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Home Energy Rating System Building Energy Simulation Test (HERS BESTEST)

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Volume 2
Tier 1 and Tier 2 Tests Reference Results

Ron Judkoff
Joel Neymark

National Renewable Energy Laboratory
1617 Cole Boulevard
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A national laboratory of the U.S. Department of Energy
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This work is divided into two volumes. Volume 1 contains the test cast specifications and is a user's manual for anyone wishing to test a computer program. Volume 2 contains the reference results and suggestions for accrediting agencies on how to use and interpret the results.

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Acknowledgments

In developing the Home Energy Rating System (HERS) Building Energy Simulation Test (BESTEST) we ran two field tests with early versions. We would like to thank the following people for participating in those field tests, providing us with their results, and providing comments:

Evan Brown, Energy Rated Homes of America
Jeanne Byrne, Pacific Gas & Electric
Bud Heiss, Columbus Southern Power
Jim Neukam, Texas Gas Transmission Corp.
Scott Roberts, Architectural Energy Corp.
Robert Scott, California Home Energy Efficiency Rating System
Charles Segerstrom, Pacific Gas & Electric/CHEERS
Dwight Shuler, Owens Corning Fiberglass Corp.
Dick Tracey, D&R International.

The authors also wish to thank past and current HERS Council Technical Committee members for providing guidance during this project:

Dick Bahn, Chairman, Honeywell, Inc.
Dick Tracey, Co-Chairman, D&R International
Cindy Baxter, Oregon Department of Energy
Evan Brown, Energy Rated Homes of America
Robert Brown, National Conference of States on Building Codes and Standards
Matthew Chwalowski, Edison Electric Institute
Frank Denney, Alabama Power Co.
Robert Egan, Washington Gas Co.
Chris Fennel, National Conference of States on Building Codes and Standards
Bud Heiss, Columbus Southern Power
Michael Holtz, Architectural Energy Corporation
Richard Holtz, RRH Associates
Bion Howard, The Alliance to Save Energy
Jack Laverty, COAD
Neil Leslie, Gas Research Institute
Duncan Prahl, Western Massachusetts Electric Company/Energy Crafted Home
Henry Rutkowski, Air Conditioning Contractors of America
Charles Segerstrom, Pacific Gas & Electric Company/CHEERS,

We also thank the following HERS Council Technical Committee Advisory Members:

Harold Crowder Jr., Virginia Power
Richard Faesy, Energy Rated Homes of Vermont
Jim Neukam, Texas Gas Transmission
Martin Petchul, Columbia Gas Transmission
Andrew Sinclair, Carrier Corporation
Doug Swartz, City of Fort Collins Light & Power

Finally, we appreciate the efforts of current and past Department of Energy (DOE) program managers for this project, including Jean Boulin, Lou Divone, Mary Margaret Jenior, Jake Kaminsky, and Robert Mackie.

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Acronyms and Abbreviations - Volume 1 and Volume 2

A	Area
Abs	Absorptance
Abs In	Inner pane absorptance
Abs Out	Outer pane absorptance
ACH	Air changes per hour
AFUE	Annual Fuel Utilization Efficiency
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
AVG DIST	Exterior wall area weighted window distribution
Base	Base case
BESTEST	Building Energy Simulation Test
Bsmt, Ins	Basement coupled to ground with 2x4 16" o.c. R-11 insulated wall on interior side of poured concrete wall
Bsmt, Unins	Uninsulated basement coupled to ground
C_p	Specific heat
CFM	Cubic feet per minute
Coef	Coefficient
COG	Center of glass
COP	Coefficient of performance
D	Door 3' x 6'8"
dir nor	Direct normal
DLEW	Double pane, low-e window with wood frame and insulated spacer
DOE	Department of Energy
DW	Double pane, clear window with wood frame and metal spacer
EEM	Energy Efficient Mortgage
E/W-Sha	East/west window orientation with overhangs and fins
E/W-Win	East/west window orientation
E,W,N,S	East, west, north, south
EOG	Edge of glass
H	Horizontal overhang projecting perpendicular to window surface
Heatcap	Heat capacity
Hemis	Hemispherical
HERS	Home Energy Rating System
HUD	Housing and Urban Development
HV	Horizontal overhangs and vertical fins projecting perpendicular to window surface
HVAC	Heating, ventilating, and air-conditioning
IEA	International Energy Agency
Ineff	Inefficient building
Infiltr	Infiltration (natural ventilation)
Infl	High infiltration rate
Ins	Well insulated
INSUL	Slab-on-grade or basement with enough insulation to effectively decouple the slab from the ground
Int	Interior
k	Thermal conductivity
LCR	Load to collector area ratio
Low abs	Exterior solar absorptance = 0.2 for selected surfaces
Low-E	Low emissivity
Max	Maximum

Min	Minimum
N/A	Not applicable
NAHB	National Association of Home Builders
NFRC	National Fenestration Rating Council
NREL	National Renewable Energy Laboratory
O.C.	On centers
Orient	Orientation
Pas Base	Passive solar base case
Pas Lo-mass	Passive solar with low mass
Pas N/S/E/W	Passive solar with exterior wall area weighted window distribution
Pas S-Sha	Passive solar with overhang
Pas 0-Win	Passive solar with no windows
Prop	Property
R	Unit thermal resistance
Ref	Reference result
Refl	Reflectance
S-Sha	South window orientation with overhang
S-Win	South window orientation
SATB	Single-pane window with aluminum frame and thermal break
SC	Shading coefficient
S.GL.A	Net south glass area (excluding window frames)
Shade	Window-shading device; horizontal overhang and/or vertical fins
SHGC	Solar heat gain coefficient
SLAB	Slab-on-grade
Slab, Ins	Slab-on-grade with 4' deep perimeter slab insulation
Slab, Unins	Uninsulated slab-on-grade coupled to ground
Surf	Surface
TMY	Typical meteorological year
Trans	Transmittance
T1	Tier 1
T2	Tier 2
U	Unit thermal resistance or overall heat transfer coefficient
UA	Thermal conductance
UA_{inf}	Equivalent thermal conductance due to infiltration
UNINS	Slab-on-grade or basement coupled to ground
UV	Ultraviolet
Val	Value
VC	Vented crawl space
W	Window, 3'x 5'
W_p	Window 2'6" x 5'5"
0-Int	No internal gains
0-Win	No windows
1.0 S	All windows are on the south wall
90% conf	90% confidence interval
α_{ext}	Exterior solar absorptance

3.0 Final Results from Reference Programs: Tables and Graphs

This work is divided into two volumes. Volume 1 contains the test case specifications and is a user's manual for anyone wishing to test a computer program. Volume 2 contains the reference results and suggestions for accrediting agencies on how to use and interpret the results.

Tier 1 reference results are included in the figures and tables of Section 3.4. Tier 2 reference results are presented in the figures and tables of Section 3.5. These results include tables and graphs of annual heating and cooling loads and tables of monthly heating and cooling loads. Additional "delta" tables and graphs show the differences between annual loads (sensitivity to variations) for each case relative to an appropriate base case.

The following programs were used to generate the reference results:

- BLAST 3.0 Level 215
- DOE2.1E - W54
- SUNCODE 5.7.

BLAST is the program the U.S. Department of Defense uses for energy efficiency improvements to its buildings (see *BLAST User Reference, Volumes 1 and 2*). DOE2.1E is considered to be the most advanced of the programs sponsored by the U.S. Department of Energy and is the technical basis for setting national building energy codes and standards in the United States (*DOE-2 Reference Manual [May 1981]; DOE-2 Supplement [January 1994]*). SUNCODE is based on the public domain program SERIRES-1.0 developed by the National Renewable Energy Laboratory (Palmiter *et al.*).

In the reference results, the following convention identifies the climate corresponding to a result:

- Cases ending in "AC" (e.g., L100AC) are for Colorado Springs, Colorado.
- Cases ending in "AL" (e.g., L100AL) are for Las Vegas, Nevada.

Because reference results for slab-on-grade ground coupling include two sets of results generated using Colorado Springs weather data (see Section 3.3), the following labeling convention applies to Cases L302 and L304:

- Cases ending in "BC" (e.g., L302BC) are additional outputs using more detailed ground coupling methods.
- Use of the "AB" suffix in figures designates the combined results of specific "AC" and "BC" outputs (e.g., L302AB includes all L302AC and L302BC outputs).

Reference results for basement ground coupling include four sets of results generated using Colorado Springs weather data (see Section 3.3). These additional results were required to cover all modeling approaches resulting from two possible ground coupling models and two possible zoning models. The following labeling convention applies to Cases L322 and L324:

- Cases ending in "A1" (e.g., L322A1) use the ASHRAE method for modeling ground coupling with the entire building modeled as a single zone.
- Cases ending in "A2" (e.g., L322A2) use the ASHRAE method for modeling ground coupling with the main floor and basement modeled as separate zones.
- Cases ending in "B1" (e.g., L322B1) use more detailed ground coupling methods with the entire building modeled as a single zone.
- Cases ending in "B2" (e.g., L322B2) use more detailed ground coupling methods with the main floor and basement modeled as separate zones.

- Use of the "AB" suffix in figures designates the combined results of specific "A1," "A2," "B1," and "B2" outputs (e.g., L322AB includes the L322A1, L322A2, L322B1, and L322B2 outputs).

The diskette included with Volume 2 contains the following:

- HERS4.WK3—Lotus 3.1 spreadsheet file containing reference results and calculations for example range setting. A brief index of the spreadsheet contents is given, starting in cell a:a1 of the spreadsheet, and appropriate spreadsheet addresses are given in small font in the tables.
- HERS4.FM3—Lotus 3.1 WYSIWYG format file for HERS4.WK3
- BLAST.ZIP—Compressed input files for BLAST 3.0 reference simulations
- DOE2.ZIP—Compressed input files including custom window library (W4LIB.DAT) for DOE2.1E reference simulations
- SUNCODE.ZIP—Compressed input files for SERIRES/SUNCODE 5.7 reference simulations
- PKUNZIP.EXE—Decompression utility
- README.TXT—Directions for data decompression.

3.1 Comparing with HERS Programs that Designate Heating and Cooling Seasons

Tables of reference monthly heating and cooling load results are provided for comparing HERS tools that designate heating and cooling seasons. For proper comparison with these types of HERS tools, simply sum the appropriate reference monthly load results for the given heating or cooling season. For comparing HERS tools that have heating or cooling seasons, or both, beginning/ending during mid-month, linearly interpolate the monthly reference results for given months as appropriate.

"Delta" results were not tabulated for the monthly results. To develop reference "delta" results for comparison with a HERS tool that designates heating and cooling seasons, do the following. For each set of cases that was compared in the tabulation of the annual "delta" results (see Table 3-2 of Section 3.4 and Table 3-6 of Section 3.5), take the differences of the seasonal sum of monthly reference results (sums per above paragraph). The spreadsheet file on the diskette accompanying this report is helpful for generating seasonal absolute and "delta" results as needed.

3.2 Example Pass/Fail Criteria

A program may be thought of as having successfully passed through the test series when its results compare favorably with passing ranges based on the reference program outputs on a case-by-case and sensitivity basis (difference or delta [Δ] between certain cases). An example for developing pass/fail criteria based on these results is given in Section 4. The certifying agency may choose to use the example pass/fail criteria of Section 4, or it may choose to develop its own pass/fail criteria.

3.3 Discussion of Selected Results

3.3.1 Detailed Ground Coupling Analysis Results for Cases L302B, L304B, L322B, and L324B

The results for two types of ground coupling models included in Section 3.4 effectively widen the range of reference results outputs (i.e, ease the passing criteria) for cases that include ground coupling analysis. This was done in case a HERS provider is using a more sophisticated algorithm than the application of ASHRAE steady-state heat transfer coefficients.

Case descriptions for the more detailed simulations of ground coupling in Cases L302B, L304B, L322B, and L324B are provided in Appendix G (Volume 1). Some issues regarding simulation of detailed ground coupling with the reference software are noted below.

In BLAST and DOE2.1E, the mathematical algorithms limit the amount of mass that these programs can effectively model. Where soil thickness (conduction path length) was greater than what a program could handle (generally 2–3 feet, depending on the case), an allowable soil amount was provided and the remaining thickness modeled as steady-state resistance.

In running the reference simulations, which are restricted to one-dimensional heat-flow modeling, the following methods were applied to approximate solar incidence on soil adjacent to the house:

- In BLAST, DOE2.1E, and SERIRES/SUNCODE, slab floors were associated with a skyward-facing, horizontal solar-receiving surface, and exterior solar absorptance was reduced from 0.6 to 0.375 to account for shading half of direct beam radiation at any given time. Because BLAST automatically accounts for shading by the building, the horizontal receiving surface was located on the south side of the building to avoid double counting the shading effect.

- In DOE2.1E and SERIRES/SUNCODE, below-grade walls were associated with a skyward-facing, horizontal solar-receiving surface, and exterior solar absorptance was reduced from 0.6 to 0.375 to account for shading half of direct beam radiation at any given time.

- In BLAST, below-grade walls were associated with skyward-facing, horizontal solar-receiving surfaces, exterior solar absorptance was kept at 0.6, and the horizontal receiving surfaces were positioned to be automatically shaded by the building.

3.3.2 Additional Basement Results for One- and Two-Zone Models

HERS BESTEST allows Cases L322A and L324A (basement series) to be modeled as one large zone or as two smaller zones (main floor and basement as separate zones) as described in the Volume 1 case descriptions. In certain cases, there was enough variation between the one- and two-zone results to justify publishing a complete set of both results. Therefore, the basement results include four outputs for each reference simulation of each case:

- ASHRAE simplified ground coupling, one zone (output designation = A1)
- ASHRAE simplified ground coupling, two zone (output designation = A2)
- Detailed ground coupling, one zone (output designation = B1)
- Detailed ground coupling, two zone (output designation = B2).

Because there are three reference simulation programs, there are a total of 12 reference outputs for each basement case.

3.3.3 Exterior Surface Coefficient Effects

Part of the spread among the reference results can be explained by different assumptions regarding treatment of heat transfer between external surfaces and the surrounding environment. This is especially evident in the Case L200A heating load output. A sensitivity test with SERIRES/SUNCODE, when comparing results using the combined exterior surface coefficients specified in Volume 1 versus those calculated by DOE2.1E (DOE2.1E's annualized average was input to SERIRES/SUNCODE), indicates the following annual heating loads for Case L200A:

- SERIRES/SUNCODE with Volume 1 exterior surface coefficient: 168 MBtu/y heating
- SERIRES/SUNCODE with DOE2.1E calculated exterior surface coefficient: 151 MBtu/y heating.

The roughly 10% effect of this parameter represents a legitimate algorithmic difference between the reference programs. However, future research examining the preferred use of one algorithm over the other is justified by the magnitude of this effect.

3.4 Tier 1 Reference Results

The following figures and tables present the Tier 1 reference results.

