Mechanical Systems

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- List of Mechanical Systems

_____
_____
_____
_____
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_____

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HVAC Systems

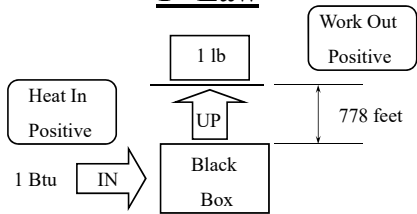APPA Facilities Management Institute

Ginsberg's Theorem

(or the laws of thermodynamics restated)

1. You can't win!
2. You can't break even!
3. You can't even quit the game!

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1st Law

Work Out
Positive

1 lb

Heat In
Positive

UP

778 feet

1 Btu   IN

Black
Box

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Heat defined as:
1 Btu = 1°F rise of 1 lb of water

Work defined as:
1 ft-lb = Raising 1 lb up 1 foot

1 Btu = 778 ft-lbs

<u>Stored Energy</u>

$E = Q - W$

<u>Potential Energy</u>

$PE = (Weight) \times (Height)$

<u>Kinetic Energy</u>

$KE = \tfrac{1}{2} \times (Mass) \times (Velocity)^2$

U= Internal Energy = E – PE - KE

<u>WORK</u>

P1

V1 → | OPEN SYSTEM | → P2 V2

Constant Pressure

$$\triangle W = p \times \triangle V$$
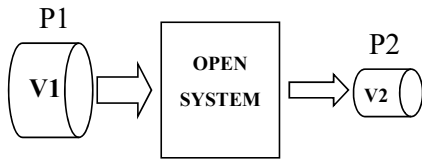
E = Q – W

Q = E + pV

Q = U + PE + KE + pV

Q = (U + pV) + PE + KE

Q = H + PE +KE

Enthalpy

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Absolute Zero

$$0^{\circ}F = 459.69^{\circ}K$$

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Perfect Efficiency?

2nd Law Efficiency = $1 - (Tl/Th)$

Ex. Furnace heats room to $70^{\circ}F$ with $180^{\circ}F$ air

Eff. = $1 - (530/640)$

= 0.17

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Design Considerations
– Building Function
– Budget
– Functional Zoning
– Available Space
– Aesthetics
– Noise/vibration

$$\text{Heat} = K \times \overset{\bullet}{V} \times \triangle T$$

Fundamental types of systems
- All air
- All water
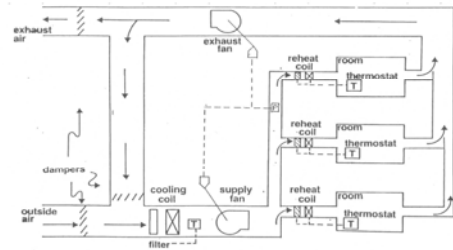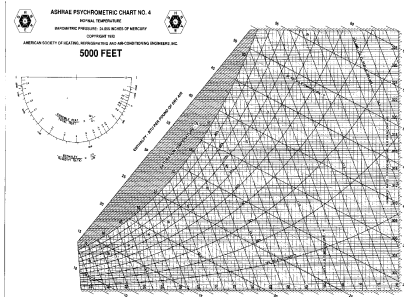- Water and Air

Single Zone System
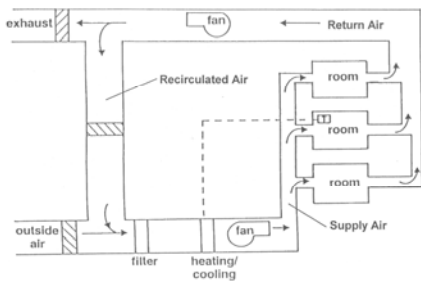
APPA Facilities Management Institute
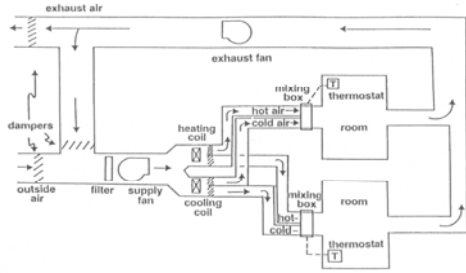**Terminal Reheat System**
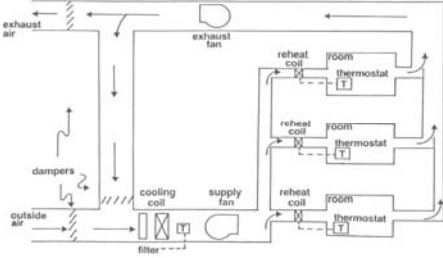
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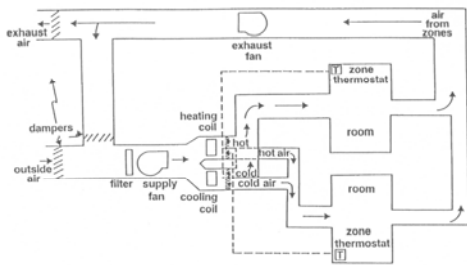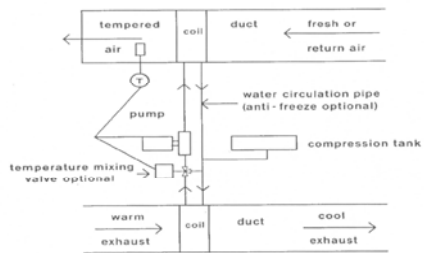**VAV Conversion of Terminal Reheat**

