

Windows and Occupant Comfort

EEBA

Building Solutions 2003

Lincolnshire, IL

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“Code” House in Zone 5

- R38 Ceiling
- R19 Wall
- R10 Basement
- U0.35 Window



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ResCheck Trade-Off

- R38 Ceiling
- R19 Wall
- R10 Basement
- **U0.35** Window
- **78%** AFUE
Furnace

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- R38 Ceiling
- R19 Wall
- R10 Basement
- **U0.55** Window
- **90%** AFUE
Furnace

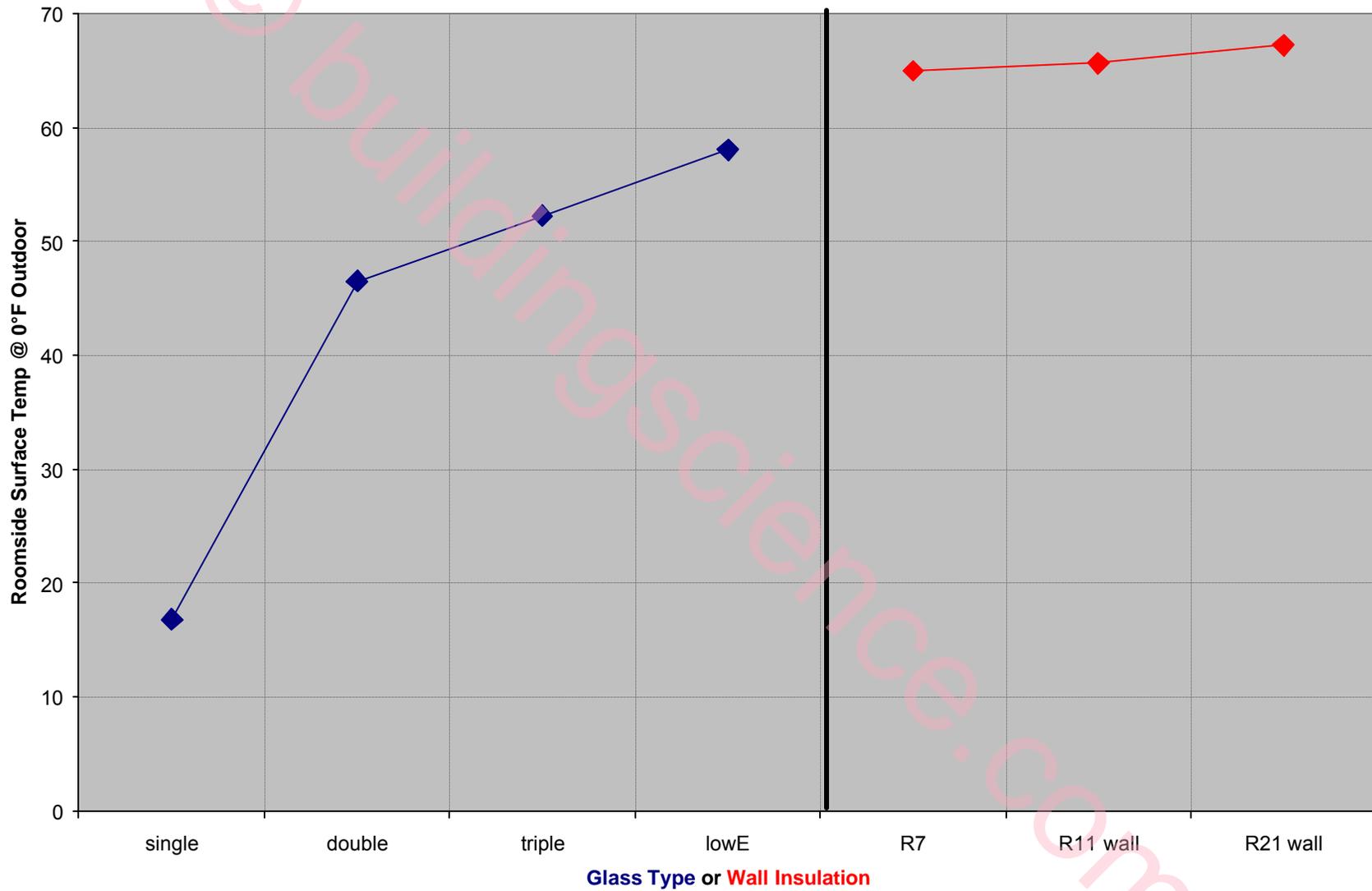
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They Might Be Equal.....

But They're Not the Same!!

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Trading Windows is Different than Trading Insulation



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Observation #1: Weatherization

Adding additional insulation to a wall with low performance windows will have a negligible effect on comfort.

When doing replacement windows insist on high performance (low-E) type products to maximize comfort.

Traditional Comfort Response

- Assume that all trade-offs provide the same comfort
- Respond to discomfort complaints on an individual basis

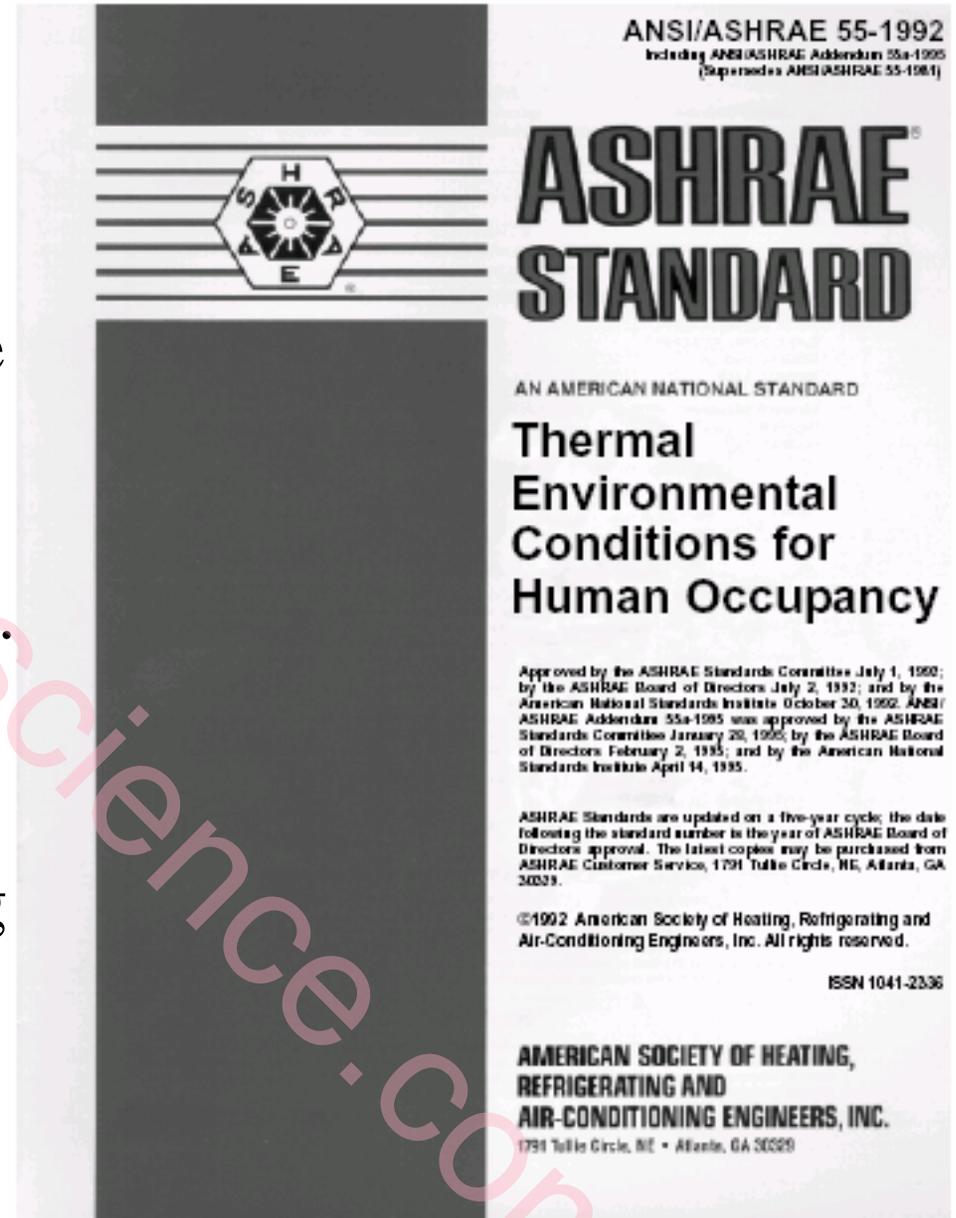
“Quality Control” mode

Comfort Science

Standard 55 predicts the statistical comfort response for a large population of people. A wide range of conditions can be analyzed.

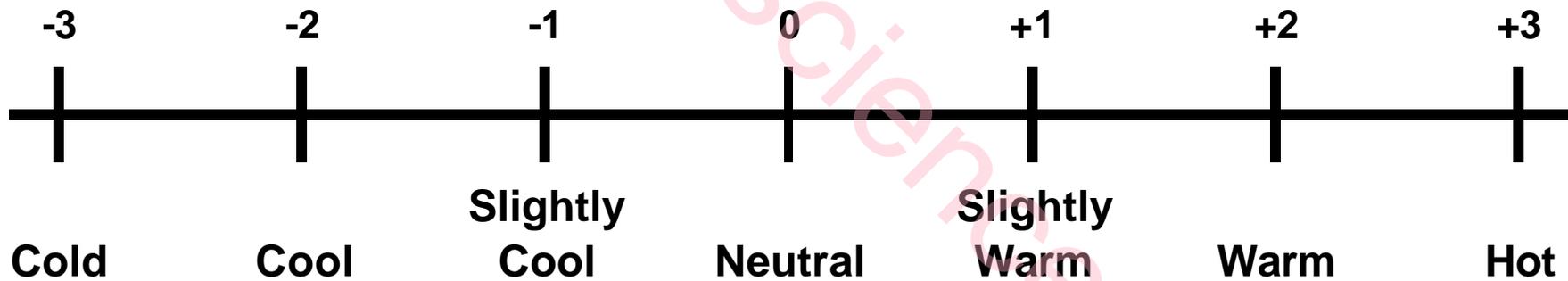
Design changes can be evaluated for comfort impacts before the building is started.

“Quality Assurance” mode.