- Figure 3-1. HERS BESTEST Tier 1 reference results—annual heating load (L100AC through L170AC) for Colorado Springs, CO
- Figure 3-2. HERS BESTEST Tier 1 reference results—annual heating load (L200AC through L324AB) for Colorado Springs, CO
- Figure 3-3. HERS BESTEST Tier 1 reference results—delta annual heating load (L100AC through L170AC) for Colorado Springs, CO
- Figure 3-4. HERS BESTEST Tier 1 reference results—delta annual heating load (L200AC through L324AB) for Colorado Springs, CO
- Figure 3-5. HERS BESTEST Tier 1 reference results—annual cooling load for Las Vegas, NV
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- Table 3-1. HERS BESTEST Tier 1 reference results—Annual Heating and Cooling Loads
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- Table 3-3. HERS BESTEST Tier 1 Reference Results—Monthly Heating Loads for Cases L100AC through L202AC
- Table 3-4. HERS BESTEST Tier 1 Reference Results—Monthly Heating Loads for Cases L302AC through L324B2
- Table 3-5. HERS BESTEST Tier 1 Reference Results—Monthly Cooling Loads for Cases L100AL through L202AL

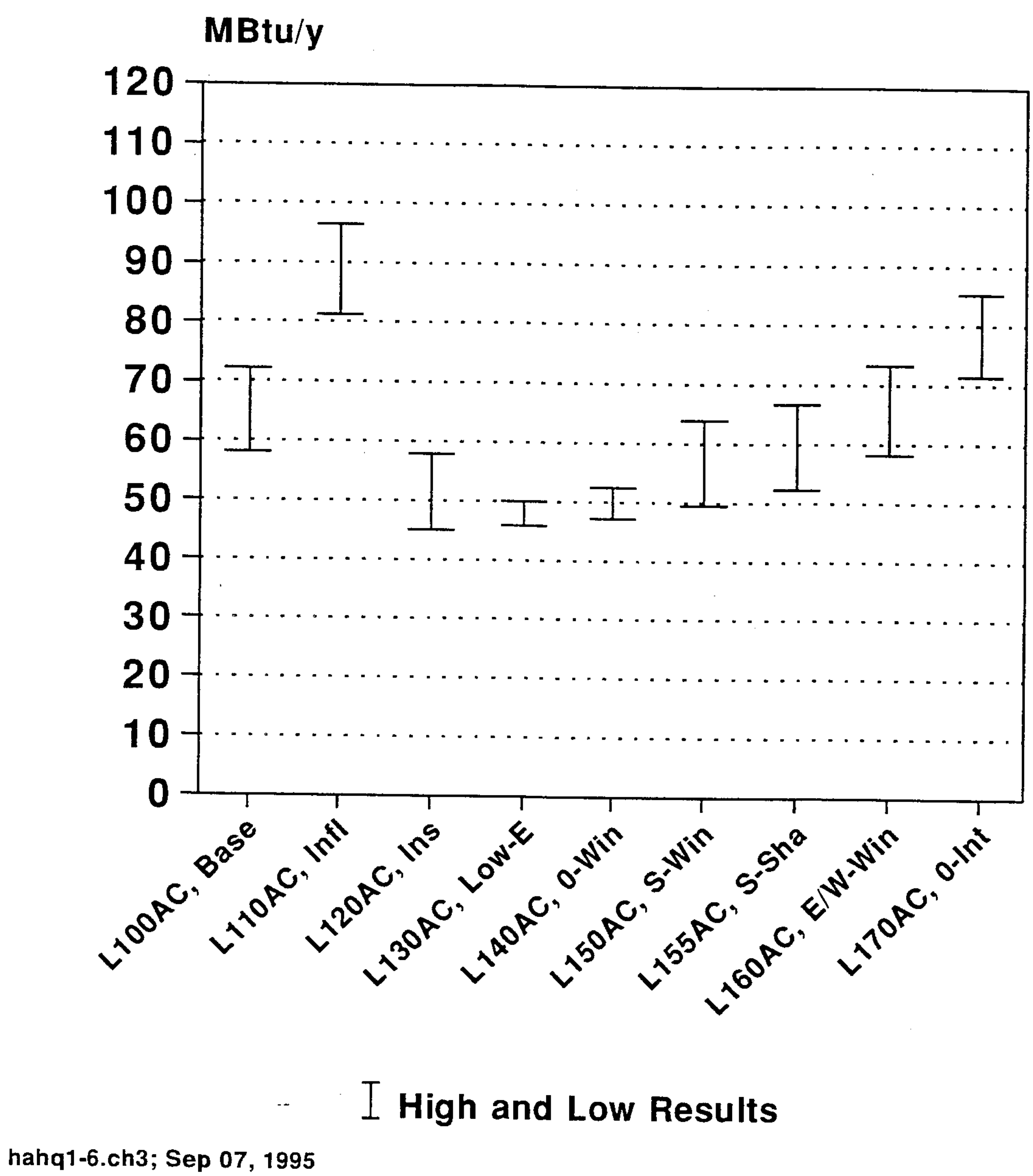

Figure 3-1. HERS BESTEST Tier 1 reference results—annual heating load (L100AC through L170AC) for Colorado Springs, CO

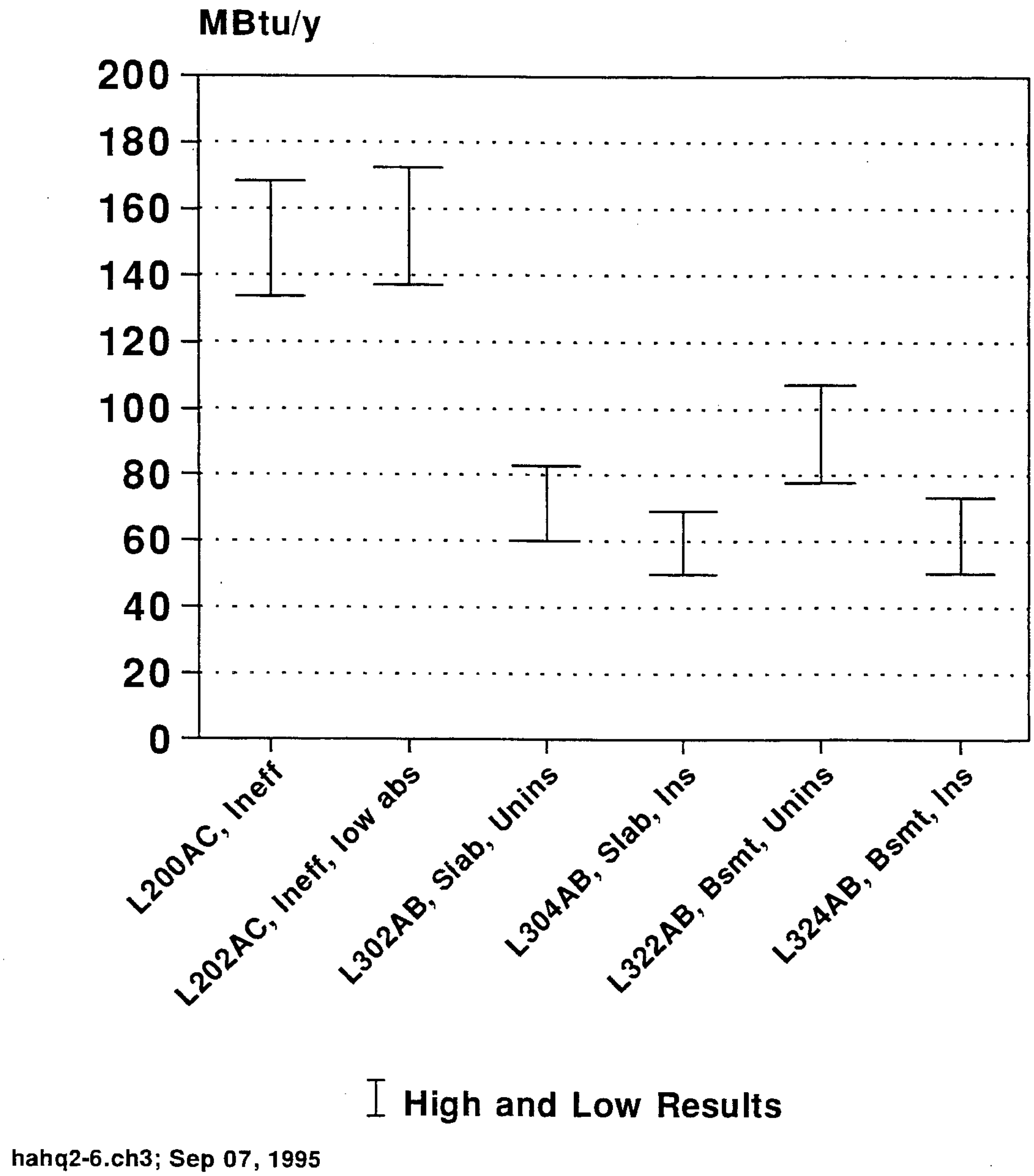

Figure 3-2. HERS BESTEST Tier 1 reference results—annual heating load (L200AC through L324AB) for Colorado Springs, CO

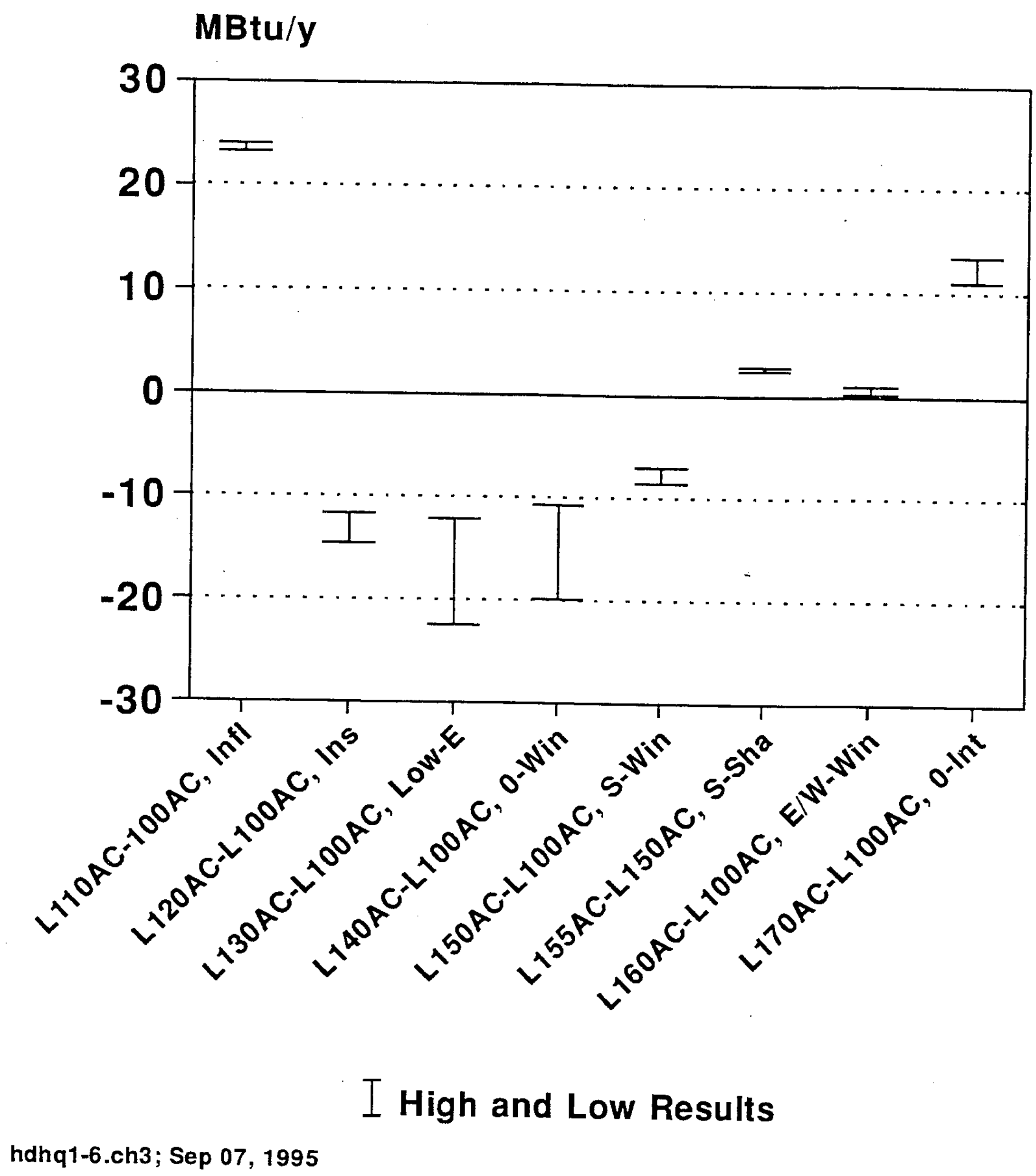

Figure 3-3. HERS BESTEST Tier 1 reference results—delta annual heating load (L100AC through L170AC) for Colorado Springs, CO

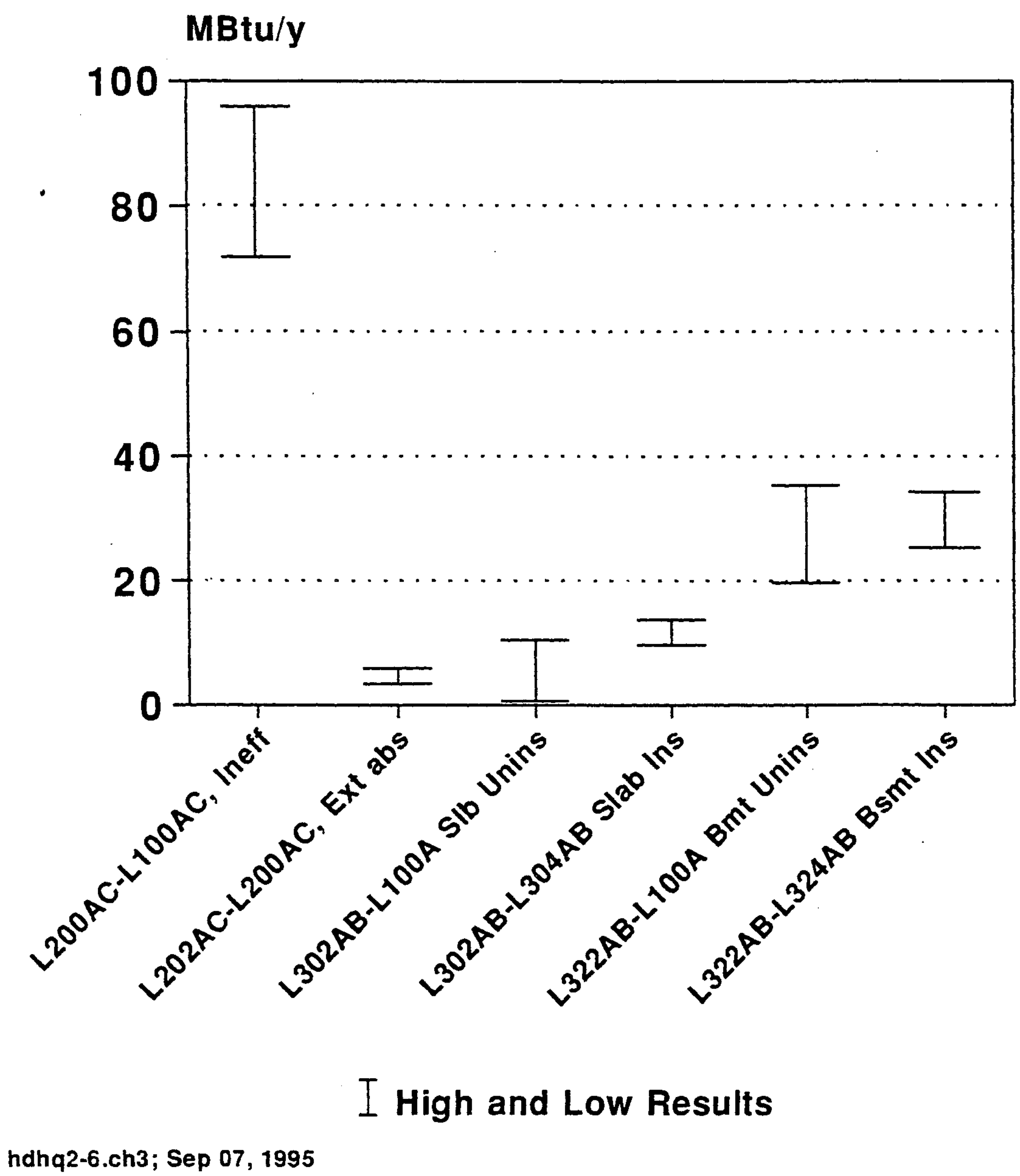

Figure 3-4. HERS BESTEST Tier 1 reference results—delta annual heating load (L200AC through L324AB) for Colorado Springs, CO

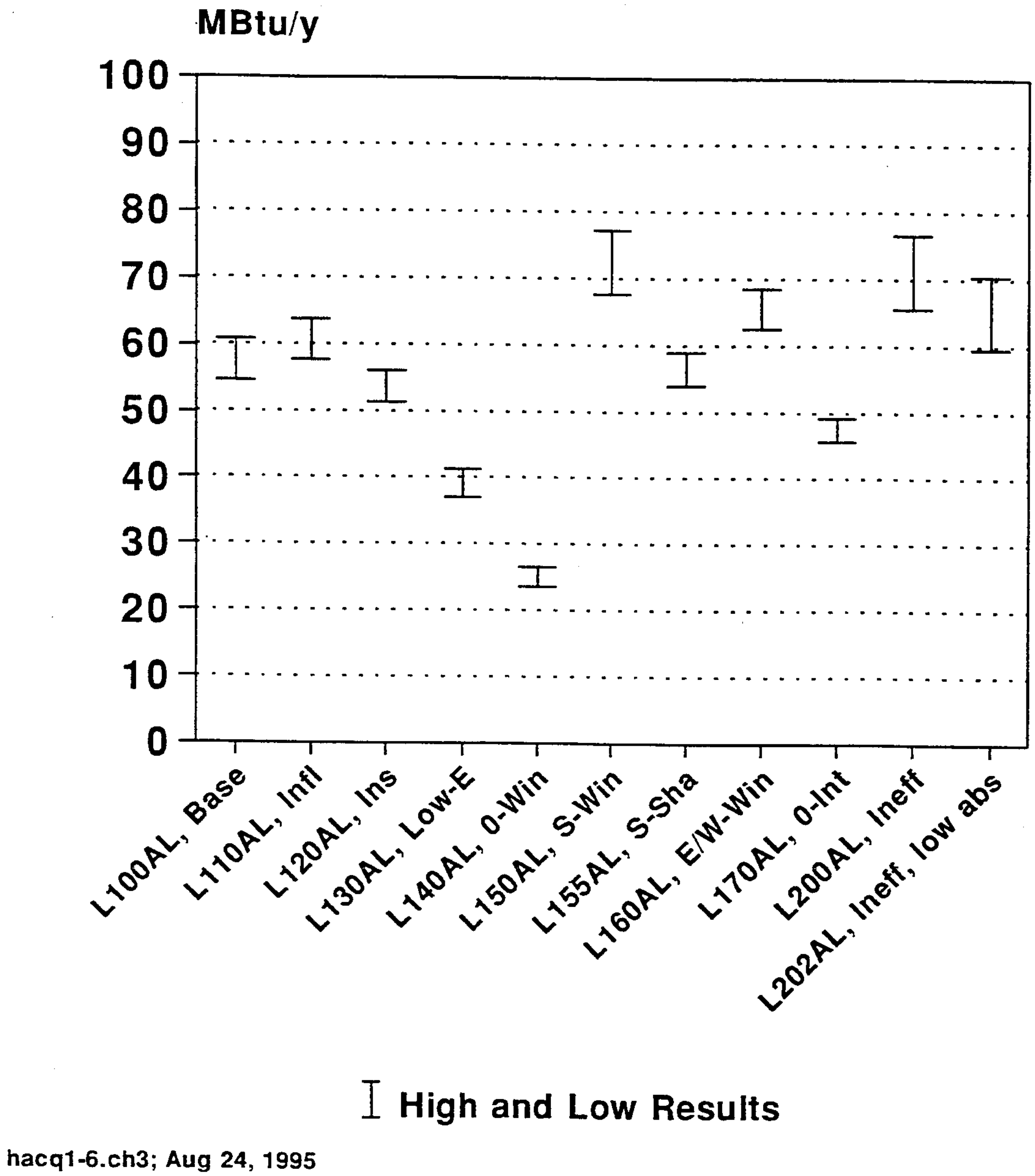

Figure 3-5. HERS BESTEST Tier 1 reference results—annual cooling load for Las Vegas, NV

