

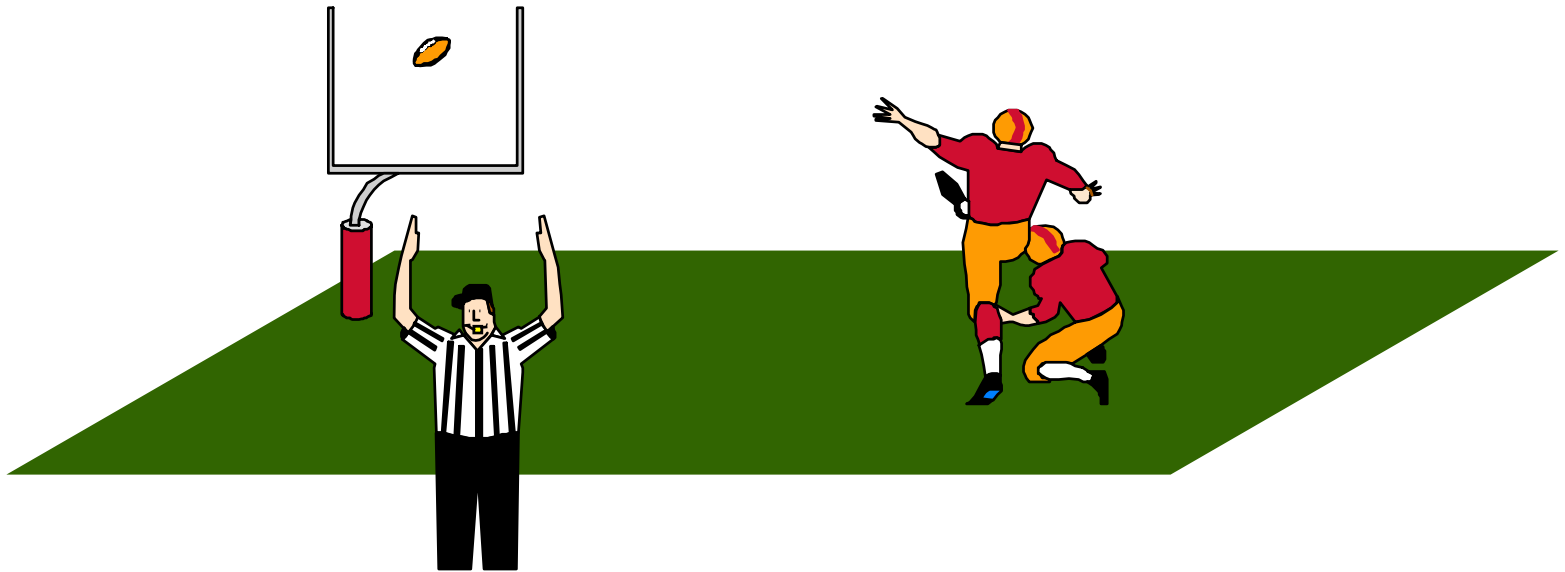
ASHRAE/IESNA Standard 90.1-1999

*An inside look at the requirements
of Standard 90.1-1999
Energy Standard for Building Except
Low-Rise Residential Building*

*Mick Schwedler, PE
Sr. Principal Applications Engineer
Member SSPC 90.1, 1995-1999
The Trane Company*

Goal

- ▲ Gain a working knowledge of ASHRAE Standard 90.1



Background

▲ Historical perspective of ASHRAE/IESNA Standard 90.1

- ◆ 90.1–1975 (**origin**)
- ◆ 90.1–1989 (**past**)
- ◆ 90.1–1999 (**present**)



Goals Of Standard 90.1–1999

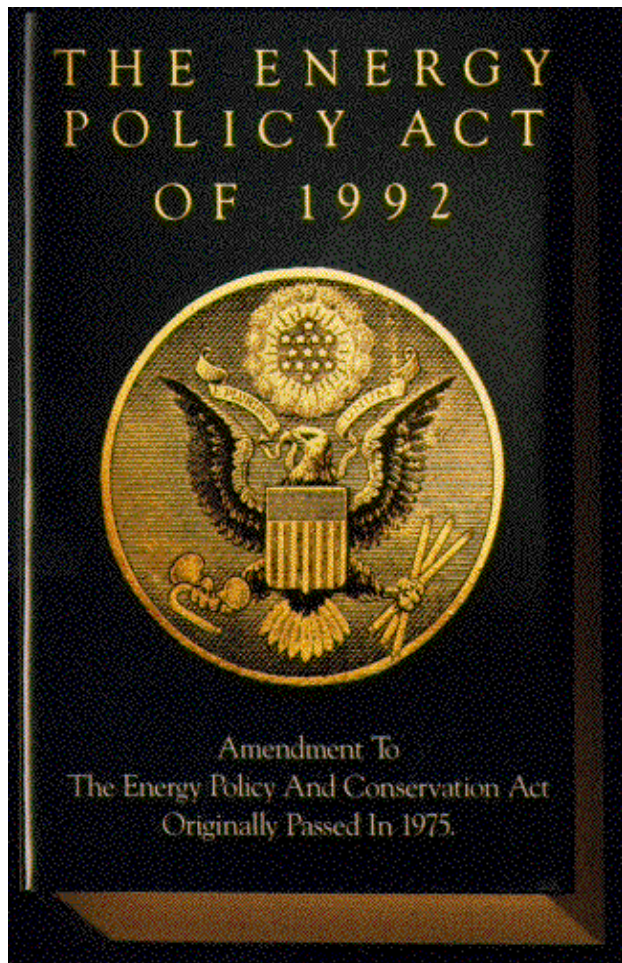
- ▲ **Energy efficiency**
 - ◆ ... But based on life-cycle cost economics
- ▲ **Ease of use**
- ▲ **Global possibilities**



Highlights of Standard 90.1–1999

- ▲ Reorganized for ease of use
- ▲ Written in code language
- ▲ Uses dual units (SI,IP)
- ▲ Implementation considered

Impact in the United States



Energy Policy Act of 1992 (EPAct)

