

Heat Loss & Heat Gain

Affordable Comfort Conference
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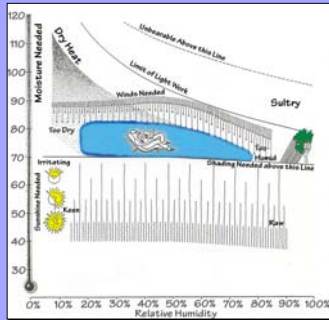
Heat Loss and Heat Gain

Human Comfort Zone (After All, it's Humans We're Experimenting With)

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Human Comfort Zone



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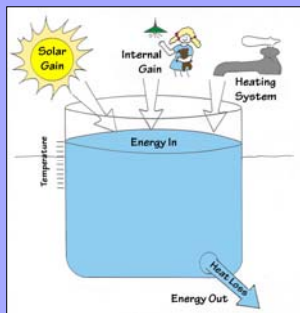
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The Bucket Analogy

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Bucket Analogy



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The Thermal Envelope



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Some Terms of Heat Transfer

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Heat Transfer Definitions - 1


- **Heat energy:**
 - Molecular motion, the lowest form of energy.
- **Temperature:**
 - Assignment of a value to the degree of molecular motion.
- **Absolute zero:**
 - The temperature at which molecular motion ceases (-460°F).

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Heat Transfer Definitions - 2


- **Temperature difference:**
 - Difference between the indoor and outdoor temperatures, often referred to as "delta T".
- **British Thermal Unit:**
 - The amount of thermal energy required to increase the temperature of one pound of water by one Fahrenheit degree. For the rest of the world, 1 Btu = 1055 Joules.

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Heat Transfer Definitions - 3

- **Internal heat gain:**
 - Thermal energy from people and appliances that gives off heat to the indoor environment.
- **Surface or transmission heat transfer:**
 - Heat transfer through solid building surfaces, including ceilings/roofs, walls, floors, windows, and doors.
- **Heat transfer due to air leakage:**
 - Results from infiltration and exfiltration.

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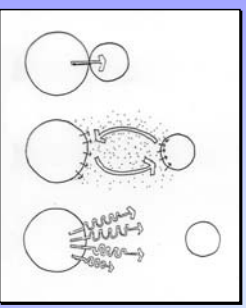
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Means of Heat Transfer

Conduction

Convection


Radiation



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Transmission or Surface Heat Transfer

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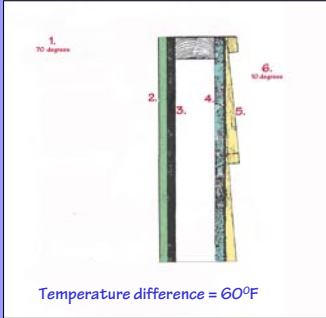
Transmission or Surface Heat Transfer is Dependent Upon

- Temperature difference between the indoors and outdoors.
- Heat transfer rate through surfaces (R-values or U-values). Surfaces include ceilings/roofs, walls, floors, windows, & doors.
- The size of the surfaces, in ft².

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Heat Transfer Through a Wall



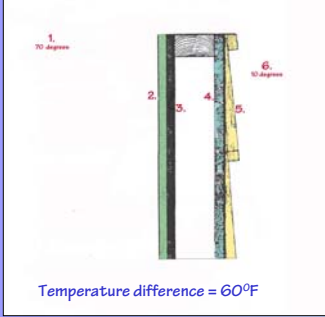
Heat transfer

- Conduction
- Convection
- Radiation

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Heat Transfer Through a Wall



Heat transfer

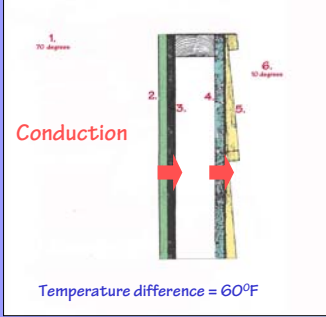
- Conduction
- Convection
- Radiation

Heat Transfer from hot to cold, or high energy to low energy.

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Heat Transfer Through a Wall



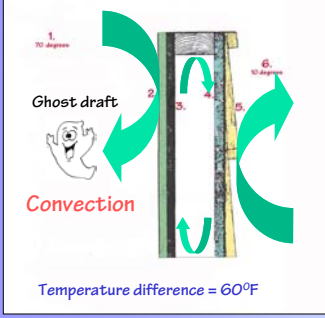
Heat transfer

- **Conduction**
- Convection
- Radiation

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Heat Transfer Through a Wall



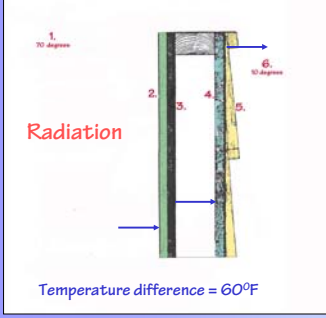
Heat transfer

- Conduction
- **Convection**
- Radiation

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Heat Transfer Through a Wall