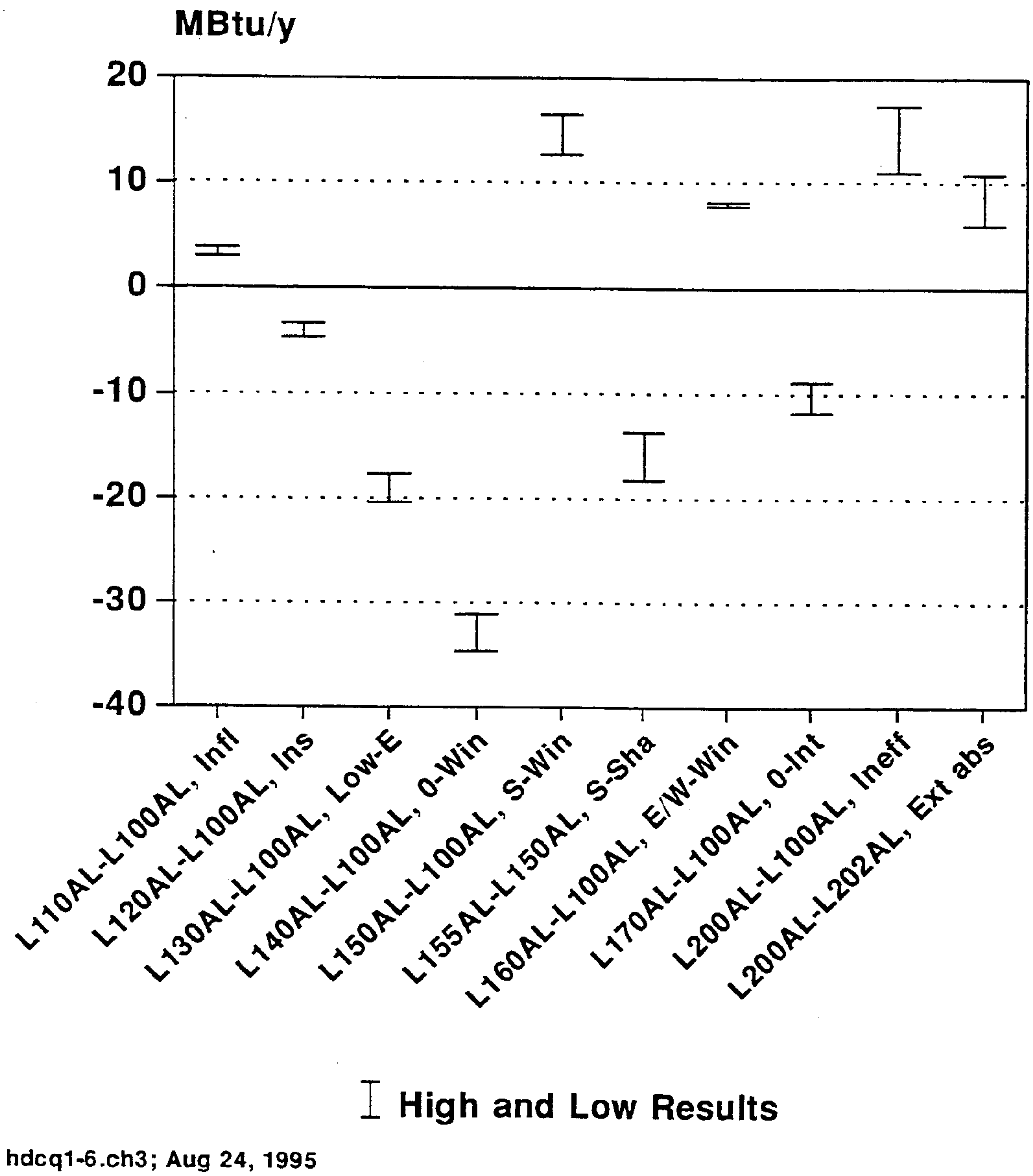

Figure 3-6. HERS BESTEST Tier 1 reference results—delta annual cooling load for Las Vegas, NV

Table 3-1. HERS BESTEST Tier 1 Reference Results Annual Heating and Cooling Loads

Colorado Spring, CO Annual Heating (MBtu/y) Case #	BLAST	DOE2	SERIRES/ SUNCODE	Las Vegas, NV Annual Cooling (MBtu/y) Case #	BLAST	DOE2	SERIRES/ SUNCODE
L100AC	61.94	58.00	72.40	L100AL	54.66	60.80	59.32
L110AC	85.93	81.36	96.52	L110AL	57.70	63.83	63.16
L120AC	50.27	45.08	57.83	L120AL	51.34	56.14	55.01
L130AC	46.34	45.82	49.98	L130AL	36.95	41.26	38.92
L140AC	49.14	47.24	52.48	L140AL	23.52	26.54	24.65
L150AC	54.92	49.47	64.03	L150AL	67.72	77.35	72.04
L155AC	57.38	52.28	66.91	L155AL	54.08	59.06	57.51
L160AC	62.88	58.28	73.50	L160AL	62.61	68.68	67.60
L170AC	73.06	71.64	85.45	L170AL	45.83	49.06	49.31
L200AC	133.97	136.12	168.33	L200AL	65.70	73.10	76.71
L202AC	137.46	142.06	172.54	L202AL	59.61	62.24	70.58
L302AC	70.48	67.43	82.90				
L302BC	65.25	60.12	73.10				
L304AC	60.06	56.62	69.15				
L304BC	55.59	50.11	61.58				
L322A1	91.66	88.27	105.94				
L322A2	92.50	86.33	107.69				
L322B1	81.82	77.71	92.38				
L322B2	87.97	82.87	92.11				
L324A1	64.90	61.10	72.56				
L324A2	65.02	60.31	73.47				
L324B1	56.57	50.38	62.44				
L324B2	60.40	51.88	65.30				

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Table 3-2. HERS BESTEST Tier 1 Reference Results
Delta Annual Heating and Cooling Loads

Colorado Spring, CO Delta Annual Heating (MBtu/y) Case	BLAST	DOE2	SERIRES/ SUNCODE
L110AC-L100AC	23.99	23.37	24.12
L120AC-L100AC	-11.67	-12.92	-14.57
L130AC-L100AC	-15.60	-12.18	-22.42
L140AC-L100AC	-12.80	-10.76	-19.92
L150AC-L100AC	-7.02	-8.53	-8.37
L155AC-L150AC	2.46	2.81	2.88
L160AC-L100AC	0.94	0.28	1.10
L170AC-L100AC	11.12	13.64	13.05
L200AC-L100AC	72.03	78.12	95.93
L202AC-L200AC	3.49	5.94	4.22
L302AC-L100AC	8.54	9.43	10.50
L302BC-L100AC	3.31	2.13	0.71
L302AC-L304AC	10.42	10.81	13.75
L302BC-L304BC	9.66	10.02	11.53
L322A1-L100AC	29.72	30.27	33.54
L322A2-L100AC	30.56	28.33	35.29
L322B1-L100AC	19.88	19.72	19.98
L322B2-L100AC	26.03	24.87	19.71
L322A1-L324A1	26.76	27.17	33.37
L322A2-L324A2	27.48	26.02	34.22
L322B1-L324B1	25.25	27.34	29.95
L322B2-L324B2	27.57	30.99	26.81

Las Vegas, NV Delta Annual Cooling (MBtu/y) Case	BLAST	DOE2	SERIRES/ SUNCODE
L110AL-L100AL	3.04	3.02	3.84
L120AL-L100AL	-3.32	-4.67	-4.31
L130AL-L100AL	-17.71	-19.54	-20.40
L140AL-L100AL	-31.14	-34.26	-34.68
L150AL-L100AL	13.06	16.55	12.72
L155AL-L150AL	-13.64	-18.29	-14.53
L160AL-L100AL	7.95	7.88	8.28
L170AL-L100AL	-8.83	-11.74	-10.01
L200AL-L100AL	11.04	12.30	17.39
L200AL-L202AL	6.09	10.86	6.14

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Table 3-3. HERS BESTEST Tier 1 Reference Results
Monthly Heating Loads for Cases L100AC through L202AC

BLAST 3.0 Monthly and Total Heating Loads (MBtu/y)

	L100AC	L110AC	L120AC	L130AC	L140AC	L150AC	L155AC	L160AC	L170AC	L200AC	L202AC
Jan	11.30	15.27	9.34	8.72	8.96	9.61	9.69	11.94	12.68	22.73	23.21
Feb	9.74	13.21	8.07	7.50	7.79	8.54	8.80	9.99	11.00	19.74	20.19
Mar	9.04	12.41	7.43	6.90	7.39	8.23	8.87	8.76	10.39	18.86	19.37
Apr	5.17	7.28	4.16	3.81	4.24	5.13	5.75	4.70	6.26	11.52	11.93
May	2.43	3.66	1.84	1.63	1.89	2.54	2.79	2.17	3.30	6.33	6.57
Jun	0.69	1.20	0.46	0.40	0.47	0.76	0.82	0.60	1.11	2.55	2.65
Jul	0.06	0.20	0.02	0.01	0.02	0.07	0.08	0.05	0.23	0.79	0.83
Aug	0.13	0.34	0.05	0.04	0.04	0.13	0.17	0.11	0.37	1.16	1.22
Sep	1.20	1.92	0.82	0.70	0.79	1.10	1.25	1.13	1.80	3.68	3.80
Oct	3.46	5.03	2.66	2.38	2.71	2.95	3.12	3.50	4.46	8.36	8.60
Nov	8.18	11.21	6.70	6.23	6.66	6.86	6.99	8.71	9.50	17.12	17.54
Dec	10.54	14.22	8.72	8.03	8.19	9.01	9.06	11.24	11.96	21.13	21.56
Tot	61.94	85.93	50.27	46.34	49.14	54.92	57.38	62.88	73.06	133.97	137.46

DOE2.1E Monthly and Total Heating Loads (MBtu/y)

	L100AC	L110AC	L120AC	L130AC	L140AC	L150AC	L155AC	L160AC	L170AC	L200AC	L202AC
Jan	10.58	14.39	8.46	8.56	8.67	8.63	8.73	11.11	12.30	22.72	23.56
Feb	9.04	12.35	7.23	7.28	7.46	7.62	7.80	9.17	10.58	19.67	20.46
Mar	8.32	11.55	6.59	6.67	7.01	7.31	7.80	7.88	9.96	18.83	19.74
Apr	4.79	6.83	3.67	3.73	3.98	4.61	5.12	4.30	6.11	11.65	12.33
May	2.27	3.51	1.60	1.67	1.76	2.36	2.67	2.03	3.33	6.63	7.00
Jun	0.66	1.19	0.40	0.45	0.48	0.76	0.85	0.57	1.19	2.83	3.00
Jul	0.06	0.21	0.02	0.02	0.02	0.08	0.10	0.05	0.28	0.96	1.04
Aug	0.13	0.35	0.05	0.07	0.05	0.13	0.19	0.12	0.45	1.37	1.46
Sep	1.17	1.93	0.71	0.81	0.81	1.00	1.30	1.13	1.91	4.07	4.26
Oct	3.33	4.93	2.36	2.50	2.63	2.67	3.05	3.38	4.55	8.83	9.20
Nov	7.63	10.56	6.00	6.10	6.39	6.11	6.38	7.97	9.22	17.15	17.88
Dec	10.02	13.59	8.01	7.98	7.99	8.20	8.31	10.58	11.77	21.41	22.13
Tot	58.00	81.36	45.08	45.82	47.24	49.47	52.28	58.28	71.64	136.12	142.06

SERIRES/SUNCODE 5.7 Monthly and Total Heating Loads (MBtu/y)

	L100AC	L110AC	L120AC	L130AC	L140AC	L150AC	L155AC	L160AC	L170AC	L200AC	L202AC
Jan	13.38	17.31	10.94	9.46	9.55	11.39	11.50	14.11	15.00	28.72	29.22
Feb	11.34	14.77	9.26	8.05	8.25	9.89	10.17	11.67	12.80	24.72	25.25
Mar	10.35	13.70	8.37	7.35	7.78	9.42	10.18	10.01	11.91	23.41	24.06
Apr	5.94	8.08	4.69	4.07	4.50	5.86	6.59	5.40	7.22	14.40	14.93
May	2.81	4.08	2.07	1.74	2.03	2.96	3.23	2.52	3.84	7.98	8.31
Jun	0.83	1.37	0.54	0.44	0.53	0.92	0.99	0.72	1.34	3.24	3.38
Jul	0.09	0.25	0.03	0.02	0.02	0.10	0.12	0.08	0.31	0.99	1.05
Aug	0.19	0.42	0.08	0.06	0.06	0.19	0.24	0.16	0.51	1.50	1.57
Sep	1.47	2.23	0.98	0.78	0.93	1.31	1.50	1.39	2.19	4.70	4.85
Oct	4.10	5.73	3.07	2.60	2.98	3.45	3.66	4.15	5.28	10.62	10.91
Nov	9.51	12.55	7.67	6.70	7.09	7.95	8.08	10.11	11.04	21.44	21.94
Dec	12.38	16.04	10.12	8.71	8.76	10.59	10.64	13.19	14.02	26.62	27.08
Tot	72.40	96.52	57.83	49.98	52.48	64.03	66.91	73.50	85.45	168.33	172.54

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Table 3-4. HERS BESTEST Tier 1 Reference Results
Monthly Heating Loads for Cases L302AC through L324B2

BLAST 3.0 Monthly and Total Heating Loads (MBtu/y)												
	L302AC	L302BC	L304AC	L304BC	L322A1	L322A2	L322B1	L322B2	L324A1	L324A2	L324B1	L324B2
Jan	12.52	12.22	10.86	10.50	16.19	16.41	15.72	16.37	11.91	11.99	11.16	11.26
Feb	10.81	10.87	9.37	9.34	14.05	14.26	14.02	14.54	10.29	10.36	9.84	10.14
Mar	10.11	9.96	8.70	8.51	13.25	13.46	12.90	13.56	9.53	9.61	8.87	9.30
Apr	5.92	5.35	5.01	4.58	7.82	7.96	6.62	7.39	5.42	5.45	4.43	4.96
May	2.99	2.13	2.42	1.75	3.95	3.96	2.18	2.90	2.49	2.46	1.36	1.88
Jun	1.01	0.44	0.73	0.34	1.29	1.20	0.38	0.58	0.66	0.62	0.22	0.38
Jul	0.19	0.00	0.09	0.00	0.21	0.15	0.00	0.00	0.03	0.02	0.00	0.00
Aug	0.31	0.00	0.17	0.00	0.35	0.27	0.00	0.00	0.09	0.06	0.00	0.00
Sep	1.62	0.68	1.25	0.48	2.05	1.96	0.28	0.79	1.18	1.09	0.15	0.56
Oct	4.18	3.09	3.45	2.52	5.39	5.36	3.22	4.18	3.56	3.47	2.03	2.72
Nov	9.16	8.94	7.87	7.61	11.96	12.16	11.61	12.22	8.63	8.68	7.98	8.35
Dec	11.68	11.56	10.13	9.96	15.14	15.34	14.89	15.44	11.12	11.20	10.55	10.85
Tot	70.48	65.25	60.06	55.59	91.66	92.50	81.82	87.97	64.90	65.02	56.57	60.40