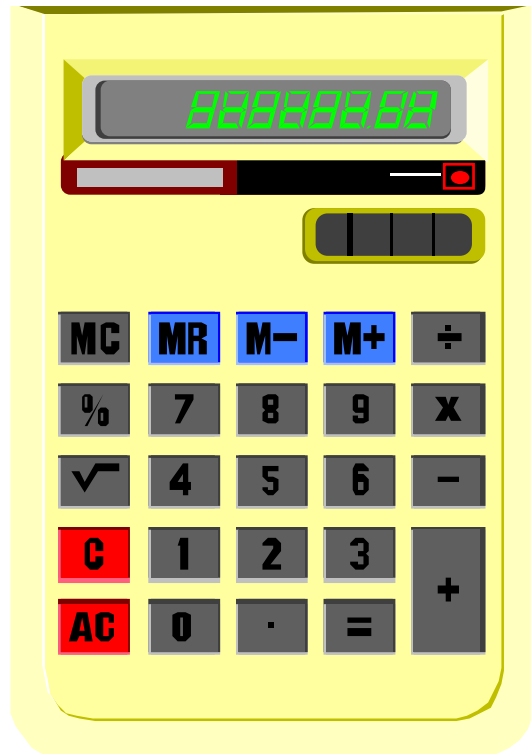
Impact in the United States

EPA Act

- ▲ **States must meet or exceed the requirements of Standard 90.1–1989**
- ▲ **DOE must evaluate any revisions to 90.1**
- ▲ **DOE can then obligate states to update their codes**



Economic Criteria



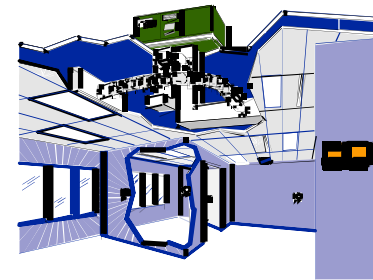
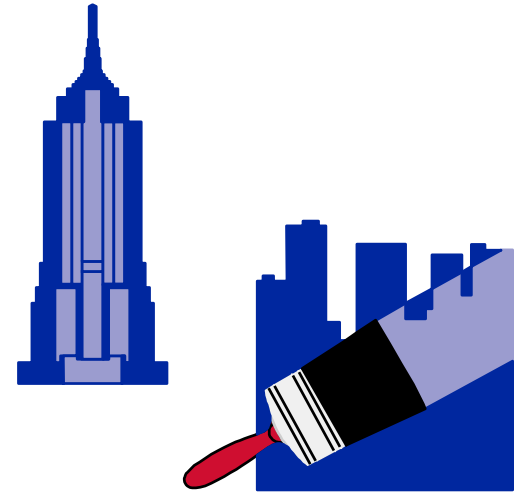
- ▲ Common economic criteria applied to all sections

Purpose of Standard 90.1 - 1999

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

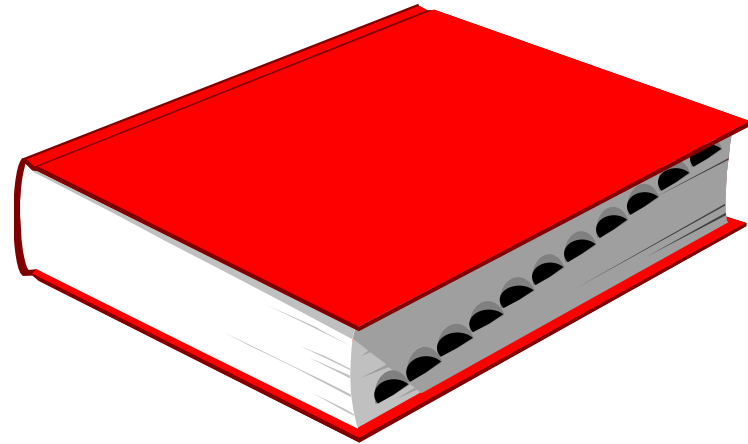
Scope Of Standard 90.1–1999

- ▲ New buildings, systems
- ▲ New *portions* of buildings and their systems
- ▲ New systems and equipment in existing buildings
- ▲ **Excludes** low-rise residential - Standard 90.2



Definitions

- ▲ **Definitions**
- ▲ **Abbreviations**
- ▲ **Acronyms**



Administration & Enforcement

▲ Compliance requirements

- ◆ new buildings
- ◆ existing buildings
 - *additions*
 - *alterations*

▲ Compliance documentation

- ◆ drawings, manuals
- ◆ labeling



Complying With 90.1–1999

▲ New buildings

- ◆ Requirement of each section

... OR ...

Energy Cost Budget (ECB)

- ◆ Specific tradeoffs for compliance

▲ Existing buildings

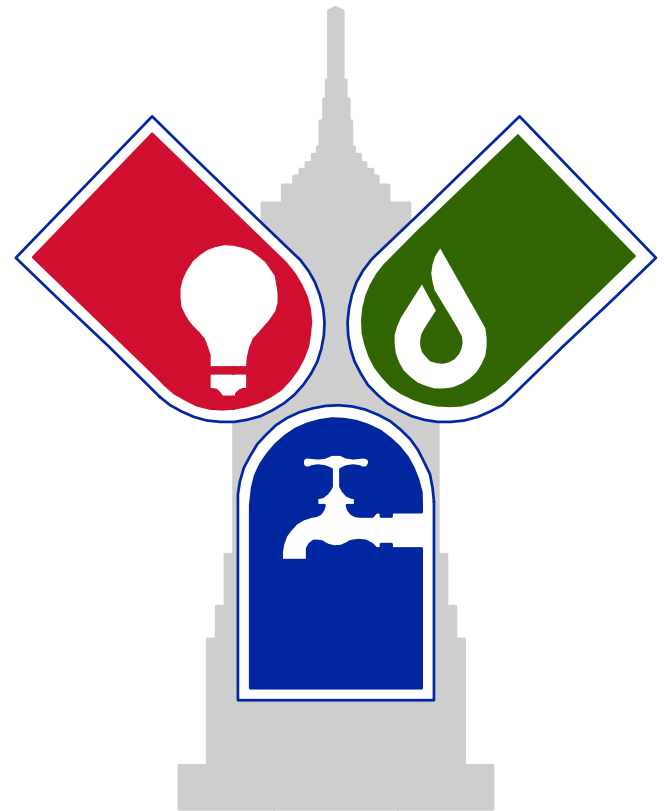
- ◆ Requirements of each section - limited

- ◆ Specific tradeoffs for compliance



Standard 90.1–1999 Covers ...