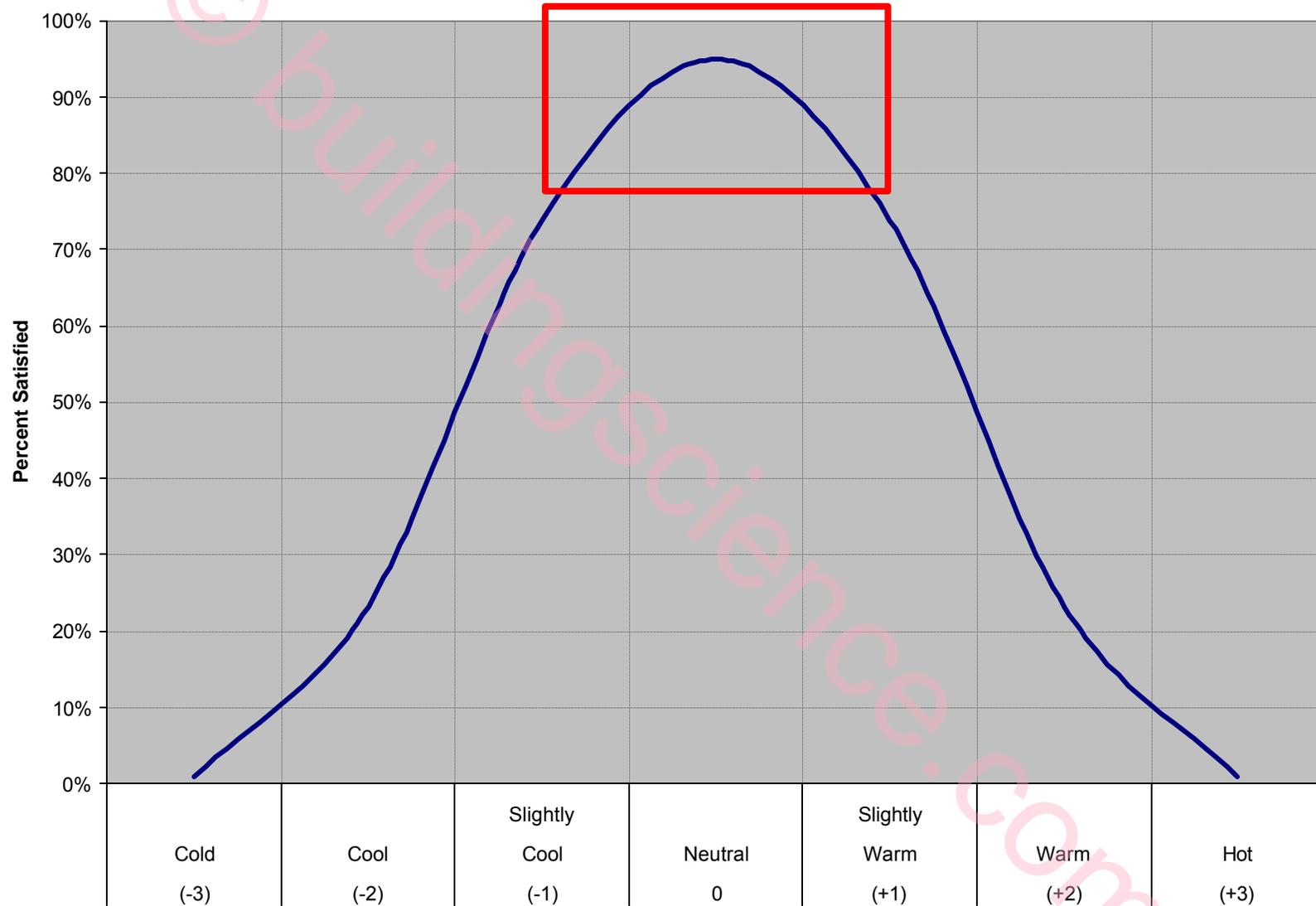
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The 7 Point Comfort Scale



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80% Satisfaction Criteria



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Human Factors Affecting Comfort

- Activity Level

Standard 55 assumes light sedentary activity to represent typical office or home environment

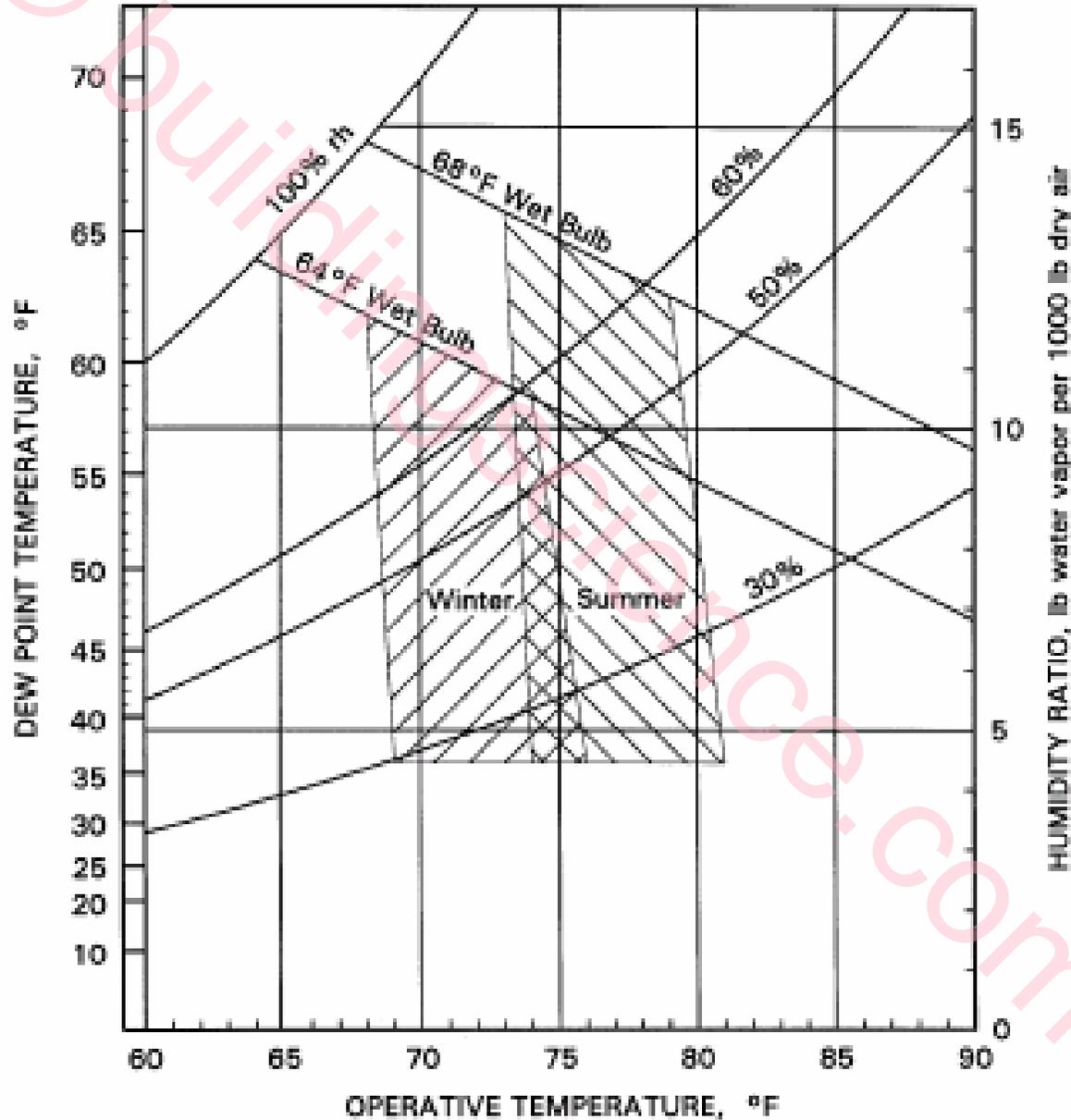
- Clothing

Standard 55 assumes seasonal differences in clothing levels. Winter clothing “insulation” level approximately twice that of summer clothing level

Building Factors Influencing Comfort

- Air Temperature
- Mean Radiant Temperature
- Relative Humidity
- Air Movement

ASHRAE Comfort Zones



The ASHRAE Comfort Program

Basic Thermal Comfort Model Parameters

Environmental Conditions

Air Temperature *F

MRT Link with Air *F

Air Velocity fpm

Relative Humidity %

Summer Winter

Activity



Metabolic Rate met

Clothing



Clothing level clo

Results

ET* *F



SET* *F

TSENS

DISC Comfortable

PMV



PPD %

PD %

PS %

TS

Tneutral (Humphreys)

Tneutral (Auliciems)

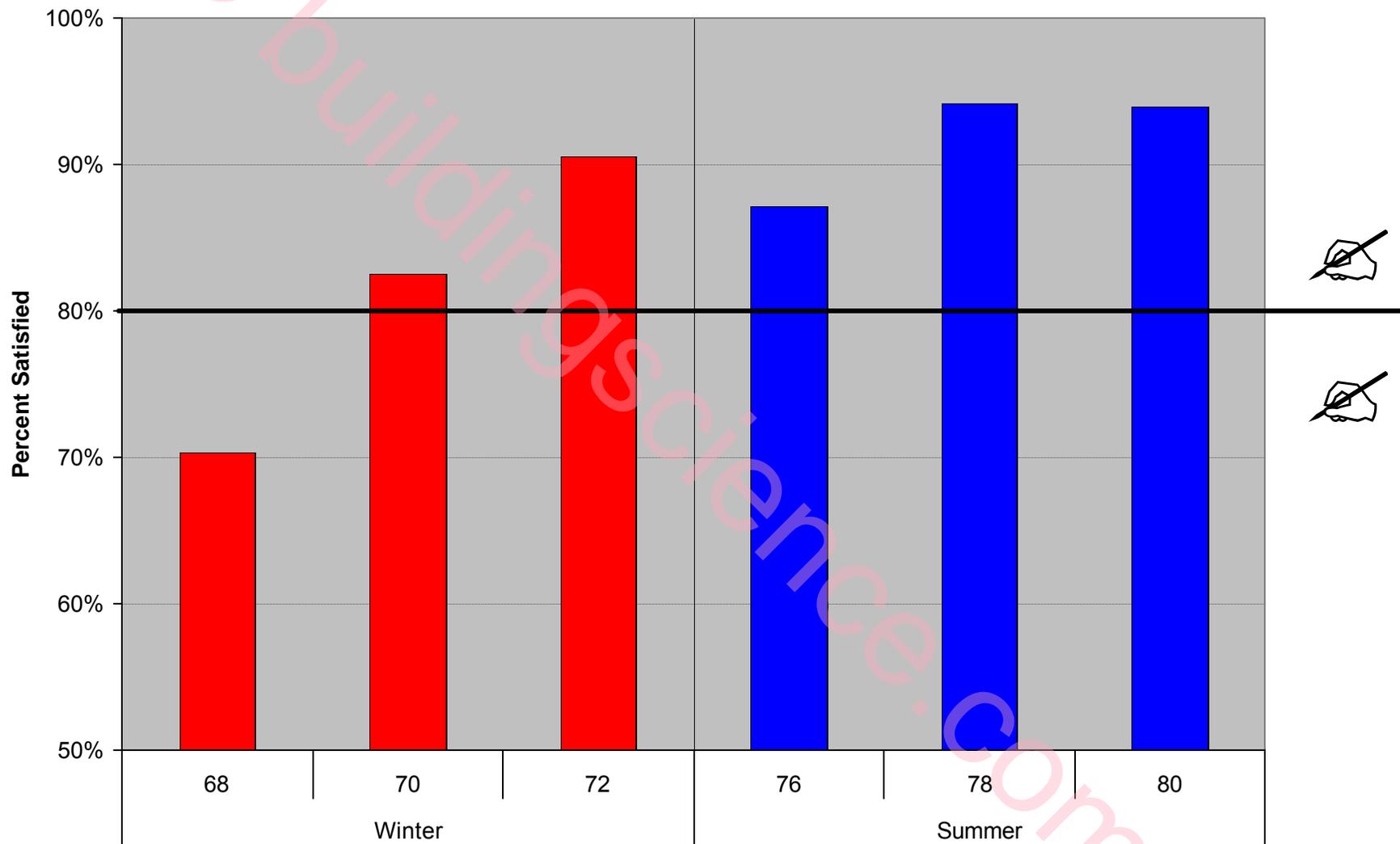
Live demo of comfort program

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Using the Comfort Program to Determine Minimum Thermostat Setpoints

- Set *mean radiant temperature* equal to air temperature
(assumes exterior walls are at room temp)
- Use standard conditions for relative humidity and air movement, seasonal clothing levels, and sedentary activity

Comfort in the Hallway



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Observation #2: Thermostat Setting

The 68°F heating setpoint suggested for the HERS reference house and in IECC performance path *FAILS* to deliver acceptable comfort in the hallway