DOE2.1E Monthly and Total Heating Loads (MBtu/y)												
	L302AC	L302BC	L304AC	L304BC	L322A1	L322A2	L322B1	L322B2	L324A1	L324A2	L324B1	L324B2
Jan	11.93	11.37	10.21	9.68	15.43	15.30	15.03	15.54	11.18	11.18	10.28	9.92
Feb	10.24	9.88	8.73	8.34	13.30	13.24	13.08	13.48	9.56	9.58	8.87	8.60
Mar	9.54	8.95	8.05	7.47	12.53	12.48	11.92	12.39	8.80	8.82	7.80	7.71
Apr	5.64	4.85	4.69	3.96	7.47	7.38	6.12	6.70	5.05	4.99	3.72	4.21
May	2.89	1.91	2.30	1.48	3.90	3.67	2.09	2.60	2.37	2.21	0.99	1.60
Jun	0.99	0.41	0.73	0.30	1.36	1.12	0.38	0.53	0.67	0.56	0.12	0.33
Jul	0.17	0.00	0.09	0.00	0.26	0.14	0.00	0.00	0.05	0.03	0.00	0.00
Aug	0.30	0.00	0.18	0.00	0.43	0.25	0.00	0.01	0.12	0.06	0.00	0.00
Sep	1.60	0.68	1.24	0.45	2.14	1.83	0.36	0.85	1.18	0.98	0.06	0.51
Oct	4.11	3.01	3.36	2.33	5.41	5.06	3.32	4.27	3.47	3.23	1.57	2.51
Nov	8.74	8.19	7.39	6.86	11.41	11.34	10.95	11.56	8.07	8.07	7.13	7.01
Dec	11.29	10.87	9.67	9.25	14.62	14.51	14.47	14.94	10.59	10.60	9.84	9.48
Tot	67.43	60.12	56.62	50.11	88.27	86.33	77.71	82.87	61.10	60.31	50.38	51.88

SERIRES/SUNCODE 5.7 Monthly and Total Heating Loads (MBtu/y)												
	L302AC	L302BC	L304AC	L304BC	L322A1	L322A2	L322B1	L322B2	L324A1	L324A2	L324B1	L324B2
Jan	14.96	13.92	12.72	11.94	19.07	19.23	17.76	17.78	13.59	13.68	12.23	12.41
Feb	12.73	12.31	10.78	10.46	16.28	16.46	15.43	15.46	11.52	11.62	10.58	10.75
Mar	11.73	11.11	9.82	9.35	15.10	15.31	14.13	14.14	10.48	10.59	9.62	9.85
Apr	6.88	6.09	5.66	5.12	8.88	9.12	7.95	7.91	5.93	6.04	5.45	5.69
May	3.45	2.30	2.73	1.86	4.44	4.62	3.27	3.20	2.68	2.77	2.24	2.54
Jun	1.16	0.48	0.85	0.38	1.43	1.50	0.72	0.70	0.72	0.75	0.50	0.67
Jul	0.21	0.00	0.11	0.00	0.22	0.25	0.00	0.00	0.05	0.05	0.00	0.02
Aug	0.35	0.00	0.21	0.00	0.39	0.44	0.00	0.00	0.12	0.13	0.00	0.06
Sep	1.91	0.64	1.47	0.39	2.38	2.45	0.63	0.61	1.30	1.35	0.36	0.85
Oct	4.91	3.37	3.99	2.68	6.23	6.38	4.04	3.92	3.95	4.04	2.48	3.00
Nov	10.77	9.83	9.04	8.22	13.84	14.07	12.18	12.14	9.64	9.76	7.94	8.17
Dec	13.86	13.05	11.78	11.19	17.68	17.85	16.28	16.24	12.60	12.69	11.05	11.29
Tot	82.90	73.10	69.15	61.58	105.94	107.69	92.38	92.11	72.56	73.47	62.44	65.30

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Table 3-5. HERS BESTEST Tier 1 Reference Results
Monthly Cooling Loads for Cases L100AL through L202AL

BLAST 3.0 Monthly and Total Sensible Cooling Loads (MBtu/y)											
	L100AL	L110AL	L120AL	L130AL	L140AL	L150AL	L155AL	L160AL	L170AL	L200AL	L202AL
Jan	0.07	0.03	0.08	0.00	0.00	1.91	1.55	0.01	0.03	0.01	0.00
Feb	0.38	0.24	0.41	0.06	0.00	2.39	1.58	0.22	0.22	0.21	0.10
Mar	1.44	1.15	1.46	0.55	0.07	3.35	1.69	1.58	1.01	1.04	0.69
Apr	2.18	1.92	2.16	1.16	0.36	2.78	1.16	3.16	1.60	1.83	1.42
May	5.85	6.02	5.55	3.90	2.14	5.51	4.30	7.59	4.76	6.56	5.81
Jun	9.43	10.26	8.72	6.72	4.61	8.71	7.85	11.41	8.10	11.96	10.99
Jul	12.16	13.62	11.15	8.84	6.57	11.51	10.69	13.98	10.67	16.40	15.44
Aug	10.87	12.01	10.02	7.85	5.65	11.18	9.19	12.31	9.41	14.21	13.26
Sep	7.76	8.24	7.33	5.35	3.32	9.33	7.08	8.40	6.51	9.21	8.44
Oct	3.92	3.79	3.84	2.36	0.80	6.76	5.43	3.59	3.13	3.89	3.24
Nov	0.60	0.43	0.63	0.17	0.00	3.08	2.55	0.37	0.39	0.39	0.22
Dec	0.00	0.00	0.01	0.00	0.00	1.22	1.02	0.00	0.00	0.00	0.00
Tot	54.66	57.70	51.34	36.95	23.52	67.72	54.08	62.61	45.83	65.70	59.61

DOE2.1E Monthly and Total Sensible Cooling Loads (MBtu/y)											
	L100AL	L110AL	L120AL	L130AL	L140AL	L150AL	L155AL	L160AL	L170AL	L200AL	L202AL
Jan	0.24	0.10	0.24	0.02	0.00	2.94	2.50	0.05	0.10	0.08	0.00
Feb	0.83	0.54	0.83	0.19	0.00	3.59	2.81	0.50	0.49	0.54	0.23
Mar	2.24	1.80	2.13	0.90	0.13	4.55	3.01	2.41	1.56	1.79	0.99
Apr	2.98	2.62	2.83	1.57	0.54	3.82	2.03	4.16	2.15	2.59	1.72
May	6.50	6.71	6.03	4.39	2.55	6.01	4.46	8.51	5.13	7.46	6.13
Jun	9.88	10.84	8.97	7.26	5.14	8.74	7.79	11.98	8.21	12.71	11.10
Jul	12.64	14.29	11.42	9.49	7.15	11.76	10.61	14.52	10.75	17.18	15.68
Aug	11.41	12.71	10.37	8.47	6.19	11.58	9.15	12.92	9.58	15.03	13.48
Sep	8.46	9.03	7.89	5.91	3.76	10.35	6.69	9.00	6.92	10.20	8.91
Oct	4.57	4.47	4.37	2.76	1.08	7.73	5.26	4.15	3.58	4.79	3.67
Nov	0.99	0.70	0.99	0.29	0.00	4.13	3.04	0.49	0.60	0.72	0.33
Dec	0.06	0.01	0.07	0.00	0.00	2.15	1.71	0.00	0.01	0.01	0.00
Tot	60.80	63.83	56.14	41.26	26.54	77.35	59.06	68.68	49.06	73.10	62.24

SERIRES/SUNCODE 5.7 Monthly and Total Sensible Cooling Loads (MBtu/y)											
	L100AL	L110AL	L120AL	L130AL	L140AL	L150AL	L155AL	L160AL	L170AL	L200AL	L202AL
Jan	0.01	0.00	0.02	0.00	0.00	1.25	0.92	0.00	0.00	0.00	0.00
Feb	0.26	0.18	0.28	0.04	0.00	2.17	1.40	0.14	0.14	0.14	0.08
Mar	1.32	1.07	1.33	0.48	0.06	3.25	1.50	1.48	0.87	0.98	0.69
Apr	2.35	2.08	2.30	1.21	0.37	3.14	1.23	3.35	1.66	2.05	1.62
May	6.46	6.66	6.03	4.16	2.27	6.10	4.78	8.35	5.18	7.77	6.88
Jun	10.31	11.26	9.42	7.07	4.80	9.43	8.67	12.38	8.76	14.01	13.03
Jul	13.52	15.17	12.23	9.46	6.95	12.89	11.91	15.42	11.79	19.50	18.53
Aug	12.00	13.30	10.95	8.33	5.91	12.36	10.19	13.49	10.32	16.78	15.85
Sep	8.62	9.19	8.05	5.76	3.50	10.54	8.14	9.18	7.18	10.96	10.10
Oct	4.04	3.95	3.94	2.33	0.78	7.09	5.65	3.63	3.14	4.26	3.64
Nov	0.43	0.32	0.46	0.09	0.00	2.87	2.35	0.20	0.26	0.26	0.15
Dec	0.00	0.00	0.00	0.00	0.00	0.94	0.77	0.00	0.00	0.00	0.00
Tot	59.32	63.16	55.01	38.92	24.65	72.04	57.51	67.60	49.31	76.71	70.58

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3.5 Tier 2 Reference Results

The following figures and tables present the Tier 2 reference results.

- Figure 3-7. HERS BESTEST Tier 2 reference results—annual heating load for Colorado Springs, CO
- Figure 3-8. HERS BESTEST Tier 2 reference results—annual cooling load for Colorado Springs, CO
- Figure 3-9. HERS BESTEST Tier 2 reference results—delta annual heating load for Colorado Springs, CO
- Figure 3-10. HERS BESTEST Tier 2 reference results—delta annual cooling load for Colorado Springs, CO
- Table 3-6. HERS BESTEST Tier 2 Reference Results—Annual Heating and Cooling Loads
- Table 3-7. HERS BESTEST Tier 2 Reference Results—Monthly Heating Loads
- Table 3-8. HERS BESTEST Tier 2 Reference Results—Monthly Cooling Loads

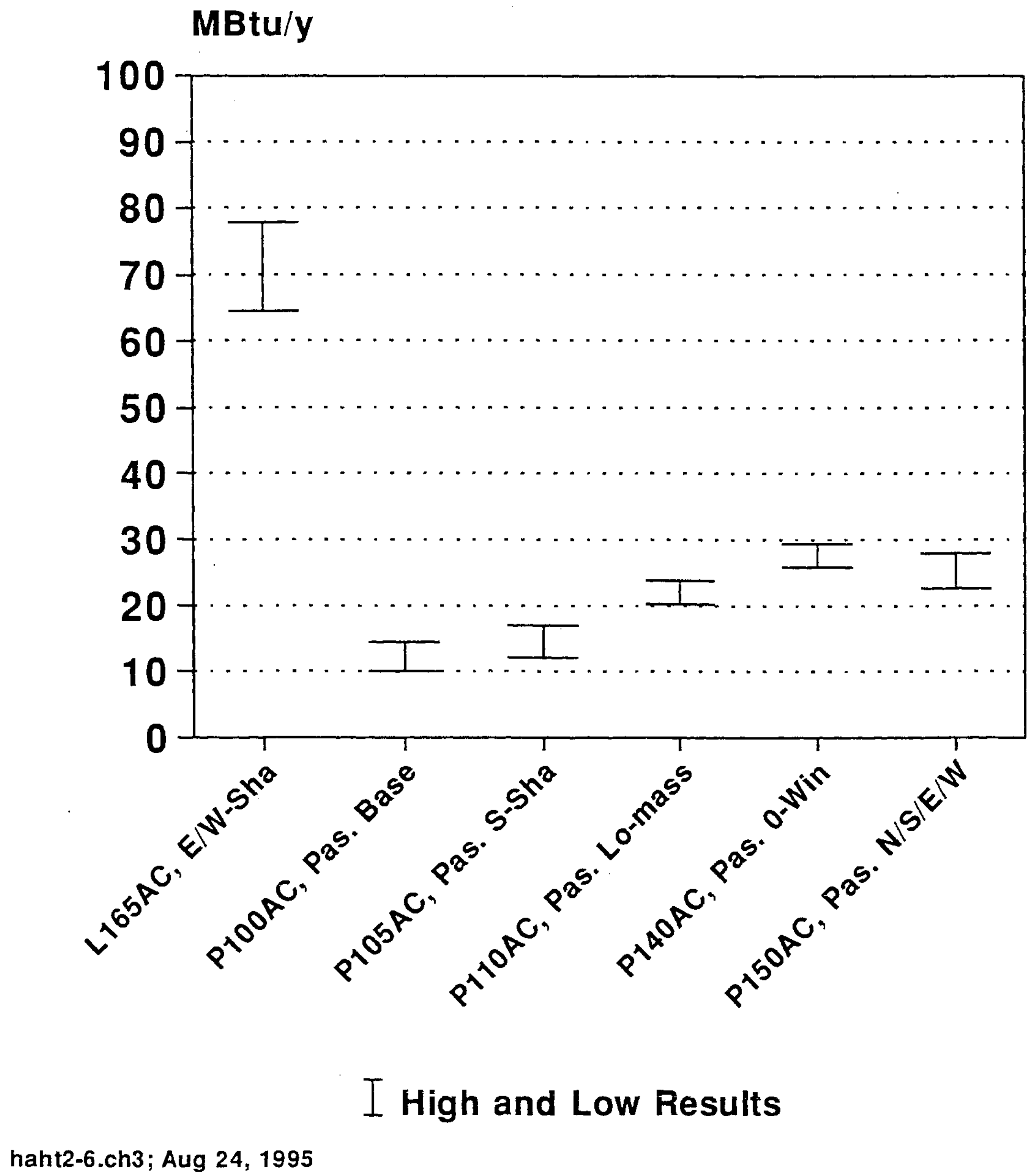

Figure 3-7. HERS BESTEST Tier 2 reference results—annual heating load for Colorado Springs, CO

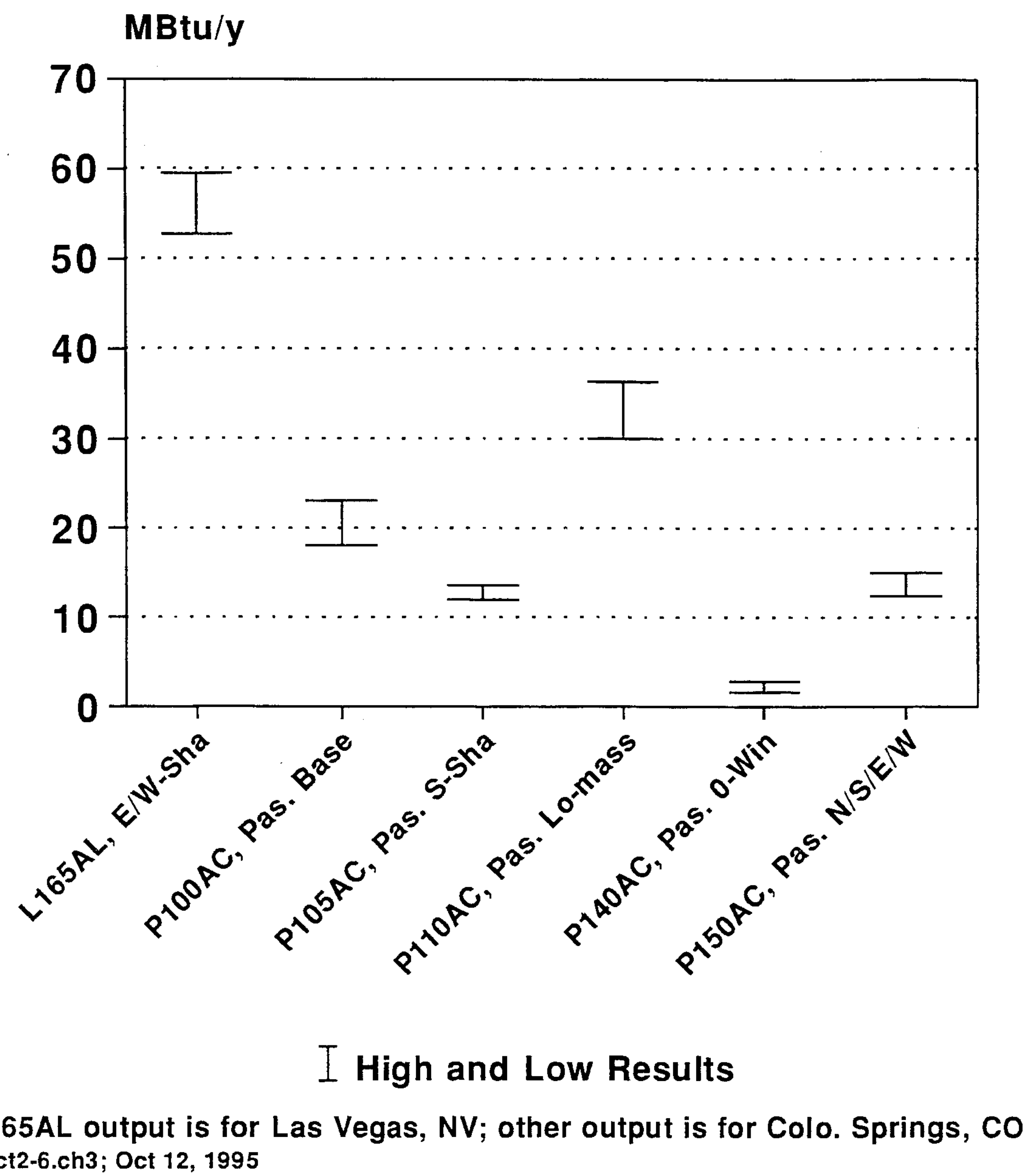

Figure 3-8. HERS BESTEST Tier 2 reference results—annual cooling load for Colorado Springs, CO

