ASHRAE/IESNA Standard 90.1-1999

Envelope Requirements

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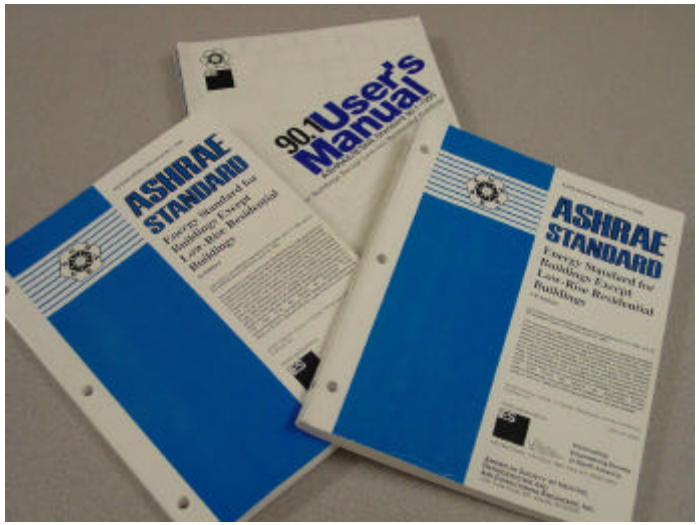
Owens Corning

Past Chair of ASHRAE SSPC 90.1

How to Get the Standard



Standard 90.1-2001 is now available

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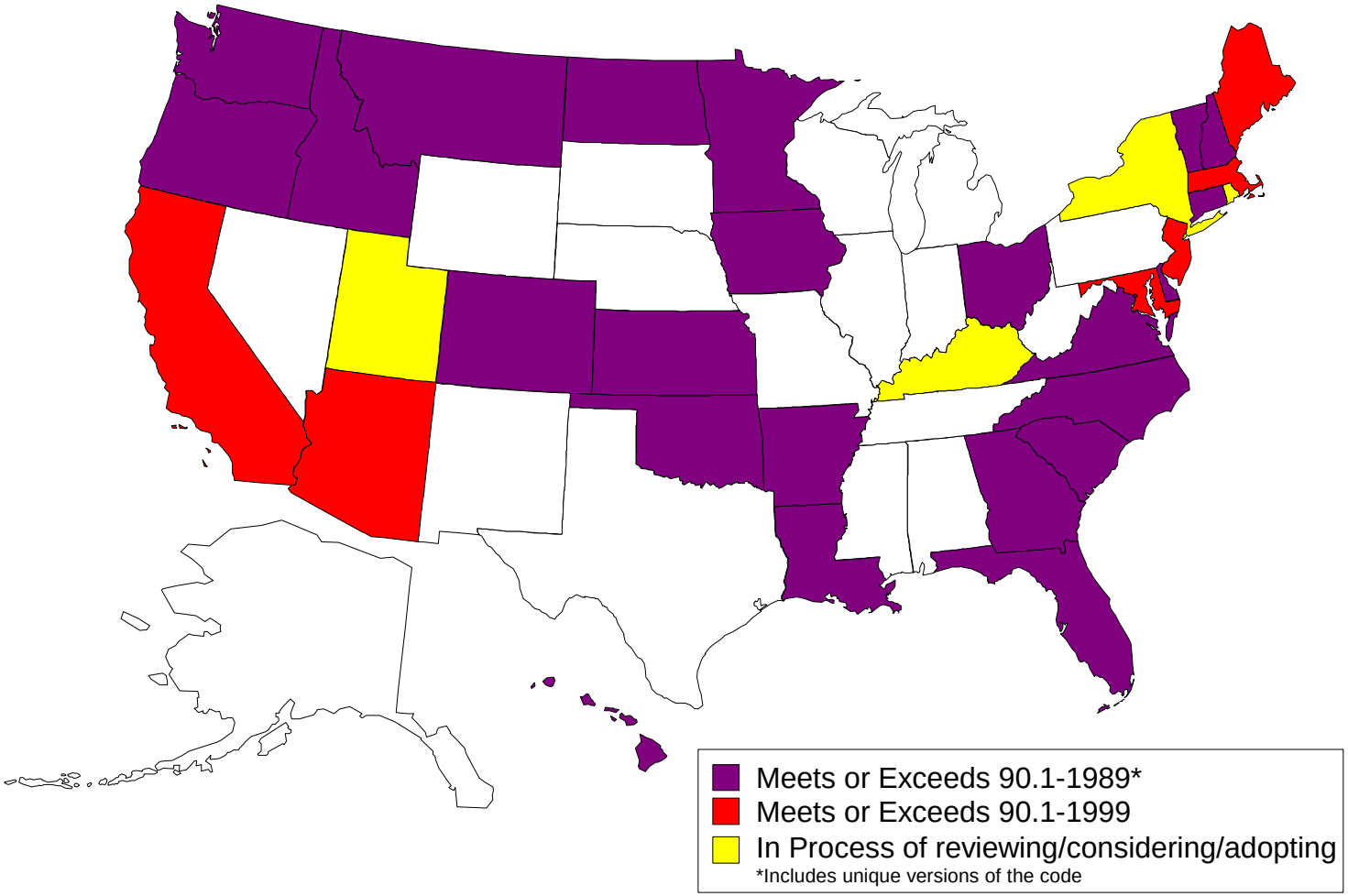
Status of State Adoption



Overview

- 1 – Background
- 2 – Development
- 3 – Criteria
- 4 – Compliance
- 5 – Errata
- 6 – Addenda

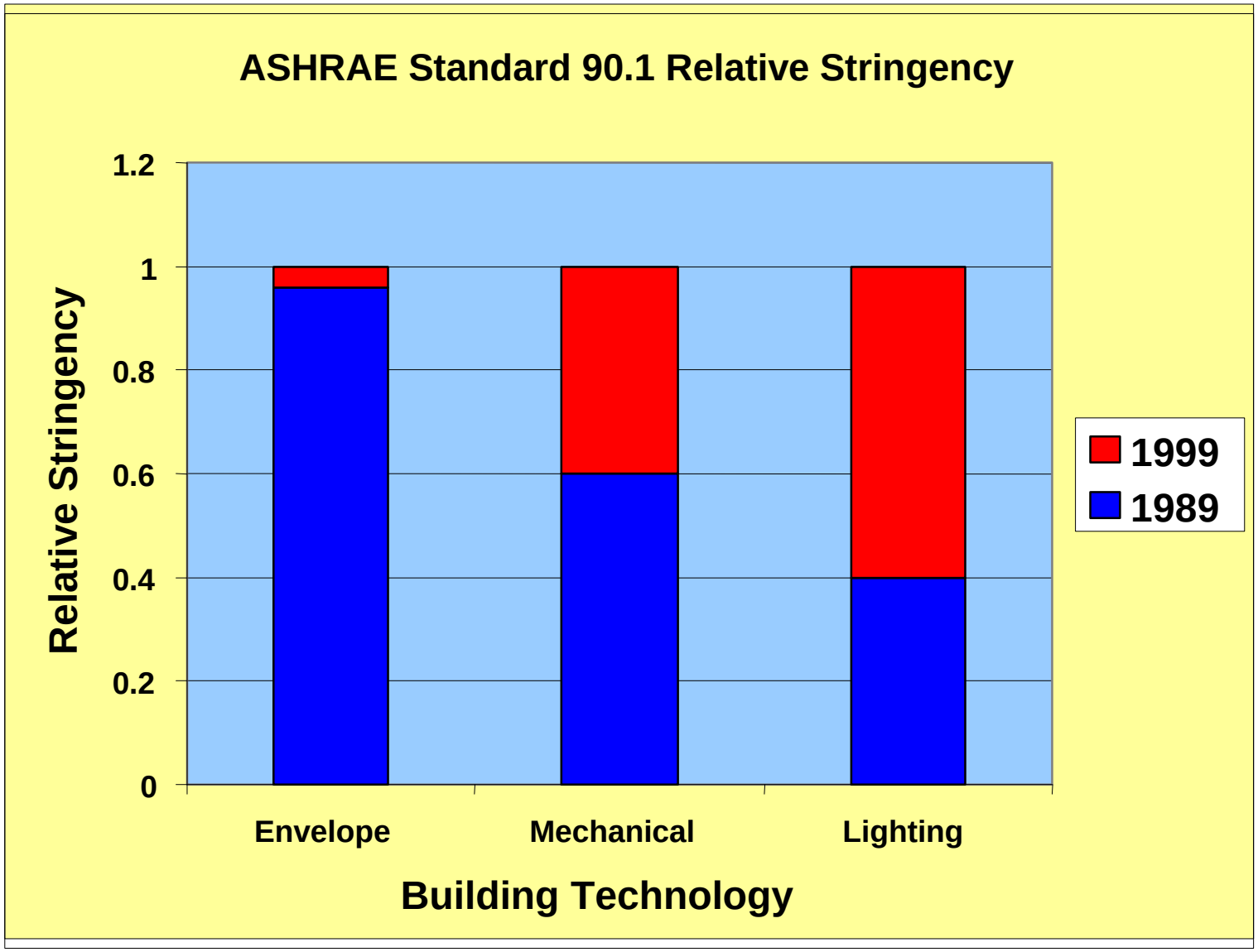
1 - Background

Background

Issues	1989	1999
Criteria Development	Professional Judgement	Life-Cycle Cost Economics
Simplified Criteria	U-Factor	Insulation R-Value
Component Tradeoffs	Equal Energy Consumption	Equally Cost Effective
Envelope Tradeoffs	Windows and Walls	Entire Envelope

Criteria Development

- **Objectives**
  - Technically Feasible
  - Economically Justified
  - Balanced
- **Approach**
  - Analyze Actual Products
  - Life Cycle Cost Analyses
  - Equate All Marginal Costs to Savings Ratios

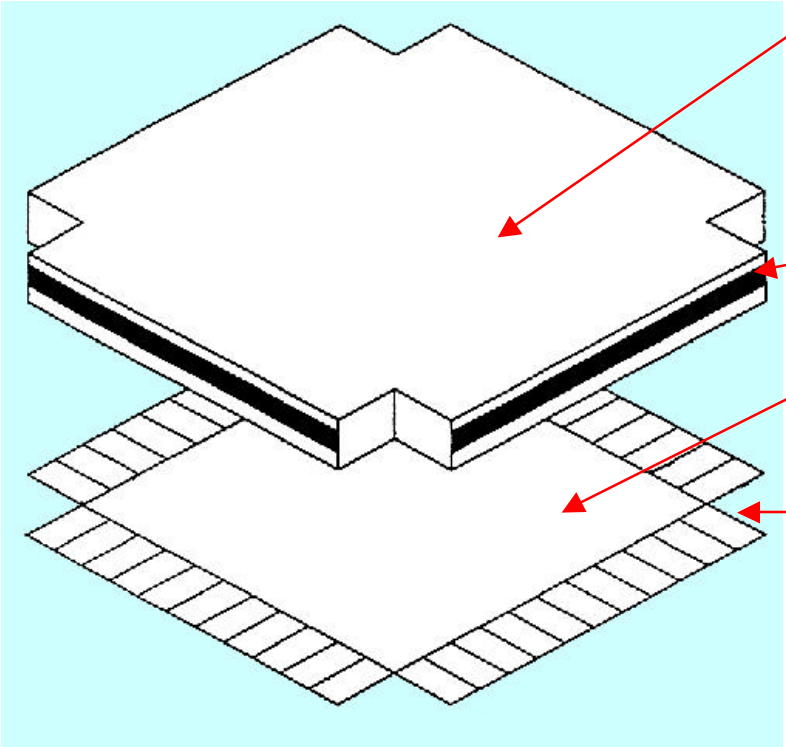

ASHRAE Standard 90.1 Relative Stringency
Relative Stringency
1.2
1
0.8
0.6
0.4
0.2
0
Envelope
Mechanical
Lighting
Building Technology
1999
1989

2- Criteria Development

Modeling Assumptions

- Building Types
  - Retail
  - Office
- HVAC
  - Roof Top Units
  - Gas Fired
  - Evaporative Cooling
- Fuel Prices
  - National Averages
  - Heating $0.66/therm
  - Cooling $0.08/kWh
- Locations
  - 11 Cities from across all U.S. census divisions and regions

Modeled Retail Building
One Story



12,000 ft^2

13 ft floor to floor

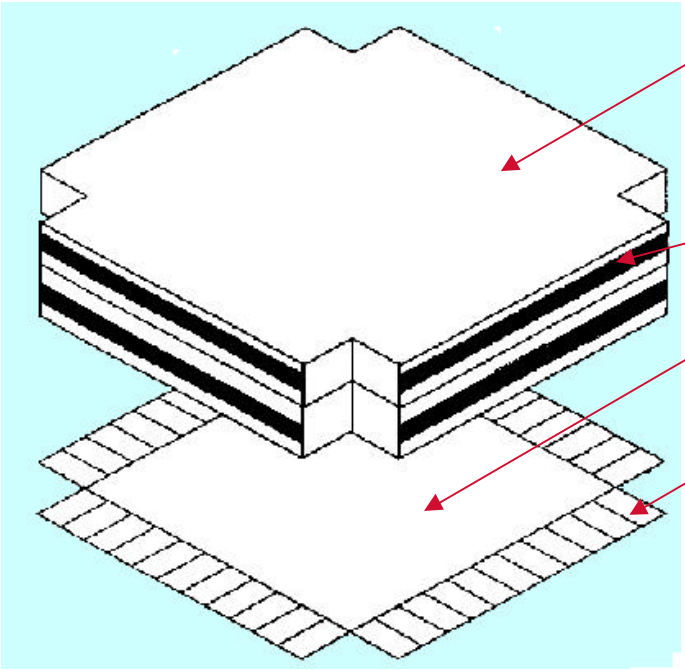
WWR = 0.15

100 ft x 100 ft core

15 ft. perimeter spaces

Floor Construction
15% slab on grade
15% exposed to outside air
70% adjacent to plenum below