Psych Chart

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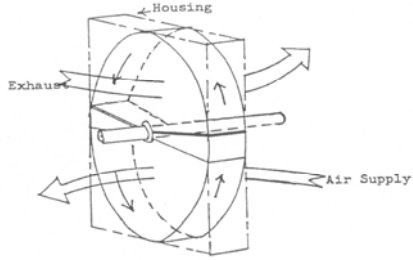**Dual Duct System**

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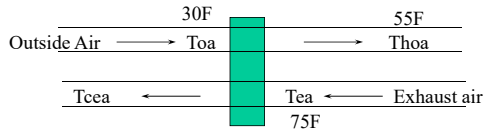**Multizone System**

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Run-around Heat Recovery System

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Heat Recovery Wheel

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Outside Air → Toa —(30F)→ Thoa (55F)

Tcea ← Tea ← Exhaust air (75F)

$$\% \text{ Eff.} = \frac{\text{Thoa - Toa}}{\text{Tea - Toa}}$$

$$= 56\%$$

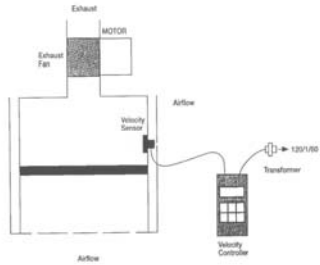APPA Facilities Management Institute

Laboratory Fume Hoods
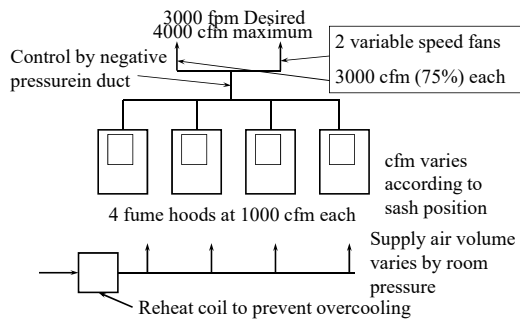- Chemical
- Radiostope
- Perchloric Acid

Biological Safety Cabinets
- Class 1
- Class II-A
- Class II-B
- Class III

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Variable Flow Hood Design

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3000 fpm Desired
4000 cfm maximum

2 variable speed fans

Control by negative
pressurein duct

3000 cfm (75%) each

cfm varies
according to
sash position

4 fume hoods at 1000 cfm each

Supply air volume
varies by room
pressure

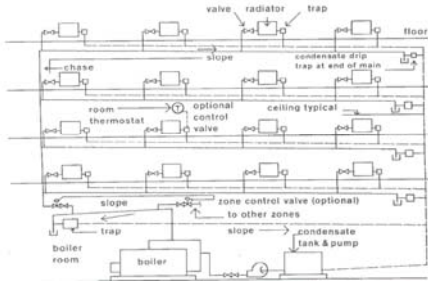Reheat coil to prevent overcooling

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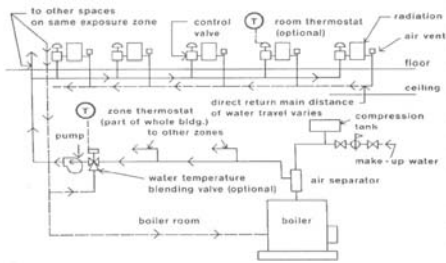APPA Facilities Management Institute

Codes and Standards

- OSHA
  - User Safety – Fed. Reg. 29 CFR 1910.1003
- Scientific Apparatus Makers Association
  - Lab Fume Hoods Standard: LF 10 – 1980
- ASHRAE
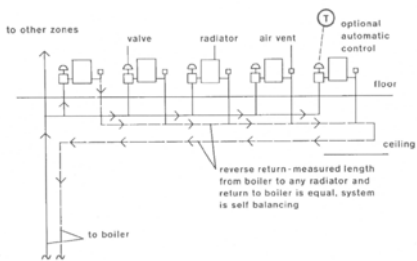 - Method of Testing Lab Fume Hoods: 110-1985