- ▲ Envelope
- ▲ HVAC
- ▲ Service water heating
- ▲ Power
- ▲ Lighting
- ▲ Electric motors



Building Envelope



Building Envelope

Based on climate and space type

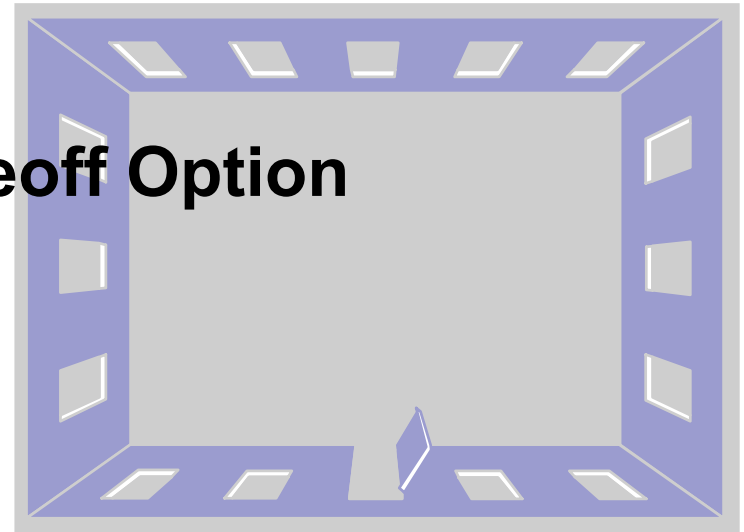
▲ **Glazing limit (windows)**

... OR ...

Building Envelope Tradeoff Option

▲ **Insulation levels**

- ◆ Construction
- ◆ Space Type



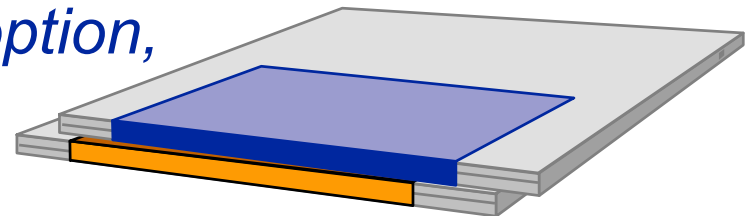
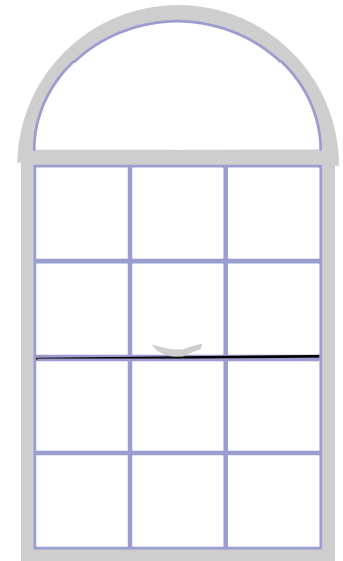
Features

- ▲ **Envelope criteria based on typical envelope assemblies and class construction**
- ▲ **New true prescriptive option**
- ▲ **Precalculated values for compliance**
- ▲ **Benefit is more uniform and fairer implementation**

Building Envelope

- ▲ **Glazing —**
U-factor, solar heat gain coefficient
 - ◆ Orientation
 - ◆ Percentage
- ▲ **Air leakage —**
sealing, weatherseals, vestibules

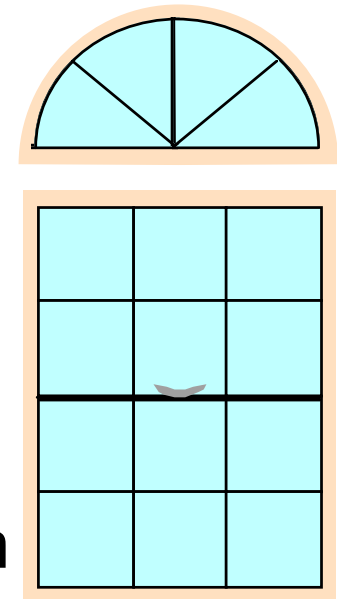
*Building envelope tradeoff option,
ENVSTD 3.0 software*



Prescriptive Compliance

Fenestration

- ▲ **Skylight area as a % of gross roof area**
- ▲ **Vertical fenestration glazing area as a % of gross wall area**
- ▲ **U-factor is dependent on type**
- ▲ **SHGC is dependent on orientation**



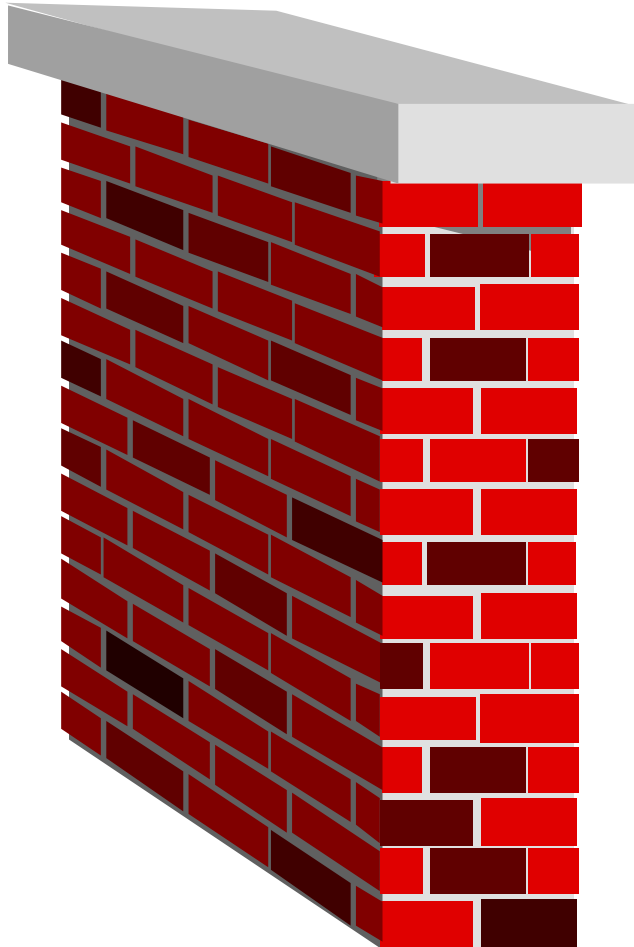
Prescriptive Compliance-Opaque

- ▲ **No calculations required**
- ▲ **Specify insulation R-value or...**
- ▲ **Look up common U-factors**

Overall U-factors: Roofs

- ▲ **Roofs with insulation above deck**
- ▲ **Metal building roofs**
- ▲ **Roofs with metal joists**
- ▲ **Wood-framed roofs with attics**
- ▲ **Single-rafter roof/ceilings with wood joists**

Overall U-Factors: Above-Grade Walls



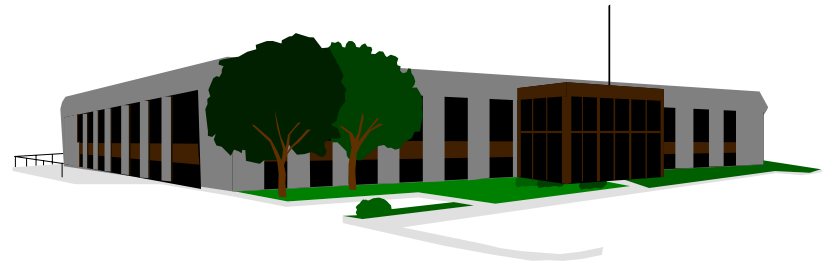
- ▲ **Mass walls**
- ▲ **Metal building walls**
- ▲ **Metal-framed walls**
- ▲ **Wood-framed walls**