Modeled Office Building
Two Story



22,000 ft^2

13 ft floor to floor

WWR = 0.2

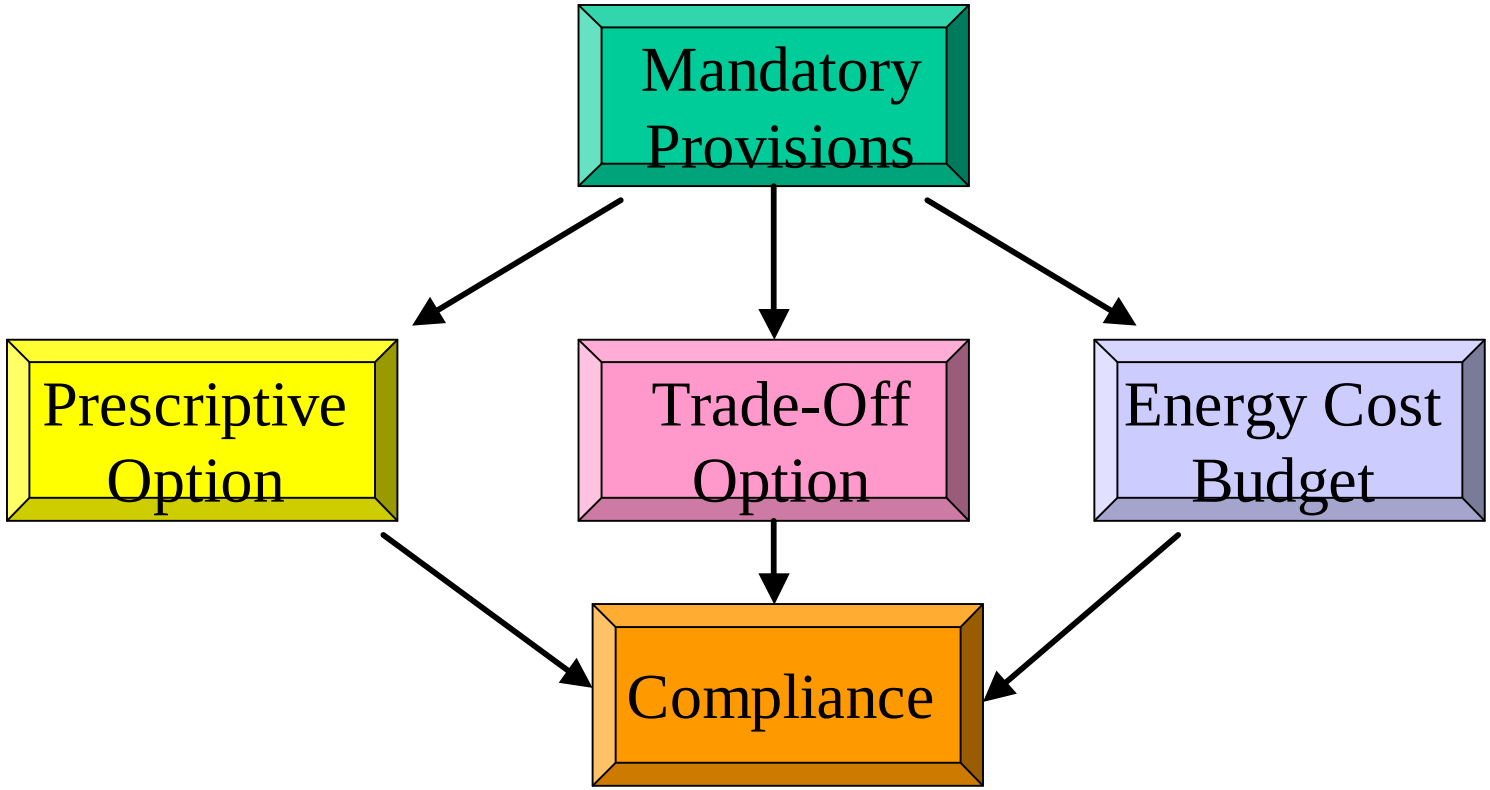
100 ft x 100 ft core

15 ft. perimeter spaces

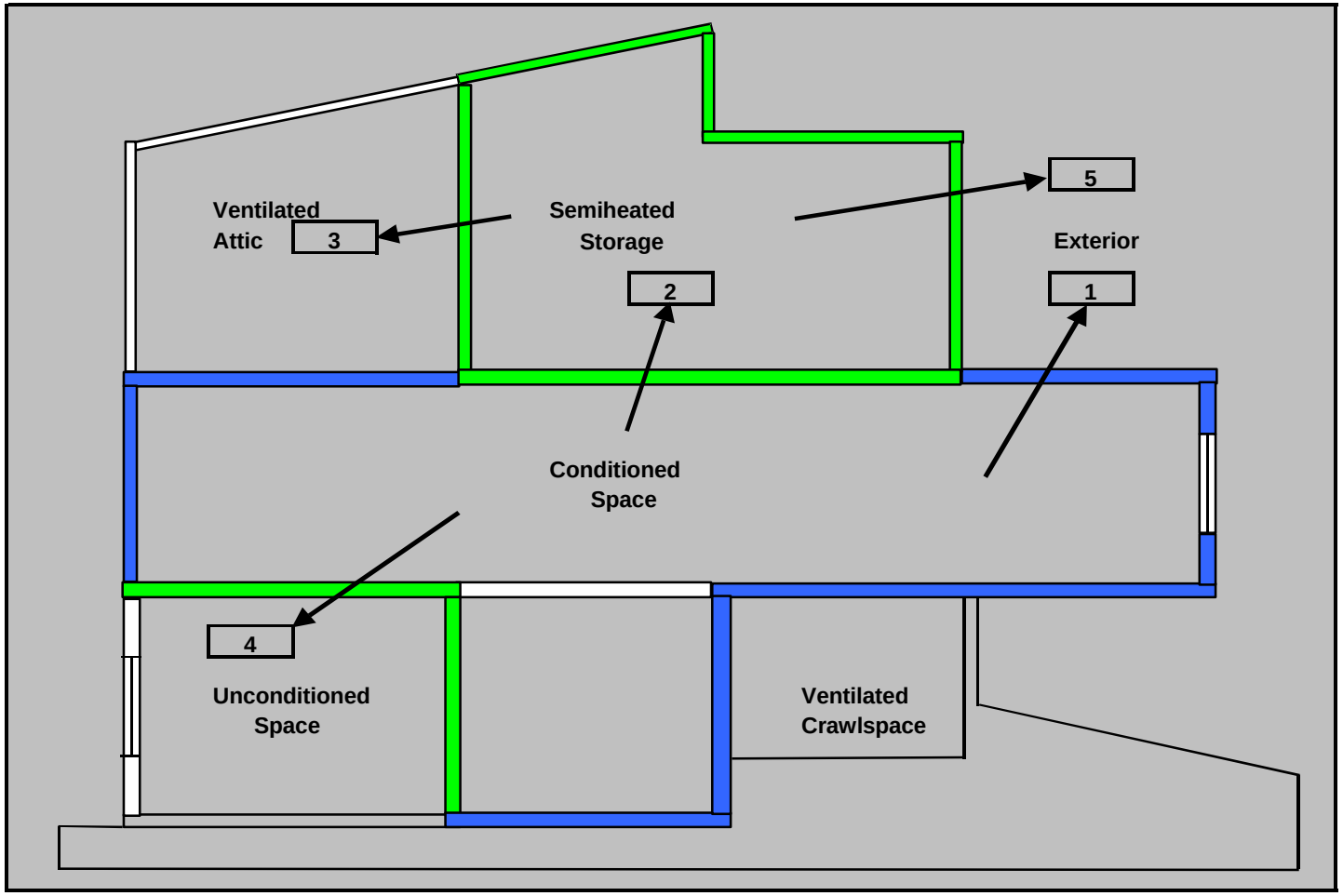
Floor Construction
15% slab on grade
15% exposed to outside air
70% adjacent to plenum below

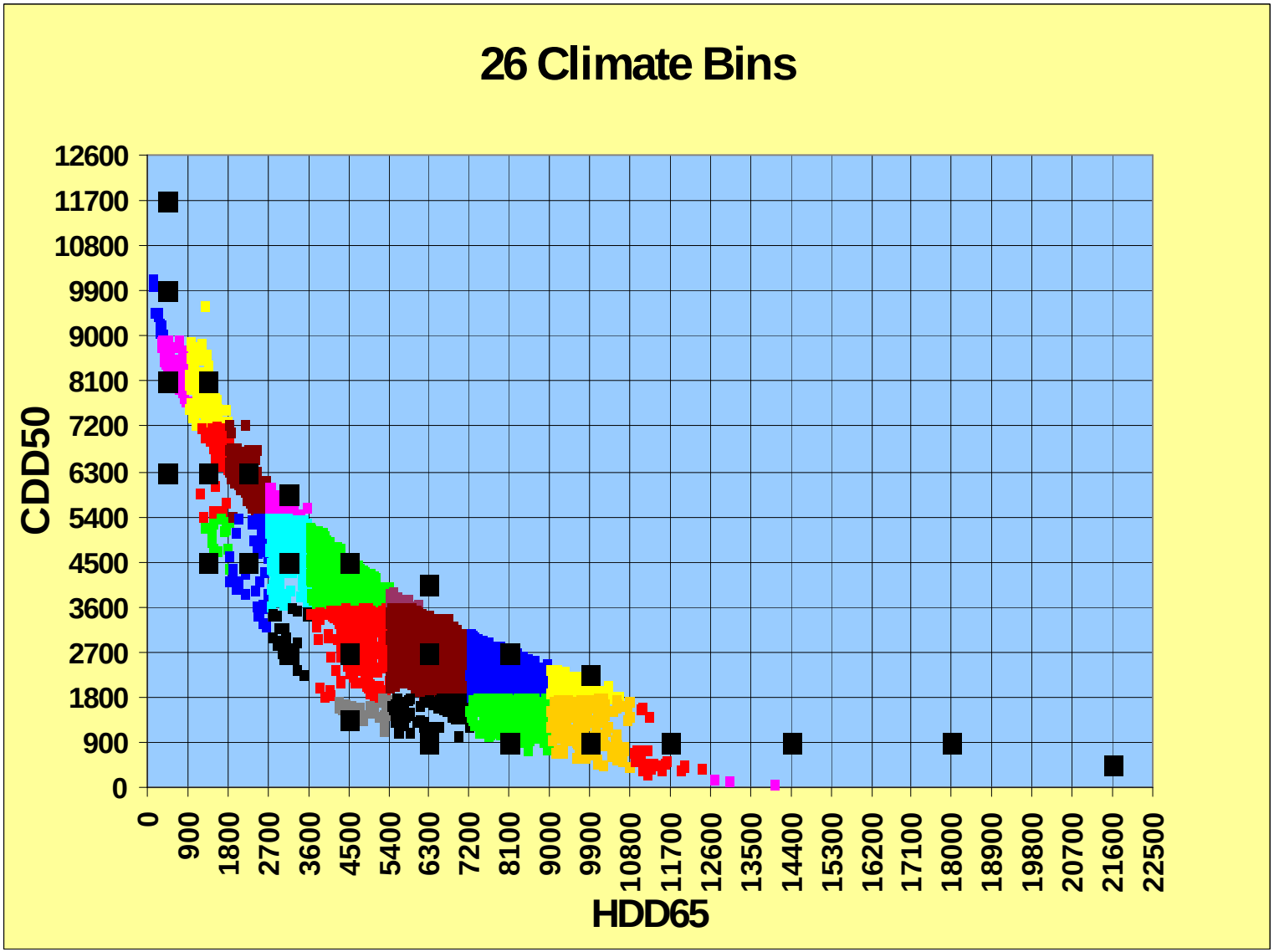
3 - Criteria

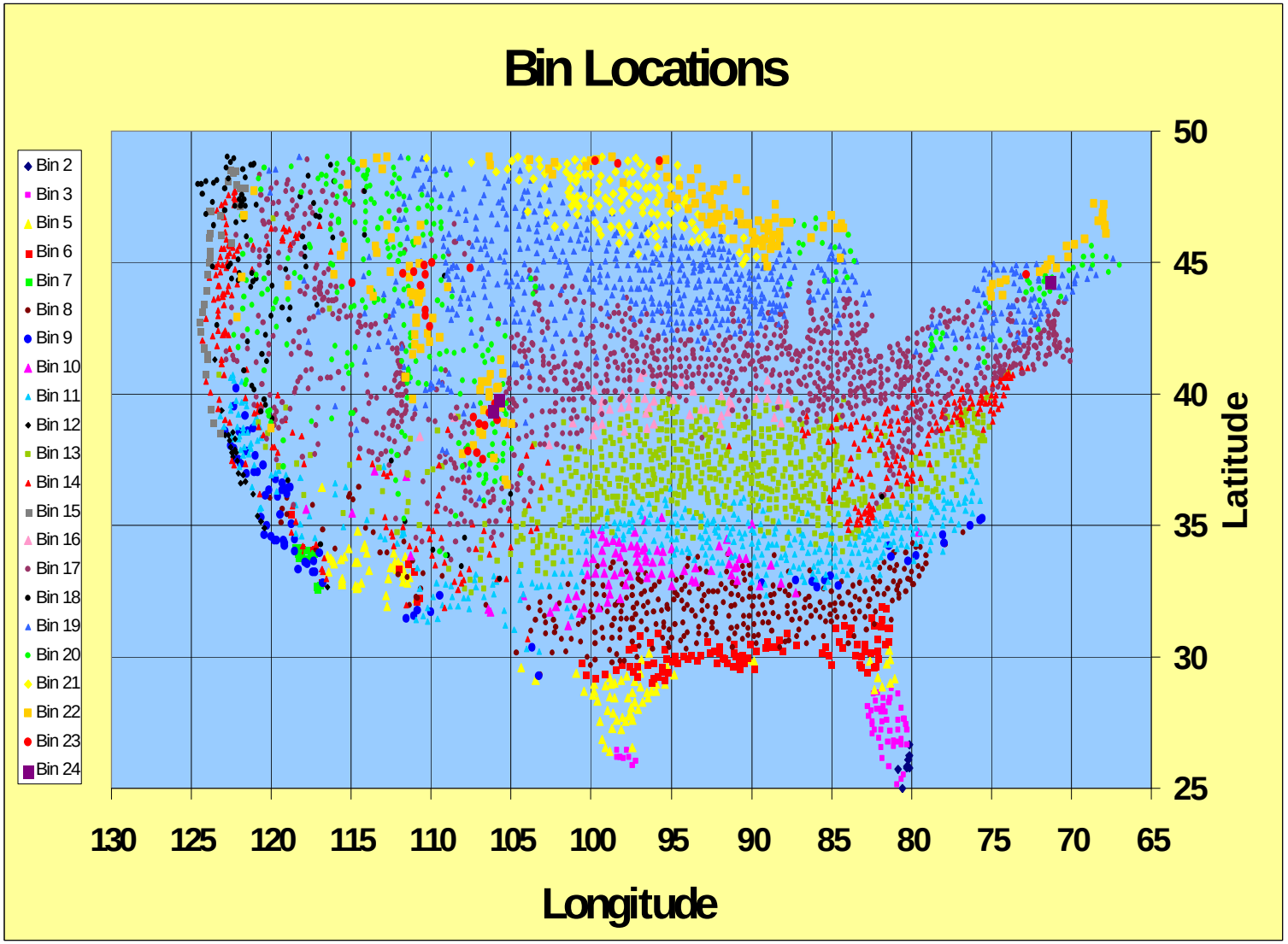
Criteria


Mandatory Provisions
Prescriptive Option
Trade-Off Option
Energy Cost Budget
Compliance