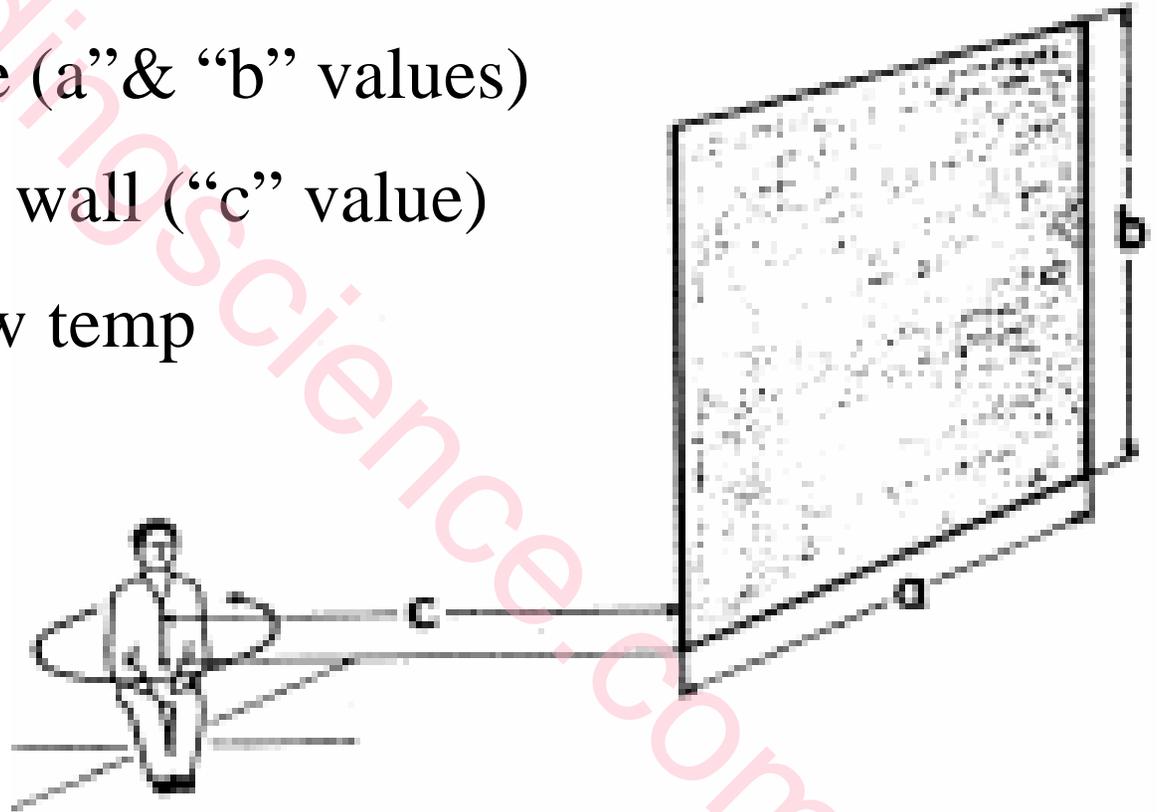
Using the Comfort Program for Exterior Walls & Windows

1. Establish mean radiant temperature (MRT).
2. For windows and sunlit conditions, calculate offset in comfort scale due to direct beam solar gain.

Determining Mean Radiant Temperature

Need to know:

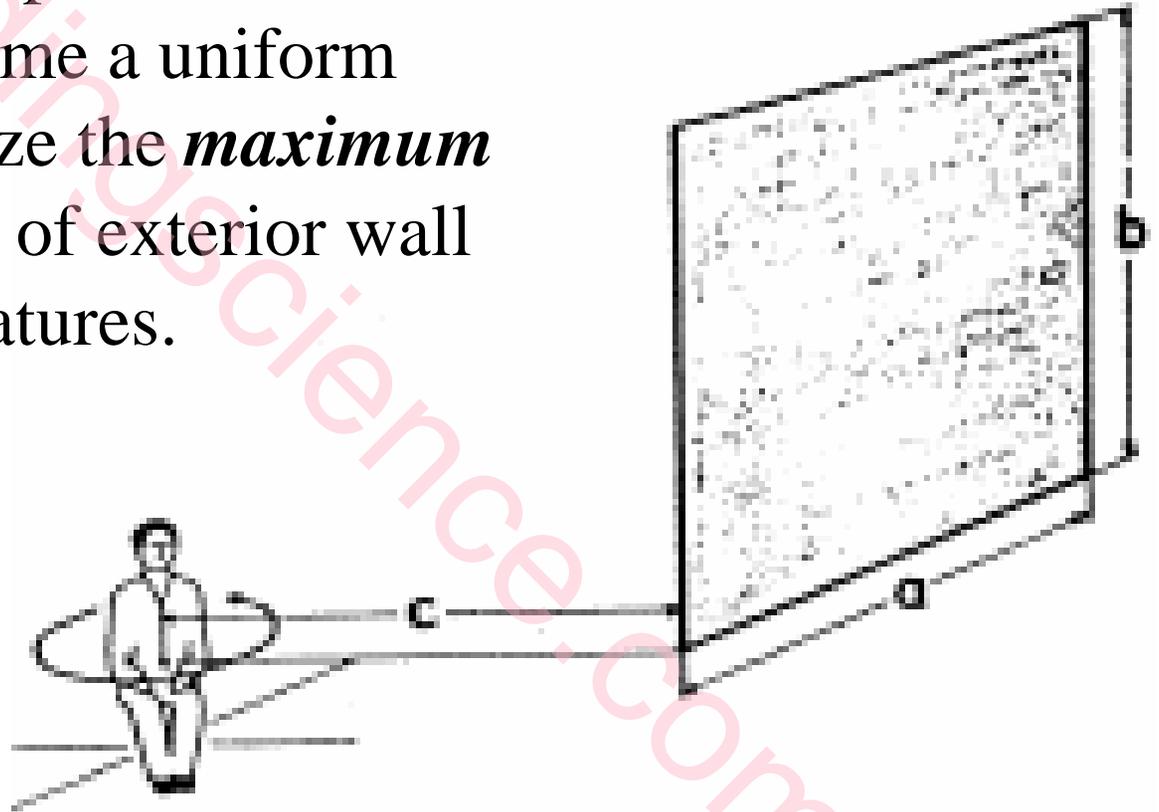
- Window size (“a” & “b” values)
- Proximity to wall (“c” value)
- Wall/window temp



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Window Size

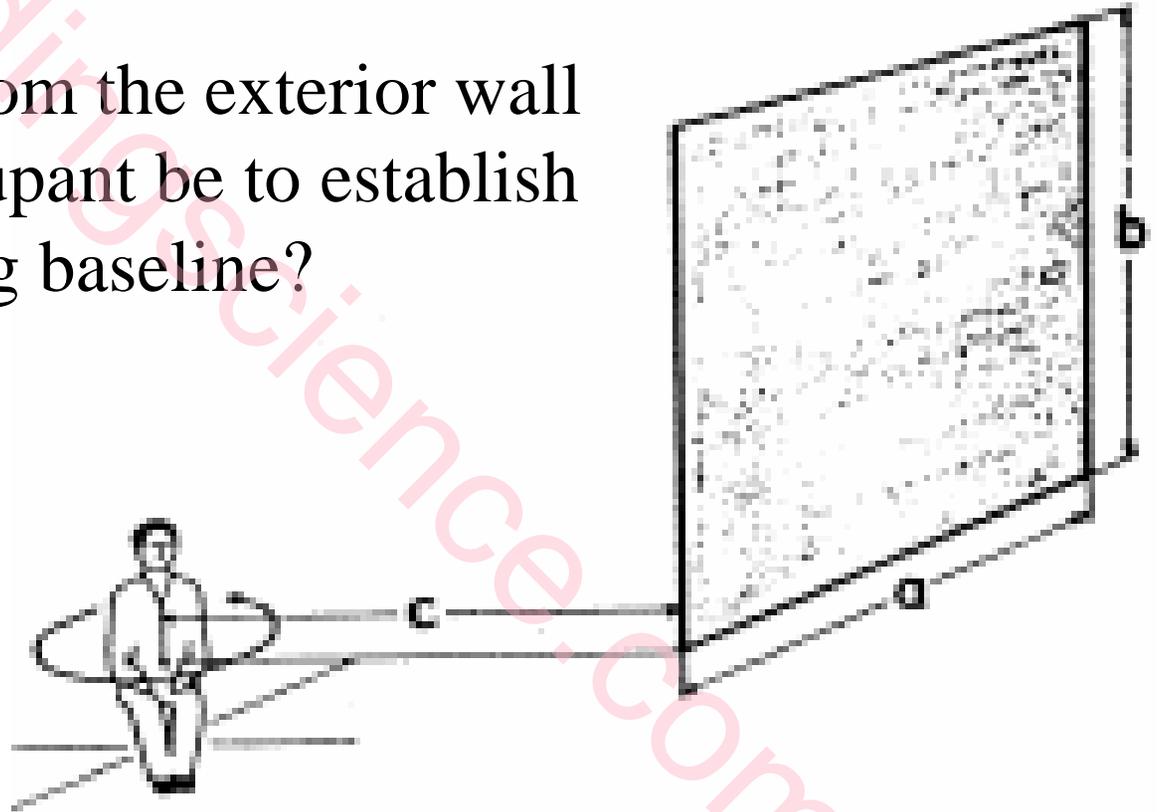
The comparisons presented in this discussion assume a uniform facade to analyze the *maximum* comfort impact of exterior wall surface temperatures.



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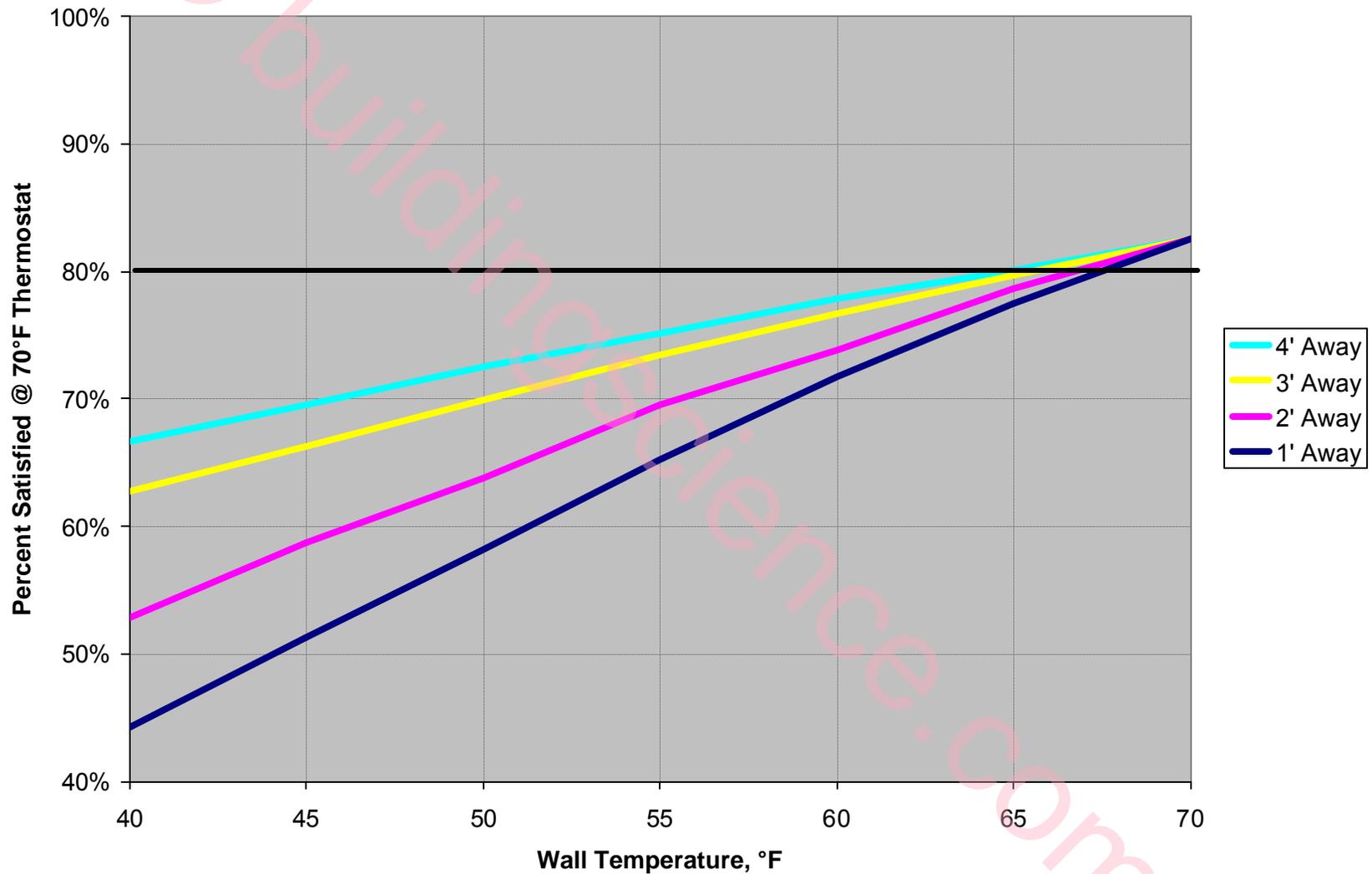
Proximity

How far away from the exterior wall should the occupant be to establish a comfort rating baseline?



