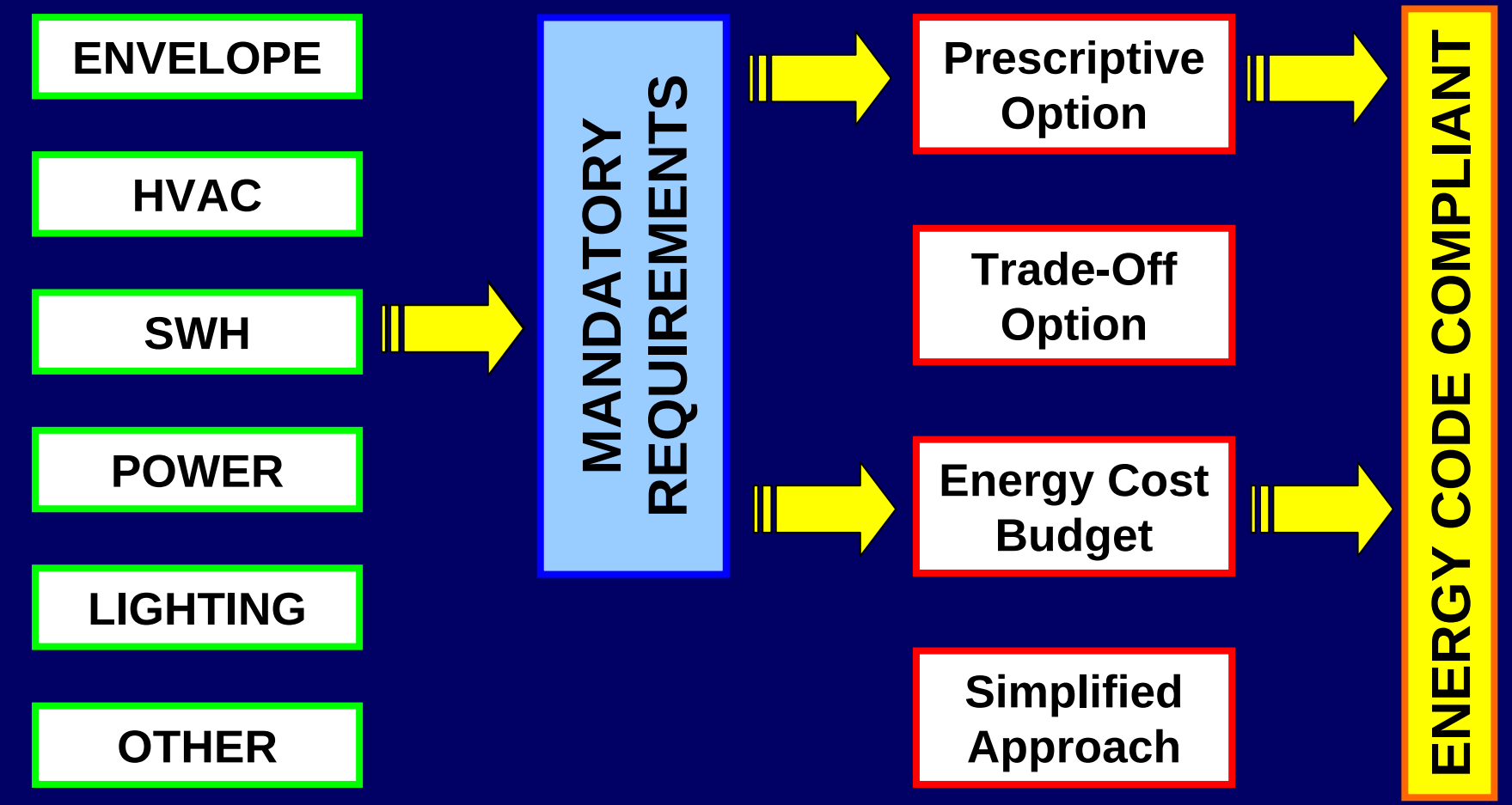
7.1.2 Compliance

Compliance is met by meeting

- 7.2 (Mandatory Provisions) and 7.3 (Prescriptive Path) or
- 7.2 (Mandatory Provisions) along with Section 11 (Energy Cost Budget Method)

Section 7.1: General

7.1.2 Compliance



Section 7.2: Mandatory

7.2.1 Sizing of Systems

Design loads shall be determined according to manufacturers' published guidelines