General - Building Envelope Scope

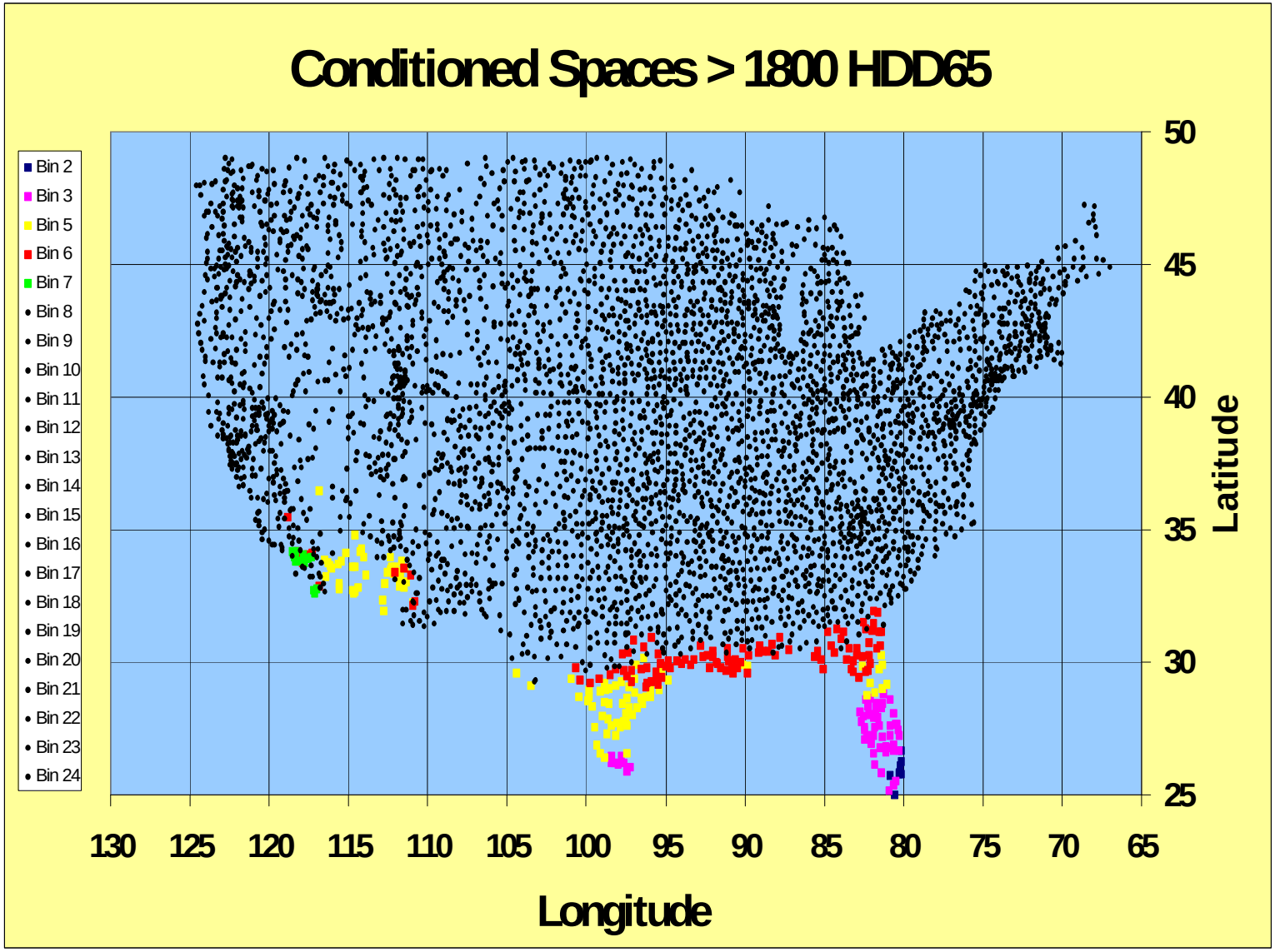



26 Climate Bins
CDD50
12600
11700
10800
9900
9000
8100
7200
6300
5400
4500
3600
2700
1800
900
0
HDD65
0
900
1800
2700
3600
4500
5400
6300
7200
8100
9000
9900
10800
11700
12600
13500
14400
15300
16200
17100
18000
18900
19800
20700
21600
22500


Bin Locations
Bin 2
Bin 3
Bin 5
Bin 6
Bin 7
Bin 8
Bin 9
Bin 10
Bin 11
Bin 12
Bin 13
Bin 14
Bin 15
Bin 16
Bin 17
Bin 18
Bin 19
Bin 20
Bin 21
Bin 22
Bin 23
Bin 24
50
45
40
35
30
25
Latitude
130
125
120
115
110
105
100
95
90
85
80
75
70
65
Longitude

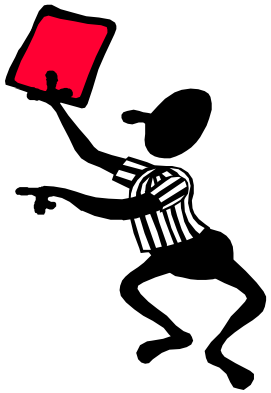
Space-Conditioning Categories

- Nonresidential Conditioned Space
- Residential Conditioned Space
- Semiheated Space


Conditioned Spaces > 1800 HDD65
Bin 2
Bin 3
Bin 5
Bin 6
Bin 7
Bin 8
Bin 9
Bin 10
Bin 11
Bin 12
Bin 13
Bin 14
Bin 15
Bin 16
Bin 17
Bin 18
Bin 19
Bin 20
Bin 21
Bin 22
Bin 23
Bin 24
50
45
40
35
30
25
Latitude
130
125
120
115
110
105
100
95
90
85
80
75
70
65
Longitude

Mandatory Criteria

- Insulation
- Fenestration
- Air Leakage



Insulation

- Rated R-Values per Manufacturer
- Substantial Contact
- Recessed Equipment
- Suspended Ceilings
- Exterior Insulation Protected

Fenestration

- U-factor Criteria
  - Production line units or purchased by consumer
  - NFRC 100
  - Accredited Laboratory
  - Labeled and Certified by Manufacturer
- Exceptions
  - Glazed Wall Systems & Skylights - A.8.1
  - Low Emissivity Coatings - NFRC
  - Vertical Fenestration except for (a) - A.8.2
  - Opaque Doors - A.7
  - Garage Doors - NAGDM

Fenestration

- SHGC Criteria
  - NFRC
  - Accredited Laboratory
  - Labeled and Certified by Manufacturer
- Exceptions
  - SC x 0.86 - NFRC
  - Center of Glass - NFRC
  - Glazed Wall Systems - A.8.1
  - Vertical Fenestration - A.8.2

Fenestration

- Visible Light Transmission
  - NFRC
  - Verified and Certified by Manufacturer

Air Leakage

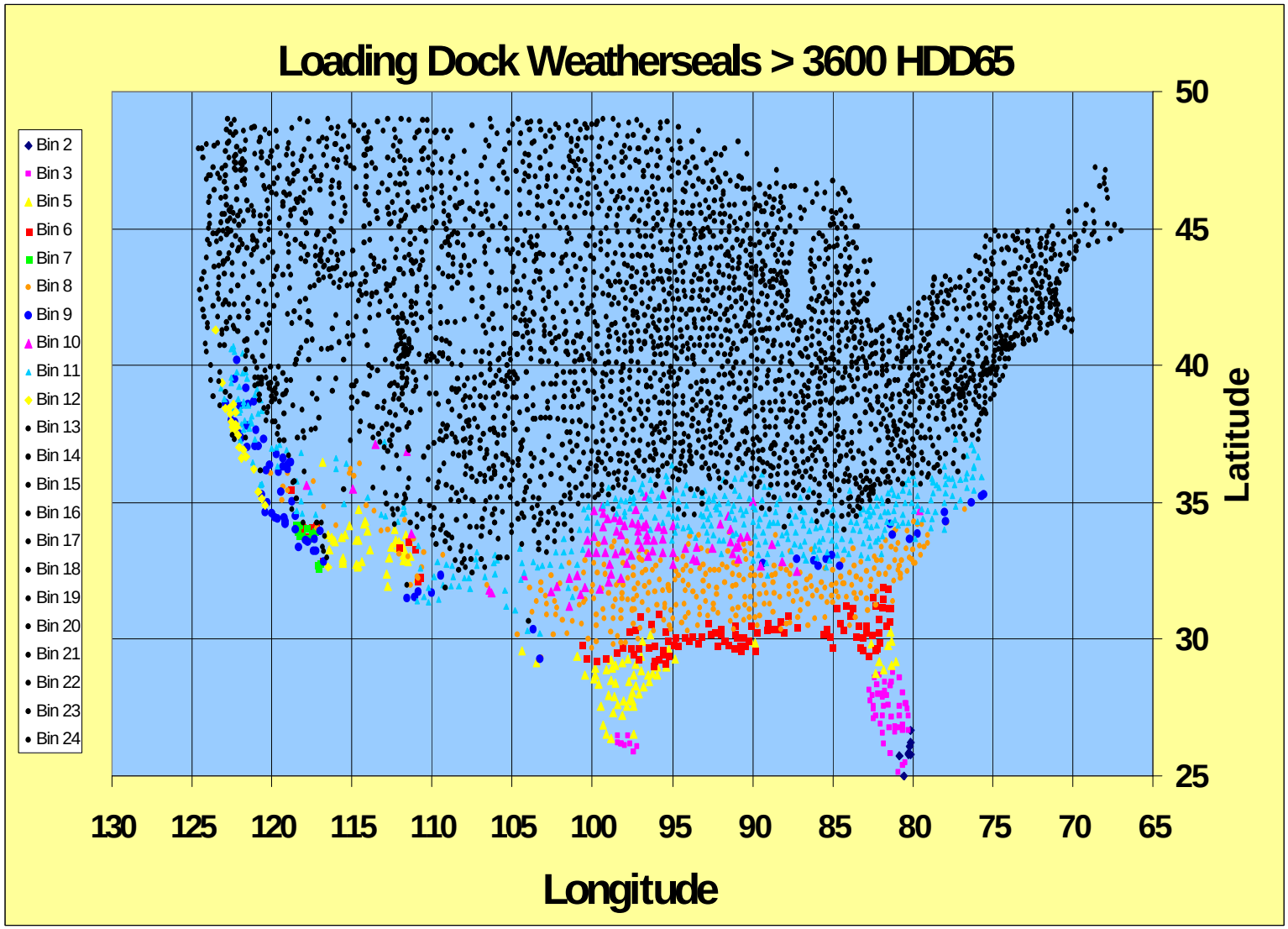
- Minimize air leakage by sealing, caulking, gasketing, or weather-stripping
  - joints around fenestration & door frames
  - junctions between walls and roofs
  - utility services
  - site built fenestration
  - ducts and plenums
  - vapor retarder joints, seams, and holes
  - all other openings

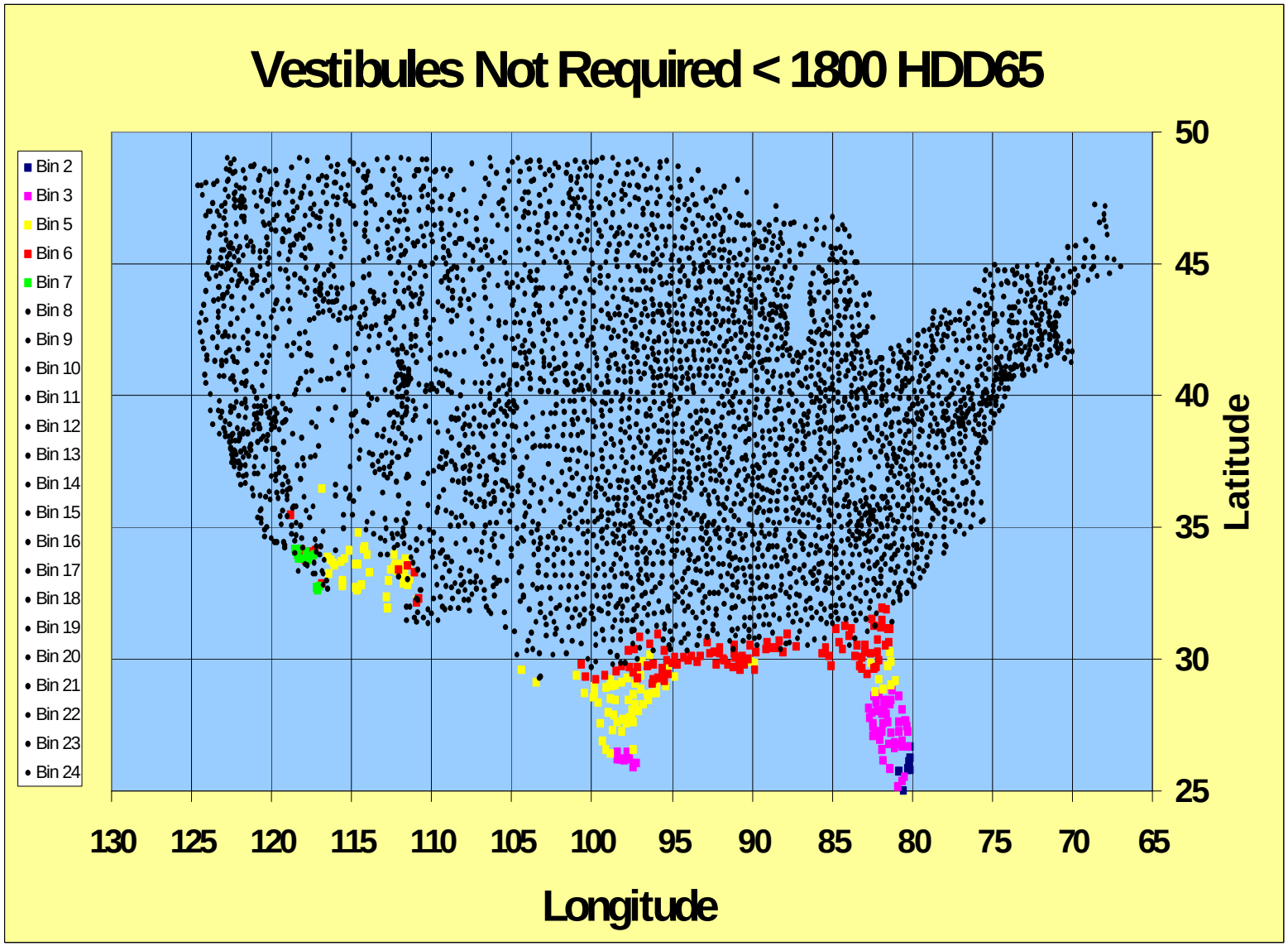
Air Leakage

- Seal
  - Outside air intakes
  - Exhaust outlets
  - Relief outlets
  - Stair shaft
  - Elevator shaft smoke relief openings
  - Shut off damper control - 6.2.3.2.4
  - Gravity vent controls - 6.2.3.3