Typical Table

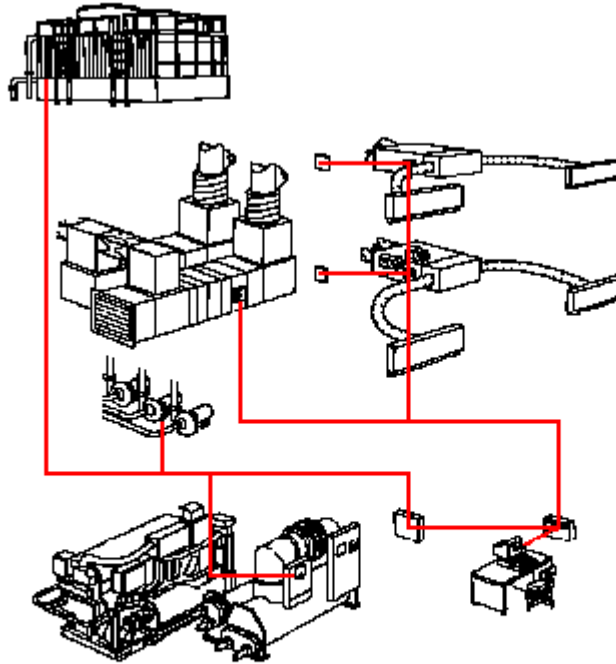
Components	Nonresidential Assembly Maximum	Insulation Minimum
Roofs		
Insulation Entirely above Deck	U-0.093	R-10 cont. ins.
Metal Building	U-0.070	R-19
Attic and Other	U-0.034	R-30

Envelope summary

- ▲ **Based on space type**
- ▲ **Single table per climate**
- ▲ **Common U-factors available**
- ▲ **Trade-off procedure**



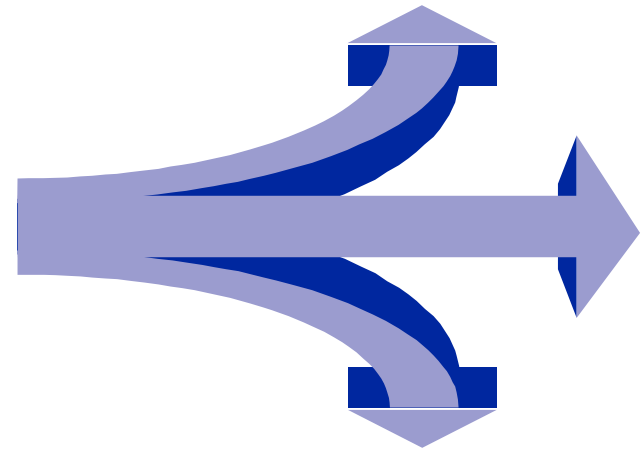
HVAC & Service Water Heating



HVAC Section

▲ 3 paths to compliance ...

- ◆ Simplified Approach
- ◆ Mandatory plus prescriptive
- ◆ Mandatory and ECB

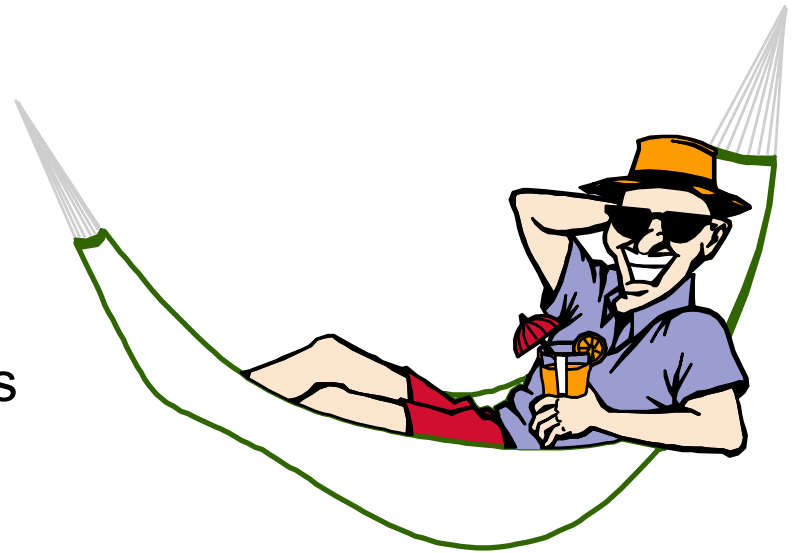


There's more ...

Simplified Approach

HVAC Section

- ▲ **Purpose**
- ▲ **Same requirements**
- ▲ **Fits on two pages**
- ▲ **Limited to ...**
 - ◆ Buildings with 1 or 2 stories
 - ◆ Air-cooled HVAC systems dedicated to a single zone
 - ◆ Buildings less than 25,000 square feet



Mandates

HVAC Section

▲ Requirements address ...

- ◆ Equipment Efficiencies
- ◆ Controls
- ◆ Construction and insulation
- ◆ Drawings, manuals and commissioning

▲ Part of prescriptive and ECB compliance paths



Equipment Covered

HVAC Section

- ▲ **Packaged equipment**
- ▲ **Heat pumps**
- ▲ **Chillers**
- ▲ **Packaged terminal/room air conditioners**
- ▲ **Furnaces**
- ▲ **Boilers**
- ▲ **Cooling towers**



Equipment Efficiency Examples

HVAC Section

Type	Minimum Efficiency	Efficiency 10/29/2001
15-ton rooftop	8.5 EER	9.7 EER
300-ton water-cooled centrifugal chiller	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV

Equipment Covered for the First Time

HVAC Section

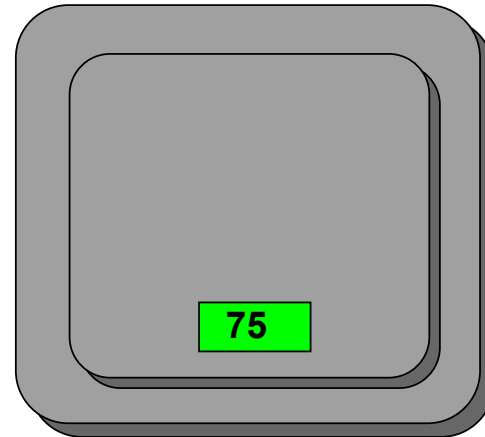
- ▲ **Ground-source heat pumps**
- ▲ **Replacement PTAC's PTHP's**
- ▲ **Single- and double-effect absorption chillers**
- ▲ **Heat rejection equipment**
- ▲ **Hot water boilers**