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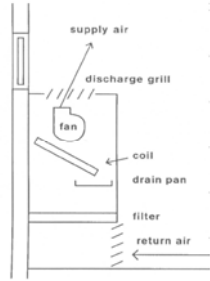**Steam Heating System**

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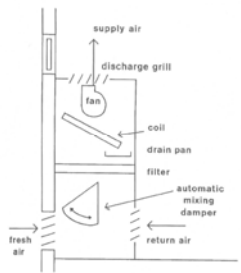**Hot Water Heating System – Direct Return**

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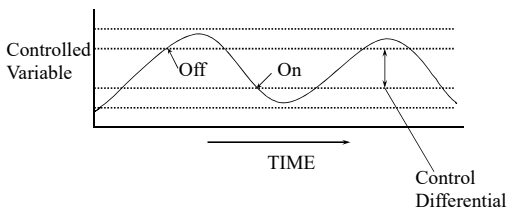**Hot Water Heating System – Reverse Return**
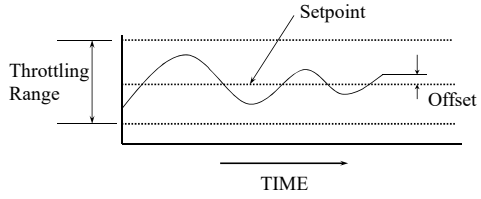
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Fan coil Unit

supply air

discharge grill

fan

coil

drain pan

filter

return air

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Unit Ventilator

supply air

discharge grill

fan

coil

drain pan

filter

automatic
mixing
damper

fresh
air

return air

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Two Position Control

Controlled
Variable

Off   On

TIME

Control
Differential

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Proportional Control

Setpoint

Throttling Range

Offset

TIME

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Proportional + Integral Control

Setpoint

Throttling Range

No Offset

TIME
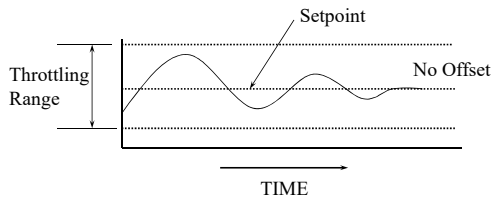
APPA Facilities Management Institute
Proportional + Integral + Derivative Control

Setpoint

Throttling Range

No Offset

TIME

Damped out more quickly

12
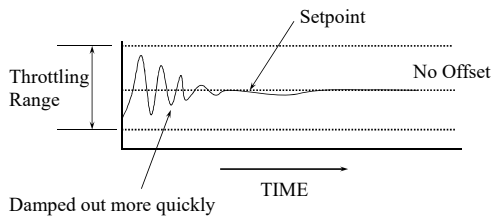
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Other
Control
Issues

_____
_____
_____
_____
_____
_____
_____

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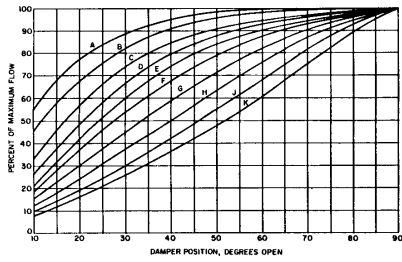
Parallel Blade Damper Characteristics

_____
_____
_____
_____
_____
_____
_____

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Opposed Blade Damper Characteristics

_____
_____
_____
_____
_____
_____
_____

Parallel Blade Dampers		Opposed Blade Dampers	
% Resist.	Curve	% Resist.	Curve
0.5-1.0	A	0.3-0.5	A
1.5-2.5	C	0.8-1.5	C
3.5-5.5	E	2.5-5.5	E
5.5-9.0	F	5.5-13.5	F
20.0-30.0	J	13.5-25.5	G
30.0-50.0	K	25.5-37.5	H

50% loss here

PUMP

HOT WATER SOURCE

HEATING COIL

CONTROL VALVE
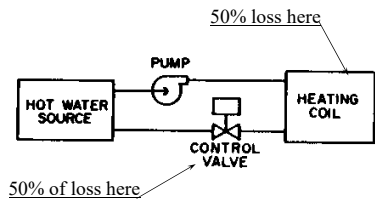
50% of loss here
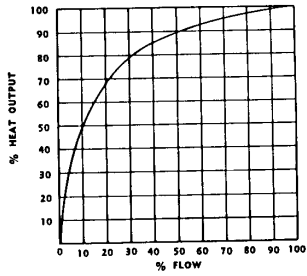

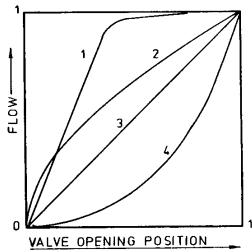$$\text{Pressure Drop} = \left(\frac{\text{GPM}}{C_v}\right)^2$$