Section 7.2: Mandatory

7.2.2 Equipment Efficiency

Equipment must meet criteria

- Table 7.2.2
- Where multiple criteria are listed, all must be met
- Equipment not listed has no minimum requirements

Equipment with over 140 gal of storage capacity need not meet the standby loss when

a) Tank surface is thermally insulated to R-12.5
b) Standing pilot light is not installed, and
c) Gas or oil fired heaters have flue damper or fan-assisted combustion

Section 7.2: Mandatory

7.2.3 Service Hot Water Piping Insulation

The following piping must meet insulation levels from Table 6.2.4.5

a) Recirculating system supply/return piping
b) First 8 ft of outlet piping for a constant temperature nonrecirculating storage system
c) Inlet pipe between the storage tank and a heat trap in a nonrecirculating storage system
d) Externally heated pipes (i.e. heat trace)

Section 7.2: Mandatory

7.2.4 Service Water Heating System Controls

Temperature Controls

- Allow for storage temperature adjustment from 120°F or lower (unless specified by manufacturer) to maximum temperature

Temperature Maintenance Controls

- Switch off usage when not required

Outlet Temperature Controls

- Maximum lavatory faucet temperature of 110°F

Circulating Pump Controls

- Used to limit recirculating pump use

Section 7.2: Mandatory

7.2.5 Pools

Pool Heaters

- On-off switch shall be installed
- Shall not have continuously burning pilot light

Pool Covers

- Heated pools shall be equipped with a vapor retardant pool cover

Time Switches

- Time switches shall be installed on pool heaters and pumps
- Unless public health standards require 24 hour operation

Section 7.2: Mandatory

7.2.6 Heat Traps

Heat traps shall be installed on the inlet and outlet piping on a nonrecirculating system

Section 7.3: Prescriptive

7.3.1 Space Heating and Water Heating

Gas or oil fired space heating complying with Section 6 is allowed when one of the following is met

a) Standby losses do not exceed specifications
b) Demonstrate that single heat source will consume less energy than separate units
c) Combined energy input is less than 150,000 Btu/h

Section 7.3: Prescriptive

7.3.2 Service Water Heating Equipment

Service water heating equipment used for space heating must meet requirements of Section 7

Section 8: Power

Section 8.1

- General

Section 8.2

- Mandatory Provisions

Section 8.1: General

Applies to

- All building power distribution systems

Section 8.2: Mandatory

8.2.1 Voltage Drop

Feeders

- Feeder conductor shall be designed for a maximum voltage drop of 2% at full load

Branch Circuits

- Branch circuit conductors shall be designed for a maximum voltage drop of 3% at full load

Section 8.2: Mandatory

8.2.2 Completion Requirements

Drawings

- As-built drawings are required within 30 days of acceptance
- Includes a single-line drawing of distribution and floor plans of areas served

Manuals

- Operating and maintenance manual are required
- Includes the following
  a) Submittal data stating equipment rating and options
  b) Operation and maintenance manuals for each piece of equipment requiring maintenance
  c) Contact information for at least one qualified service agency
  d) Complete narrative of how each system is intended to operate

Section 9: Lighting

Section 9.1

- General

Section 9.2

- Mandatory Provisions

Section 9.3

- Prescriptive Path

Section 9.1: General

Applies to

a) Interior spaces of buildings
b) Exterior building features
c) Exterior building grounds

Does not apply to

a) Emergency lighting that is automatically off during normal building operation
b) Living units
c) Lighting required for health or life safety
d) Decorative gas lighting

Section 9.2: Mandatory

9.2.1 Lighting Control

Automatic Lighting Shutoff

- Buildings larger than 5,000 ft^2
- Automatic control device will shut off building lighting
- Automatic control device shall function on either
  a) Time-of-day
  b) Occupancy sensors
  c) Occupant intervention
- Controls not needed for 24-hour operation

Section 9.2: Mandatory

9.2.1 Lighting Control (continued)

Space Control

- Each space enclosed by ceiling-height partitions
- Shall have one control device activated either manually or automatically sensing occupancy
- Each control device shall
  a) Control a maximum of 2,500 ft^2 (areas < 10,000 ft^2) and control a maximum of 10,000 ft^2 (areas > 10,000 ft^2)
  b) Overriding the shutoff control required in 9.2.1.1
  c) Be readily accessible unless safety reasons do not permit it