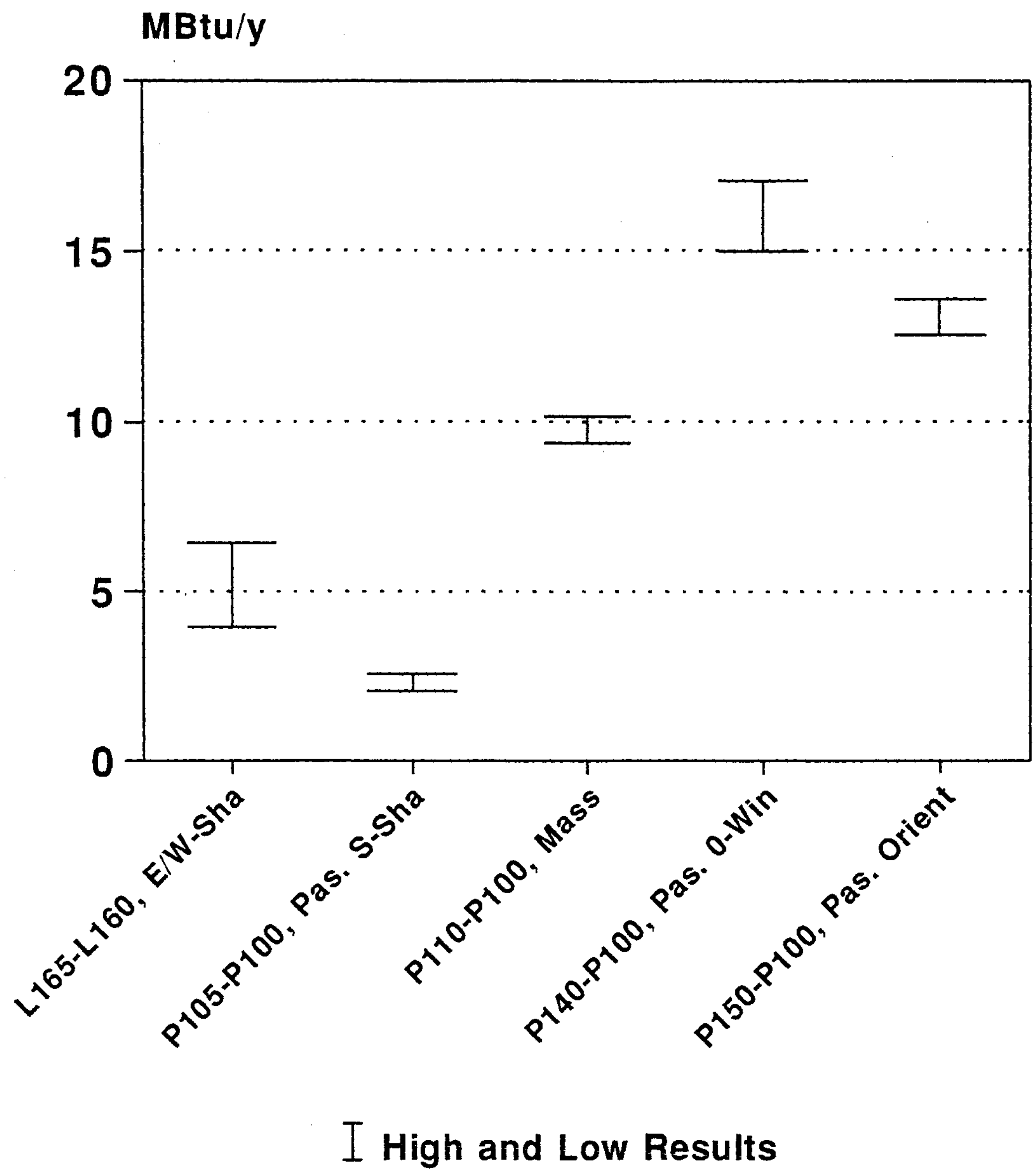

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Figure 3-9. HERS BESTEST Tier 2 reference results—delta annual heating load for Colorado Springs, CO

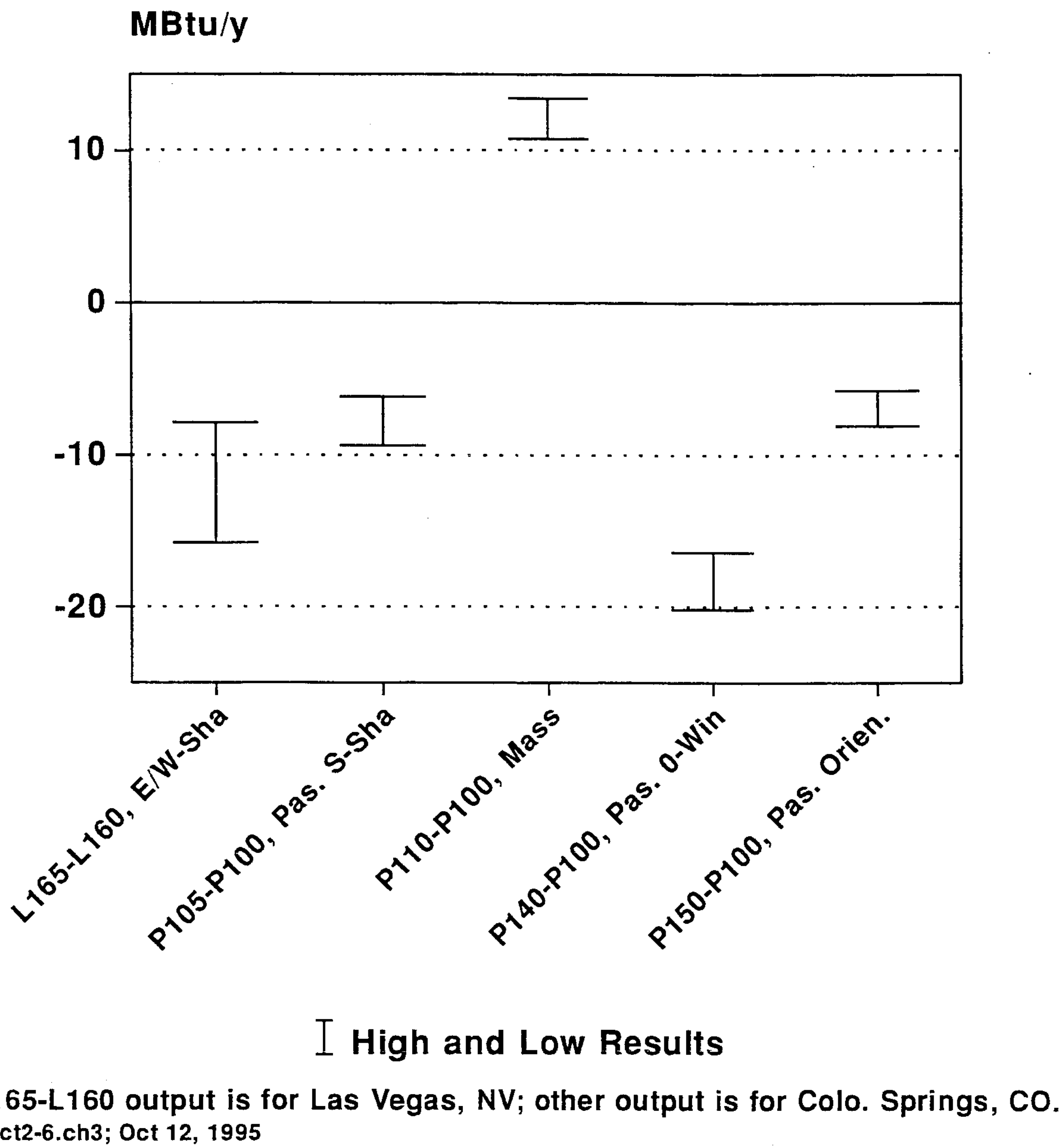

Figure 3-10. HERS BESTEST Tier 2 reference results—delta annual cooling load for Colorado Springs, CO

Table 3-6. HERS BESTEST Tier 2 Reference Results Annual Heating and Cooling Loads

Annual Heating (MBtu/y) Colorado Springs, CO Case #	BLAST	DOE2	SERIRES/ SUNCODE
L165AC	66.84	64.72	78.04
P100AC	12.31	10.02	14.40
P105AC	14.59	12.10	16.97
P110AC	22.38	20.19	23.79
P140AC	29.40	25.82	29.42
P150AC	25.10	22.58	27.99

Annual Cooling (MBtu/y) Las Vegas, NV Case #	BLAST	DOE2	SERIRES/ SUNCODE
L165AL	54.77	52.88	59.59
Colorado Springs, CO			
P100AC	18.11	23.03	20.08
P105AC	11.95	13.63	13.45
P110AC	30.18	36.49	30.86
P140AC	1.67	2.84	1.73
P150AC	12.42	15.03	14.03

Delta Annual Heating (MBtu/y) Colorado Springs, CO Case	BLAST	DOE2	SERIRES/ SUNCODE
L165AC-L160AC	3.96	6.43	4.55
P105AC-P100AC	2.28	2.08	2.57
P110AC-P100AC	10.07	10.17	9.39
P140AC-P100AC	17.09	15.80	15.02
P150AC-P100AC	12.79	12.56	13.60

Delta Annual Cooling (MBtu/y) Las Vegas, NV Case	BLAST	DOE2	SERIRES/ SUNCODE
L165AL-L160AL	-7.84	-15.81	-8.01
Colorado Springs, CO			
P105AC-P100AC	-6.16	-9.41	-6.63
P110AC-P100AC	12.07	13.45	10.78
P140AC-P100AC	-16.44	-20.19	-18.35
P150AC-P100AC	-5.69	-8.00	-6.05

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**Table 3-7. HERS BESTEST Tier 2 Reference Results
Monthly Heating Loads**

BLAST 3.0 Monthly and Total Heating Loads (MBtu/y)						
	L165AC	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	12.63	2.44	2.45	4.20	5.68	5.44
Feb	10.63	2.41	2.61	3.88	4.98	4.68
Mar	9.33	2.23	3.04	3.63	4.67	3.87
Apr	4.95	1.29	2.18	2.15	2.48	1.67
May	2.29	0.36	0.62	0.81	0.80	0.36
Jun	0.63	0.05	0.09	0.18	0.15	0.03
Jul	0.05	0.00	0.00	0.00	0.00	0.00
Aug	0.12	0.00	0.00	0.00	0.00	0.00
Sep	1.20	0.00	0.00	0.13	0.11	0.00
Oct	3.78	0.23	0.27	0.75	1.28	0.50
Nov	9.37	1.11	1.15	2.68	4.13	3.45
Dec	11.86	2.19	2.19	3.96	5.14	5.10
Tot	66.84	12.31	14.59	22.38	29.40	25.10

DOE2.1E Monthly and Total Heating Loads (MBtu/y)						
	L165AC	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	12.14	2.04	2.12	3.71	5.14	4.94
Feb	10.14	1.90	2.01	3.44	4.45	4.17
Mar	8.89	1.80	2.32	3.27	4.09	3.42
Apr	4.83	1.05	1.73	1.98	2.06	1.47
May	2.36	0.33	0.63	0.81	0.58	0.34
Jun	0.70	0.05	0.11	0.19	0.09	0.03
Jul	0.08	0.00	0.00	0.00	0.00	0.00
Aug	0.16	0.00	0.00	0.00	0.00	0.00
Sep	1.30	0.00	0.01	0.14	0.06	0.00
Oct	3.75	0.22	0.29	0.70	1.02	0.48
Nov	8.89	0.86	1.02	2.34	3.66	3.04
Dec	11.49	1.77	1.86	3.59	4.67	4.69
Tot	64.72	10.02	12.10	20.19	25.82	22.58

SERIRES/SUNCODE 5.7 Monthly and Total Heating Loads (MBtu/y)						
	L165AC	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	14.90	2.97	3.01	4.56	5.69	6.09
Feb	12.38	2.77	2.95	4.08	4.95	5.12
Mar	10.64	2.57	3.44	3.83	4.62	4.26
Apr	5.69	1.43	2.40	2.25	2.46	1.89
May	2.66	0.39	0.72	0.88	0.81	0.43
Jun	0.77	0.05	0.10	0.20	0.14	0.04
Jul	0.09	0.00	0.00	0.00	0.00	0.00
Aug	0.18	0.00	0.00	0.00	0.00	0.00
Sep	1.48	0.00	0.00	0.14	0.13	0.01
Oct	4.48	0.23	0.28	0.77	1.32	0.66
Nov	10.87	1.29	1.33	2.79	4.13	3.85
Dec	13.91	2.70	2.73	4.28	5.17	5.66
Tot	78.04	14.40	16.97	23.79	29.42	27.99

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Table 3-8. HERS BESTEST Tier 2 Reference Results
Monthly Cooling Loads

BLAST 3.0 Monthly and Total Sensible Cooling Loads (MBtu/y)						
	L165AL	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	0.00	0.62	0.62	2.17	0.00	0.00
Feb	0.07	0.17	0.14	1.42	0.00	0.00
Mar	1.01	0.03	0.00	1.09	0.00	0.00
Apr	2.38	0.25	0.00	0.91	0.00	0.16
May	6.53	0.48	0.03	1.27	0.00	0.48
Jun	10.26	2.05	1.34	2.55	0.21	2.42
Jul	12.92	3.10	2.33	3.47	0.65	3.46
Aug	11.28	3.70	2.02	4.15	0.53	3.25
Sep	7.40	3.59	2.00	4.40	0.29	2.01
Oct	2.75	3.29	2.68	4.64	0.00	0.65
Nov	0.17	0.58	0.54	2.33	0.00	0.00
Dec	0.00	0.25	0.24	1.79	0.00	0.00
Tot	54.77	18.11	11.95	30.18	1.67	12.42

DOE2.1E Monthly and Total Sensible Cooling Loads (MBtu/y)						
	L165AL	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	0.00	1.19	1.12	2.80	0.00	0.00
Feb	0.11	0.47	0.39	2.13	0.00	0.00
Mar	1.10	0.21	0.03	1.54	0.00	0.00
Apr	2.48	0.43	0.13	1.34	0.00	0.27
May	6.39	0.73	0.10	1.56	0.00	0.81
Jun	9.74	2.18	1.40	2.69	0.44	2.75
Jul	12.32	3.51	2.45	3.86	1.09	3.92
Aug	10.79	4.14	2.09	4.55	0.91	3.71
Sep	7.14	4.31	1.91	5.15	0.40	2.56
Oct	2.66	3.94	2.40	5.31	0.00	1.01
Nov	0.14	1.28	1.03	3.11	0.00	0.00
Dec	0.00	0.62	0.56	2.44	0.00	0.00
Tot	52.88	23.03	13.63	36.49	2.84	15.03

SERIRES/SUNCODE 5.7 Monthly and Total Sensible Cooling Loads (MBtu/y)						
	L165AL	P100AC	P105AC	P110AC	P140AC	P150AC
Jan	0.00	0.87	0.83	2.07	0.00	0.00
Feb	0.05	0.25	0.19	1.39	0.00	0.00
Mar	0.92	0.07	0.00	0.98	0.00	0.00
Apr	2.49	0.30	0.01	0.95	0.00	0.22
May	7.23	0.55	0.05	1.30	0.00	0.64
Jun	11.21	2.09	1.44	2.56	0.23	2.63
Jul	14.35	3.37	2.46	3.72	0.68	3.76
Aug	12.42	3.88	2.12	4.31	0.54	3.49
Sep	8.11	4.02	2.39	4.83	0.29	2.41
Oct	2.75	3.54	2.91	4.83	0.00	0.88
Nov	0.05	0.78	0.73	2.31	0.00	0.00
Dec	0.00	0.35	0.33	1.61	0.00	0.00
Tot	59.59	20.08	13.45	30.86	1.73	14.03

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4.0 Example Pass/Fail Criteria

Example pass/fail criteria are included in this report to illustrate how a certifying agency may evaluate a HERS tool with HERS BESTEST. The certifying agency using HERS BESTEST may adopt these example pass/fail criteria or develop its own pass/fail criteria. Neither DOE, NREL, nor the authors of this report can be held responsible for any misfortunes that occur due to the use of these example pass/fail criteria in your certification program.

4.1 Passing a Test

A HERS tool may be thought of as having successfully passed through the test series when its results compare favorably with reference program outputs on a case-by-case and sensitivity basis (difference or delta [Δ] between certain cases).

Example pass/fail ranges for Tier 1 developed according to the procedure described below are presented in Section 4.7 for annual loads; example pass/fail ranges for Tier 2 are included in Section 4.8. In these figures, example passing ranges are represented by "error" bars. The reference result maxima and minima corresponding to each passing range are also indicated within the error bars. A HERS tool passes a case if its result for that case falls within the passing range represented by the error bars for that case. Here the term "case" is meant to include either "absolute" cases (e.g., L100AC) or "delta" cases (e.g., L110AC–L100AC). A HERS tool passes HERS BESTEST if its results are passing for all the cases (including both absolute and delta cases). In the tables and figures, the "AC," "AL," and "AB" suffixes to case numbers carry the same meaning as in Section 3.