Air Leakage

- Fenestration and Doors - NFRC
  - Swinging Entrance - < 1.0 cfm/ft^2
  - Revolving Doors
  - All other products - < 0.4 cfm/ft^2
- Exceptions
  - Field Fabricated
  - Garage Doors - NAGDM 105
  - Expired on January 1, 2000


Loading Dock Weatherseals > 3600 HDD65
Bin 2
Bin 3
Bin 5
Bin 6
Bin 7
Bin 8
Bin 9
Bin 10
Bin 11
Bin 12
Bin 13
Bin 14
Bin 15
Bin 16
Bin 17
Bin 18
Bin 19
Bin 20
Bin 21
Bin 22
Bin 23
Bin 24
50
45
40
35
30
25
Latitude
130
125
120
115
110
105
100
95
90
85
80
75
70
65
Longitude


Vestibules Not Required < 1800 HDD65
Bin 2
Bin 3
Bin 5
Bin 6
Bin 7
Bin 8
Bin 9
Bin 10
Bin 11
Bin 12
Bin 13
Bin 14
Bin 15
Bin 16
Bin 17
Bin 18
Bin 19
Bin 20
Bin 21
Bin 22
Bin 23
Bin 24
50
45
40
35
30
25
Latitude
130
125
120
115
110
105
100
95
90
85
80
75
70
65
Longitude

Prescriptive Criteria

- U-factors (Roofs, Walls, Floors, Fenestration)
- C-factors (Below Grade Walls)
- F-factors (Slab-On-Grade Floors)
- R-values (Roofs, Walls, Floors)
- Exception
  - N/A No requirement
- SHGC (Fenestration)

Prescriptive Criteria

- Opaque Areas in Multiple Assemblies
  - Allowed
    - Area Weight within Single Class of Construction
    - Area Weight U-factors, C-factors and F-factors
  - Not Allowed
    - Area Weight R-values
    - Area Weight Across Multiple Classes of Construction
    - Area Weight across multiple Space-Conditioning Categories

TABLE B-13

Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
Fenestration	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing. % of Wall						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

TABLE B-13

Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
Fenestration	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing. % of Wall						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

TABLE B-13

Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, BelowGrade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
Fenestration	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Manx. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing. % of Wall						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

TABLE B-13

Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
Fenestration	Assembly Manx. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Manx. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Manx. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing. % of Wall						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

TABLE B-1.3 Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)						
	Nonresidential		Residential		Semiheated	
Opaque Elements	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
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						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						
* Exception to 5.3.1.2a applies.						

Nonresidential

- Automotive Facility
- Convention Center
- Court House
- Dining: Bar Lounge/Leisure
- Dining: Cafeteria/Fast Food
- Dining: Family
- Exercise Center
- Gymnasium
- Library
- Manufacturing Facility
- Motion Picture Theater
- Museum
- Office
- Performing Art Theater
- Post Office
- Religious Building
- Retail
- School/University
- Sports Arena
- Town Hall
- Transportation
- Workshop

TABLE B-13

Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
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						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

Residential

- Dormitory
- Hospital
- Health Care
- Hotel/Motel
- Multi-family
- Penitentiary
- Police Station
- Fire Station

TABLE B-13

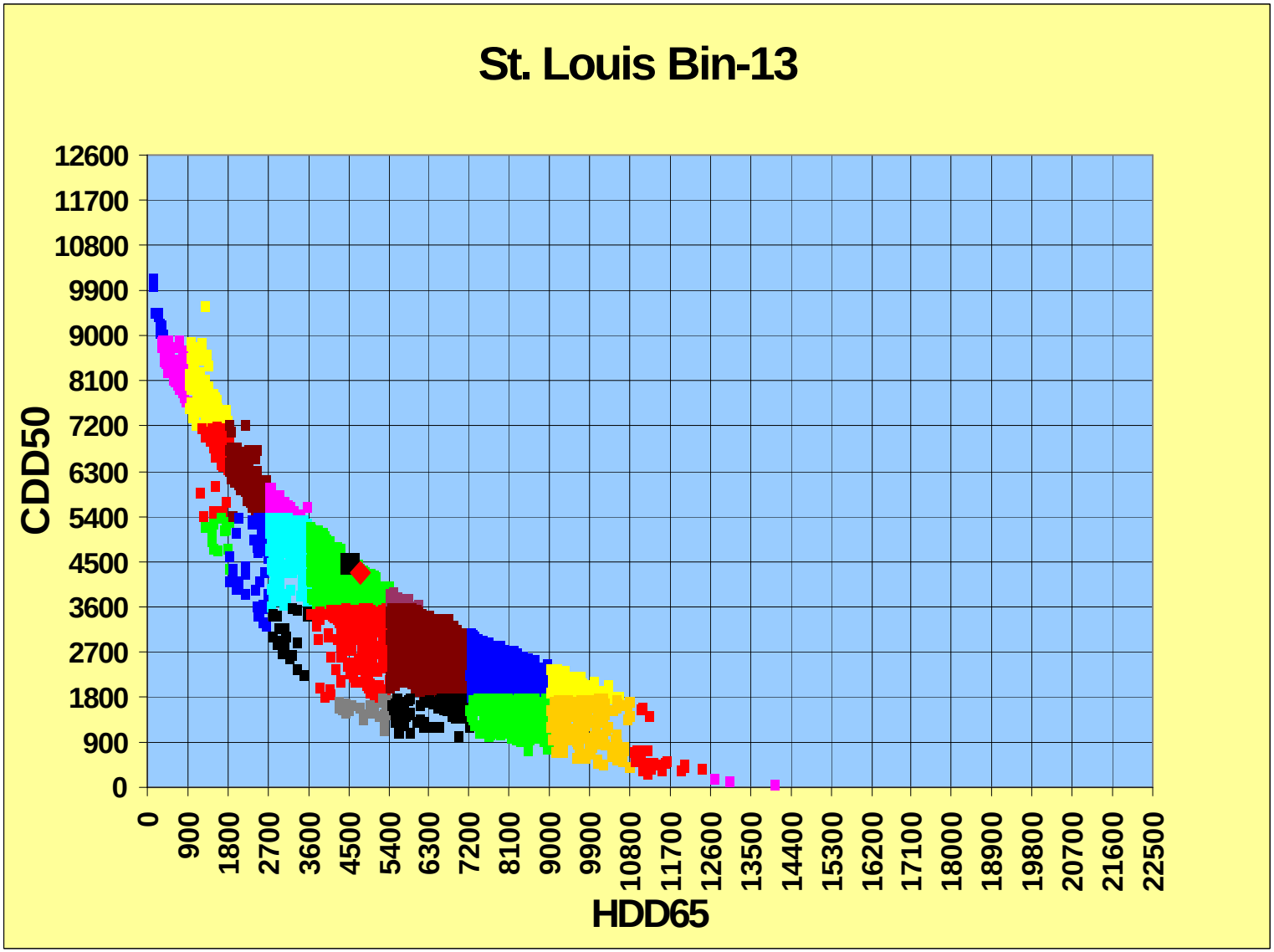
Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value	Assembly Maximum	Insulation Min. R-value
Roofs						
Walls, Above Grade						
Walls, Below Grade						
Floors						
Slab-On-Grade Floors						
Opaque Doors						
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						
Skylight with Curb, Glass, % of Roof						
Skylight with Curb, Plastic, % of Roof						
Skylight without Curb, All, % of Roof						

* Exception to 5.3.1.2a applies.

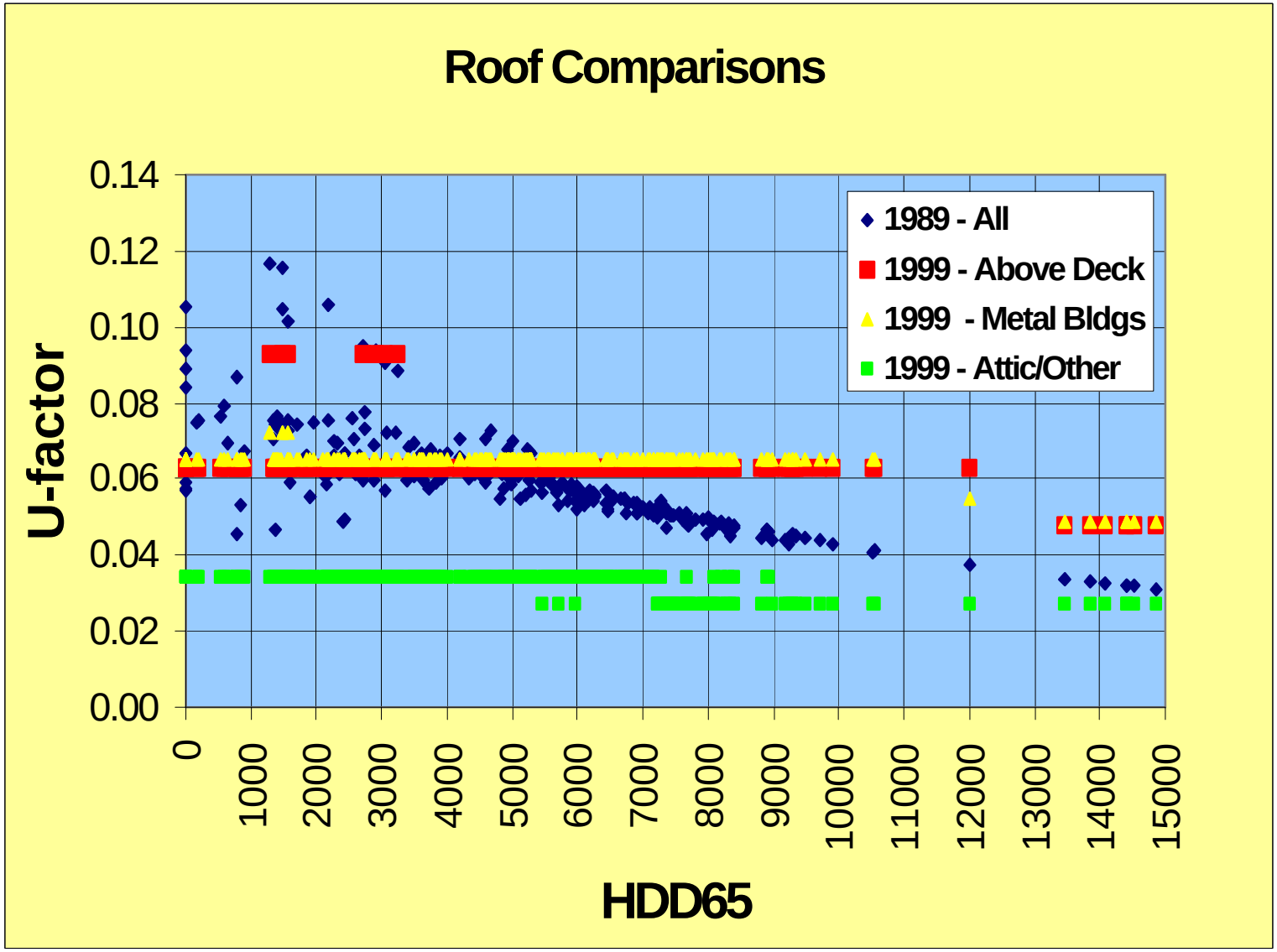
Semiheated - Warehouse

Example - St. Louis


St. Louis Bin-13
CDD50
12600
11700
10800
9900
9000
8100
7200
6300
5400
4500
3600
2700
1800
900
0
0
900
1800
2700
3600
4500
5400
6300
7200
8100
9000
9900
10800
11700
12600
13500
14400
15300
16200
17100
18000
18900
19800
20700
21600
22500
HDD65