Section 9.2: Mandatory

9.2.1 Lighting Control (continued)

Exterior Lighting Control

- Non-exempt lighting shall be automatically turned off when sufficient daylight is available
- Controlled by photosensor or astronomical time switch
- Except when required for safety, security, or eye adaptation

Section 9.2: Mandatory

9.2.1 Lighting Control (continued)

Additional Control

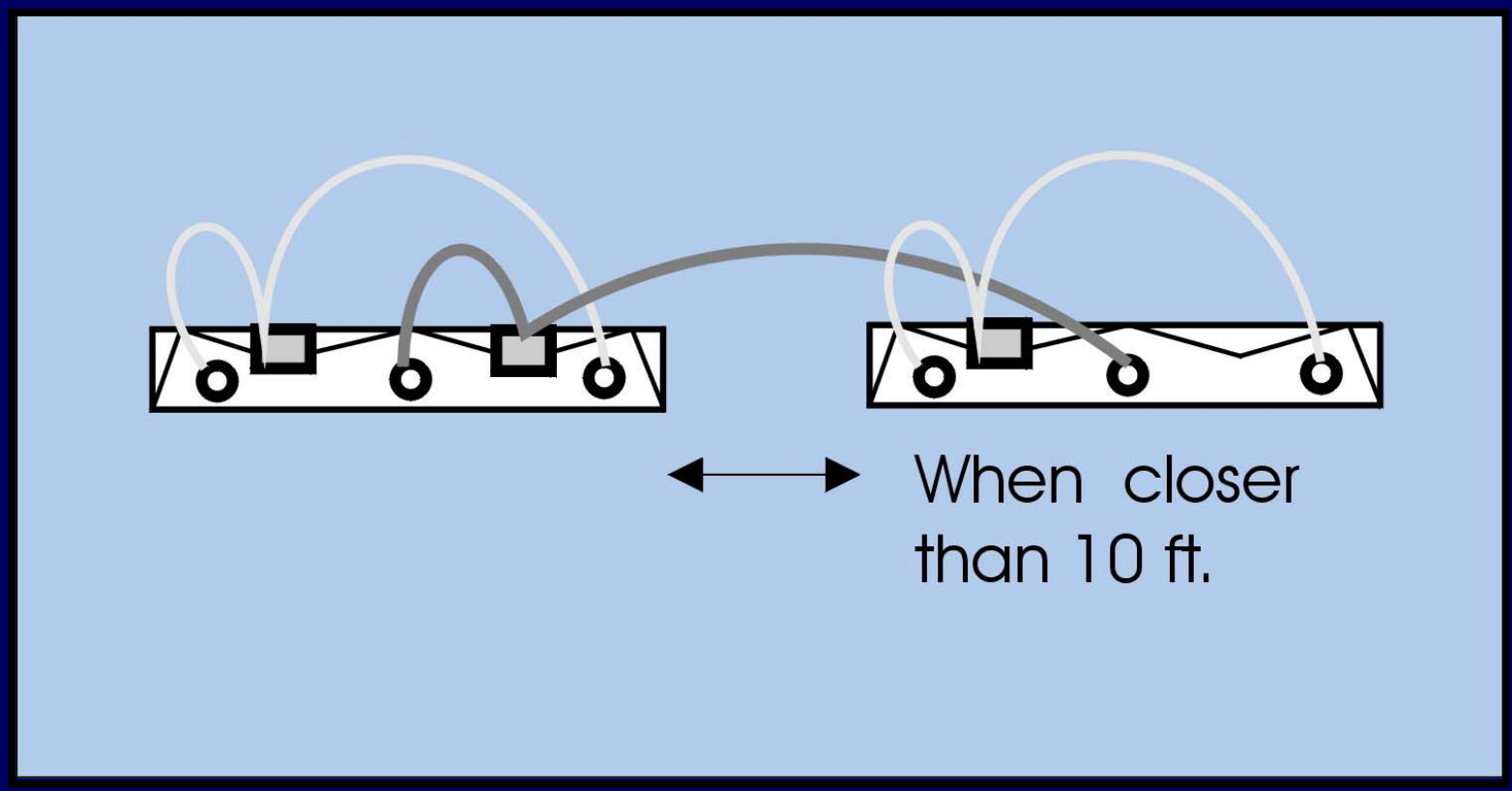
- Separate Control Device shall be used for the following
  a) Display/Accent Lighting
  b) Case Lighting
  c) Nonvisual Lighting (plant growth)
  d) Demonstration Lighting
- Hotel and Motel Guest Room Lighting shall have a master control device
- Task Lighting shall have integral or wall-mounted control