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Comfort vs. Proximity to a Cool Surface



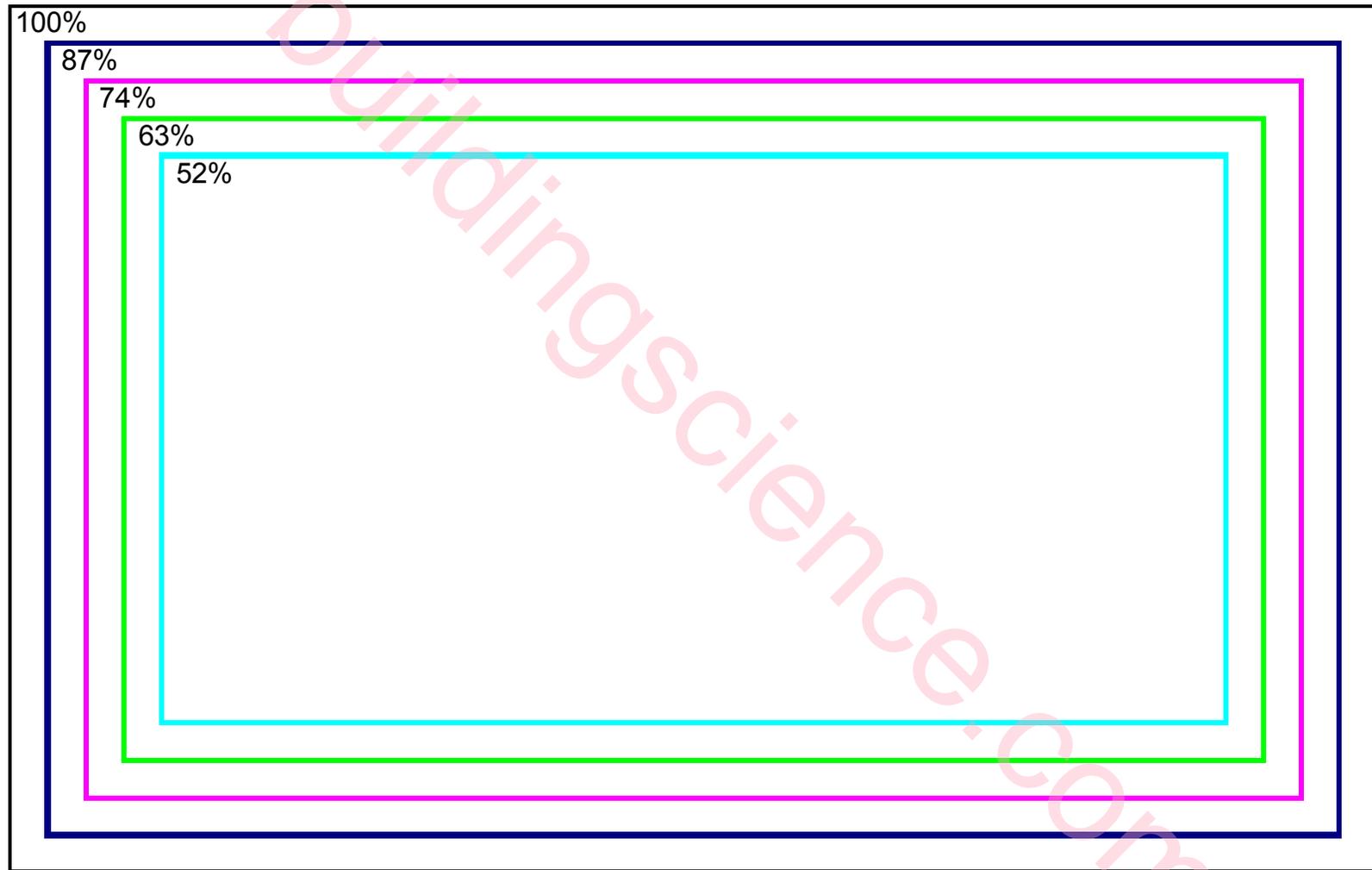
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Audience Participation

What's the right proximity to use?

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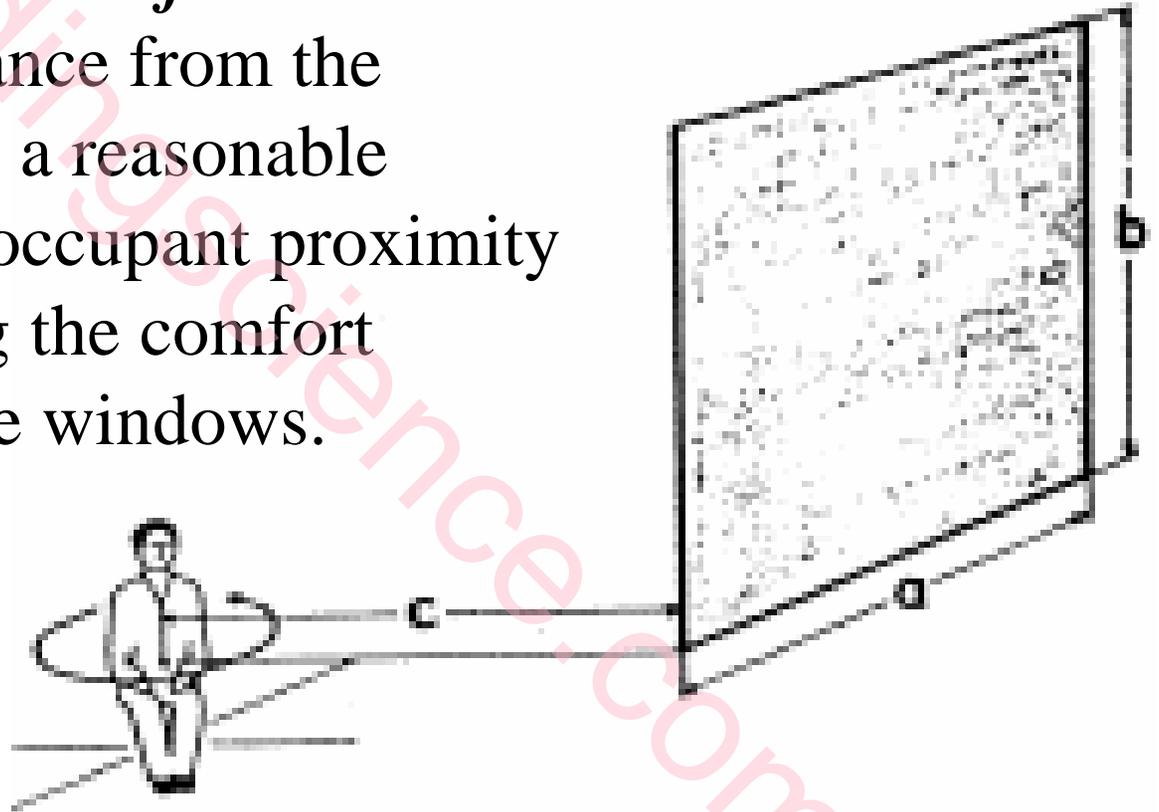
1' of Perimeter ~ 12% Floor Area



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Proximity

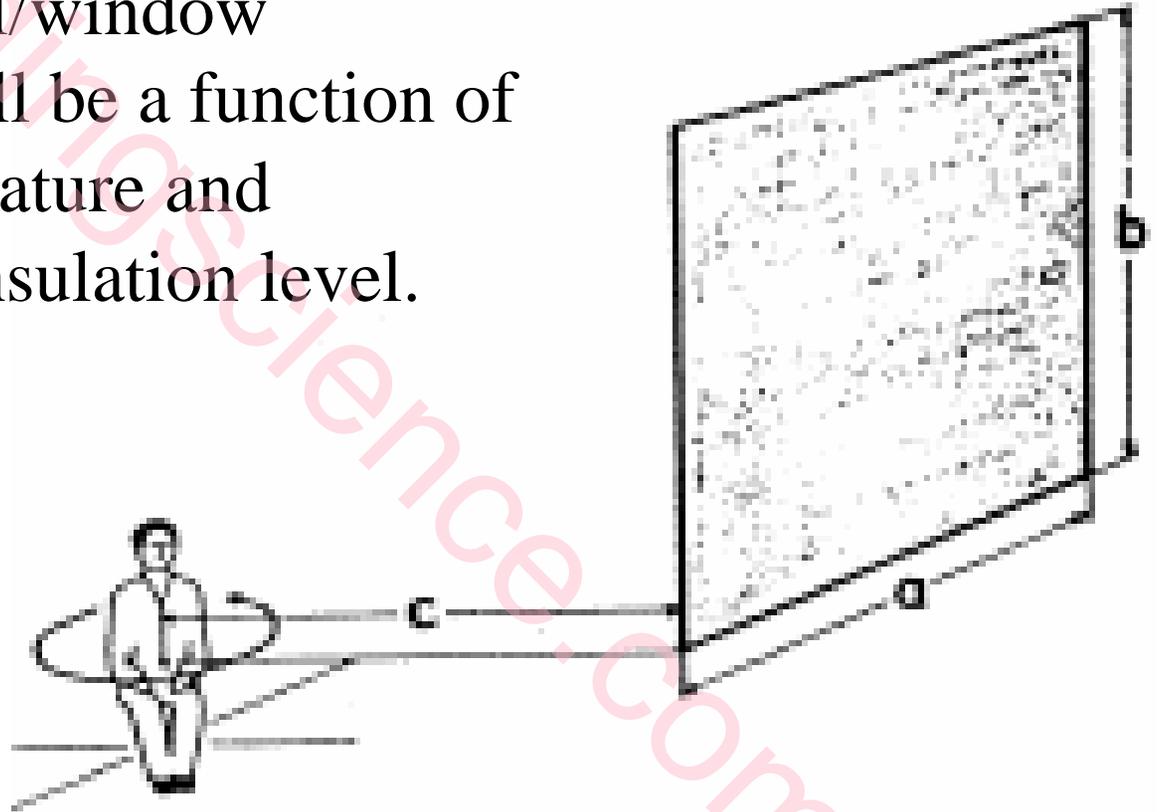
The comparisons presented in this discussion use a *two foot* separation distance from the exterior wall as a reasonable expectation of occupant proximity when analyzing the comfort impacts of large windows.