4.2 Procedure for Developing Example Passing Ranges

Example passing ranges were developed from the annual reference results (see Tables 3-1 and 3-2 of Section 3.4, and Table 3-6 of Section 3.5). Values relevant to the discussion below are included in Table 4-1 (see Section 4.7) for annual loads and in Table 4-2 (see Section 4.7) for delta annual loads; Table 4-4 (see Section 4.8) lists relevant Tier 2 values. An electronic version of the calculations is provided in the spreadsheet file included on the accompanying diskette; spreadsheet addresses are given in small font in the tables. Example passing ranges for each case were developed through the following steps:

(1) Determine the maximum reference result, the minimum reference result, the sample mean (average) of the reference results, and the sample standard deviation (n-1 method) of the reference results. The quantities are shown in Tables 4-1, 4-2, and 4-4 as "REF MAX," "REF MIN," and "REF MEAN" respectively; standard deviation is not listed separately in the tables.

(2) Calculate the 90% confidence interval for the population mean, assuming a student's "t" distribution based on the reference results (Spiegel 1961). The extremes (confidence limits) of the 90% confidence interval for the population mean are determined from:

$$L_a = X + (t_c)(s)/\sqrt{N-1} \tag{4-1}$$

$$L_b = X - (t_c)(s)/\sqrt{N-1} \tag{4-2}$$

where:

L_a = maximum confidence limit for the confidence interval
L_b = minimum confidence limit for the confidence interval
X = sample mean
t_c = confidence coefficient (see below)
s = sample standard deviation
N = number of samples.

The confidence coefficient (t_c) is determined from the number of samples and the desired confidence interval. Tables of these coefficients and an explanation of how to use the tables should be available in any introductory statistics text book. For this example with 3 samples and a desired confidence interval of 90%,

$$t_c = 2.92 \ . \qquad (4\text{-}3)$$

Equations 4-1 and 4-2 then reduce to:

$$L_a = X + 2.92(s)/\sqrt{2} \qquad (4\text{-}4)$$

$$L_b = X - 2.92(s)/\sqrt{2} \ . \qquad (4\text{-}5)$$

The resulting confidence limits are shown in Tables 4-1, 4-2, and 4-4 as "REF 90% CONF MAX" and "REF 90% CONF MIN."

(3) Calculate:

(REF MAX) + 4 MBtu

and

(REF MIN) - 4 MBtu.

The results of these calculations are shown in Tables 4-1, 4-2, and 4-4 as "REF MAX + 4 MBtu" and "REF MIN - 4 MBtu."

(4) The example passing range ("RANGE MAX", "RANGE MIN") is then determined by taking the maximum of "REF 90% CONF MAX" and "REF MAX + 4 MBtu" as "RANGE MAX" and the minimum of "REF 90% CONF MIN" and "REF MIN - 4 MBtu" as "RANGE MIN." Therefore, using Tables 4-1 and 4-2, a HERS tool passes a case if its test result falls within the given range for that case.

4.3 Procedure for Developing Example Passing Ranges for HERS Programs that Designate Heating and Cooling Seasons

The same procedure described above can be applied to developing passing ranges for HERS programs that designate heating and cooling seasons. In this case, the annual reference results must be replaced by seasonal reference results developed from the monthly output corresponding to the designated heating and cooling seasons as described in Section 3.1. The remainder of the Section 4.2 procedure then applies, except that the specific values shown in Tables 4-1, 4-2, and 4-4, and Figures 4-1 through 4-10 (see Sections 4.7 and 4.8), cannot be used. In this case, we recommend using the data provided on the accompanying diskette for making new tables or figures, or both, based on monthly results for the designated seasons.

4.4 Example Range Setting for Ground Coupling Cases

The results for two types of ground coupling models described in Section 3.3 effectively widen the range of reference results outputs and the example passing ranges for cases that include ground coupling analysis. Example range-setting criteria for the ground coupling cases are developed exactly as for other cases, except that in the ground coupling cases, there are now six samples. Thus, $t_c = 2.02$ is used for developing "90% CONF MAX" and "90% CONF MIN" values in Tables 4-1 and 4-2 (see Section 4.7).

For the basement cases (L322 and L324), although there are 12 reference results for each case, $t_c = 2.02$ corresponding to six samples is still applied. This was done because there is much greater range widening as a result of the type of ground coupling method applied than there is for the one- versus two-zone models. Thus for the purpose of statistical analysis, double counting of the one- and two-zone models is avoided.

4.5 Energy Cost Uncertainty Caused by Example Passing Ranges

Tables 4-3 (Section 4.7) and 4-5 (Section 4.8) include estimates of the ranges of energy cost associated with the reference results and example passing ranges developed above. Because RANGE MAX-MIN is either centered at or centered near the mean of the reference results, the cost uncertainty associated with an example passing range can be interpreted as:

(REF MEAN) ± (RANGE MAX-MIN)/2.

Values for "(RANGE MAX-MIN)/2" and "(REF MAX-MIN)/2" are listed in Tables 4-3 and 4-5. From the data in Table 4-3 for Case L100AC (gas heat), for example, the annual gas cost ± uncertainty (C±u) resulting from the passing range for space heating is roughly:

C±u = $481 ± $115.

4.6 Adjustment of Passing Ranges

A certifying agency may prefer to adjust the example range setting criteria to suit its particular needs. To assist with this, the following background and other thoughts about range setting are included.

4.6.1 Background

In choosing our algorithms for determining passing ranges, we wanted to have some buffer zone around the reference results because:

- The reference results do not represent the truth, but rather the state of the art in thermal analysis of buildings.
- A result just outside the range of reference results should pass.
- For cases in which reference results ranges are very narrow, we wanted to have some allowable disagreement based on economic criteria that would still pass.

Determining passing ranges using the widest range created by a 90% confidence interval and extending reference result extremes by 4 MBtu at each extreme provides the buffer zone as described below.

Use of confidence intervals provides some theoretical basis for developing passing ranges (Spiegel 1961). We chose the 90% confidence level because for cases in which there are only three samples, use of a 95% confidence interval for the population mean widens the range of passing beyond our level of comfort, based on allowable fuel cost uncertainty. Similarly, we felt the passing range produced with an 80% confidence interval would be too narrow. To adjust confidence intervals, we would choose a confidence coefficient corresponding to a confidence interval within the range of 80% to 95%.

For cases in which reference results are very close together, we used the 4 MBtu factor because, at typical gas prices, it represents roughly $25 per year, which we take as a threshold of economic uncertainty concern. Depending on fuel prices, climate, mortgage lending policy, and other circumstances in specific regions, it may also make sense to adjust this factor.

4.6.2 Case Discrimination

Some cases may deserve to have more strict passing criteria. A possible example of this is the annual heating load for the energy inefficient case (L200AC). Here the percentage disagreement among reference results, though consistent with that for the Case L100AC results, produces a much greater extension of the passing range in terms of fuel cost than is seen for Case L100AC. Thus, a narrower range of allowable fuel cost for Case L200AC may be preferred.

4.7 Tier 1 Example Pass/Fail Criteria

The following figures and tables present Tier 1 example pass/fail criteria.

- Figure 4-1. HERS BESTEST Tier 1 example range setting—annual heating load (L100AC through L170AC) for Colorado Springs, CO
- Figure 4-2. HERS BESTEST Tier 1 example range setting—annual heating load (L200AC through L324AB) for Colorado Springs, CO
- Figure 4-3. HERS BESTEST Tier 1 example range setting—delta annual heating load (L100AC through L170AC) for Colorado Springs, CO
- Figure 4-4. HERS BESTEST Tier 1 example range setting—delta annual heating load (L200AC through 324AB) for Colorado Springs, CO
- Figure 4-5. HERS BESTEST Tier 1 example range setting—annual cooling load for Las Vegas, NV
- Figure 4-6. HERS BESTEST Tier 1 example range setting—delta annual cooling load for Las Vegas, NV
- Table 4-1. HERS BESTEST Tier 1 Example Range-Setting Procedure—Annual Heating and Cooling Loads
- Table 4-2. HERS BESTEST Tier 1 Example Range-Setting Procedure—Delta Annual Heating and Cooling Loads
- Table 4-3. HERS BESTEST Tier 1 Reference Results and Example Range Fuel Cost Summary

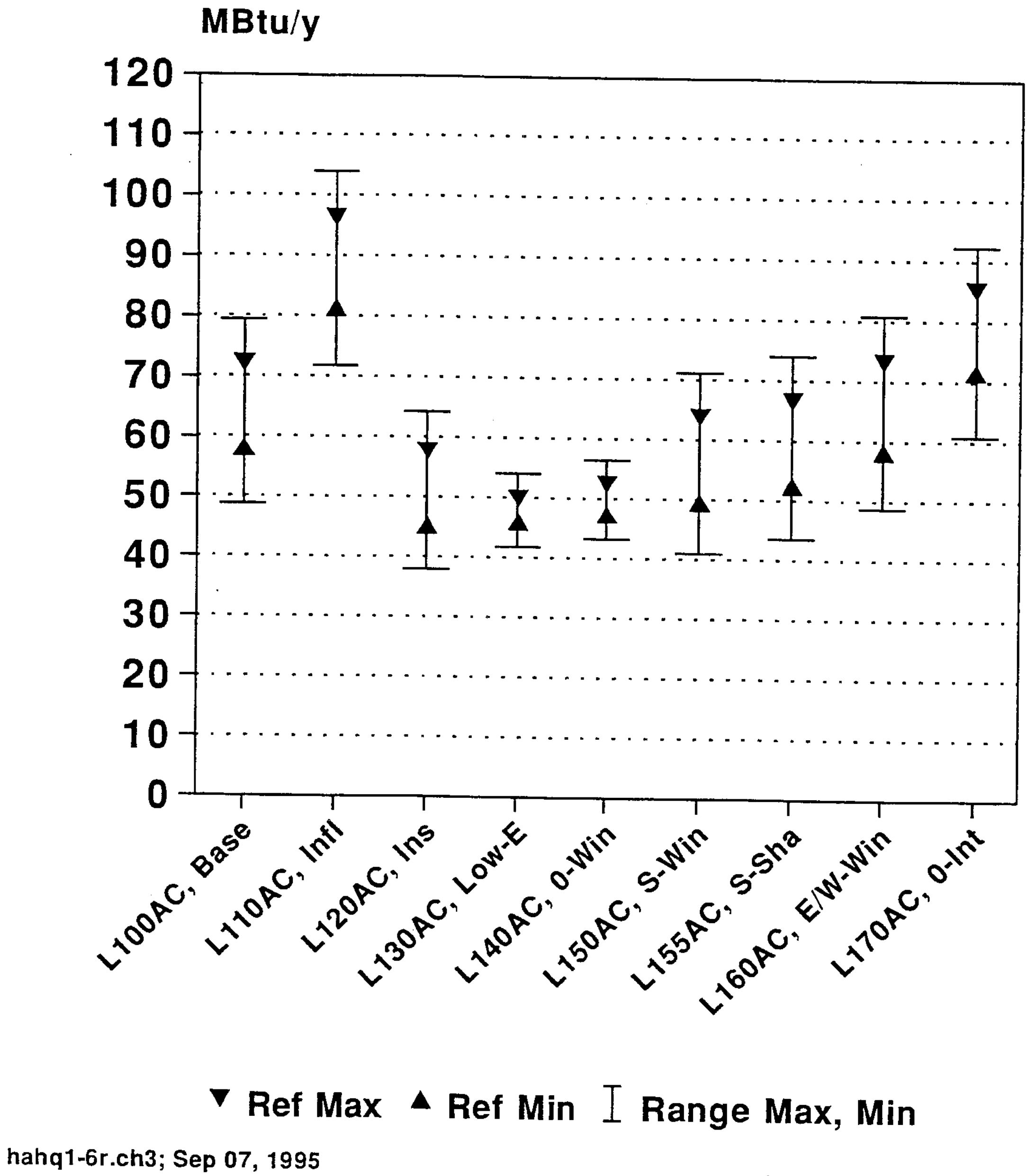

Figure 4-1. HERS BESTEST Tier 1 example range setting—annual heating load (L100AC through L170AC) for Colorado Springs, CO

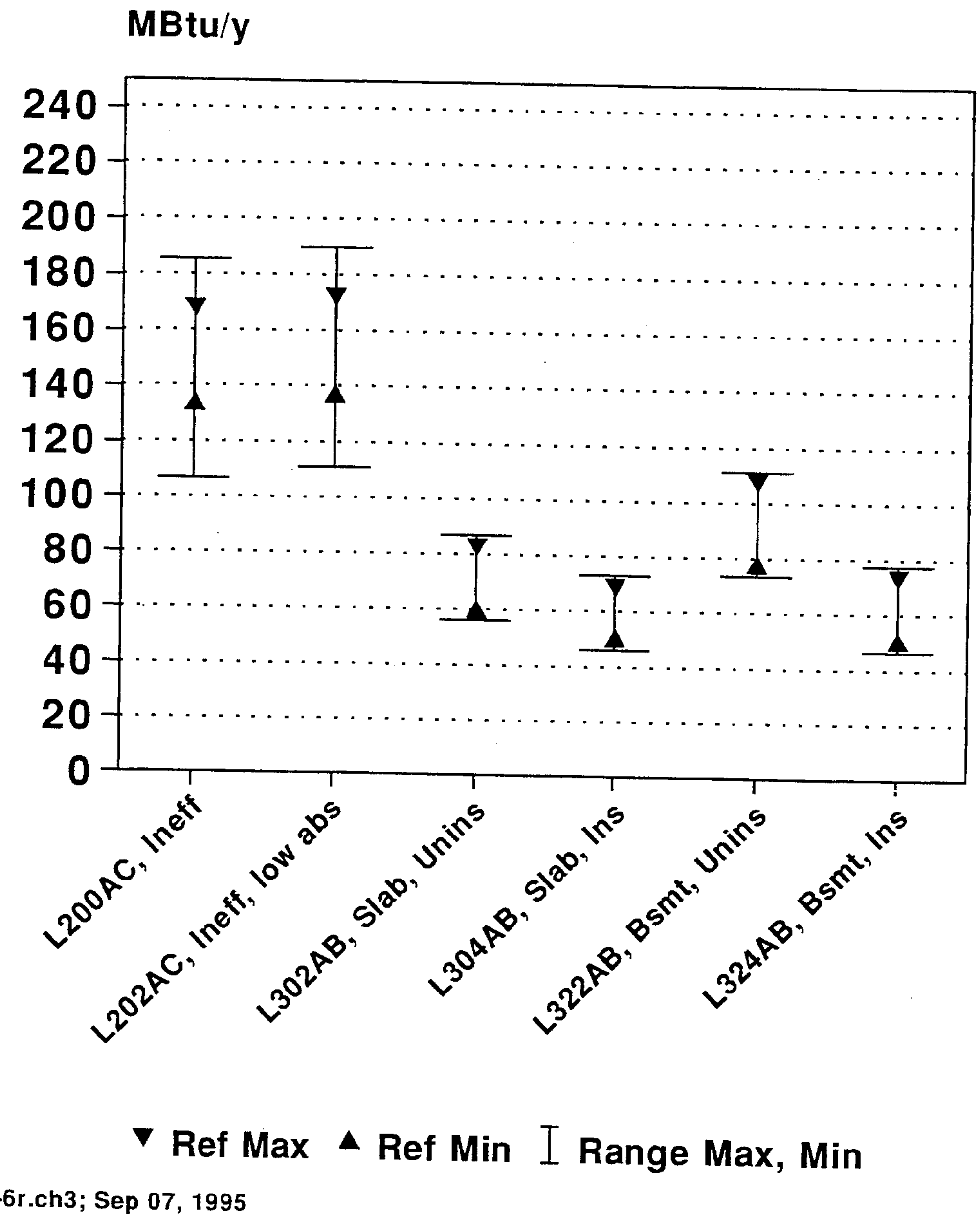

Figure 4-2. HERS BESTEST Tier 1 example range setting—annual heating load (L200AC through L324AB) for Colorado Springs, CO