Section 9.2: Mandatory

9.2.2 Tandem Wiring

Tandem wiring is required when

- Two or more luminaires are in the same space and on the same control device each with one or three lamps greater than 30W



Section 9.2: Mandatory

9.2.2 Tandem Wiring (continued)

Tandem wiring is not required when

a) Recessed luminaires more than 10 ft apart
b) Surface-mounted pendant luminaires that are not continuous
c) Luminaires using single-lamp high-frequency electronic ballasts
d) Luminaires using three-lamp high-frequency electronic or three-lamp electromagnetic ballasts
e) Luminaires on emergency circuits
f) Luminaires with no available pair

Section 9.2: Mandatory

9.2.3 Exit Signs

Exit signs operating at > 20 Watts

- Shall have minimum source efficacy of 35 lm/W

Section 9.2: Mandatory

9.2.4 Installed Interior Lighting Power

Installed interior lighting power

- Includes lamps, ballasts, current regulators, and control devices

Section 9.2: Mandatory

9.2.5 Luminaire Wattage

Determined according to the following criteria

- Incandescent or tungsten-halogen with medium screw base sockets and not containing permanent installed ballasts shall be maximum labeled wattage
- Luminaires with permanently installed or remote ballast or transformers shall be the operating input wattage based on manufacturer's literature or testing laboratories
- Line-voltage lighting track and plug-in busway shall be specified wattage with a minimum of 30 W/lin ft.
- Low-voltage lighting track, cable conductor, rail conductor, and other flexible lighting shall be specified wattage of transformer supplying the system
- Miscellaneous lighting shall be the specified wattage of the lighting equipment

Section 9.2: Mandatory

9.2.6 Exterior Building Grounds Lighting

Exterior luminaires at > 100 W

- Shall contain lamps with minimum of 60 lm/W
- Unless controlled by a motion sensor

Section 9.3: Prescriptive

9.3.1 Interior Lighting Power

Interior Lighting Power is determined by

- Building area method in 9.3.1.1
- Space-by-space method in 9.3.1.2

Section 9.3: Prescriptive

9.3.1 Interior Lighting Power

Exempt lighting with control device includes

a) Display or accent lighting
b) Manufacturer installed lighting
c) Lighting on medical equipment
d) Lighting for open and glass enclosed refrigerators/freezers
e) Lighting for food preparation equipment
f) Lighting for plant growth
g) Lighting for visually impaired
h) Lighting in retail display windows
i) Lighting for an interior historic landmark
j) Lighting integral for advertising
k) Exit signs
l) Lighting for demonstration systems
m) Theatrical lighting
n) Athletic playing areas
o) Casino gaming areas

Section 9.3: Prescriptive

9.3.1 Interior Lighting Power

Building Area Method

- Used for projects involving the entire building
- Projects involving a separate occupancy in a multi-occupancy building
- Interior Lighting Power Allowance is found as follows
  a) Determine appropriate building type from Table 9.3.1.1
  b) Determine the gross lighted floor area of building
  c) Interior Lighting Power allowance is the product of the lighted floor area of the building times the lighting power density

Section 9.3: Prescriptive

9.3.1 Interior Lighting Power (continued)

Space-by-Space Method

- Interior Lighting Power Allowance is found as follows
  a) Determine appropriate building type from Table 9.3.1.2
  b) Determine the gross interior floor area
  c) Lighting power allowance for each space is found by multiplying the space floor area times the allowed lighting power density for the space
  d) The Interior Lighting Power Allowance is the sum of lighting power allowances for all spaces
- Trade-offs are permitted
- Additional Interior Lighting Power is allowed for the following cases:
  a) For additional lighting used for decorative appearance
  b) Lighting installed to meet the requirements of visual display terminals
  c) Lighting in retail spaces used to highlight merchandise