Mandatory Control

HVAC Section

- ▲ **Zone control capability**
- ▲ **Off-hour controls**
 - ◆ Automatic Shutdown
 - ◆ Setback
 - ◆ Optimum start above 10,000 cfm
 - ◆ Shutoff damper
 - ◆ Zone isolation



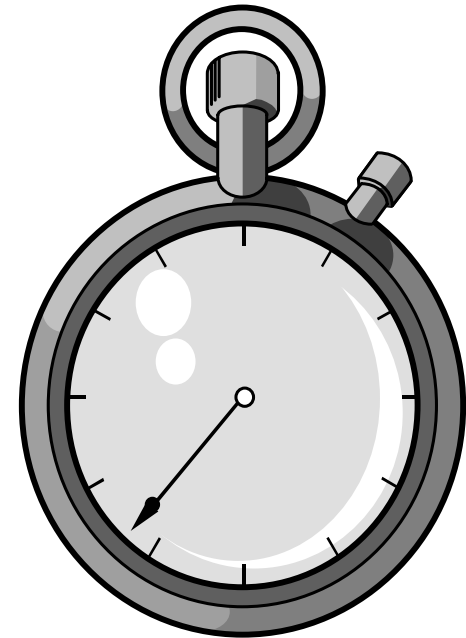
Control

Off-Hour Controls

HVAC Section

▲ Automatic Shutdown

- ◆ Automatic time clock w/10 hour battery back up
- ◆ occupancy sensor
- ◆ manually operated timer w/max. 2 hr duration
- ◆ Security system interlock

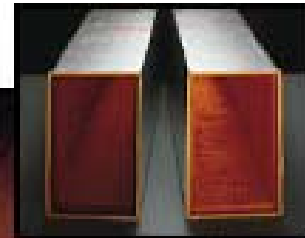


Mandatory

HVAC Section

Construction & Insulation

- ▲ “Durable” insulation
- ▲ Duct and plenum insulation
- ▲ Duct sealing
- ▲ Leakage tests
- ▲ Piping Insulation



Mandatory

HVAC Section

Completion Requirements

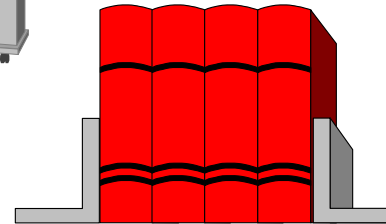
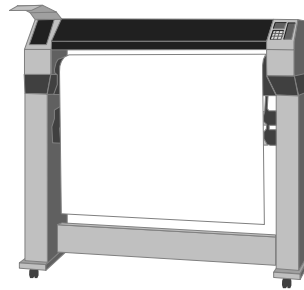
▲ Drawings

▲ Manuals

- ◆ Operating
- ◆ Maintenance

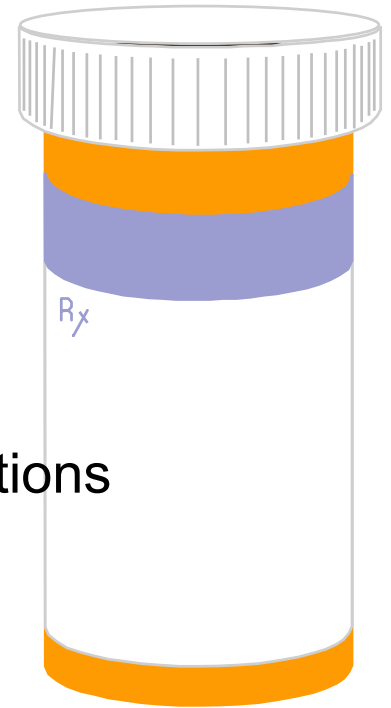
▲ Balancing

- ◆ Airside > 1hp - except calibrated VAV
- ◆ Hydronic pumps >10 hp



▲ Requirements address ...

- ◆ Economizers
- ◆ Simultaneous heating and cooling
- ◆ Air system design and control
- ◆ Hydronic system design and control
- ◆ Heat rejection equipment control and limitations
- ◆ Heat recovery
- ◆ Exhaust hoods



Prescriptive Economizers

HVAC Section

- ▲ **Climate and Size Dependent**
- ▲ **Numerous exceptions**
- ▲ **High limit controls are climate dependent**
- ▲ **Airside - up to 100% OA**
- ▲ **Waterside**
 - ◆ Size requirement
 - ◆ Reduce pressure drop effect



Economizers

Climate and Size

HVAC Section

No. of Hours Between 8 am and 4 pm with $55^{\circ}\text{F} < T_{\text{db}} < 69^{\circ}\text{F}$	1% Cooling Design Wet-Bulb Temperature		
	$T_{\text{wb}} < 69^{\circ}\text{F}$	$69^{\circ}\text{F} \leq T_{\text{wb}} \leq 73^{\circ}\text{F}$	$T_{\text{wb}} > 73^{\circ}\text{F}$
	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)
0 - 199	N.R.	N.R.	N.R.
200 - 399	135,000	N.R.	N.R.
400 - 599	135,000	N.R.	N.R.
600 - 799	65,000	135,000	N.R.
800 - 999	65,000	135,000	135,000
1000 - 1199	65,000	65,000	135,000
> 1199	65,000	65,000	65,000

R. means that there is no system size for which an economizer is a requirement in this climate.

Economizers

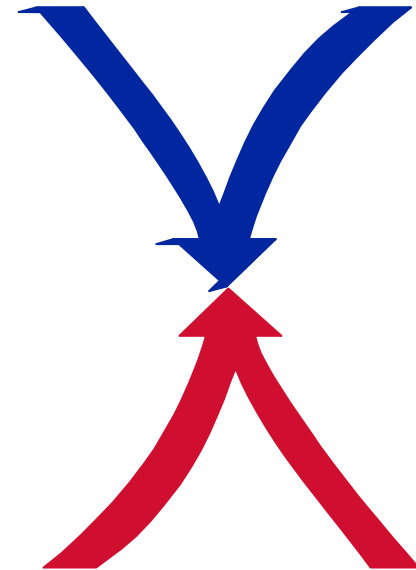
HVAC Section

Example requirements

Locale	1% Design WB	No. Hours 8 am – 4 pm 55<Tdb<69	System size at which economizer is required
Miami, FL	77	259	No economizer required
Evansville, IN	76	611	No economizer required
Chicago, IL	73	613	135,000 Btuh (11.25 tons)
New York, NY	73	790	135,000 Btuh (11.25 tons)
Denver, CO	59	739	65,000 Btuh (5.4 tons)
Boston, MA	71	713	135,000 Btuh (11.25 tons)
Minneapolis, MN	71	566	No economizer required
Tucson, AZ	65	716	65,000 Btuh (5.4 tons)
San Francisco, CA	62	1796	65,000 Btuh (5.4 tons)