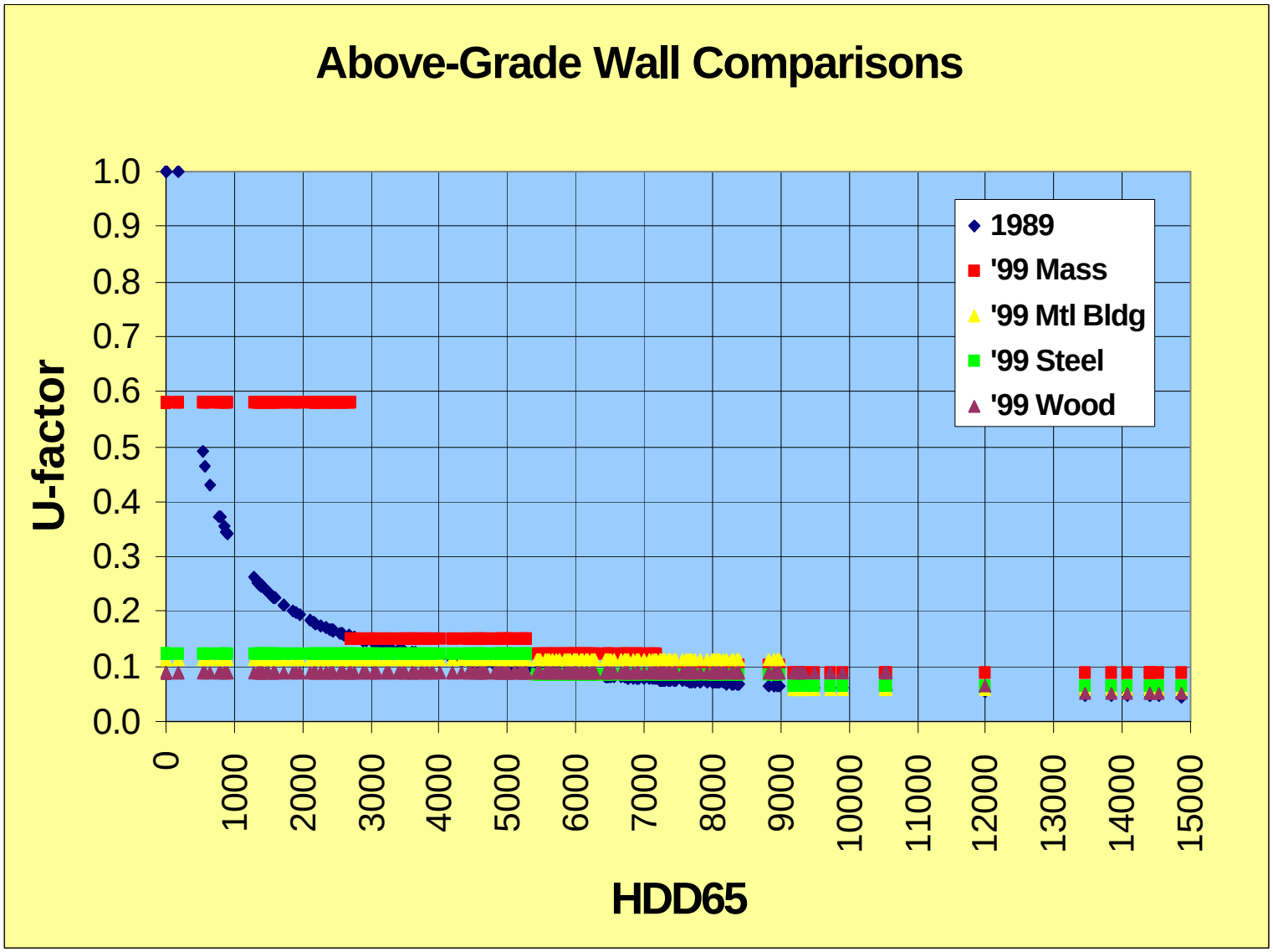
Example – St. Louis (cont'd)

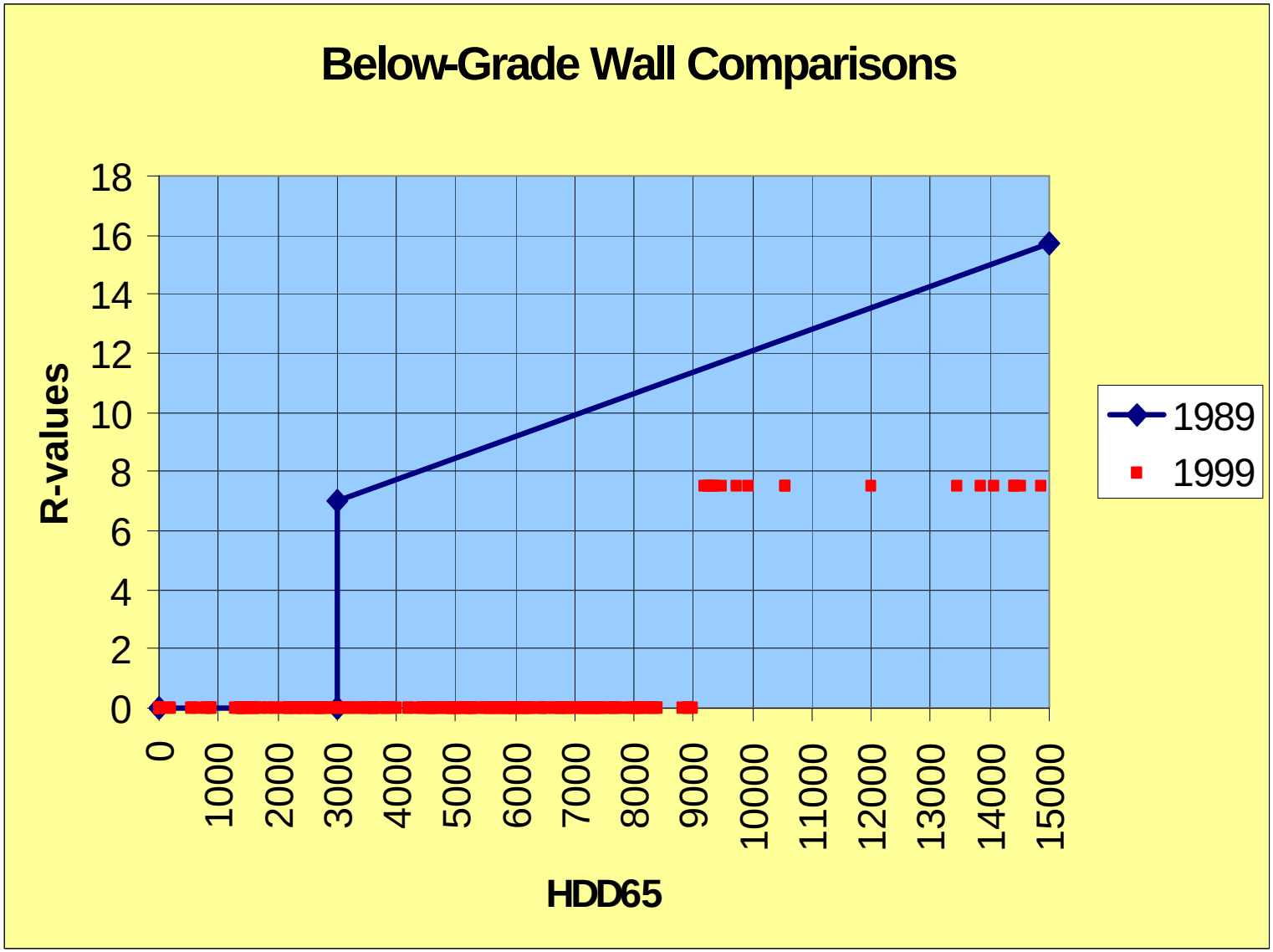
Opaque Elements	Nonresidential	
	Assembly Maximum	Insulation Min. R-value
Roofs		
Insulation Entirely Above Deck	U-0.063	R-15.0 ci
Metal Buildings	U-0.065	R-19.0
Attic and Other	U-0.034	R-30.0


Roof Comparisons
U-factor
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989 - All
1999 - Above Deck
1999 - Metal Bldgs
1999 - Attic/Other

Walls Criteria
Example - St. Louis (cont'd)

Opaque Elements	Nonresidential	
	Assembly Maximum	Insulation Min. R-value
Walls, Above Grade		
Mass	U-0.151*	R-5.7 ci
Metal Building	U-0.113	R-13.0
Steel Framed	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0
Walls, Below Grade		
Below Grade Walls	C-1.140	NR
* Exception to 5.3.1.2a applies.		

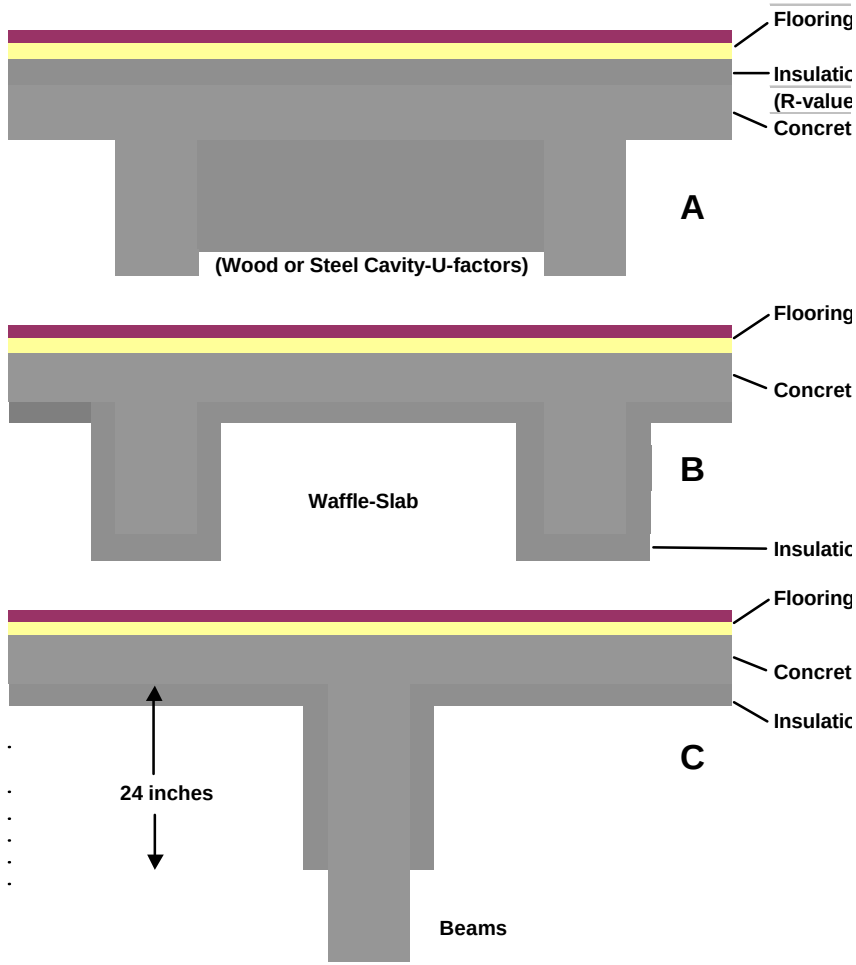

Above-Grade Wall Comparisons
U-factor
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
'99 Mass
'99 Mtl Bldg
'99 Steel
'99 Wood


Below-Grade Wall Comparisons
R-values
18
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
1999

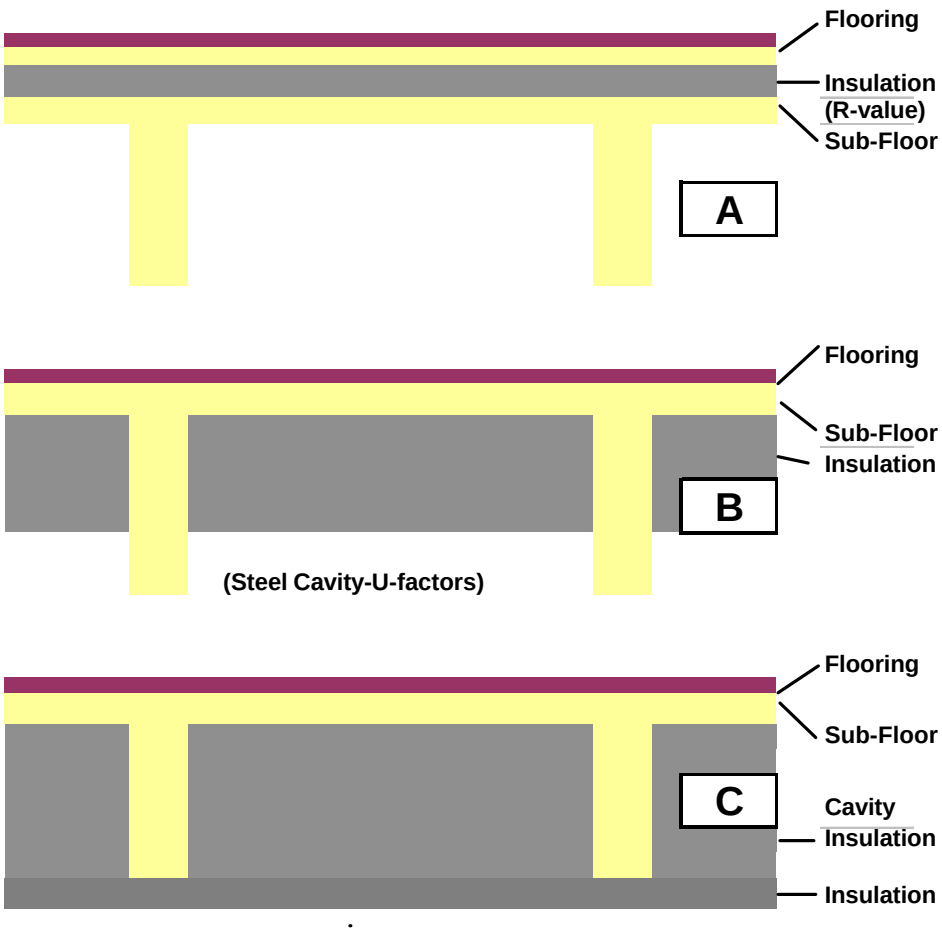
Floors Criteria
Example - St. Louis (cont'd)

Opaque Elements	Nonresidential	
	Assembly Maximum	Insulation Min. R-value
Floors		
Mass	U-0.107	R-6.3 ci
Steel Joist	U-0.052	R-19.0
Wood Framed and Other	U-0.051	R-19.0
Slab-On-Grade Floors		
Unheated	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.