Section 9.3: Prescriptive

9.3.2 Exterior Building Lighting Power

Shall comply with 9.2.6

Exceptions:

- When the following are used with a control device
  a) Specialized signal, directional, and marker lighting
  b) Lighting for public monuments and historic landmarks
  c) Lighting integral for advertising signage

Section 10: Other Equipment

Section 10.1

- General

Section 10.2

- Mandatory Provisions

Section 10.1: General

Applies to

- All permanently wired electric motors

Section 10.2: Mandatory

Electric Motors

- Shall comply with requirements of the Energy Policy Act of 1992
- Shown in Table 10.2

Section 11: ECBM

Section 11.1
- General

Section 11.2
- Mandatory Provisions

Section 11.3
- Calculation of the Design Energy Cost

Section 11.4
- Calculation of the Energy Cost Budget

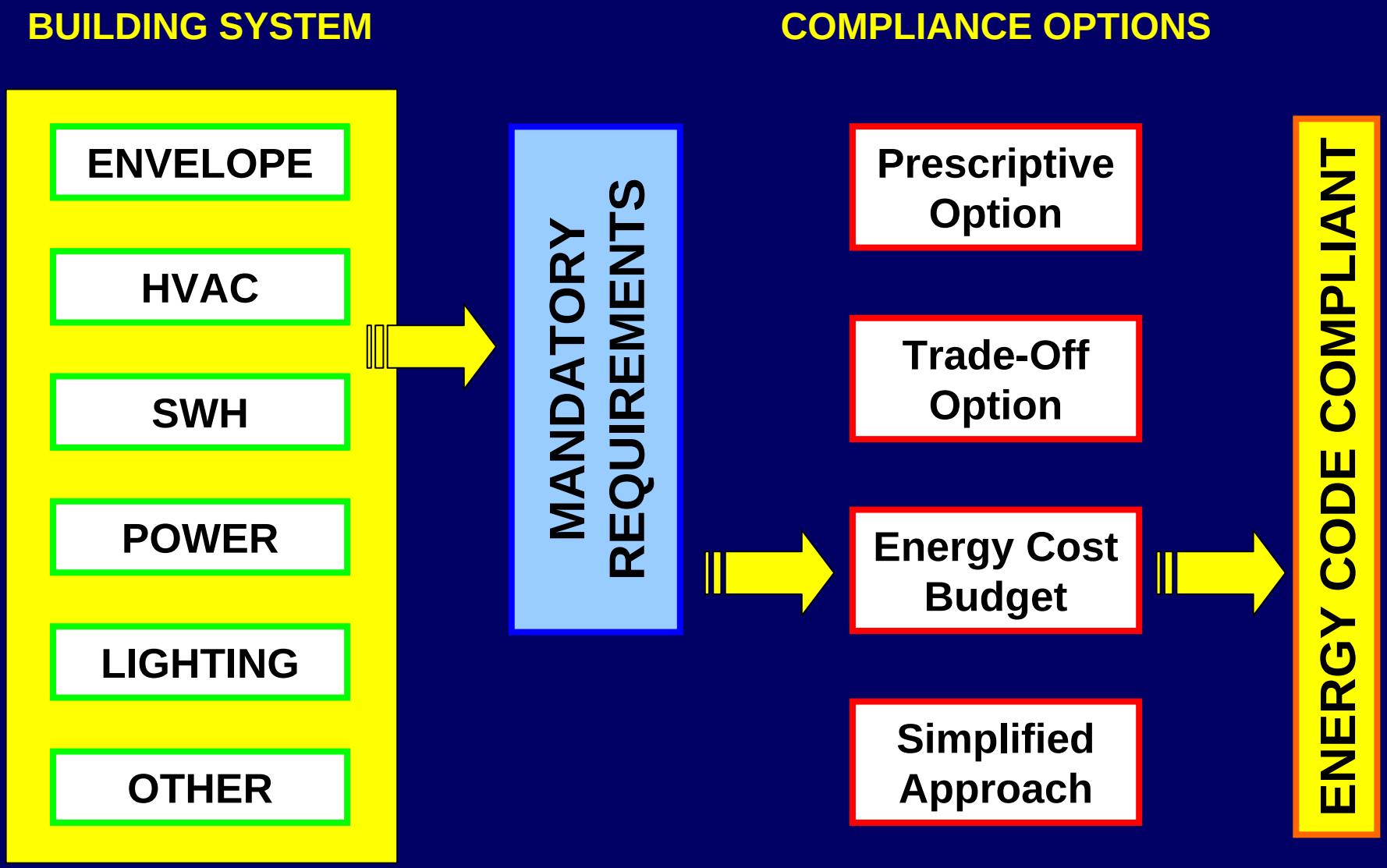
Section 11.5
- Exceptional Calculation Methods