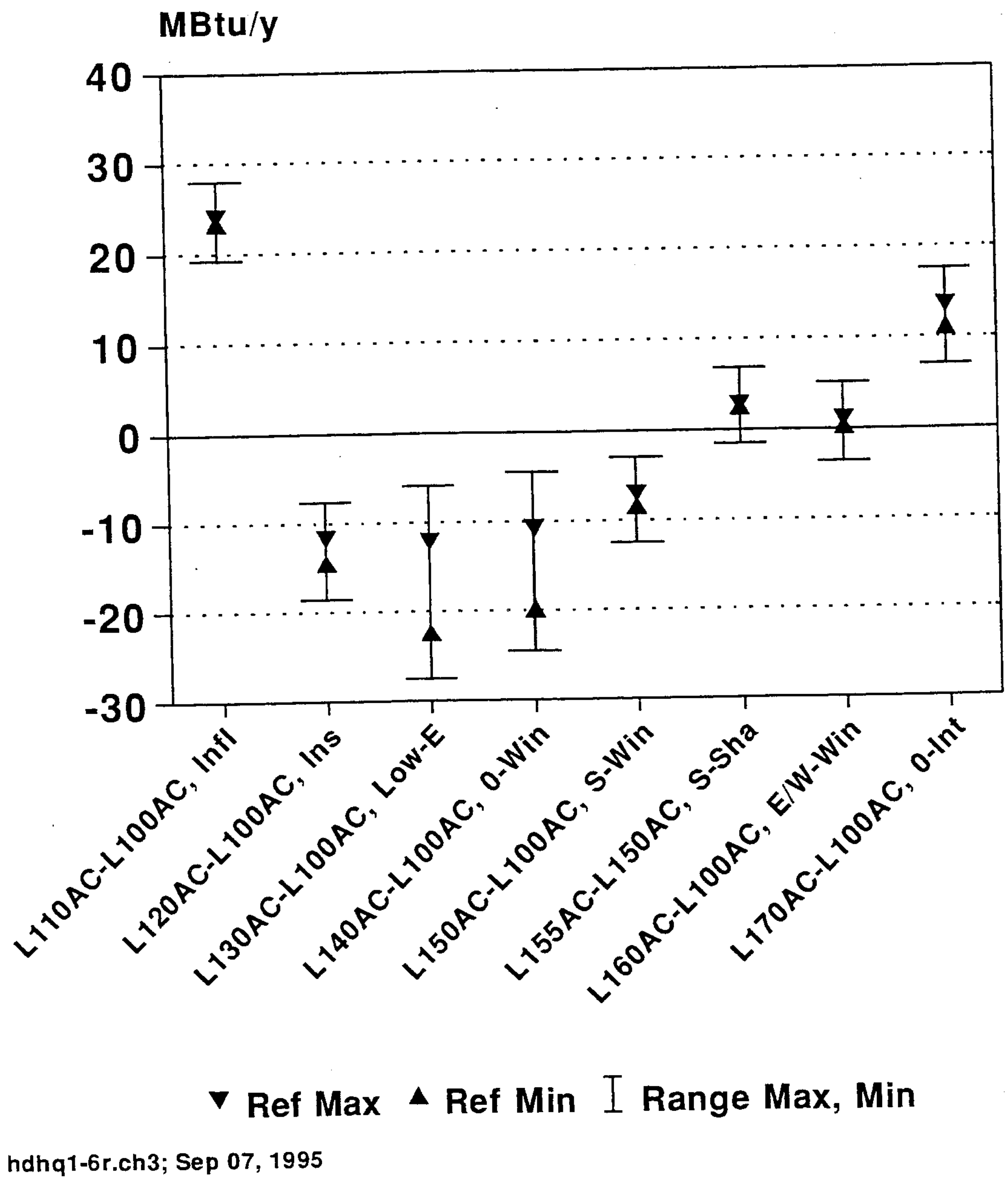

Figure 4-3. HERS BESTEST Tier 1 example range setting—delta annual annual heating load (L100AC through L170AC) for Colorado Springs, CO

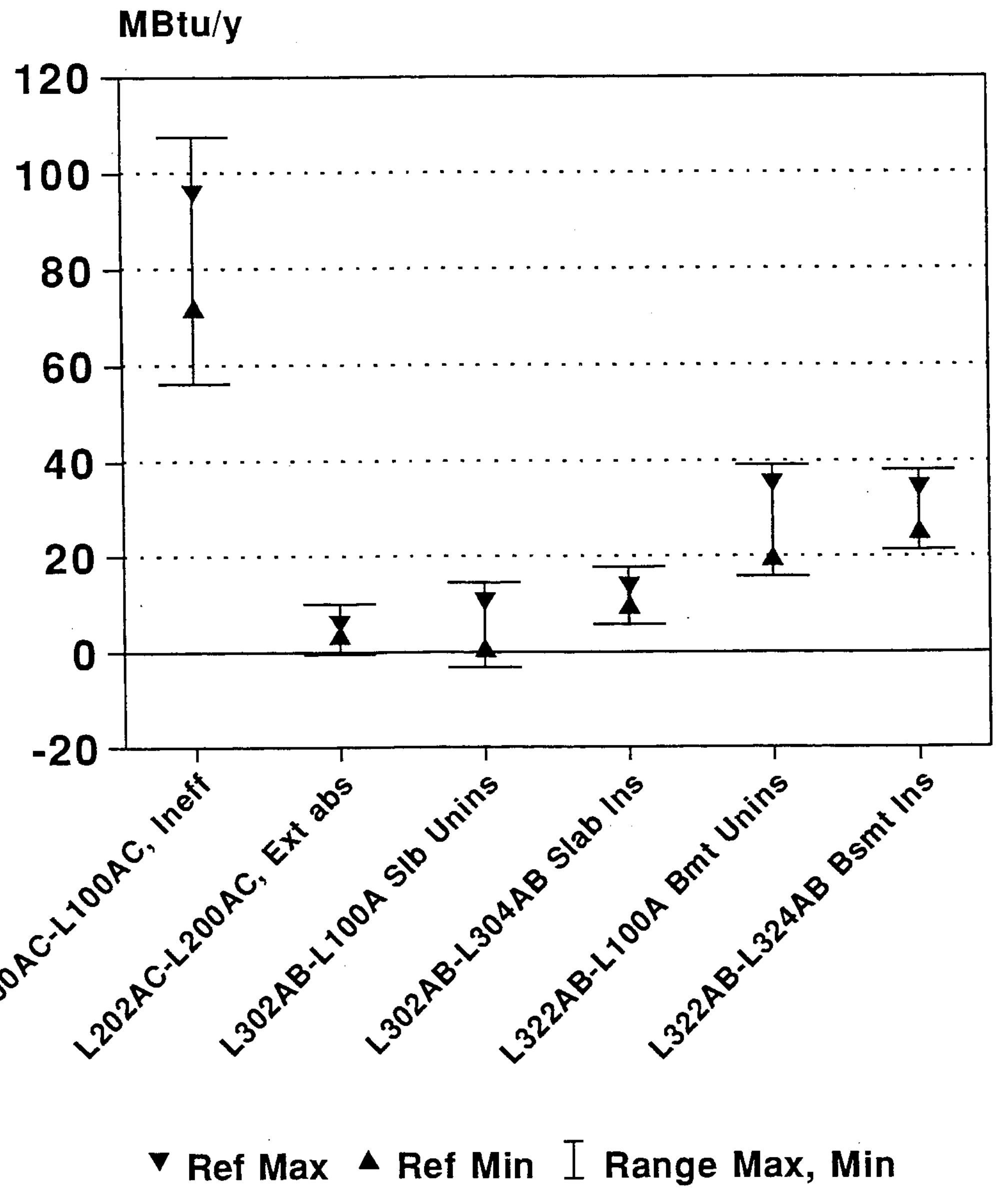

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Figure 4-4. HERS BESTEST Tier 1 example range setting—delta annual heating load (L200AC through 324AB) for Colorado Springs, CO

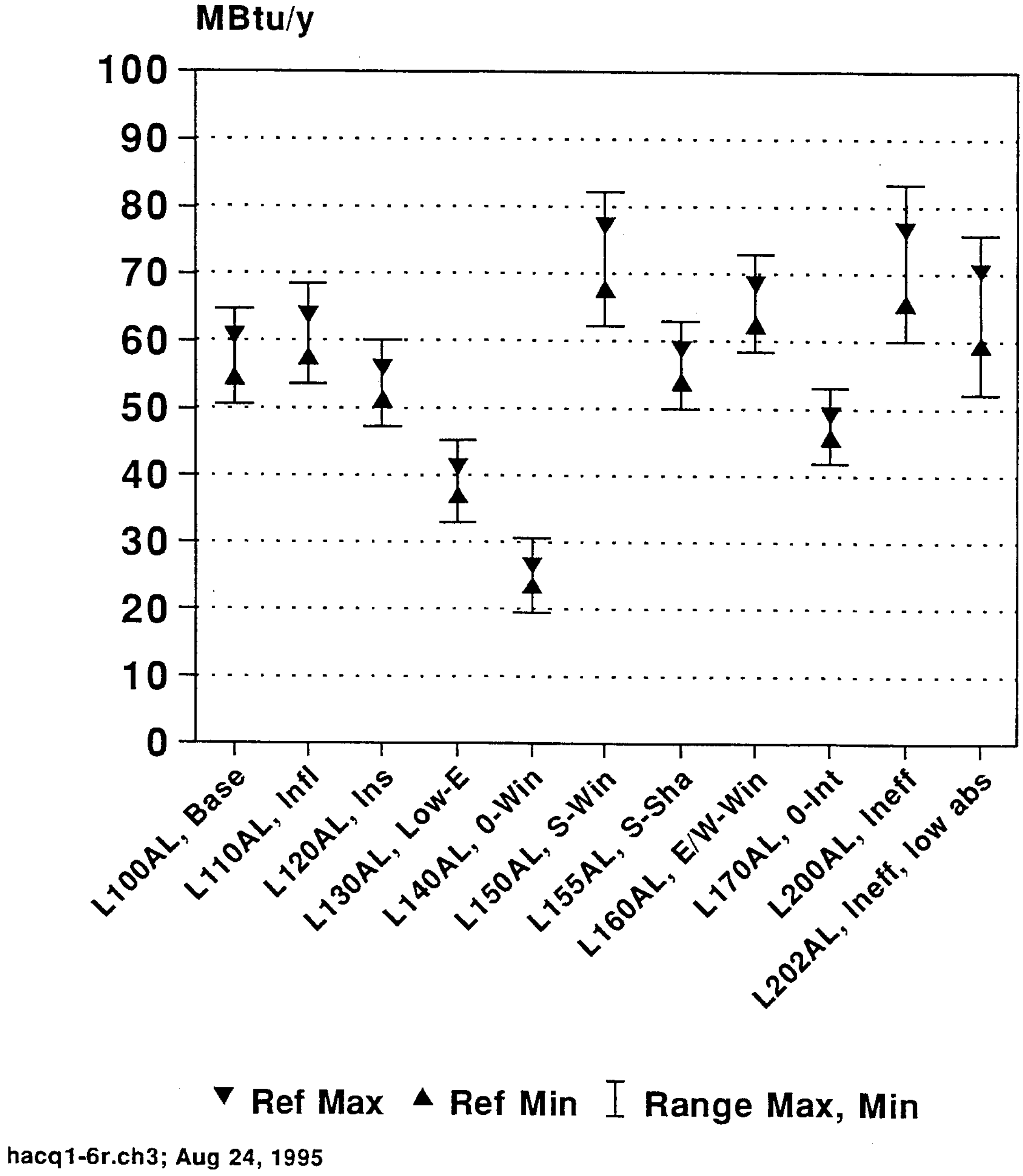

Figure 4-5. HERS BESTEST Tier 1 example range setting—annual cooling load for Las Vegas, NV

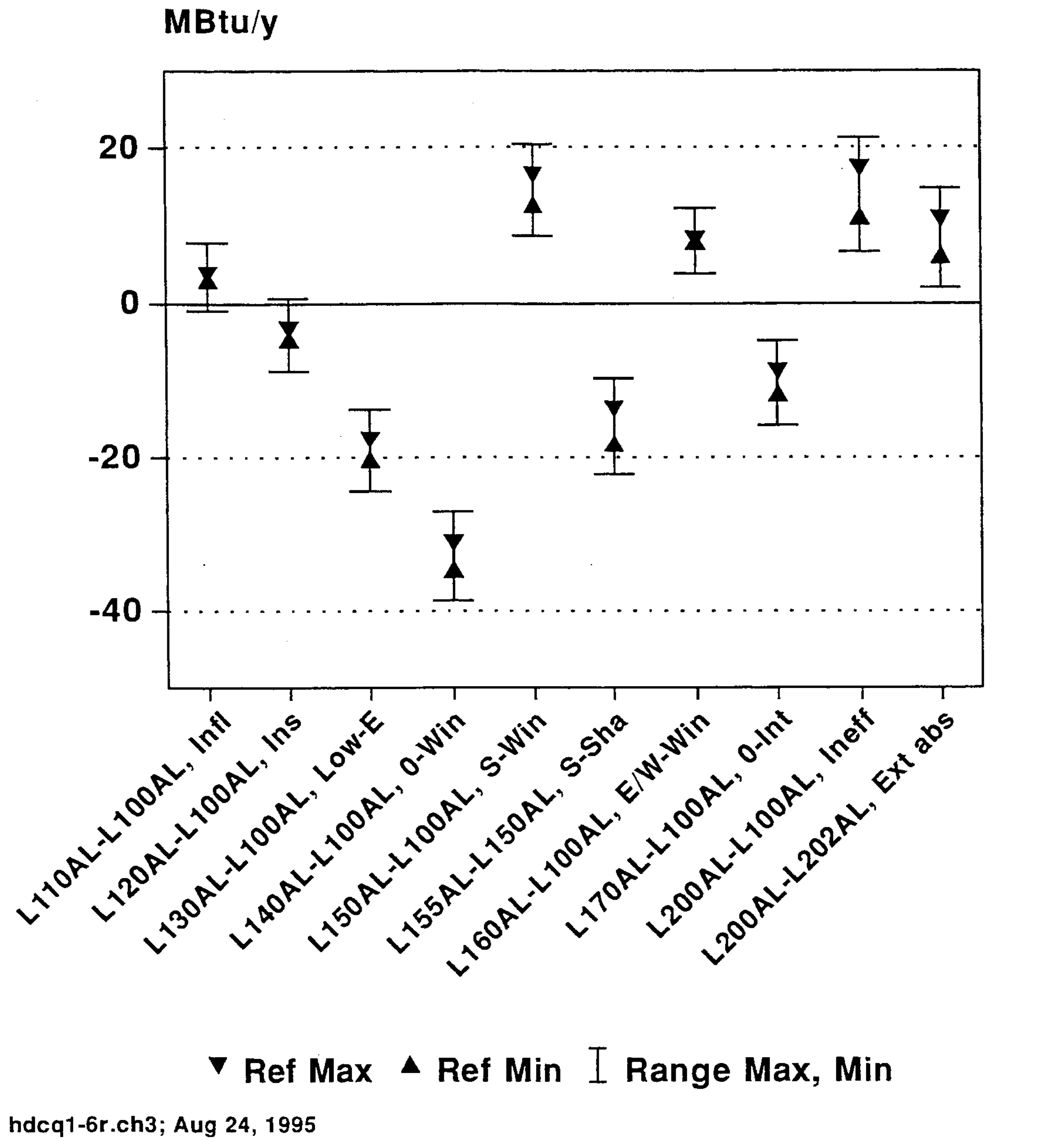

Figure 4-6. HERS BESTEST Tier 1 example range setting—delta annual cooling load for Las Vegas, NV

Table 4-1. HERS BESTEST Tier 1 Example Range-Setting Procedure Annual Heating and Cooling Loads

ANNUAL HEATING LOADS, COLORADO SPRINGS

HEATING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L100AC	72.40	58.00	64.11	79.48	48.75	76.40	54.00	79.48	48.75
L110AC	96.52	81.36	87.94	103.99	71.88	100.52	77.36	103.99	71.88
L120AC	57.83	45.08	51.06	64.30	37.82	61.83	41.08	64.30	37.82
L130AC	49.98	45.82	47.38	52.06	42.70	53.98	41.82	53.98	41.82
L140AC	52.48	47.24	49.62	55.10	44.15	56.48	43.24	56.48	43.24
L150AC	64.03	49.47	56.14	71.33	40.95	68.03	45.47	71.33	40.95
L155AC	66.91	52.28	58.86	74.18	43.53	70.91	48.28	74.18	43.53
L160AC	73.50	58.28	64.89	81.00	48.78	77.50	54.28	81.00	48.78
L170AC	85.45	71.64	76.72	92.40	61.03	89.45	67.64	92.40	61.03
L200AC	168.33	133.97	146.14	185.87	106.41	172.33	129.97	185.87	106.41
L202AC	172.54	137.46	150.69	190.05	111.32	176.54	133.46	190.05	111.32
L302AB	82.90	60.12	69.88	81.00	58.77	86.90	56.12	86.90	56.12
L304AB	69.15	50.11	58.85	68.04	49.66	73.15	46.11	73.15	46.11
L322AB	107.69	77.71	90.60	103.31	77.89	111.69	73.71	111.69	73.71
L324AB	73.47	50.38	62.03	72.08	51.97	77.47	46.38	77.47	46.38

Note: "90% CONF" statistics for cases with "AB" suffix are for six samples where tc = 2.02, see text for discussion.
For cases with "AC" suffix, tc = 2.92 (three samples).