Pressure drop should be at least 50% of total available head.
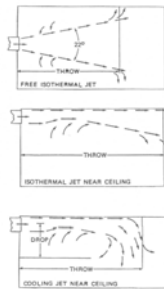
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Typical Hot or Cold Water Coil Characteristic

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VALVE OPENING POSITION

1 QUICK OPENING   3 LINEAR
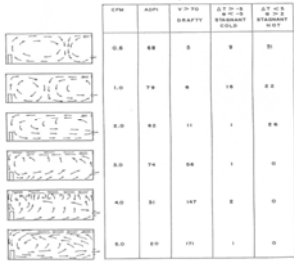
2 SQUARE ROOT   4 EQUAL PERCENTAGE

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Proper High Sidewall Grill Throw
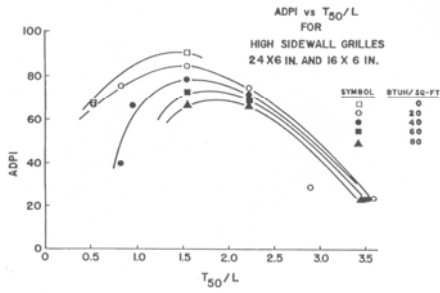
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Air Diffuser Performance Index (ADPI)

AIR DISTRIBUTION — SMOKE PATTERNS
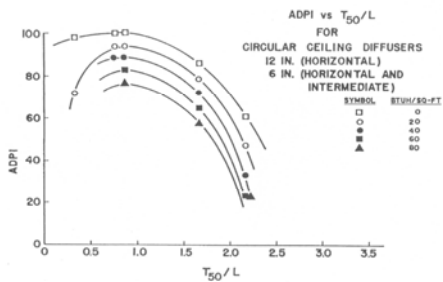HIGH SIDEWALL GRILLE 24 X 6 IN.
ROOM LOAD = 20 BTUH / SQFT

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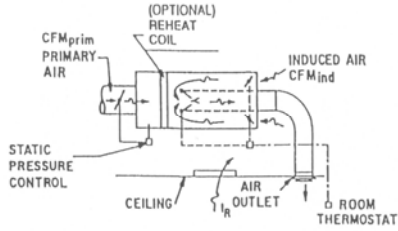**ADPI for High Sidewall Grill**

ADPI vs T_{50}/L
FOR
HIGH SIDEWALL GRILLES
24 X 6 IN. AND 16 X 6 IN.

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ADPI for Circular Ceiling Diffuser

ADPI vs T_{50}/L
FOR
CIRCULAR CEILING DIFFUSERS
12 IN. (HORIZONTAL)
6 IN. (HORIZONTAL AND
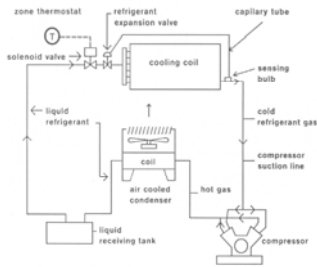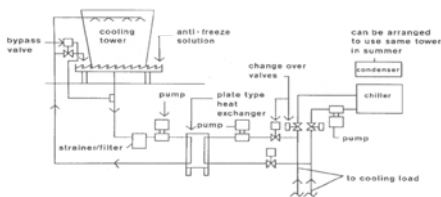INTERMEDIATE)

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Ceiling Induction Unit

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Direct Expansion (Dx) Refrigeration
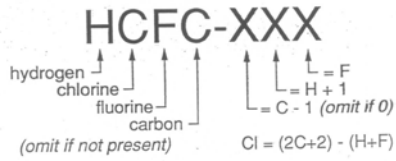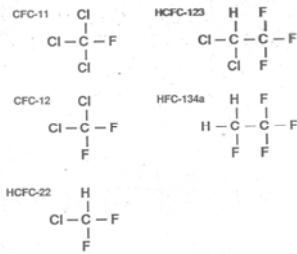

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Chiller Free Cooling

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Refrigerant Designations

HCFC-XXX

hydrogen
chlorine
fluorine
carbon
(omit if not present)

= F
= H + 1
= C - 1 (omit if 0)

Cl = (2C+2) - (H+F)

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CFC-11
CFC-12
HCFC-22
HCFC-123
HFC-134a

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Ozone Depletion Values

- CFC11 – 1.0
- CFC12 – 1.0
- CFC113 – 0.8
- CFC114 – 1.0
- CFC115 – 0.6

- HCFC22 – 0.05
- HCFC123 – 0.02
- HCFC – 134a – 0.0

- Halon 1211 – 3.0
- Halon 1301 – 10.0

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The End