Simultaneous heating and cooling

- ▲ **Limits recooling, reheating or mixing**
- ▲ **Limited airflow per zone**
- ▲ **Hydronic systems**
 - ◆ Three pipe not allowed
 - ◆ Two pipe changeover control
- ▲ **Heat pump systems**
 - ◆ Two-position valve

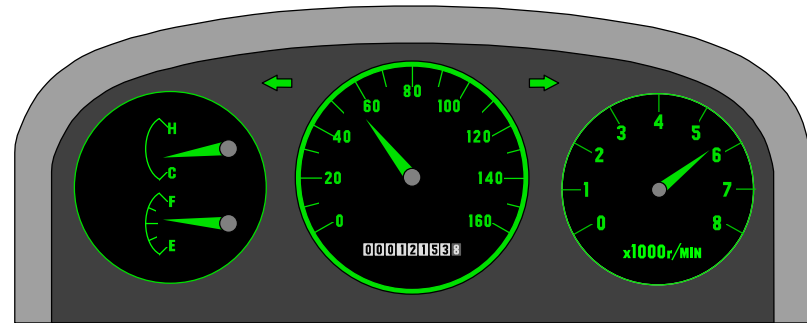


Simultaneous heating and cooling

Airflow limits per zone

HVAC Section

- ▲ Standard 62 zone requirements, or...
- ▲ 0.4 cfm/ft², or...
- ▲ 300 cfm, or...
- ▲ Standard 62, 6-1 implementation



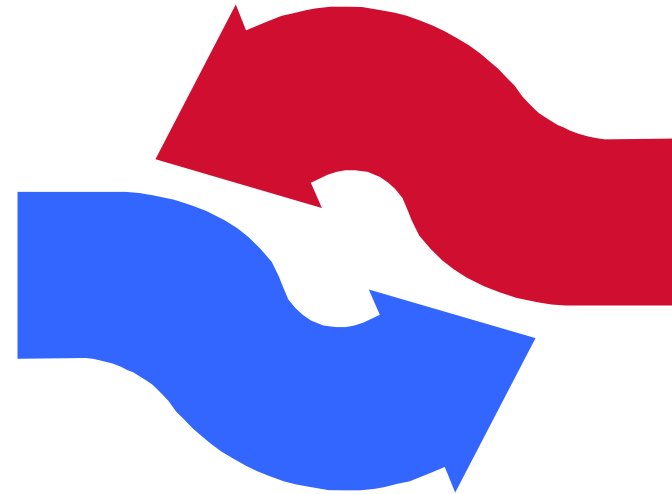
Simultaneous heating and cooling

Dehumidification

HVAC Section

▲ Prevent

- ◆ Reheating
- ◆ Mixing of hot and cold air streams
- ◆ Heating and cooling of same air stream



Simultaneous heating and cooling

Dehumidification

HVAC Section

▲ Exceptions

- ◆ Reducing supply air flow to 50%, or min. ventilation
- ◆ Systems under 6.67 tons that can unload at least 50%
- ◆ Systems smaller than 3.3 tons
- ◆ Process applications
- ◆ 75% of reheat or recool energy is recovered or solar

EXCEPT

Air system design and control

▲ Fan system power limitation

- ◆ Applies to systems > 5 hp
- ◆ Limits based on **nameplate** hp
- ◆ Credits available

▲ VAV fan control

- ◆ Motors ≥ 25 hp
- ◆ 30% design wattage at 50% air volume

▲ DDC: Fan pressure optimization



Air system design and control

Fan system power

HVAC Section

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
< 20,000 cfm (9400 L/s)	1.2 hp/1000 cfm (1.9 kW/1000 L/s)	1.7 hp/1000 cfm (2.7 kW/1000 L/s)
≥ 20,000 cfm (9400 L/s)	1.1 hp/1000 cfm (1.7 kW/1000 L/s)	1.5 hp/1000 cfm (2.4 kW/1000 L/s)

Hydronic system design and control

▲ Variable flow required when

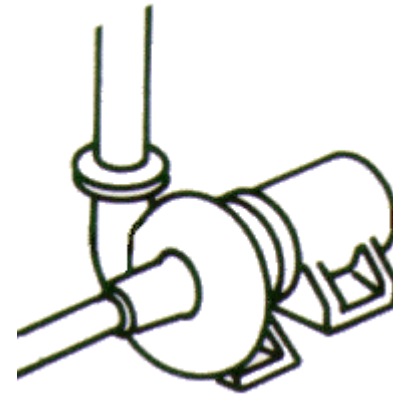
- ◆ > 100 feet *and* 50 hp motor

▲ Pump isolation

- ◆ Series chiller exception
- ◆ Written to give latitude

▲ Reset with Exceptions

- ◆ Improper operation
- ◆ Variable flow



Prescriptive

HVAC Section

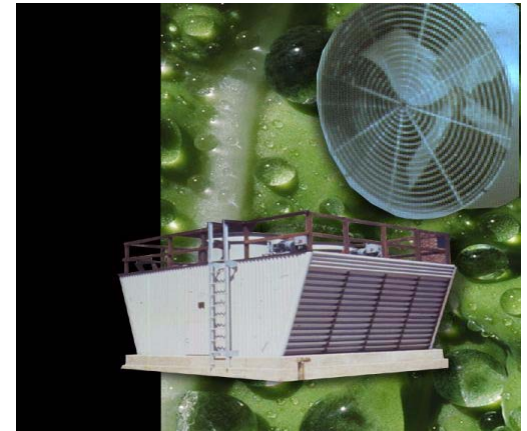
Heat rejection equipment

▲ Fan speed control 7.5 hp and up

- ◆ capability to operate at 2/3 speed or less

▲ Exceptions

- ◆ Condenser fans on multiple circuits
- ◆ Condenser fans on flooded condensers
- ◆ Climates with a lot of cooling.
- ◆ 1/3 of the fans on a multiple fan application