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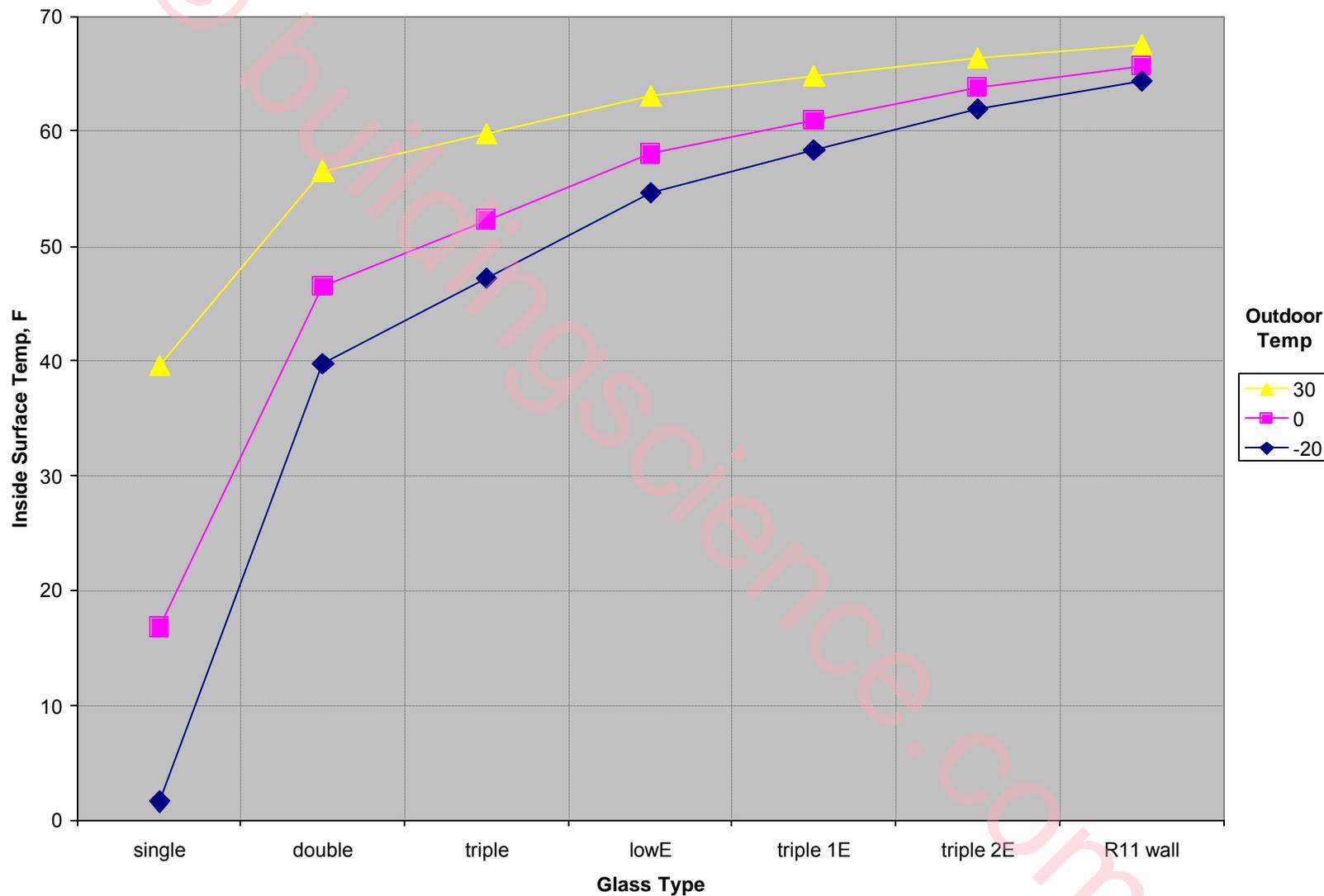
Exterior Wall/Window Temperatures

The exterior wall/window temperature will be a function of outdoor temperature and wall/window insulation level.



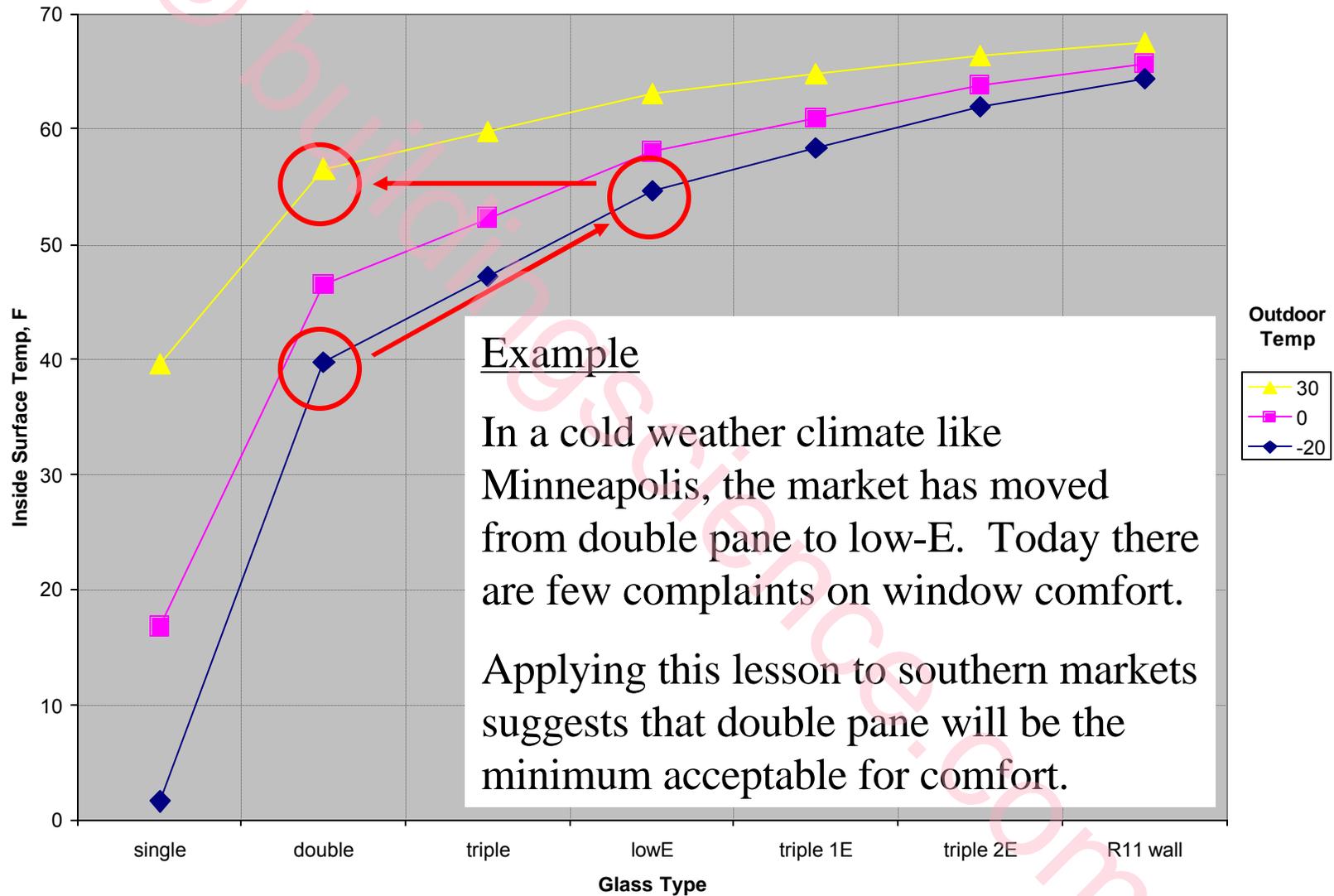
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Glass Temperature vs. Weather



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Learn From Past Experiences



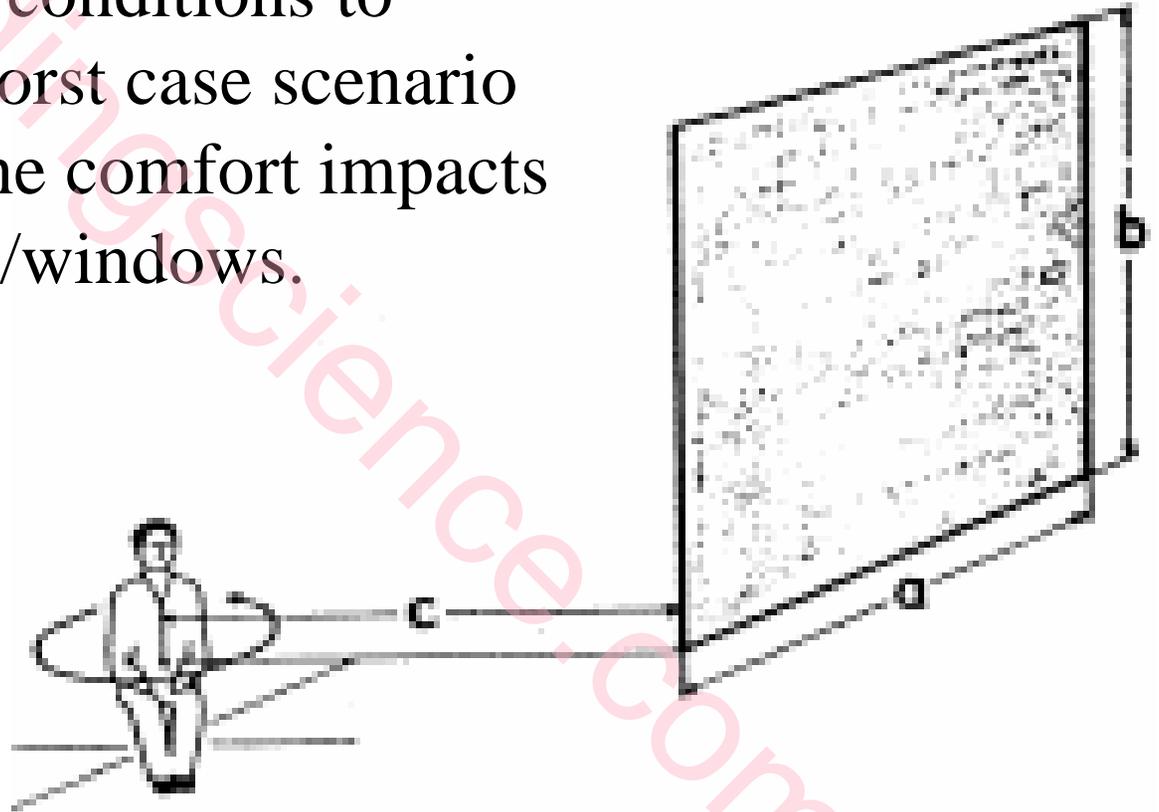
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Observation #3: Mandatory Minimums

Mandatory trade-off limits are necessary in a performance path analysis to ensure that “btus” don’t get confused with real life

Exterior Wall/Window Temperatures

Use local *design* conditions to represent the worst case scenario for analyzing the comfort impacts of exterior wall/windows.



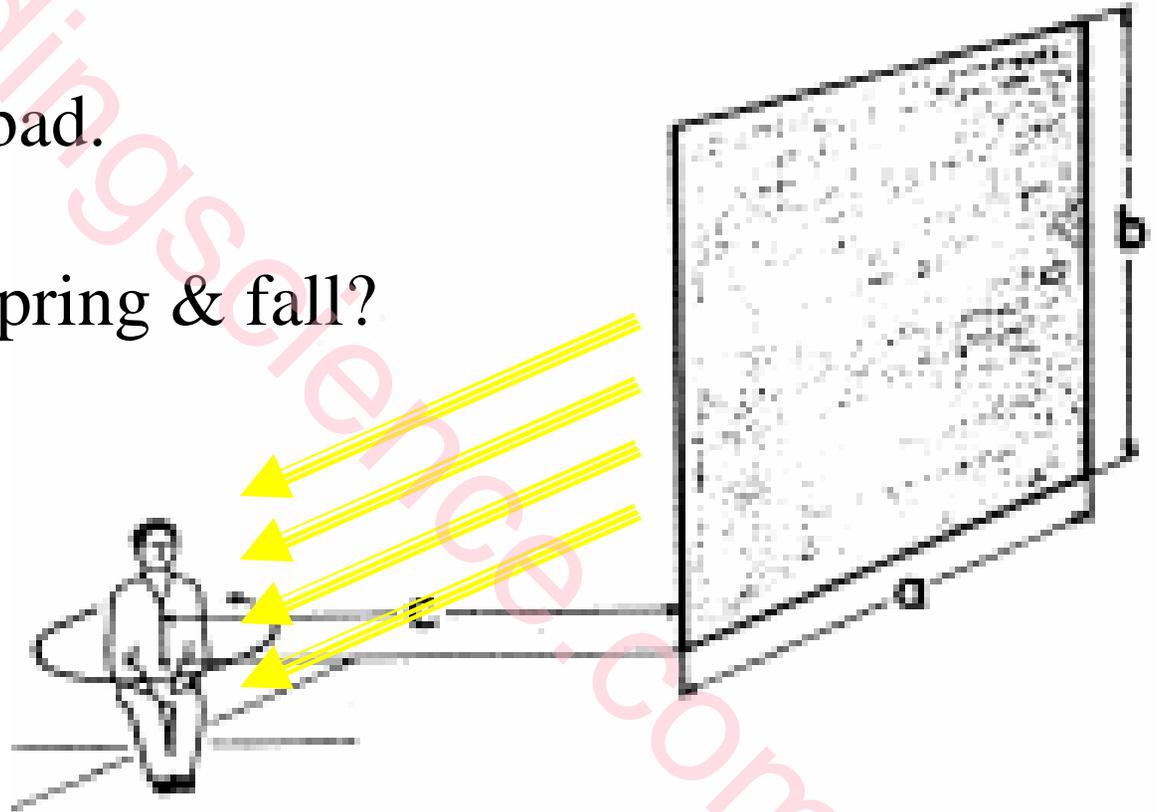
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Solar Gain Offset to Comfort

Winter gain is good.