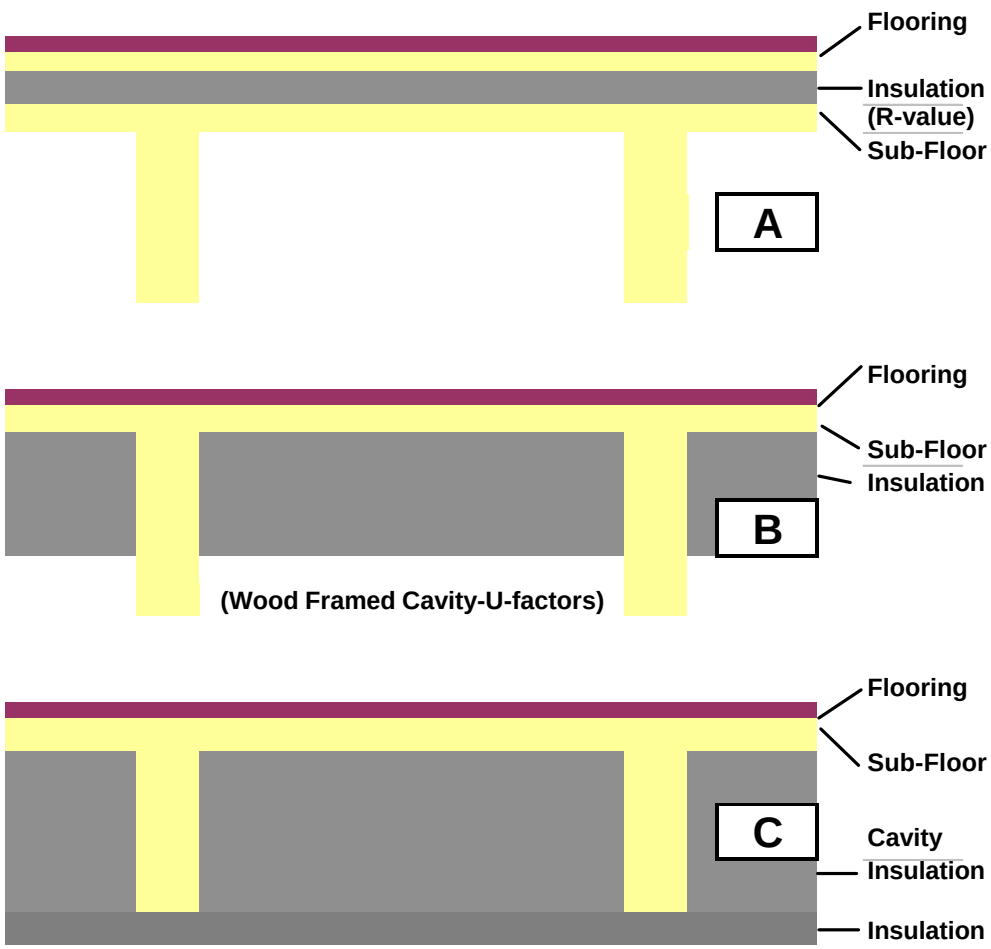
Mass Floor Insulation

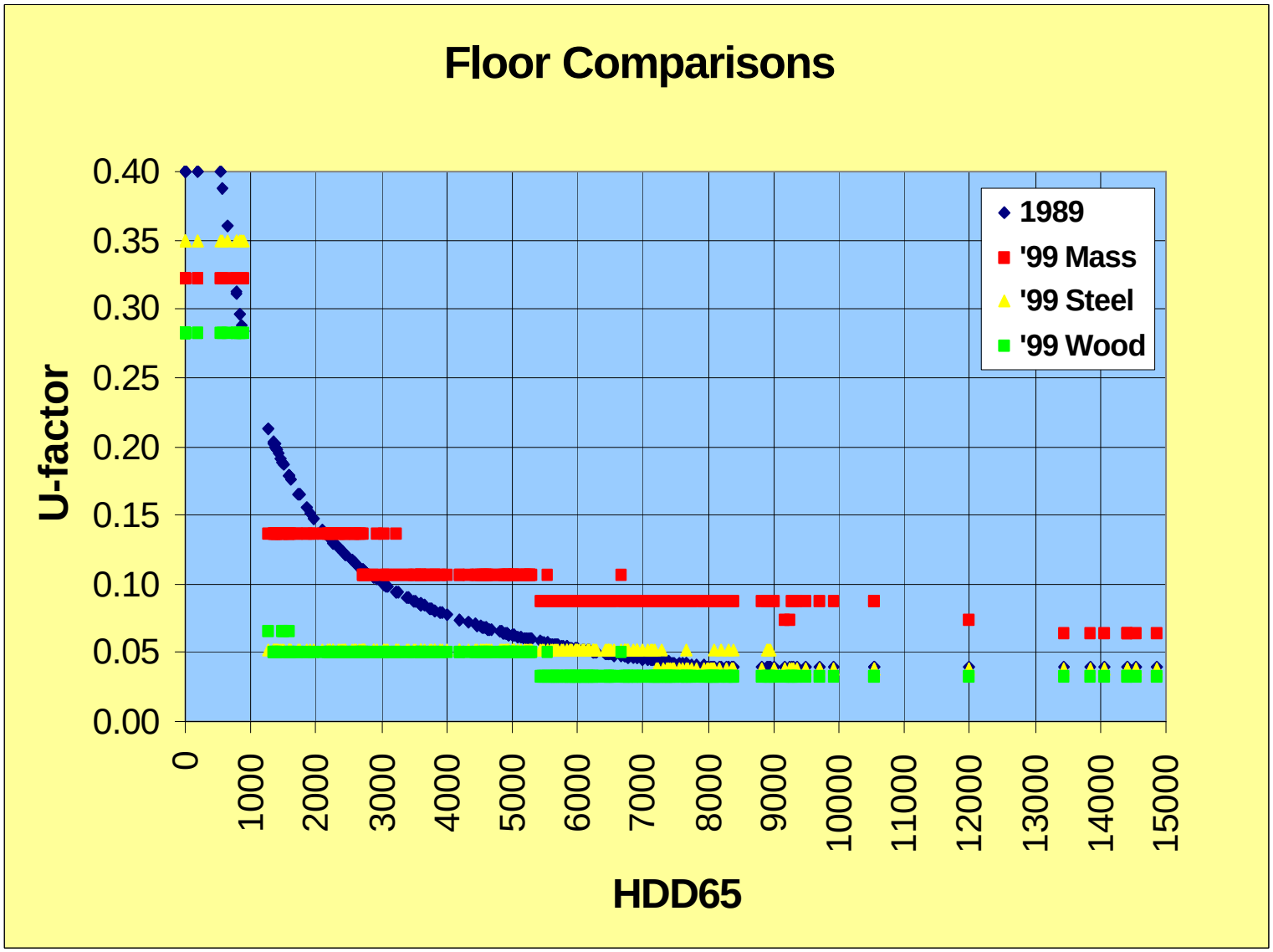


Steel Joist Floors

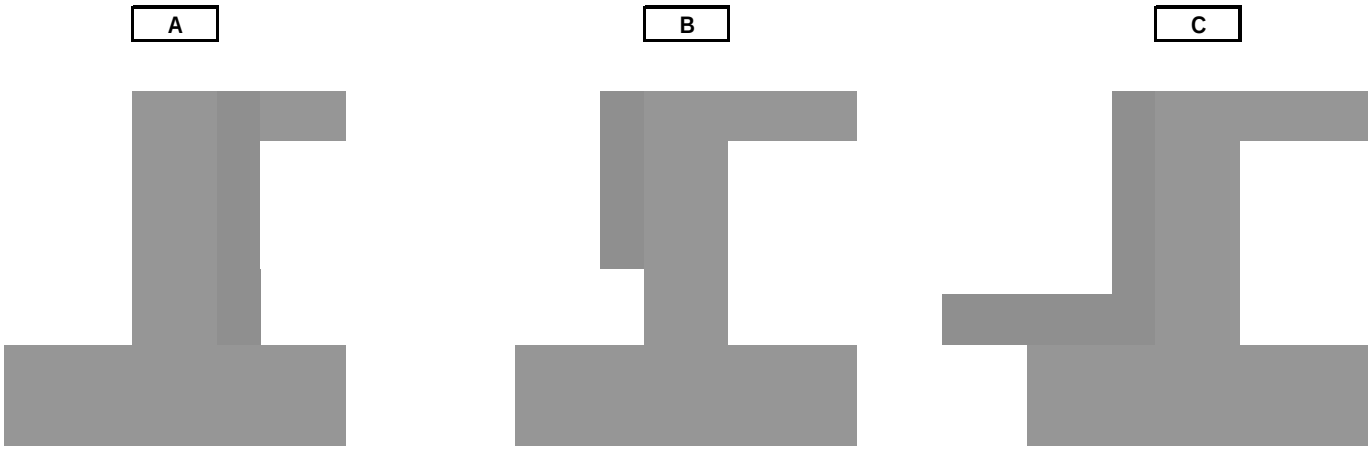


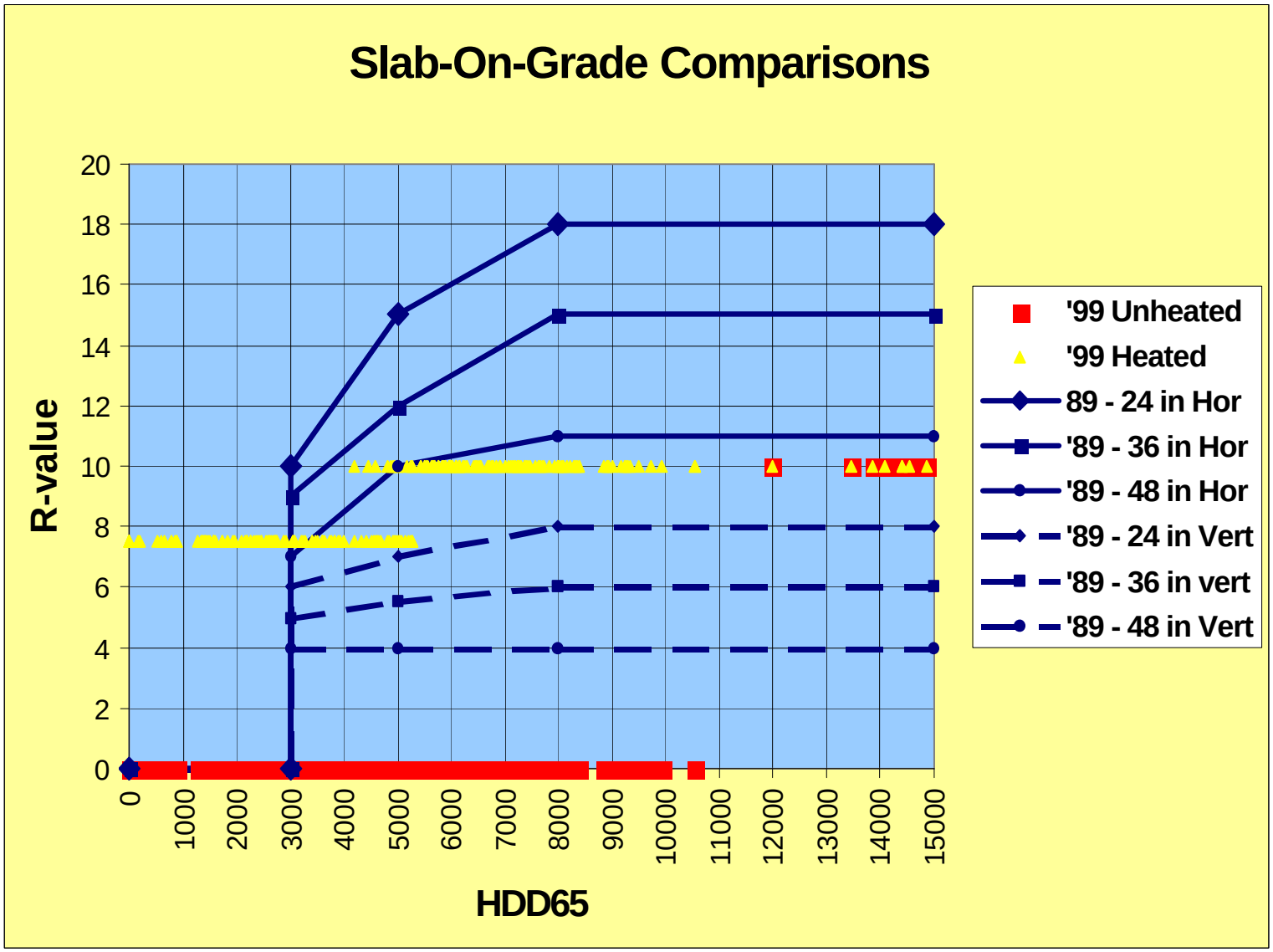
Wood Framed Floors




Floor Comparisons
U-factor
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
'99 Mass
'99 Steel
'99 Wood