Prescriptive Energy recovery

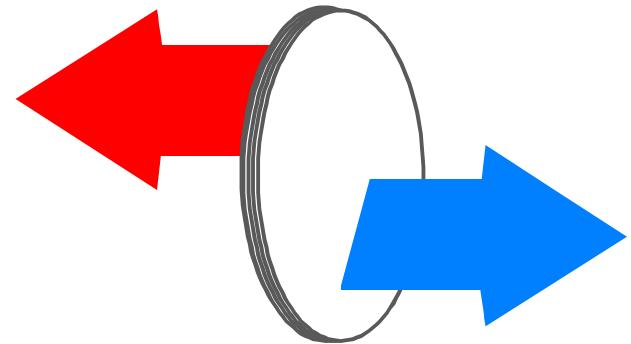
HVAC Section

▲ Airside

- ◆ 70% OA and 5000 cfm total
- ◆ 50% effectiveness

▲ Service Water Heating

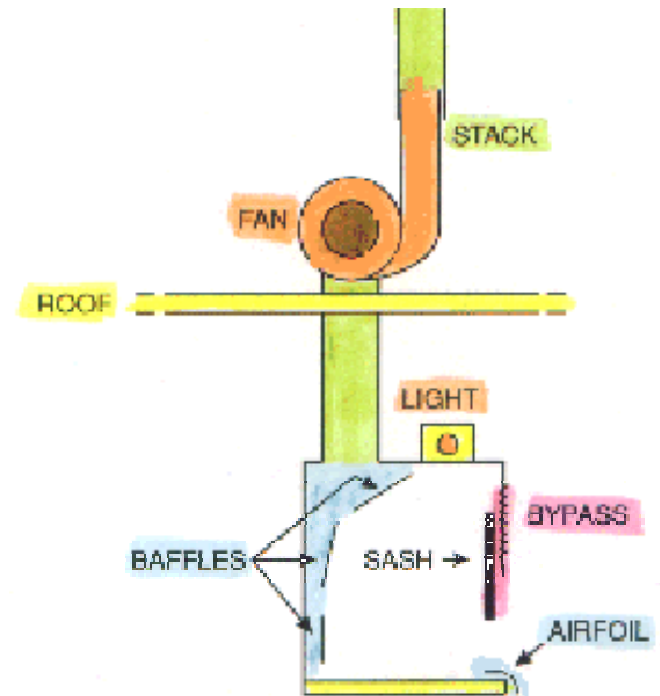
- ◆ 24 hrs per day **and**
- ◆ Heat rejection > 6 MMBtuh **and**
- ◆ SWH load 1 MMBtuh



Prescriptive Exhaust hoods

HVAC Section

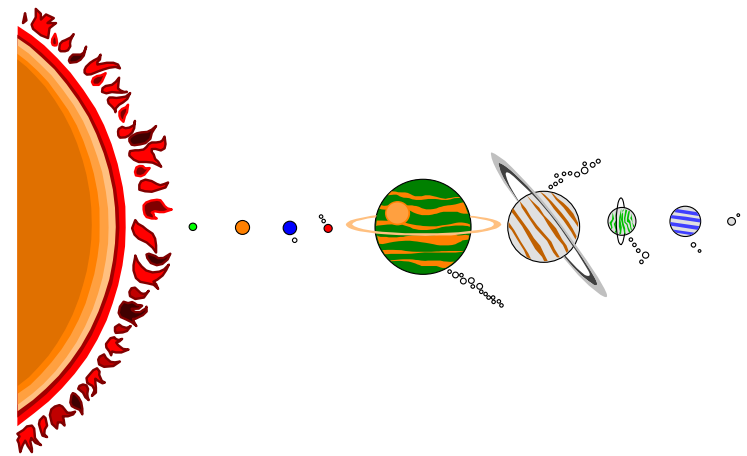
- ▲ **Kitchen hoods > 5,000 cfm**
- ▲ **Fume hoods**
Total > 15,000 cfm
 - ◆ Capability to < 50% or...
 - ◆ Direct make-up at least 75% of exhaust rate at specified conditions or...
 - ◆ Heat recovery for make-up air



Prescriptive Radiant heating

HVAC Section

- ▲ Loading docks
- ▲ Unenclosed spaces



Prescriptive

HVAC Section

Hot Gas Bypass Limitation

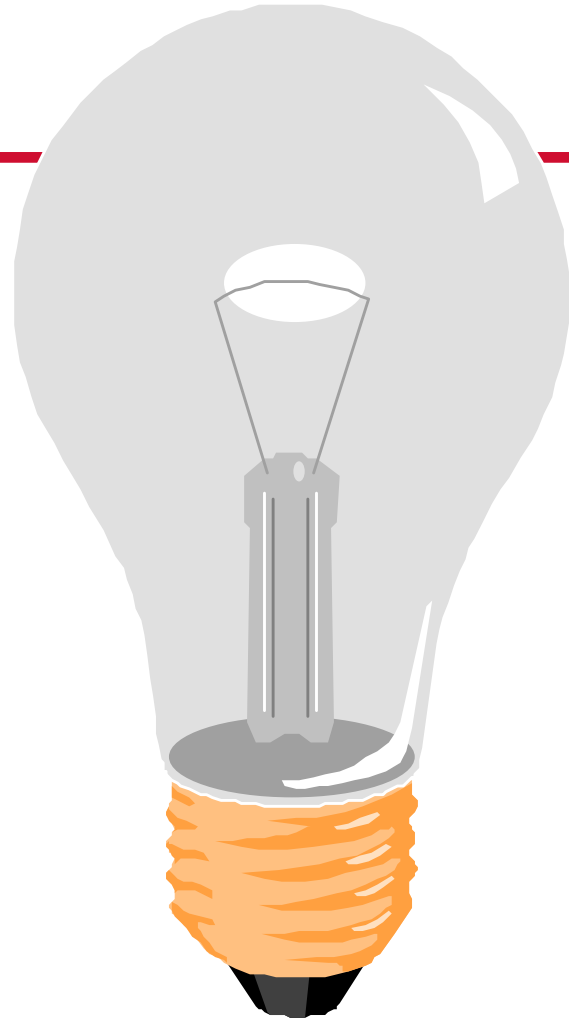
- ▲ **≥ 7.5 tons**
- ▲ **Multiple steps or continuous unloading**

Rated Capacity	Maximum Hot Gas Bypass Capacity (% of Total Capacity)
$\leq 240,000$ Btu/h (70 kW)	50%
$> 240,000$ Btu/h (70 kW)	25%

Service Water Heating

- ▲ **Efficiency**
- ▲ **Insulation**
- ▲ **Service Water Heating System Controls**
- ▲ **Pool heaters and covers**
- ▲ **Prescriptive for**
 - ◆ Space and water heating
 - ◆ Service water heating