Summer gain is bad.

What about the spring & fall?



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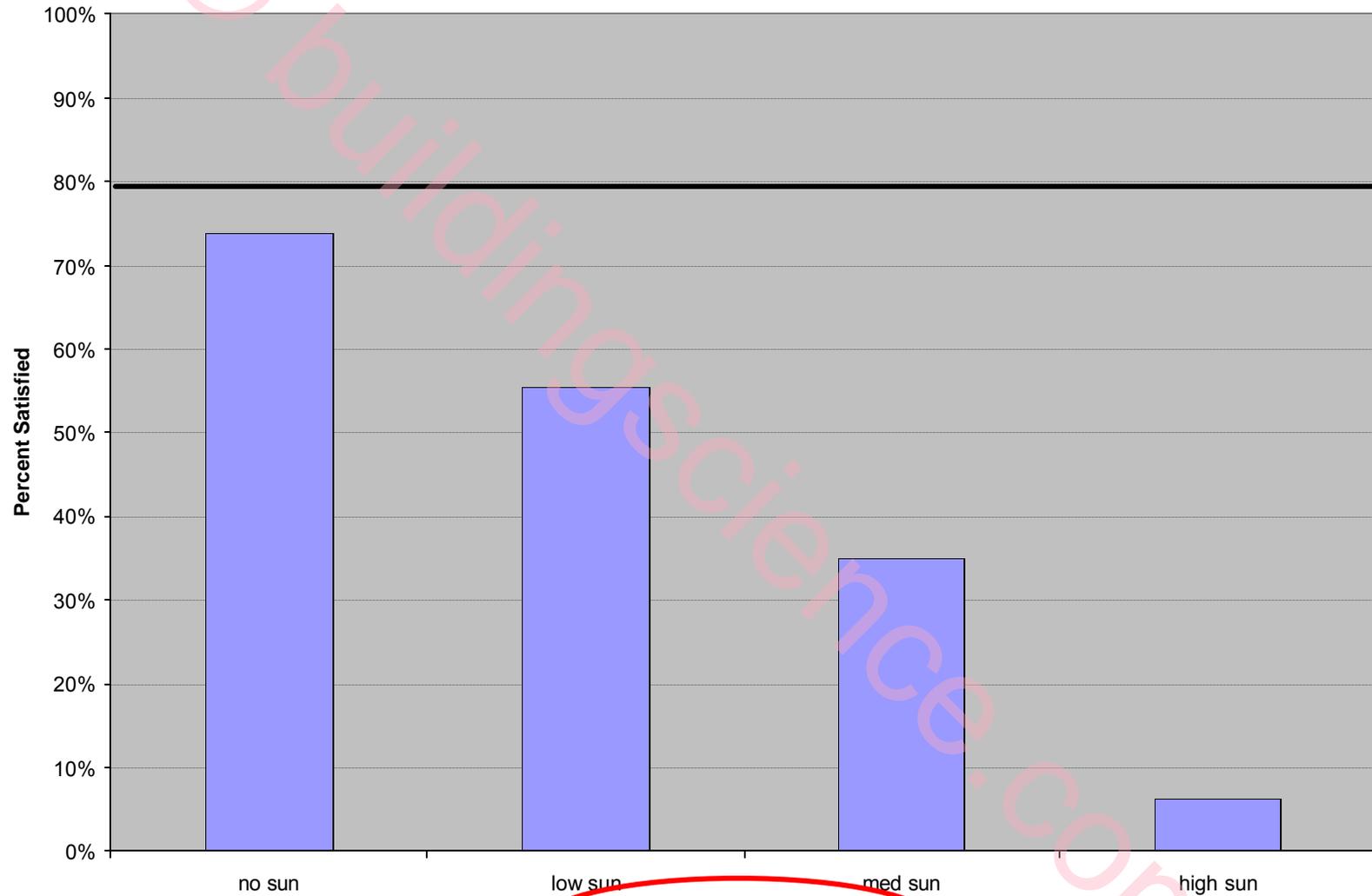
Winter Solar Gain Can Aid Comfort



Initial Condition: Cool (-2)

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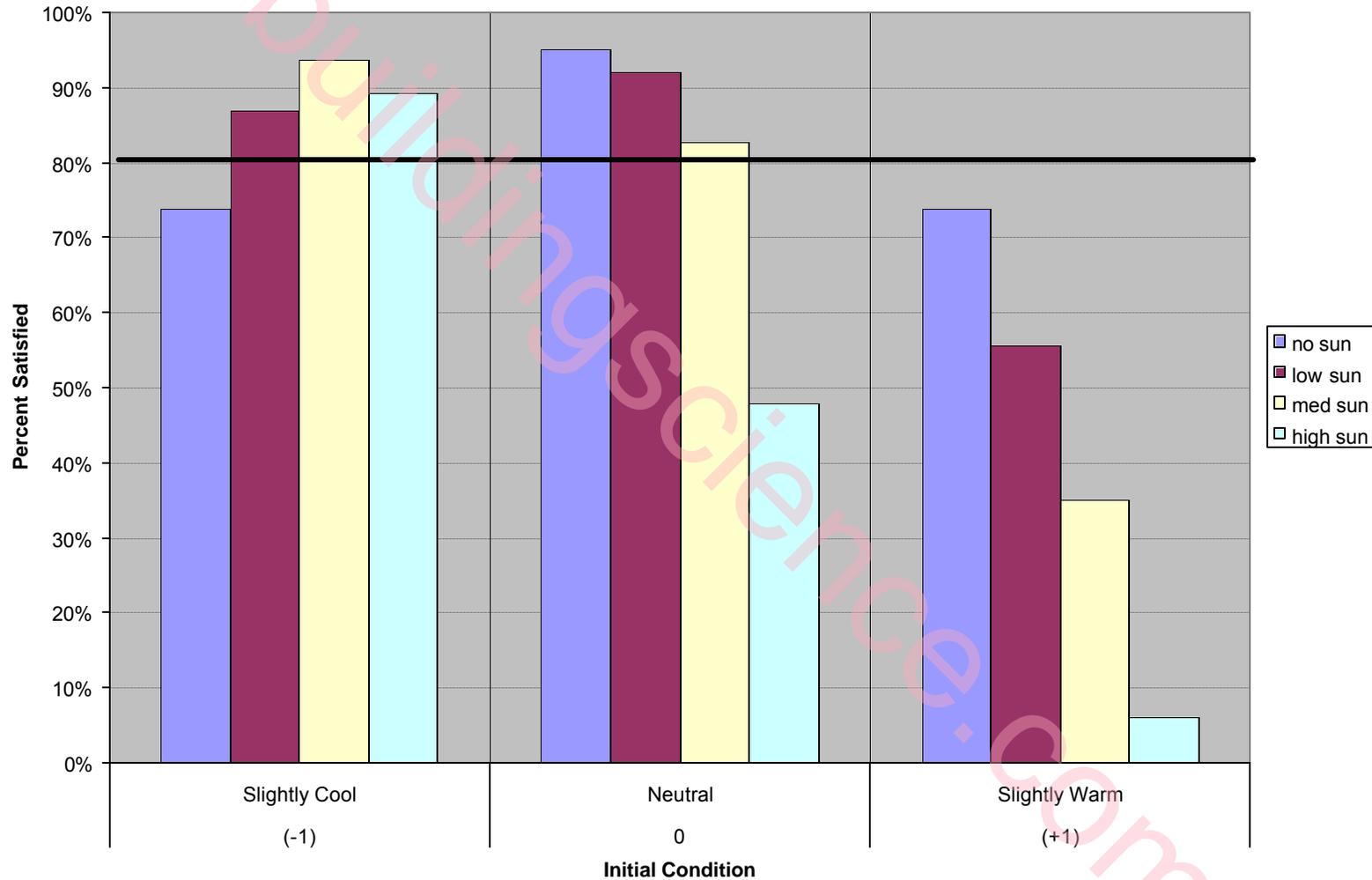
Summer Solar Gain Detracts Comfort



Initial Condition: Slightly Warm (+1)

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Observation #4: Solar Gain Offsets Comfort

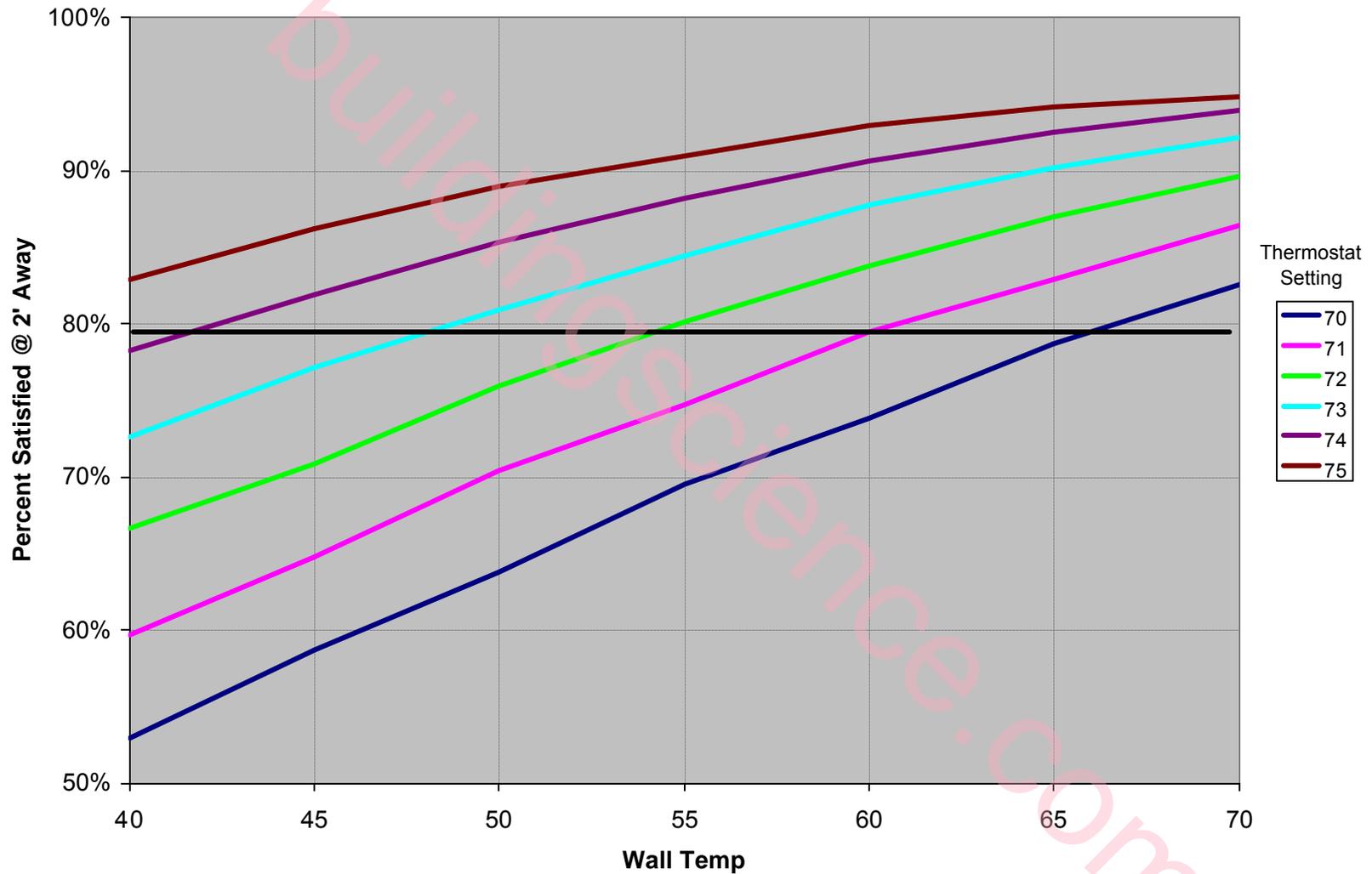


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Recommended Conditions for Exterior Wall/Window Comfort Comparisons