Section 11.1: General

Alternative to prescriptive provisions

Section 7.1: General

7.1.2 Compliance



Section 11.2: Simulation

Simulation Program

- Computer-based program (i.e. DOE-2 or BLAST)

Climatic Data

- Representative climatic data shall be used

Purchased Energy Rates

- Annual energy costs based on utility rates

Compliance Calculations

- Design energy cost and energy cost budget shall be calculated using same program and data

Section 11.3: Calculation

Calculation of the Design Energy Cost

The model must be consistent with design data, system and operation

Section 11.4: Calculation

Calculation of the Energy Cost Budget

The energy cost budget must be consistent with budget building design

Includes minimums from Sections 5-10

Section 11.5: Exceptions

Exceptional Calculation Methods

When no simulation program is available other approved calculation methods can be used

Software Tools

ComCHECK-EZ

South Dakota State University's

Energy Analysis Lab

Crothers Engineering Hall Room 241
Mechanical Engineering Department
Brookings, SD 57007
(605) 688-4301

SOURCE: ASHRAE. 1999. ASHRAE Standard 90.1-1999. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

TABLE B-19
Building Envelope Requirements (HDD65: 7201-9000, CDD50: 1801+)

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 ci	U-0.322	NR
Steel Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-.0066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10.0 for 24 in.	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.550	R-10.0	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.58	U_{all}-0.74	$SHGC_{all}$-0.55	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

SOURCE: ASHRAE. 1999. ASHRAE Standard 90.1-1999. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

TABLE 6.2.4.2A

Minimum Duct Insulation R-Value,* Cooling and Heating Only Supply Ducts and Return Ducts

Climate Zone			Duct Location						
Envelop Criteria Table	HDD65	CDD50	Exterior	Ventilated Attic	Unvented Attic with Backloaded Ceiling	Unvented Attic with Roof Insulation	Unconditioned Space†	Indirectly Conditioned Space**	Buried
Heating Ducts Only									
5-1 to 5-7	0-1800	all	none	none	none	none	none	none	none
5-8 to 5-12	1801-3600	all	R-3.5	none	none	none	none	none	none
5-13 to 5-15	3601-5400	all	R-3.5	none	none	none	none	none	none
5-16 to 5-18	5401-7200	all	R-6	R-3.5	none	none	none	none	R-3.5
5-19 to 5-20	7201-9000	all	R-6	R-6	R-3.5	none	none	none	R-3.5
5-21 to 5-22	9001-10800	all	R-8	R-6	R-6	none	R-3.5	none	R-3.5
5-23	10801-12600	all	R-8	R-6	R-6	none	R-6	none	R-6
5-24	12601-16200	all	R-8	R-8	R-6	none	R-6	none	R-6
5-25	16201-19800	all	R-10	R-8	R-8	none	R-6	none	R-6
5-26	19801+	all	R-10	R-10	R-8	none	R-8	none	R-6
Cooling Only Ducts									
5-15, 18, 20, 22 to 26	all	0-1800	R-1.9	R-1.9	R-1.9	R-1.9	R-1.9	none	none
5-12, 14, 17, 19, 21	all	1801-3600	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
5-7, 9, 11, 13, 16	all	3601-5400	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	none
5-4, 6, 8, 10	all	5401-7200	R-6	R-6	R-6	R-3.5	R-1.9	none	none
5-3, 5-5	all	7201-9000	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5-2	all	9001-10800	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
5-1	all	10801+	R-8	R-8	R-8	R-3.5	R-3.5	none	R-3.5
Return Ducts									
5-1 to 5-26	all climates		R-3.5	R-3.5	R-3.5	none	none	none	none

* Insulation R-values, measured in $(h \cdot ft^2 \cdot °F)/Btu$, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.

† Includes crawl spaces, both ventilated and nonventilated.