Heat transfer

- Conduction
- Convection
- **Radiation**

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Heat Transfer Through a Wall

Temperature difference = 60°F

Heat transfer

- Conduction
- Convection
- Radiation

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Heat Transfer Through a Wall

Temperature difference = 60°F

Heat transfer

- Conduction
- Convection
- Radiation

Heat Transfer without insulation

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Heat Transfer Through a Wall

Temperature difference = 60°F

Heat transfer

- Conduction
- Convection
- Radiation

Heat Transfer with insulation

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Surface Heat Transfer

Layer	R
Interior Surface	.68
3/8" Gypsum Board	.32
3 1/2" Blanket Insulation (vapor barrier on warm side)	11.00
3/8" Plywood	.47
Bevel Siding	.81
Exterior Surface	.17
Overall R	13.45

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Surface Heat Transfer

- R-value is the resistance to heat transfer through a building surface. Surfaces include ceilings/roofs, walls, floors, windows, & doors.
- U-value IS the heat transfer through a building surface.
- $R=1/U$
- $U=1/R$
- R-values may be added together, U-values may not.

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The Driving Forces of Air Leakage

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What Causes Air-Leakage?

Fluid Flow Through a Hole

P_1 | P_2

$P_1 - P_2 = \Delta P$

Must have:

1. Hole.
2. Pressure difference.

Drivers can be:

1. Wind.
2. Stack effect.
3. Mechanical forces.

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Wind-Driven Air Leakage

W
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D

Factors:

- Wind speed.
- Leakage area.

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Stack-Effect Air Leakage

Cold weather only

WARM AIR RISES

NEUTRAL ZONE

Factors:

- Temp. difference.
- Leakage area.
- Effective height.

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Mechanically-Driven Air Leakage

EXHAUST FAN

NEGATIVE PRESSURE

COMBUSTION HEATING SYSTEM

Factors:

- Leakage area.
- Exhaust fan CFM.
- Heating system.

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Heat Transfer Due to Air Leakage

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Heat Transfer Due to Air Leakage is Dependent Upon:

- Temperature difference between the indoors and outdoors.
- Cubic feet of air leakage through the house for a given time period. The important part of the house is the above grade volume within the thermal envelope.

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Measuring Air Leakage



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Measuring Air Leakage

- **Blower door testing:**
 - Depressurize or pressurize a house to a pressure difference of 50 Pascals and then measure the flow through the blower door fan.
- **Air changes per hour (ACH):**
 - The number of times one house volume of air leaks through the house in one hour.

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Blower Door Testing



Blower door test results are expressed as CFM₅₀ values.

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Taking Care of Business in Maine



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Air Changes per Hour (ACH)

If this house is 40' x 32' x 16' high, its above-grade volume within the thermal envelope is 20,480 ft³.



If ACH is 1.0, then 20,480 ft³ of air moves through the house each hour;

If ACH is 0.75, then 15,360 ft³ of air; or

If ACH is 0.5, then 10,240 ft³ of air.

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Air Changes per Hour (ACH)

ACH is either estimated from a table or calculated with from a blower door CFM₅₀ value.

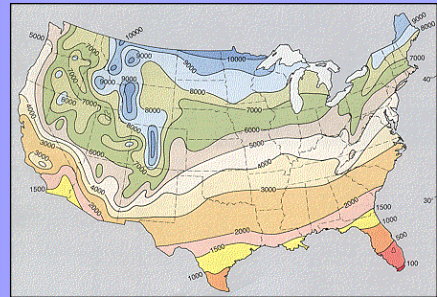


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Calculating Heat Loss

- To calculate heat transfer in a house, let's say heat loss, we must calculate the surface heat loss through all surfaces of the thermal boundary; and
- Calculate the heat loss resulting from air leakage through the thermal envelope (above grade only).
- Solar gain and internal gain are not losses in this case.

Heating Degree Day Map



Calculating Heat Gain

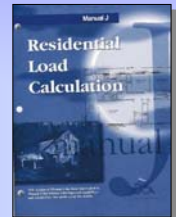
- To calculate heat gain in a house we must calculate the surface heat gain through all surfaces of the thermal boundary; and
- Calculate the heat gain resulting from air leakage through the thermal envelope (above grade only).
- Solar gain and internal gain are loads in this case, so they must be considered.

Residential Load Calculation for Heating/Cooling System Sizing

- Manual J, 7th edition (\$28.00/\$48.00).

Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206
www.acca.org

Order by Phone:
888-290-2220 or
703-575-4477



Load Calculation Manual

- Manual J, 8th edition (\$67.15 member, \$152.15 non-member!!).

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