1. Window size = Wall
2. 2' proximity
3. Design temperatures
4. Winter night - 70°F minimum thermostat
5. Summer day - 78°F maximum thermostat

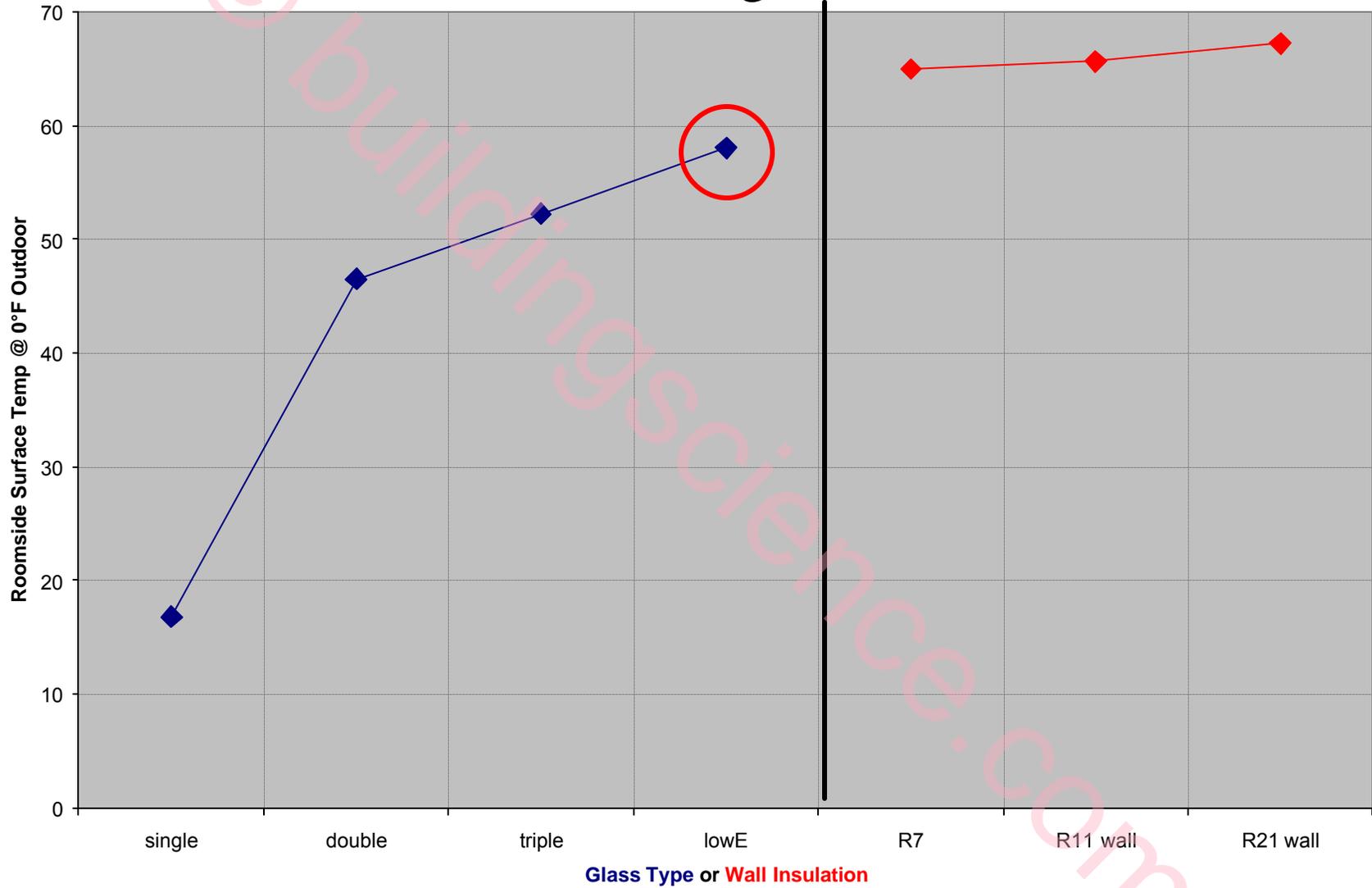
#5: 6°F Wall ? T = 1°F Change in Thermostat



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Low-E Provides Comfort in the Winter

What About During the Summer?



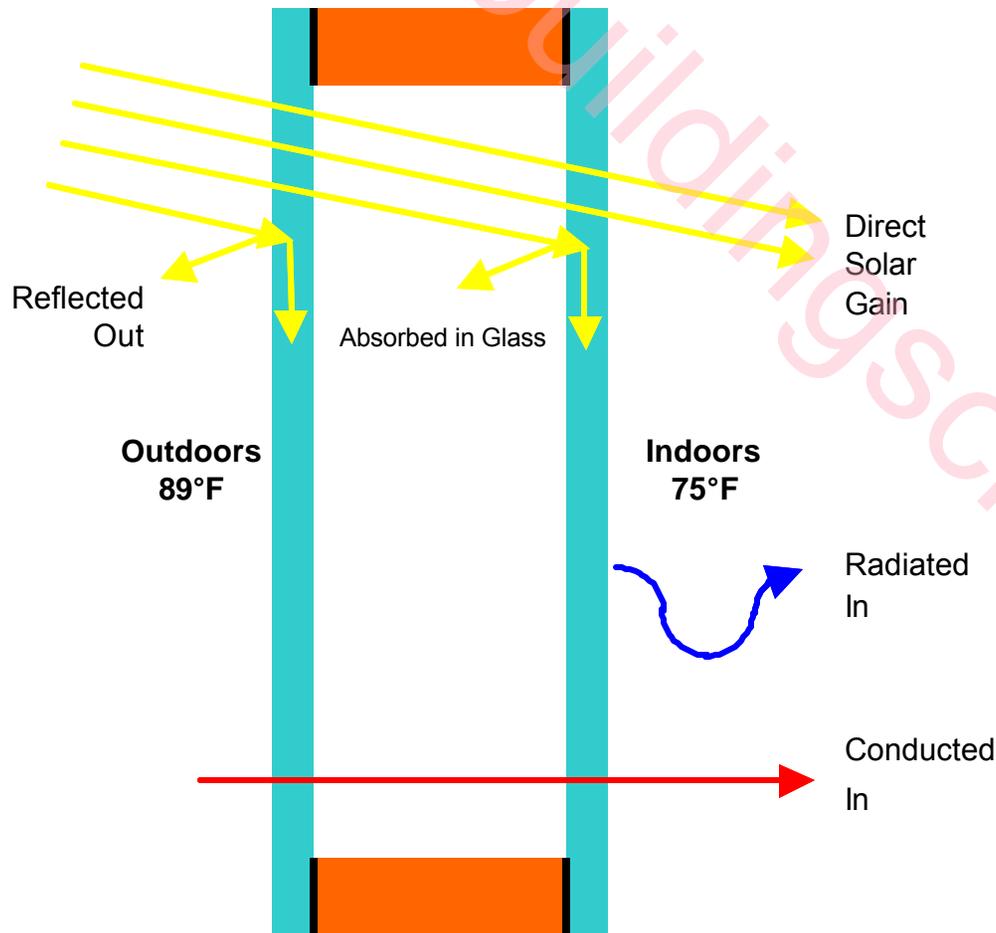
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Summer Properties of 3 Glass Types

	<u>SHGC</u>	<u>Heat Gain</u>	<u>Temp</u>
2 pane clear	0.76	182	91
High Solar Gain Low-E	0.72	169	101
Low Solar Gain Low-E	0.41	98	84

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Why is the High Solar Gain Low-E so Hot?

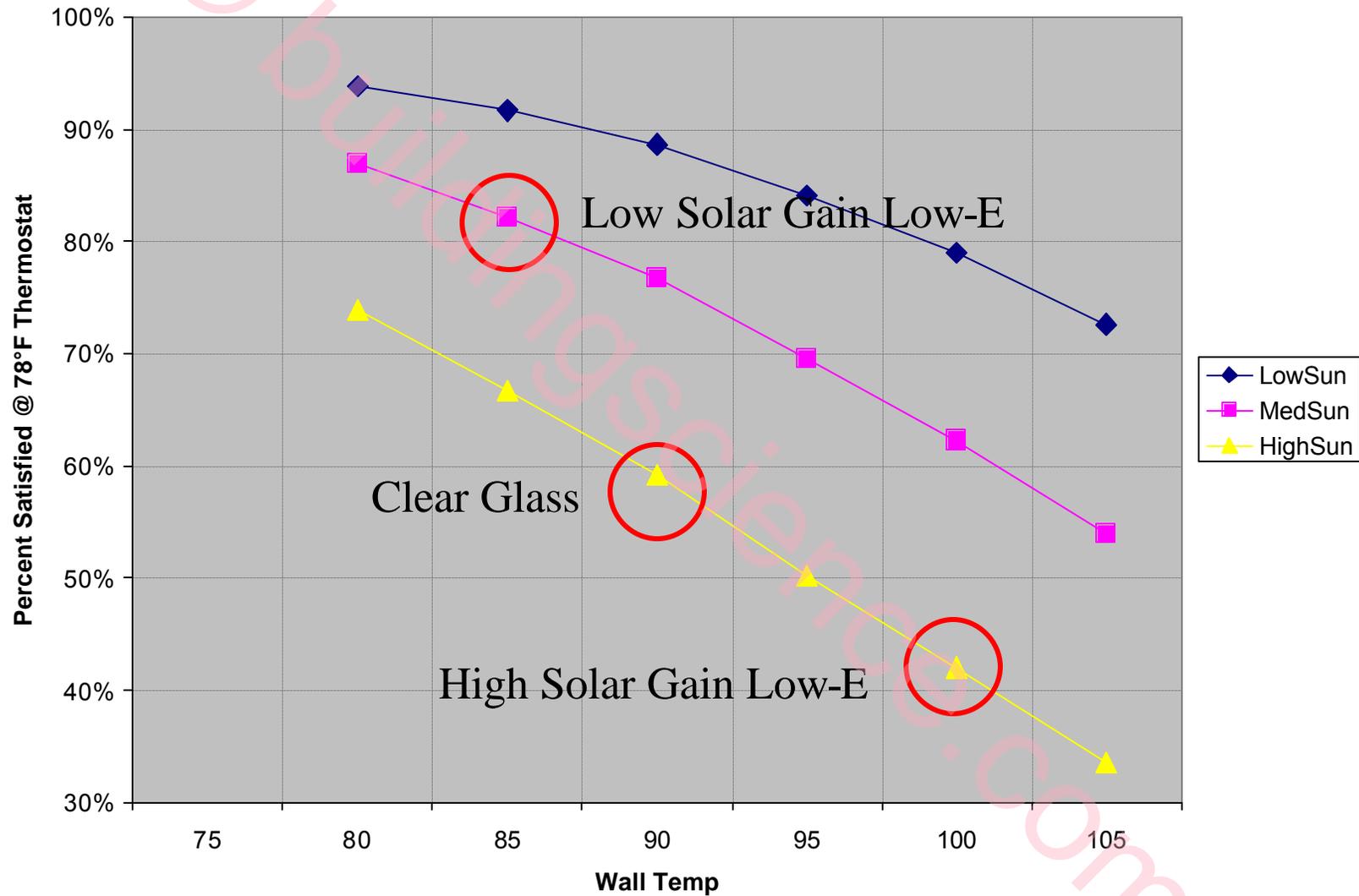


To maximize solar gains, the coating is placed on the airspace side of the inboard pane of glass.

The low-E coating absorbs twice as much solar energy as clear glass, so the inside pane of glass heats up to 25+ degrees hotter than the room air temperature.