Lighting



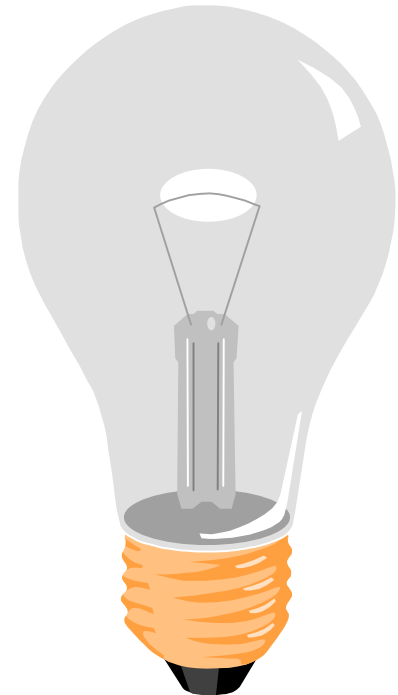
Lighting Scope

▲ Lighting Control

- ◆ Interior and exterior

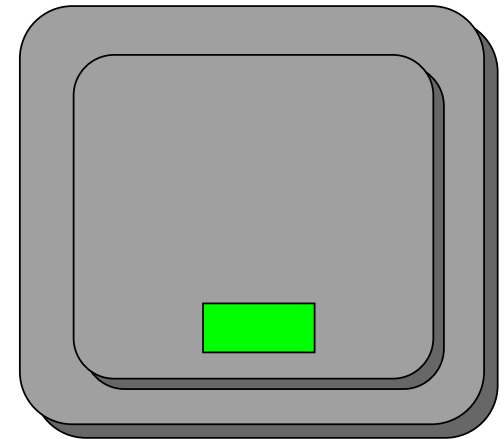
▲ Lighting Power

- ◆ Interior and exterior
- ◆ Building type and use



Interior Control Requirements

- ▲ **At least one control in each space**
- ▲ **Automatic shutoff for buildings $> 5,000 \text{ ft}^2$**
- ▲ **Reduced general lighting for use during clean-up**



Interior Lighting Power – Building Area Method –

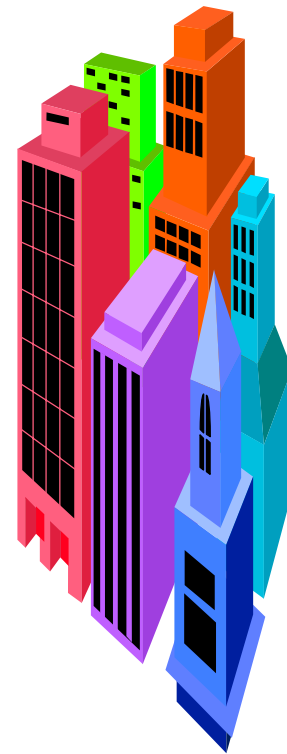
Building Budget (W) = LPD x area (ft²)

Where

LPD is Lighting Power Density (W/ft²)

Building Area Lighting Power Densities

▲ Hospital	1.6 W/ft ²
▲ Library	1.5 W/ft ²
▲ Manufacturing	2.2 W/ft ²
▲ Museum	1.6 W/ft ²
▲ Office	1.3 W/ft ²
▲ Retail	1.9 W/ft ²
▲ School	1.5 W/ft ²



Interior Lighting Power Space-by-Space Method (W/ft²)

▲ Office Enclosed	1.5	▲ Dining	1.4
▲ Office Open	1.3	▲ Food Prep	2.2
▲ Conference	1.5	▲ Corridor	0.7
▲ Training	1.6	▲ Restroom	1.0
▲ Lobby	1.8	▲ Active Storage	1.1
▲ Lounge	1.4		

Power may be traded between spaces

Additional Interior Lighting Power

- ▲ **Decorative luminaires - 1.0 W/ft² in space where used**
- ▲ **Luminaires designed to eliminate computer screen glare - 0.35 W/ft²**
- ▲ **Accent Lighting**
 - ◆ **Additional 1.6 W/ft² , or**
 - ◆ **Additional 3.9 W/ft² for fine merchandise**

Exterior Lighting Controls

- ▲ **Must have some means of automatic shutoff during daylight hours.**



Exterior Building Lighting Power

Application	Power Limits
Building Entrance w/ canopy	3 W/ft ² of canopied area
Building Entrance w/o canopy	33 W/lin ft of door width
Building exit	20 W/lin ft of door width
Building facades	0.25 W/ft ² of vertical facade

Site Lighting

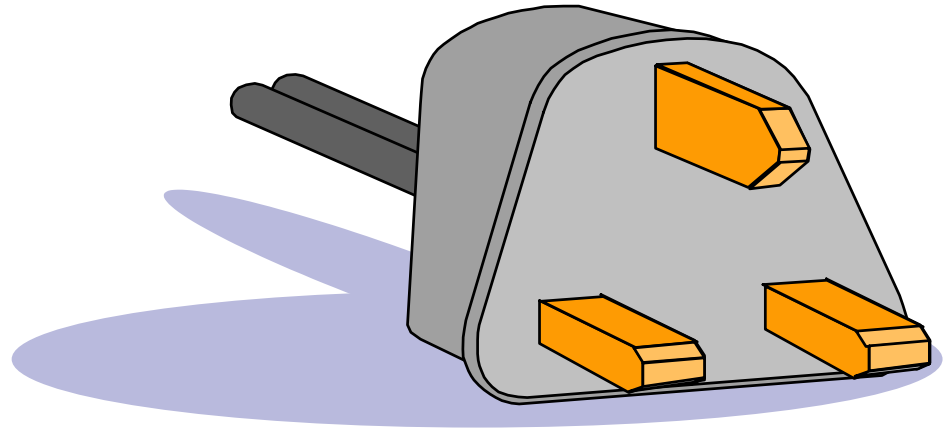
- ▲ **luminaire efficacy 60 lumens/watt for lamp/ballast combinations > 100**

Lighting Alterations in Existing Buildings

- ▲ Replacement of lighting *systems* meet the lighting power density requirements
- ▲ New control devices have a maximum area they can cover
- ▲ Exception: When <50% of luminaires replaced

Electric Motors

▲ Motor efficiency



Energy Cost Budget (ECB)

- ▲ “ ... maximum allowable energy cost for the proposed design ... ”

*Computer simulation
for tradeoffs between
building functions*



ECB

▲ Compliance =

- ◆ estimated annual energy cost of proposed building less than or equal to
- ◆ energy cost of complying equivalent building

Who's Affected?

- ▲ **Owners**
- ▲ **Occupants**
- ▲ **Consulting engineers**
- ▲ **System designers**
- ▲ **Installers**
- ▲ **Operators**



ASHRAE/IESNA Standard 90.1

◆ Published

- *Members - \$75*
- *Non-members - \$98*

◆ Available

- *www.ashrae.org*
- *800-527-4723 (U.S. & Canada)*
- *404-636-8400*

◆ Being studied by the U.S. DOE (EPAAct)

◆ Likely to be adopted by some

◆ Under continuous maintenance



Questions?