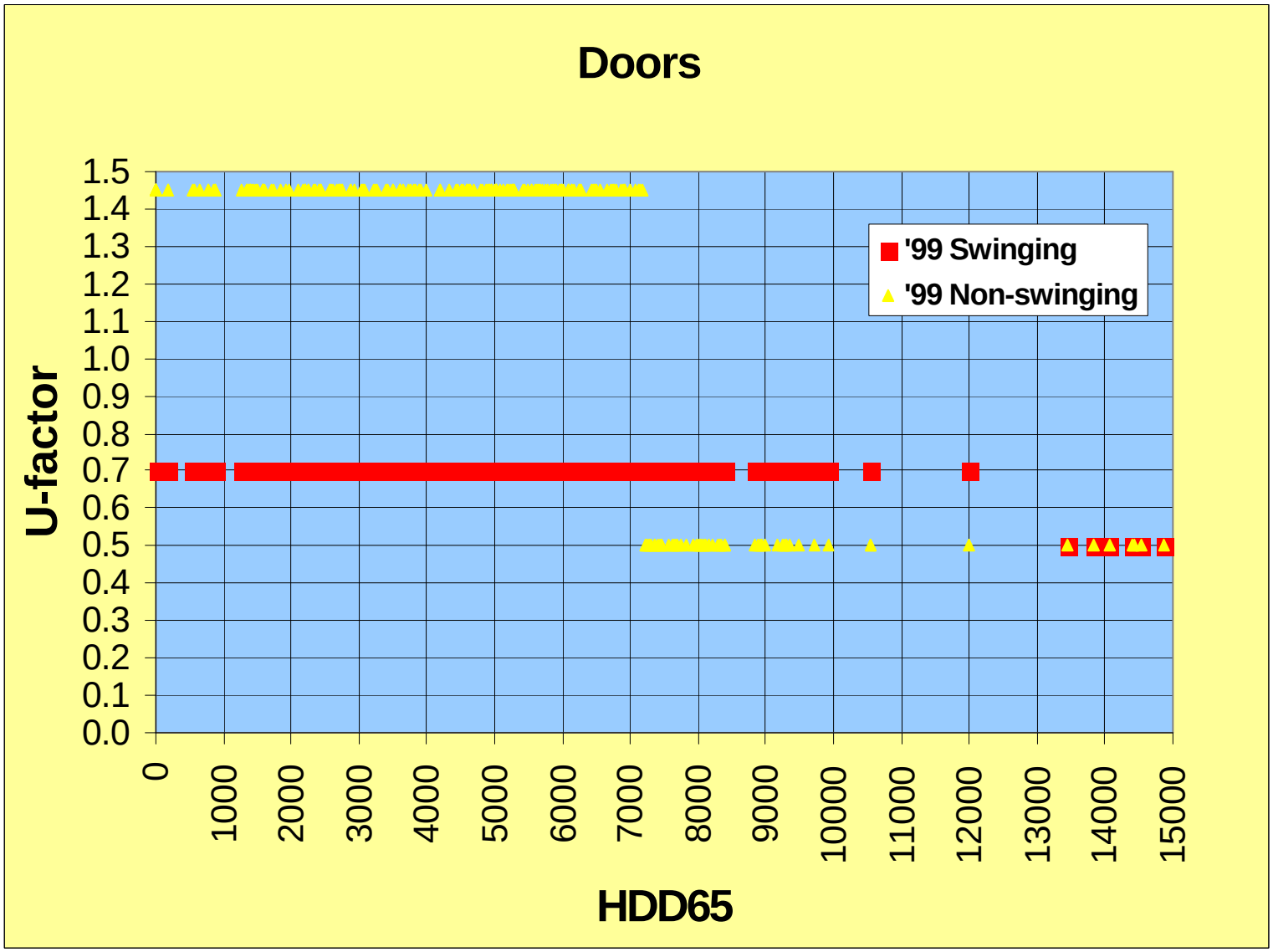
Slab-On-Grade Insulation



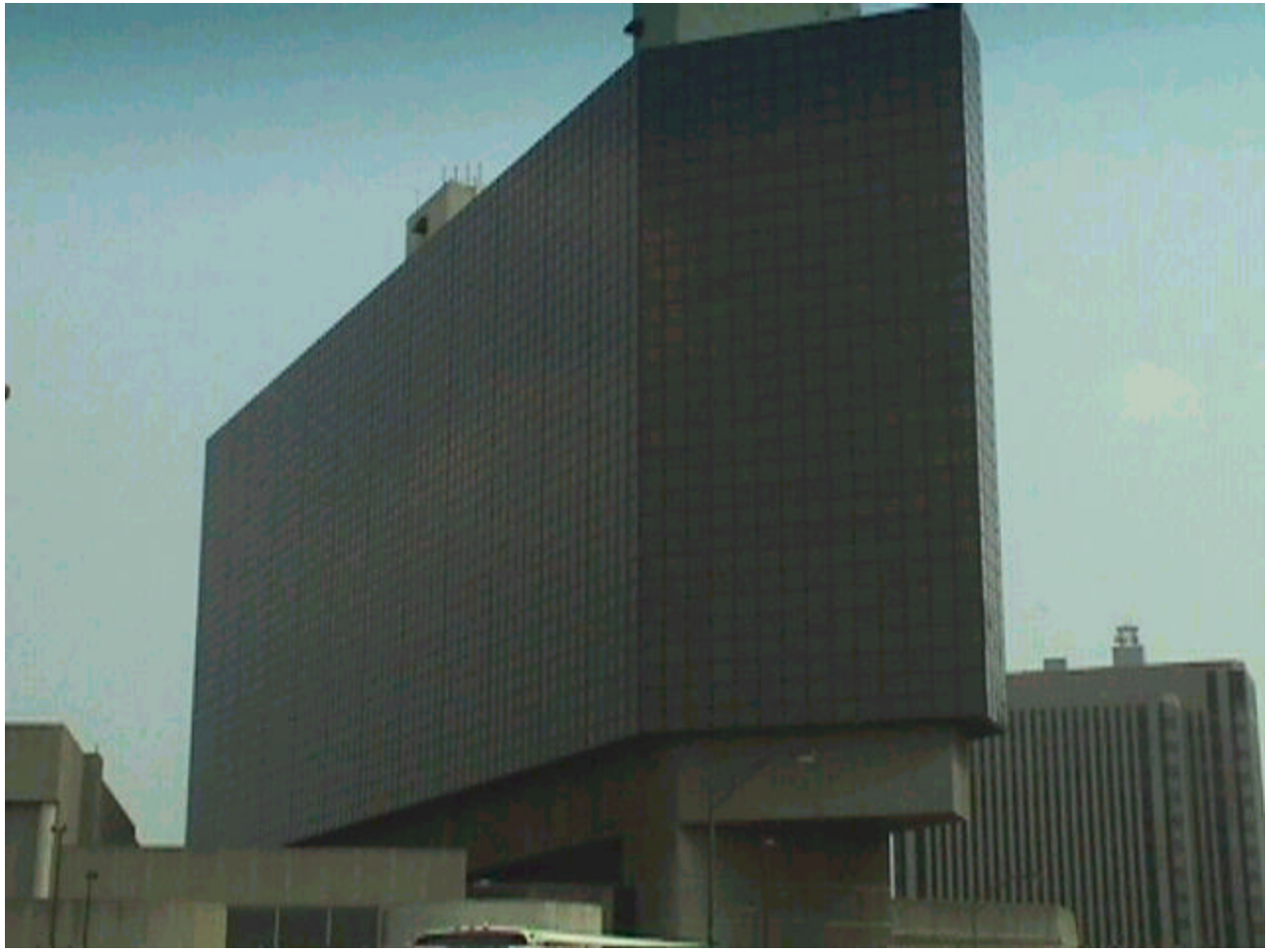

Slab-On-Grade Comparisons
R-value
20
18
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
'99 Unheated
'99 Heated
89 - 24 in Hor
'89 - 36 in Hor
'89 - 48 in Hor
'89 - 24 in Vert
'89 - 36 in vert
'89 - 48 in Vert

Opaque Doors Criteria Example – St. Louis (cont'd)

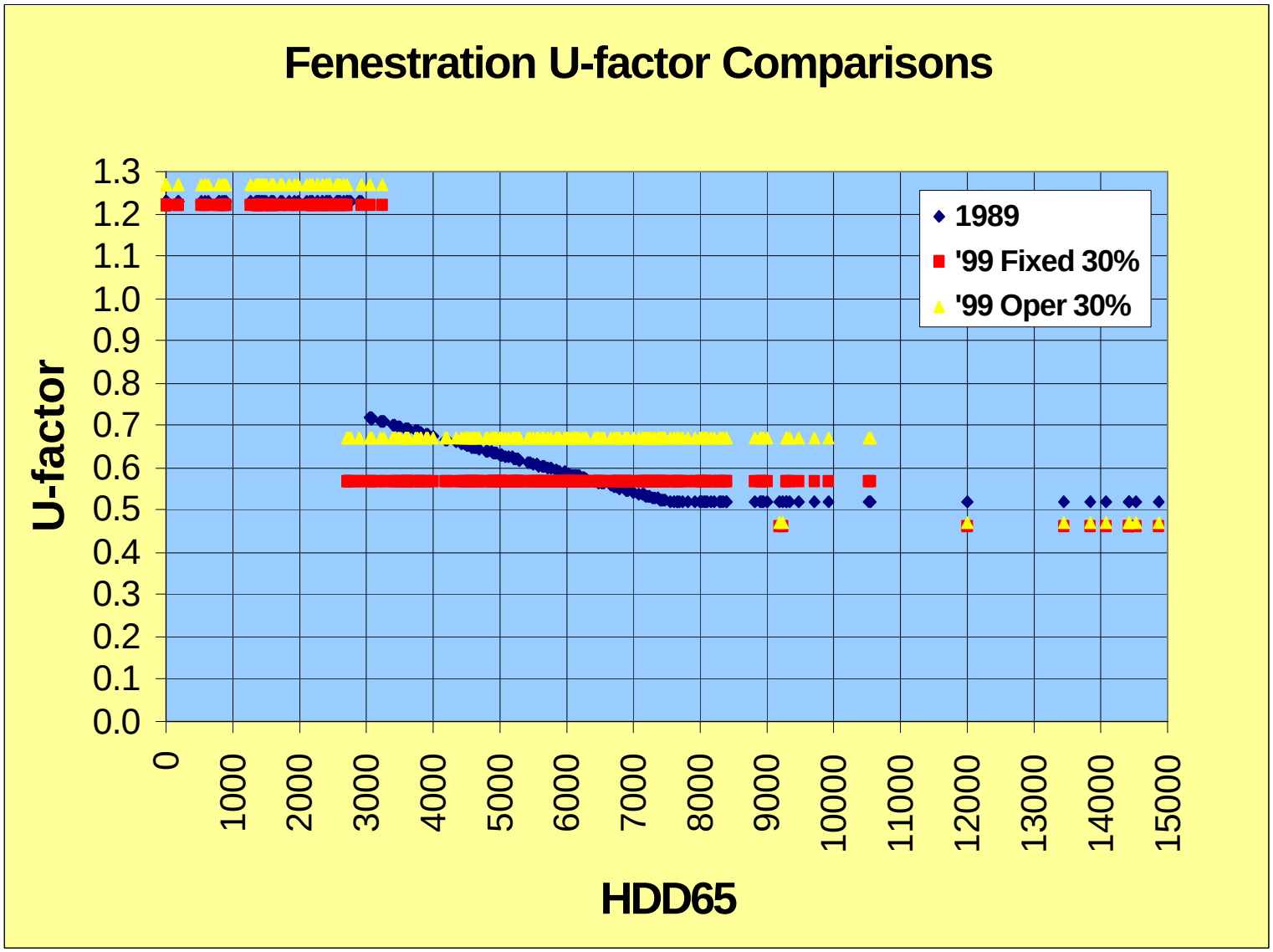
Opaque Elements	Nonresidential	
	Assembly Maximum	Insulation Min. R-value
Opaque Doors		
Swinging	U-0.700	
Non-Swinging	U-1.450	

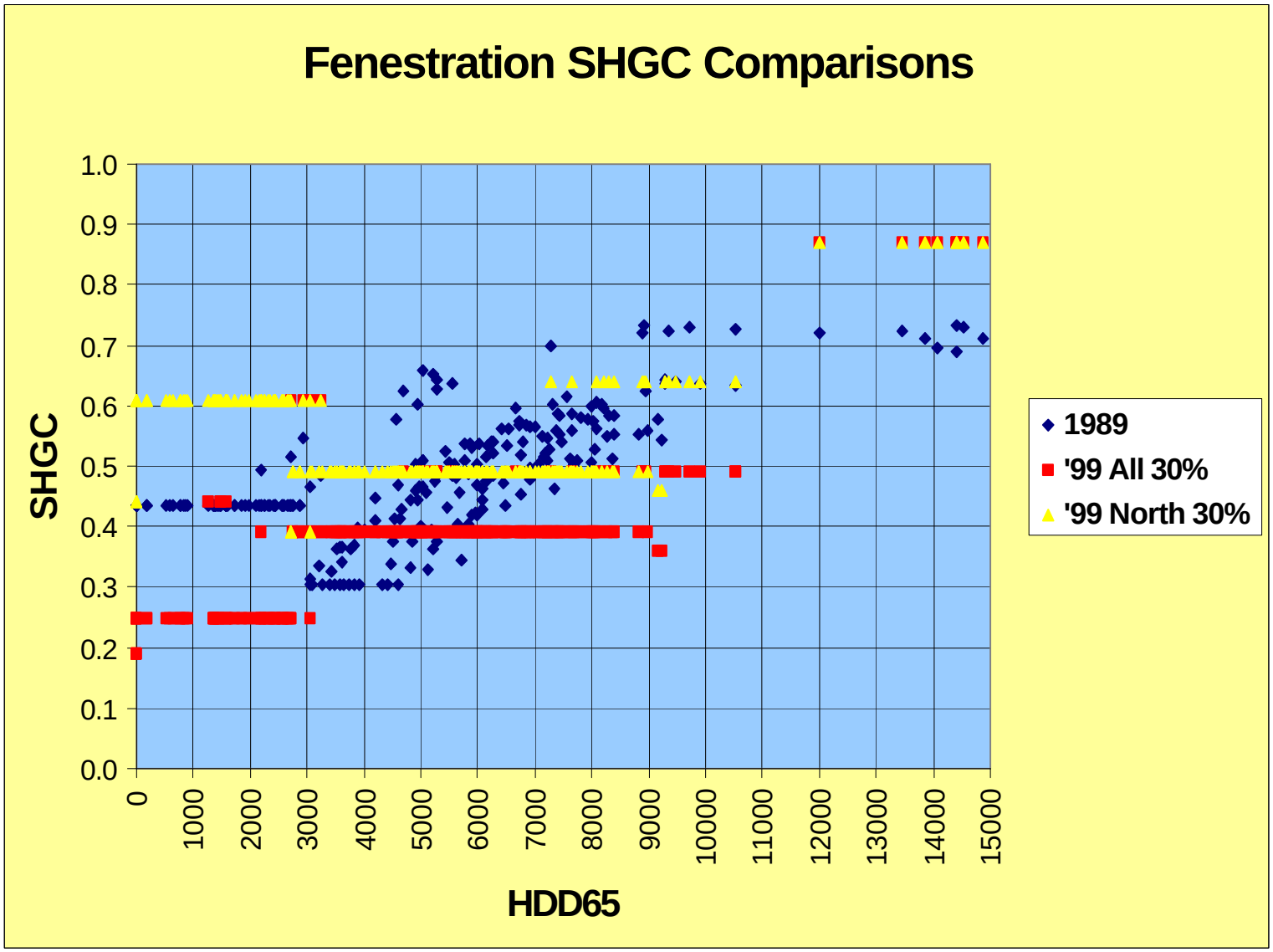

Doors
U-factor
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
'99 Swinging
'99 Non-swinging

Fenestration



Fenestration	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing. % of Wall		
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$ -0.39 $SHGC_{north}$-0.49
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$ -0.39 $SHGC_{north}$-0.49
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$ -0.39 $SHGC_{north}$-0.49
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$ -0.39 $SHGC_{north}$-0.49
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$ -0.25 $SHGC_{north}$-0.36