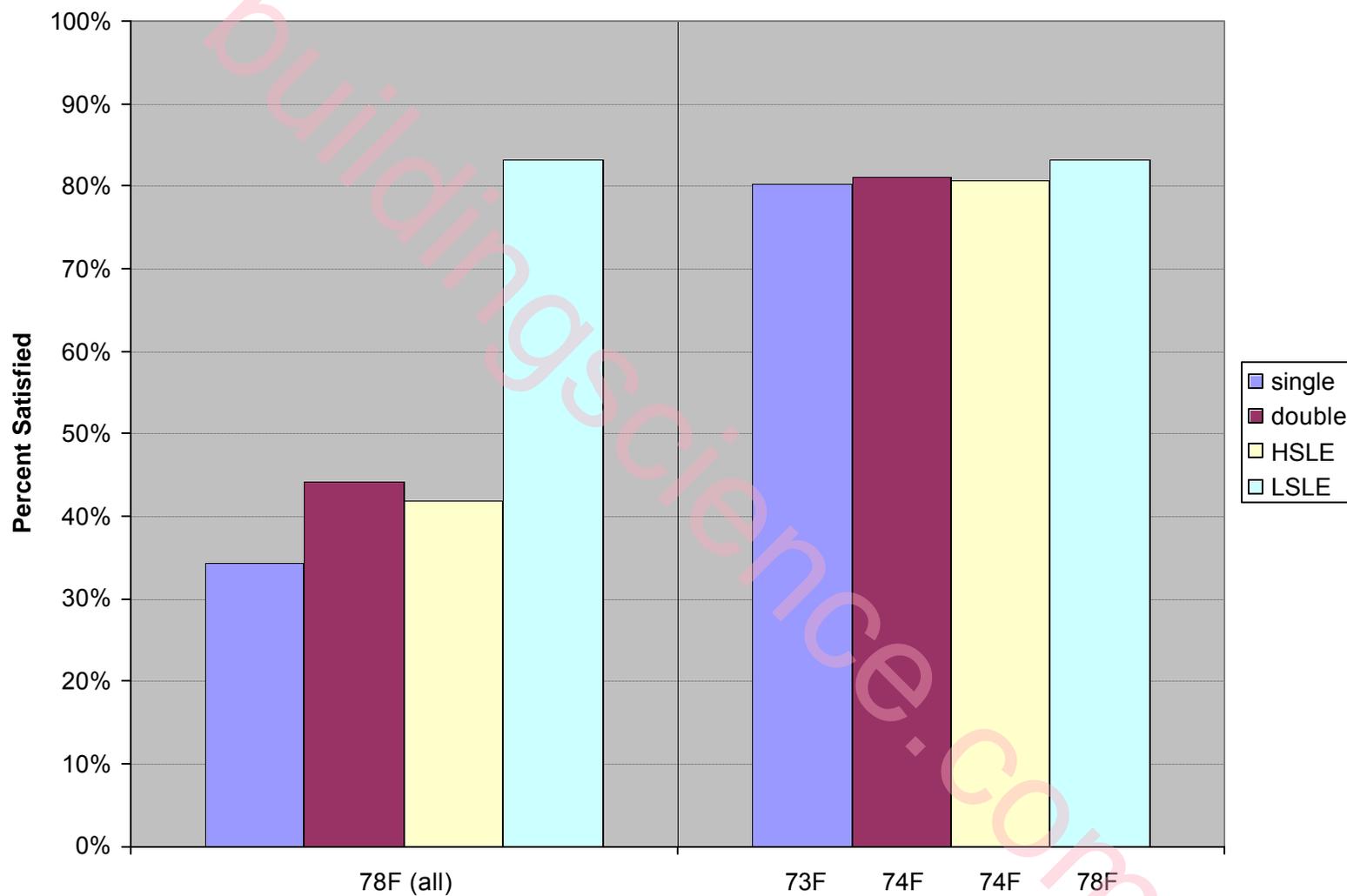
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Comfort During Summer Peak



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#6: HSG Windows are Bad for Summer Comfort



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© Cooling Summary

78°F is an adequate setpoint temperature for:

- A room with no windows
- A room with low solar gain windows

For rooms with high solar gain glass:

- Tuff it out
- Close the drapes
- Leave the room
- Turn the thermostat down

And Now

A real world example

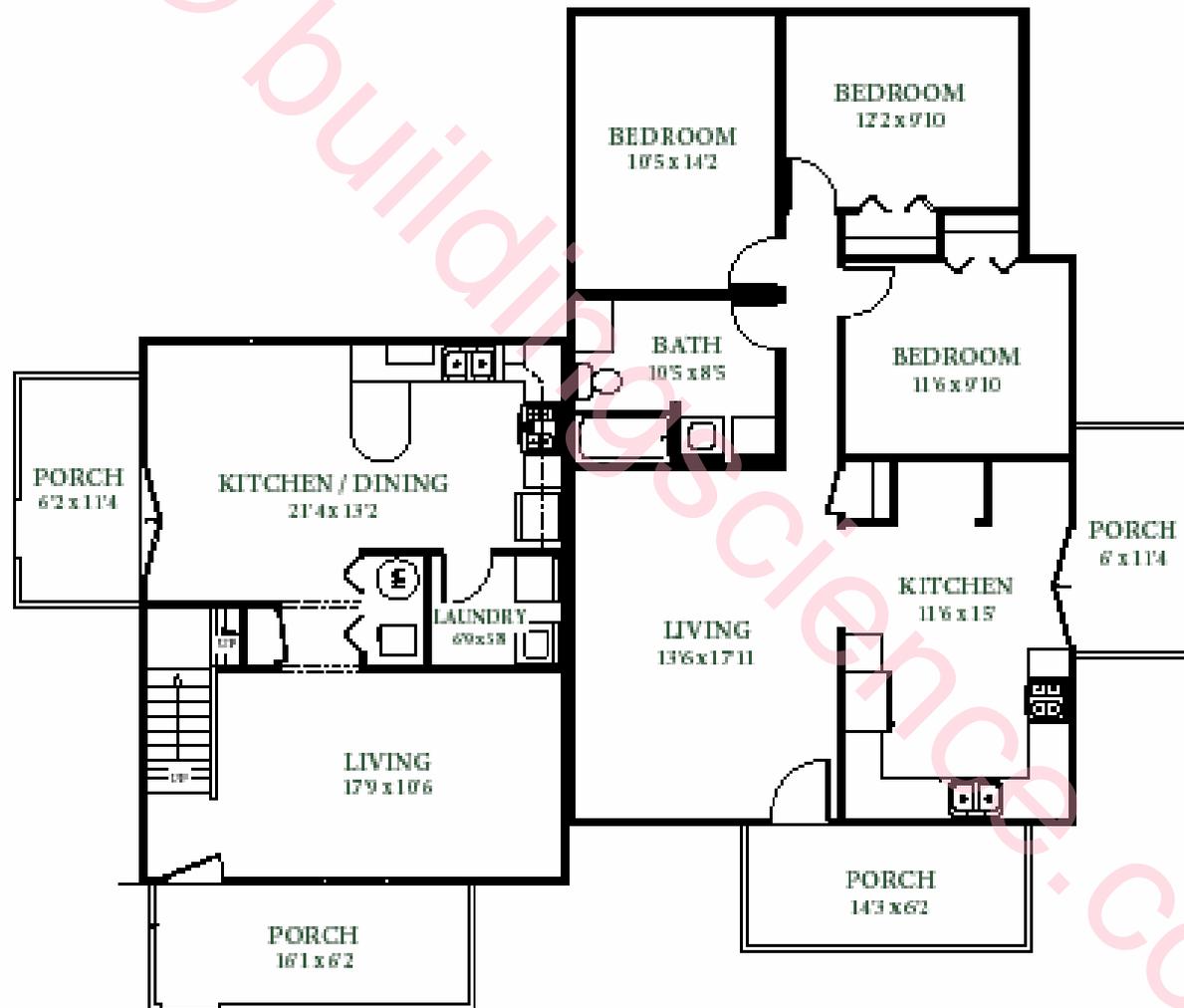
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EEBA Habitat Duplex



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EEBA Habitat Duplex

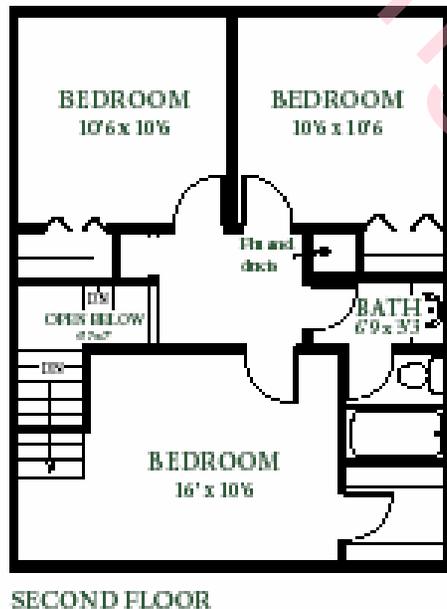


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EEBA Habitat Duplex

Attributes:

- Building America specifications
- conditioned basements
- vented attic
- mechanicals and ducts in conditioned space
- windows evenly distributed on 3 sides



LSLE with 78% Furnace

Energy Star Score: 87.5 PASS

	Interior Setpoint	Design Load	Annual Source Consumption
Heating	68 °F	18.8 kBtu/hr	27.6 MMBtu
Cooling	78 °F	13.3 kBtu/hr	13.3 MMBtu

Absolute carbon emissions 5270 pounds per year

- 37% better than MEC
- HERS standard furnace
- HERS standard setpoint
- 10 SEER air conditioner

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Double Pane with 90% furnace

Energy Star Score: 87.4 PASS

	Interior Setpoint	Design Load	Annual Source Consumption	% Increase
Heating	68 °F	21.5 kBtu/hr	28.9 MMBtu	5%
Cooling	78 °F	16.3 kBtu/hr	17.4 MMBtu	23%

Absolute carbon emissions 6000 pounds per year 12%

- Same Energy Star Score
- 18% peak cooling load increase
- Source consumption comparison

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Single Pane/90% furnace/12 SEER

Energy Star Score: 86.3 PASS

	Interior Setpoint	Design Load	Annual Source Consumption	% Increase
Heating	68 °F	26.0 kBtu/hr	37.6 MMBtu	27%
Cooling	78 °F	18.1 kBtu/hr	14.9 MMBtu	11%

Absolute carbon emissions 6710 pounds per year 21%

- Still HERS compliant
- 27% peak cooling load increase
- Extreme comparison

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Now adjust the setpoints to ensure comfort

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LSLE with 78% Furnace

Energy Star Score: 87.5 PASS

	Interior Setpoint	Design Load	Annual Source Consumption	% Increase
Heating	72 °F	19.9 kBtu/hr	33.2 MMBtu	17%
Cooling	78 °F	13.3 kBtu/hr	13.3 MMBtu	0%

Absolute carbon emissions 5960 pounds per year 12%

- Heating had to be increased beyond 68.

Double Pane with 90% furnace

Energy Star Score: 87.4 PASS

	Interior Setpoint	Design Load	Annual Source Consumption	% Increase
Heating	74 °F	23.5 kBtu/hr	37.3 MMBtu	11%
Cooling	74 °F	17.6 kBtu/hr	21.5 MMBtu	37%

Absolute carbon emissions 7610 pounds per year 31%

- 24% peak cooling load increase
- \$120 extra a year in heating and cooling costs. (Local utility rates)

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Single Pane/90% furnace/12 SEER

Energy Star Score: 86.3 PASS

	Interior Setpoint	Design Load	Annual Source Consumption	% Increase
Heating	75 °F	28.8 kBtu/hr	49.7 MMBtu	33%
Cooling	73 °F	20.1 kBtu/hr	19.9 MMBtu	32%

Absolute carbon emissions 8880 pounds per year 41%

- 34% peak cooling load increase
- \$180 extra a year in heating and cooling costs.

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Summary

Degradation of the “thermal” envelope can be overcome with equipment efficiency.

Degradation of the “comfort” envelope will be overcome with:

- Comfort complaints, customer dissatisfaction
or
- Increased energy expense and pollution

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Make Them Equal.....

Make Sure They're the Same!!

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