** Includes return air plenums with or without exposed roofs above.

SOURCE: ASHRAE. 1999. ASHRAE Standard 90.1-1999. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

TABLE 9.3.1.1
Lighting Power Densities Using the Building Area Method

Building Type	Lighting Power Density (W/ft^2)
Automotive Facility	1.5
Convention Center	1.4
Court House	1.4
Dining: Bar Lounge/Leisure	1.5
Dining: Cafeteria/Fast Food	1.8
Dining: Family	1.9
Dormitory	1.5
Exercise Center	1.4
Gymnasium	1.7
Hospital/Health Care	1.6
Hotel	1.7
Library	1.5
Manufacturing Facility	2.2
Motel	2.0
Motion Picture Theater	1.6
Multi-Family	1.0
Museum	1.6
Office	1.3
Parking Garage	0.3
Penitentiary	1.2
Performing Arts Theater	1.5
Police/Fire Station	1.3
Post Office	1.6
Religious Building	2.2
Retail	1.9
School/University	1.5
Sports Arena	1.5
Town Hall	1.4
Transportation	1.2
Warehouse	1.2
Workshop	1.7

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method

Building Type	Space-by-Space Method LPDs																		
	Common Space Types and LPDs (W/ft²)																	Building Specific Space Types and LPDs (W/ft²)		Additional Power Allowance (see 9.3.1.2)
	Office—Enclosed	Office—Open Plan	Conference Meeting/Multipurpose	Classroom/Lecture/Training	Audience/Seating Area	Lobby	Atrium—first three floors	Atrium—each additional floor	Lounge/Recreation	Dining Area	Food Preparation	Restrooms	Corridor/Transition	Stairs—Active	Active Storage	Inactive Storage	Electrical/Mechanical			
Athletic Facility Buildings																				
Gymnasium	1.5	1.3	1.5		0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Playing Area	1.9	
																		Dressing/Locker/Fitting Room	0.8	
																		Exercise Area	1.1	
Exercise Center	1.5	1.3	1.5		0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Exercise Area	1.1	✓
																		Dressing/Locker/Fitting Room	0.8	
Civil Service Buildings																				
Courthouse	1.5	1.3	1.5	1.6	1.6	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Courtroom	2.1	✓
																		Confinement Cells	1.1	
																		Judges Chambers	1.1	
Police Stations	1.5	1.3	1.5	1.6	1.6	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Police Station Laboratory	1.8	
Fire Stations	1.5	1.3	1.5	1.6		1.8			1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Fire Station Engine Room	0.9	
																		Sleeping Quarters	1.1	
Post Office	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Sorting Area	1.7	✓ ✓
Town Hall	1.5	1.3	1.5	1.6	1.6	1.8				1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3			✓ ✓
Convention Center Buildings																				
Convention Center	1.5	1.3	1.5	1.6	0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Exhibit space	3.3	
Educational Buildings																				
School/University	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3			✓ ✓ ✓
Library	1.5	1.3	1.5	1.6		1.8	1.3	0.2		1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Card File and Cataloging	1.4	✓ ✓ ✓
																		Stacks	1.9	✓ ✓ ✓
																		Reading Area	1.8	✓ ✓ ✓
Food Service Buildings																				
Dining: Bar Lounge/ Leisure	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.2	2.2	1.0	0.7	0.9	1.1	0.3	1.3			✓ ✓
Dining: Family	1.5	1.3	1.5			1.8	1.3	0.2	1.4	2.2	2.2	1.0	0.7	0.9	1.1	0.3	1.3			✓ ✓
Dining: Cafeteria	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3			✓ ✓

SOURCE: ASHRAE. 1999. ASHRAE Standard 90.1-1999. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

SOURCE: ASHRAE. 1999. ASHRAE Standard 90.1-1999. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

TABLE 10.2
Minimum Nominal Efficiency for General Purpose *Design A* and *Design B* Motors*

	Minimum Nominal Full-Load Efficiency (%)					
	Open Motors			Enclosed Motors		
Number of Poles ==>	2	4	6	2	4	6
Synchronous Speed (RPM) ==>	3600	1800	1200	3600	1800	1200
Motor Horsepower						
1	-	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

* Nominal efficiencies shall be established in accordance with NEMA Standard MG1.