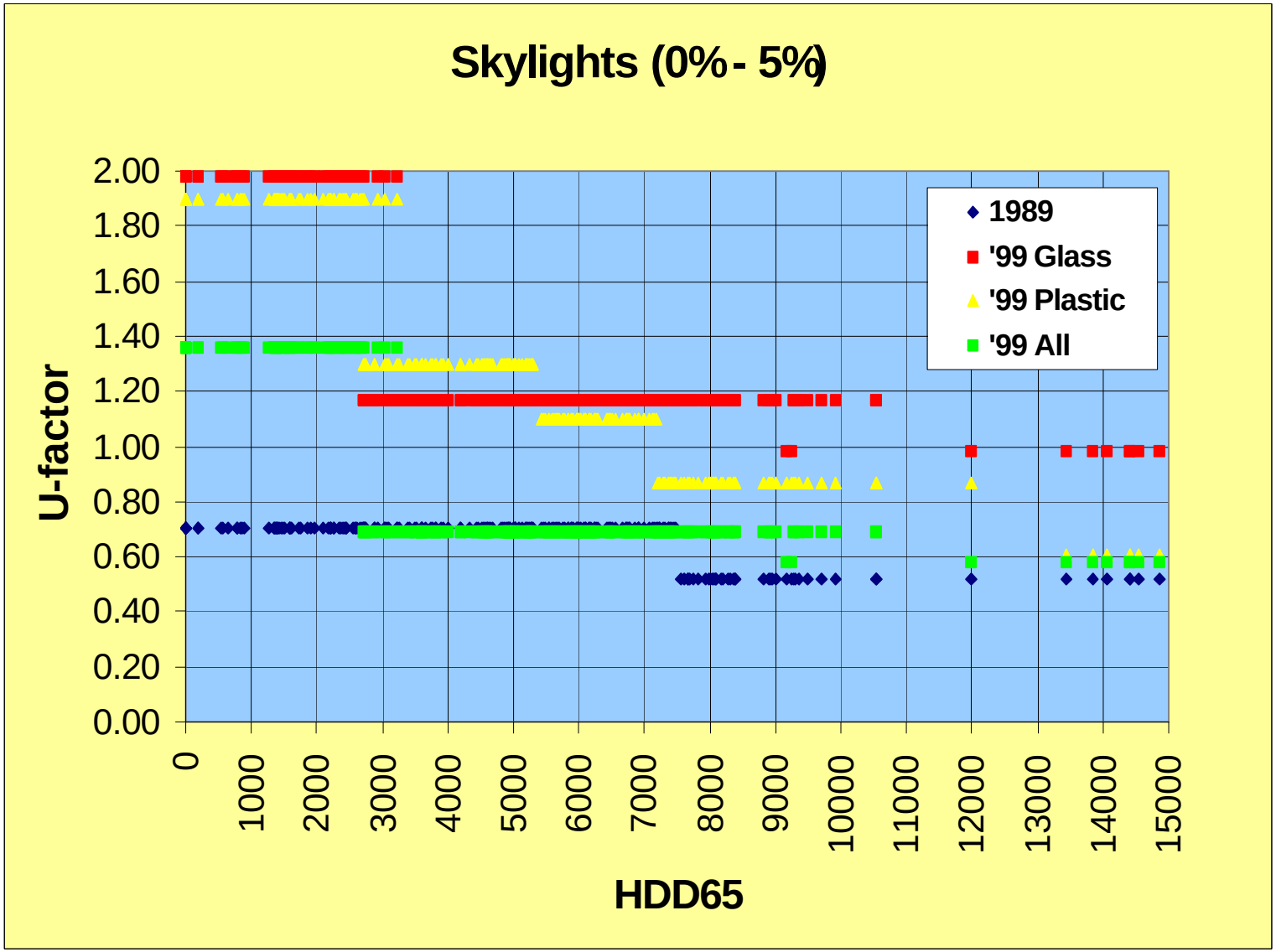

Fenestration U-factor Comparisons
U-factor
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
'99 Fixed 30%
'99 Oper 30%

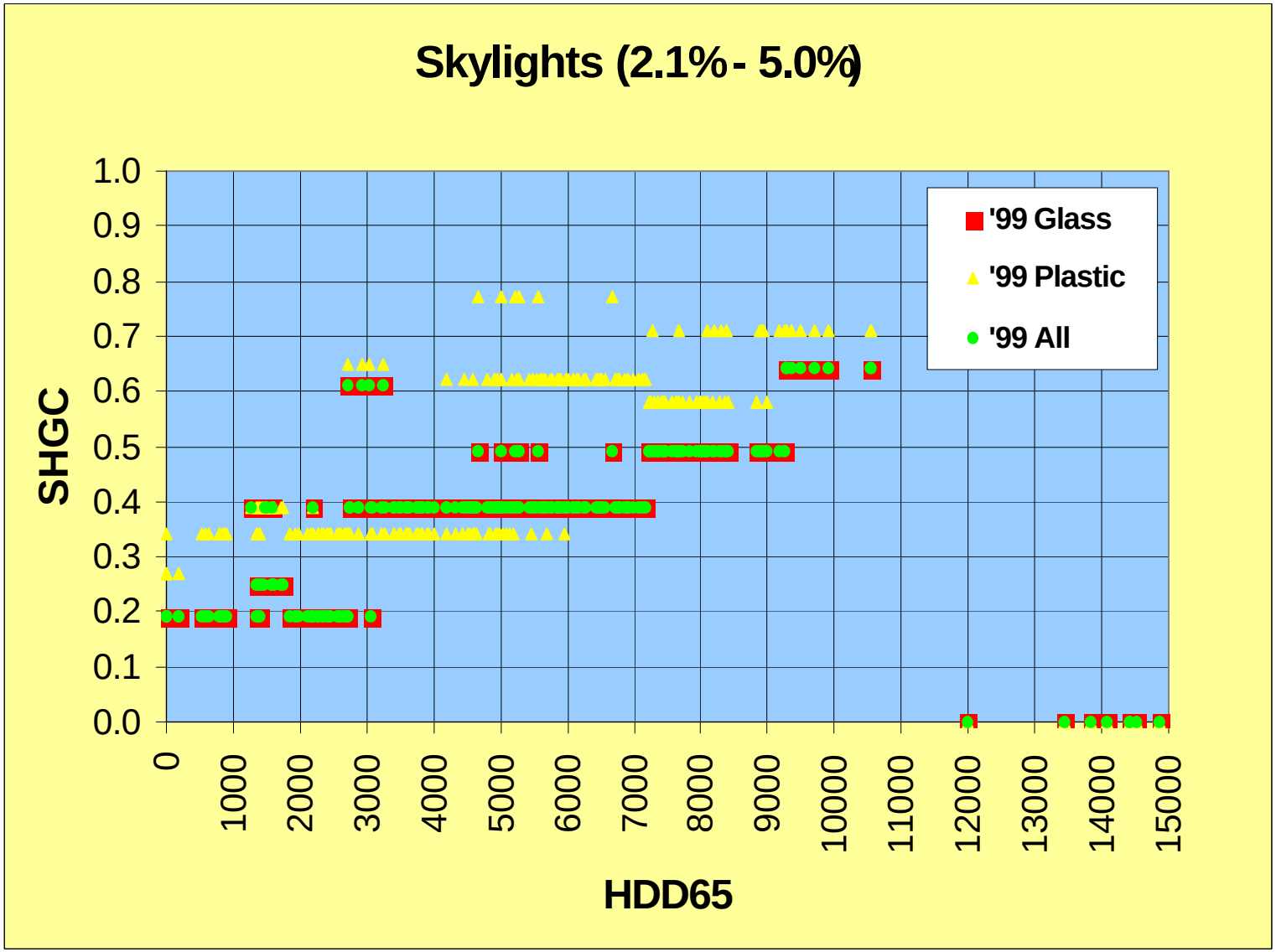

Fenestration SHGC Comparisons
SHGC
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
'99 All 30%
'99 North 30%

Skylights

Skylight Criteria

Fenestration	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Skylight with Curb, Glass, % of Roof		
0-2.0%	U_{all}-1.17	$SHGC_{all}$ -0.49
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$ -0.39
Skylight with Curb, Plastic, % of Roof		
0-2.0%	U_{all}-1.30	$SHGC_{all}$ -0.65
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$ -0.34
Skylight without Curb, All, % of Roof		
0-2.0%	U_{all}-0.69	$SHGC_{all}$ -0.49
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$ -0.39


Skylights (0% - 5%)
U-factor
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
1989
'99 Glass
'99 Plastic
'99 All


Skylights (2.1% - 5.0%)
SHGC
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
HDD65
'99 Glass
'99 Plastic
'99 All

4- Compliance

Compliance Paths

- Mandatory Requirements
- Prescriptive = R-values
- Components = U-factor, C-factor, F-factor, SHGC
- Envelope Tradeoffs = ENVSTD 4.0
- Whole Building Tradeoffs = ECB

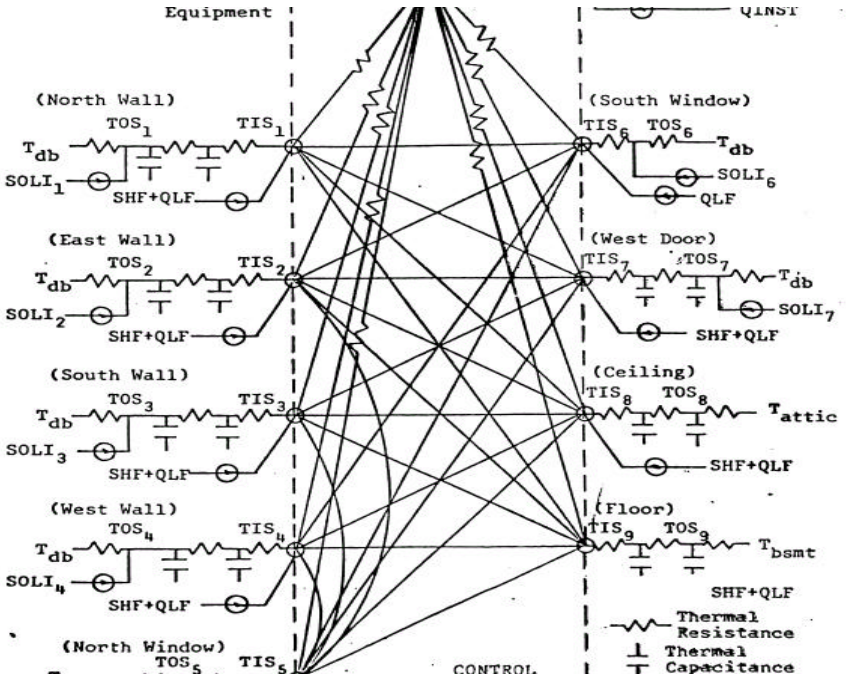
Appendix A - Assemblies

- U-factors
  - Roofs/Ceilings
  - Walls
  - Floors
  - Fenestration
- C-factors
  - Foundations
- F-factors
  - Slabs
- SHGC
- VLT

Appendix B - 26 Criteria Tables

- Roofs
- Walls
- Floors
- Slabs
- Doors
- Vertical Glazing
- Skylights

Appendix C - Envelope Trade-Offs

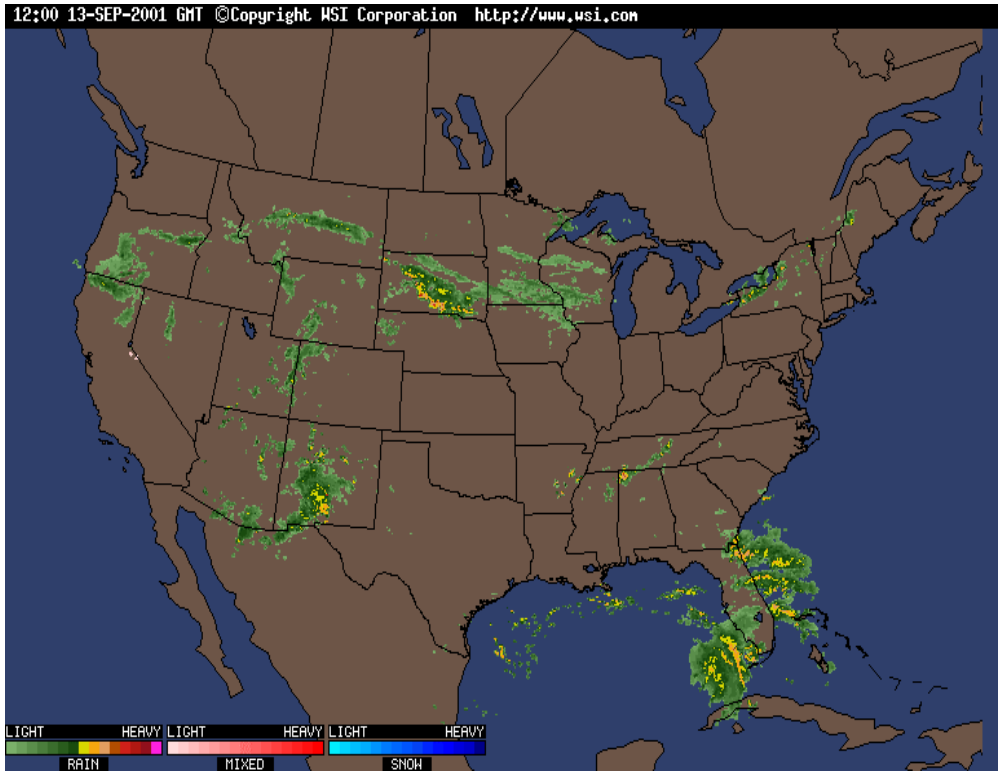


- Roofs/Ceilings
- Walls
- Fenestration
- Foundations

ENVSTD 4.0

Energy Cost Budget

Appendix D - Climate Data



- United States
  - 650 sites
- Canada
  - 86 sites
- International
  - 140 sites

5 - Errata

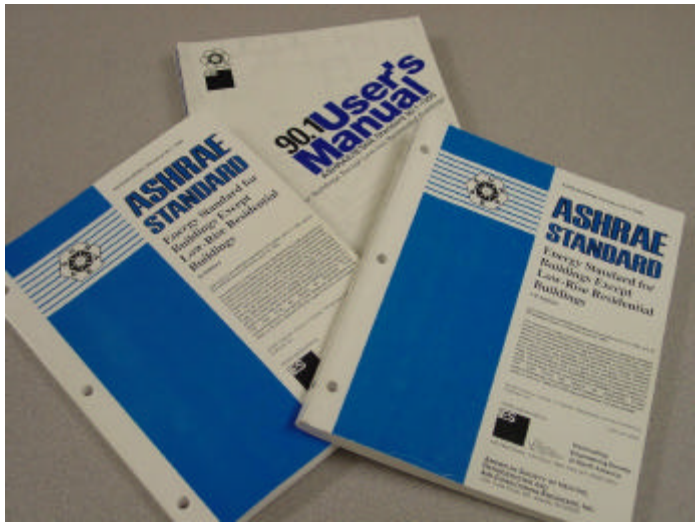
- May 2, 2001
- August 20, 2001

6 – Addenda

a Substantial Contact of Insulation
b Roof Insulation Exception 5.3.1.1
d Clarify Slab-On Grade F-Factor Trade-Offs
e Heat Capacity Calculations - A9
f Unheated Slab-On-Grade – Residential-Appendix B
g Heated Slab-On-Grade - Tables 19-26
ag Revised U-Factor - Vertical Glazed Walls
ak Revise All SI U-Factors - Appendix B
ao Editorial - easier to read and use

Questions?

How to Get the Standard



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