ANNUAL SENSIBLE COOLING LOADS, LAS VEGAS, NV

COOLING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L100AL	60.80	54.66	58.26	64.88	51.64	64.80	50.66	64.88	50.66
L110AL	63.83	57.70	61.56	68.50	54.62	67.83	53.70	68.50	53.70
L120AL	56.14	51.34	54.16	59.34	48.98	60.14	47.34	60.14	47.34
L130AL	41.26	36.95	39.04	43.50	34.59	45.26	32.95	45.26	32.95
L140AL	26.54	23.52	24.90	28.06	21.75	30.54	19.52	30.54	19.52
L150AL	77.35	67.72	72.37	82.33	62.41	81.35	63.72	82.33	62.41
L155AL	59.06	54.08	56.88	62.15	51.62	63.06	50.08	63.06	50.08
L160AL	68.68	62.61	66.30	72.99	59.61	72.68	58.61	72.99	58.61
L170AL	49.31	45.83	48.07	52.07	44.06	53.31	41.83	53.31	41.83
L200AL	76.71	65.70	71.84	83.43	60.25	80.71	61.70	83.43	60.25
L202AL	70.58	59.61	64.14	75.96	52.32	74.58	55.61	75.96	52.32

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Table 4-2. HERS BESTEST Tier 1 Example Range-Setting Procedure Delta Annual Heating and Cooling Loads

DELTA ANNUAL HEATING LOADS, COLORADO SPRINGS

HEATING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L110AC-L100AC	24.12	23.37	23.83	24.66	22.99	28.12	19.36	28.12	19.36
L120AC-L100AC	-11.67	-14.57	-13.05	-10.05	-16.05	-7.67	-18.57	-7.67	-18.57
L130AC-L100AC	-12.18	-22.42	-16.73	-5.97	-27.50	-8.18	-26.42	-5.97	-27.50
L140AC-L100AC	-10.76	-19.92	-14.49	-4.56	-24.42	-6.76	-23.92	-4.56	-24.42
L150AC-L100AC	-7.02	-8.53	-7.97	-6.26	-9.68	-3.02	-12.53	-3.02	-12.53
L155AC-L150AC	2.88	2.46	2.72	3.18	2.25	6.88	-1.54	6.88	-1.54
L160AC-L100AC	1.10	0.28	0.77	1.66	-0.12	5.10	-3.72	5.10	-3.72
L170AC-L100AC	13.64	11.12	12.60	15.32	9.88	17.64	7.12	17.64	7.12
L200AC-L100AC	95.93	72.03	82.03	107.66	56.39	99.93	68.03	107.66	56.39
L202AC-L200AC	5.94	3.49	4.55	7.15	1.95	9.94	-0.51	9.94	-0.51
L302AB-L100AC	10.50	0.71	5.77	11.78	-0.24	14.50	-3.29	14.50	-3.29
L302AB-L304AB	13.75	9.66	11.03	13.14	8.92	17.75	5.66	17.75	5.66
L322AB-L100AC	35.29	19.71	26.49	34.58	18.41	39.29	15.71	39.29	15.71
L322AB-L324AB	34.22	25.25	28.58	32.71	24.44	38.22	21.25	38.22	21.25

Note: "90% CONF" statistics for cases with "AB" suffix are for six samples where tc = 2.02, see text for discussion. Also for statisical analysis, cases like "L302AB-L100AC" are treated like "L302AB-L304AB". For cases with "AC" suffix, tc = 2.92 (three samples).

DELTA ANNUAL COOLING LOADS, LAS VEGAS, NV

SENSIBLE COOLING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L110AL-L100AL	3.84	3.02	3.30	4.26	2.34	7.84	-0.98	7.84	-0.98
L120AL-L100AL	-3.32	-4.67	-4.10	-2.66	-5.54	0.68	-8.67	0.68	-8.67
L130AL-L100AL	-17.71	-20.40	-19.22	-16.38	-22.06	-13.71	-24.40	-13.71	-24.40
L140AL-L100AL	-31.14	-34.68	-33.36	-29.37	-37.35	-27.14	-38.68	-27.14	-38.68
L150AL-L100AL	16.55	12.72	14.11	18.49	9.73	20.55	8.72	20.55	8.72
L155AL-L150AL	-13.64	-18.29	-15.49	-10.39	-20.59	-9.64	-22.29	-9.64	-22.29
L160AL-L100AL	8.28	7.88	8.04	8.48	7.60	12.28	3.88	12.28	3.88
L170AL-L100AL	-8.83	-11.74	-10.19	-7.17	-13.22	-4.83	-15.74	-4.83	-15.74
L200AL-L100AL	17.39	11.04	13.58	20.52	6.63	21.39	7.04	21.39	6.63
L200AL-L202AL	10.86	6.09	7.70	13.36	2.03	14.86	2.09	14.86	2.03

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Table 4-3. HERS BESTEST Tier 1 Reference Results and Example Range Fuel Cost Summary

"ABSOLUTE" RESULTS

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	Annual Gas Heating, Note 1 Colorado Springs, CO			Annual El. Res. Heating, Note 2 Colorado Springs, CO				Annual Cooling, Note 3 Las Vegas, NV		
CASE	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	CASE	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y
L100AC	$481	$54	$115	$1,667	$187	$400	L100AL	$505	$27	$62
L110AC	$660	$57	$120	$2,286	$197	$417	L110AL	$534	$27	$64
L120AC	$383	$48	$99	$1,328	$166	$344	L120AL	$469	$21	$55
L130AC	$355	$16	$46	$1,232	$54	$158	L130AL	$338	$19	$53
L140AC	$372	$20	$50	$1,290	$68	$172	L140AL	$216	$13	$48
L150AC	$421	$55	$114	$1,460	$189	$395	L150AL	$627	$42	$86
L155AC	$441	$55	$115	$1,530	$190	$399	L155AL	$493	$22	$56
L160AC	$487	$57	$121	$1,687	$198	$419	L160AL	$575	$26	$62
L170AC	$575	$52	$118	$1,995	$180	$408	L170AL	$417	$15	$50
L200AC	$1,096	$129	$298	$3,800	$447	$1,033	L200AL	$623	$48	$100
L202AC	$1,130	$132	$295	$3,918	$456	$1,023	L202AL	$556	$48	$102
L302AB	$524	$85	$115	$1,817	$296	$400				
L304AB	$441	$71	$101	$1,530	$248	$352				
L322AB	$680	$112	$142	$2,356	$390	$494				
L324AB	$465	$87	$117	$1,613	$300	$404				

"DELTA" RESULTS

	Annual Gas Heating, Note 1 Colorado Springs, CO			Annual El. Res. Heating, Note 2 Colorado Springs, CO				Annual Cooling, Note 3 Las Vegas, NV		
CASE	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	CASE	REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y
L110AC-L100AC	$179	$3	$33	$619	$10	$114	L110AL-L100AL	$29	$4	$38
L120AC-L100AC	($98)	$11	$41	($339)	$38	$142	L120AL-L100AL	($36)	$6	$40
L130AC-L100AC	($125)	$38	$81	($435)	$133	$280	L130AL-L100AL	($167)	$12	$46
L140AC-L100AC	($109)	$34	$74	($377)	$119	$258	L140AL-L100AL	($289)	$15	$50
L150AC-L100AC	($60)	$6	$36	($207)	$20	$124	L150AL-L100AL	$122	$17	$51
L155AC-L150AC	$20	$2	$32	$71	$5	$109	L155AL-L150AL	($134)	$20	$55
L160AC-L100AC	$6	$3	$33	$20	$11	$115	L160AL-L100AL	$70	$2	$36
L170AC-L100AC	$95	$9	$39	$328	$33	$137	L170AL-L100AL	($88)	$13	$47
L200AC-L100AC	$615	$90	$192	$2,133	$311	$667	L200AL-L100AL	$118	$28	$64
L202AC-L200AC	$34	$9	$39	$118	$32	$136	L200AL-L202AL	$67	$21	$56
L302AB-L100AC	$43	$37	$67	$150	$127	$231				
L302AB-L304AB	$83	$15	$45	$287	$53	$157				
L322AB-L100AC	$199	$58	$88	$689	$203	$307				
L322AB-L324AB	$214	$34	$64	$743	$117	$221				

Note 1: Assumes AFUE = 0.8, w/dist eff = 1.0, and $6/MBtu gas.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
Note 2: Assumes AFUE = 1.0, w/dist eff = 1.0, and $26/MBtu electric.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
Note 3: Assumes COP = 3.0, w/dist eff = 1.0, and $26/MBtu electric.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
MAX-MIN = difference between maximum and minimum for reference results or example ranges as noted.
RANGE = example range results developed using the algorithm described in the accompanying text.
REF = Reference results using BLAST 3.0, DOE2.1E and SERIRES/SUNCODE 5.7.

4.8 Tier 2 Example Pass/Fail Criteria

The following figures and tables present the Tier 2 example pass/fail criteria.

- Figure 4-7. HERS BESTEST Tier 2 example range setting—annual heating load for Colorado Springs, CO
- Figure 4-8. HERS BESTEST Tier 2 example range setting—annual cooling load for Colorado Springs, CO
- Figure 4-9. HERS BESTEST Tier 2 example range setting—delta annual heating load for Colorado Springs, CO
- Figure 4-10. HERS BESTEST Tier 2 example range setting—delta annual cooling load for Colorado Springs, CO
- Table 4-4. HERS BESTEST Tier 2 Example Range-Setting Procedure—Annual Heating and Cooling Loads
- Table 4-5. HERS BESTEST Tier 2 Reference Results and Example Range Fuel Cost Summary

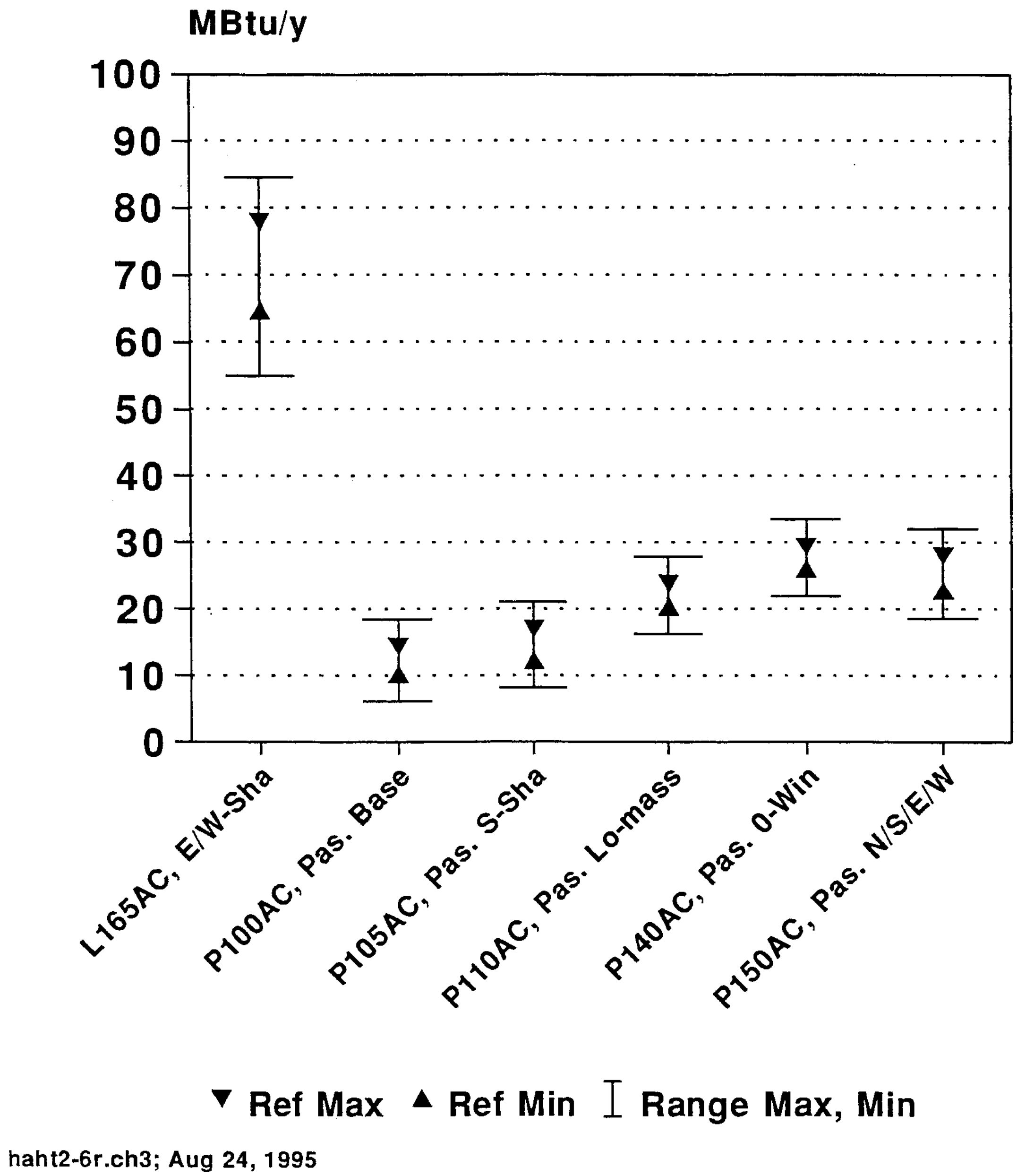


Figure 4-7. HERS BESTEST Tier 2 example range setting—annual heating load for Colorado Springs, CO

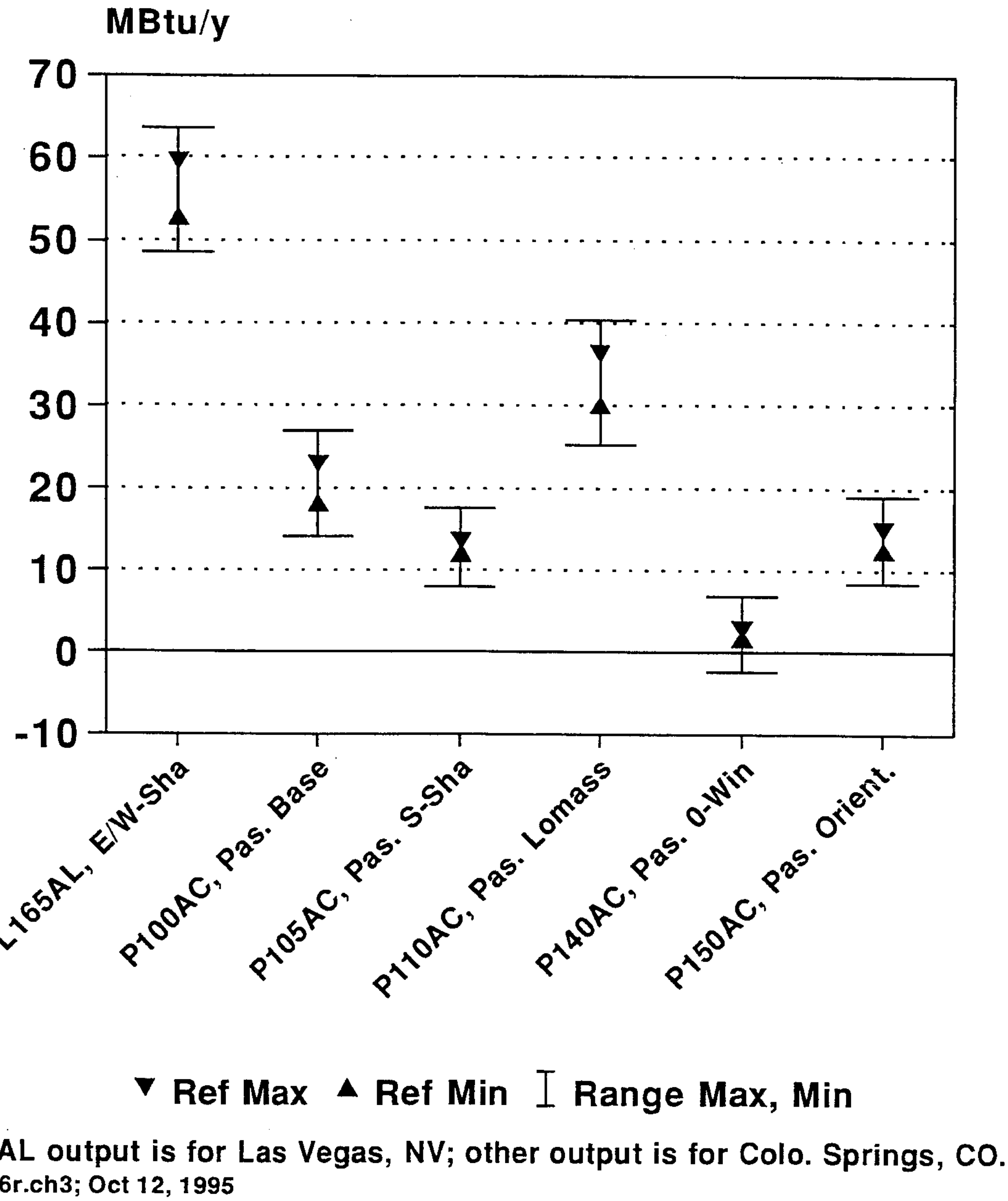


Figure 4-8. HERS BESTEST Tier 2 example range setting—annual cooling load for Colorado Springs, CO

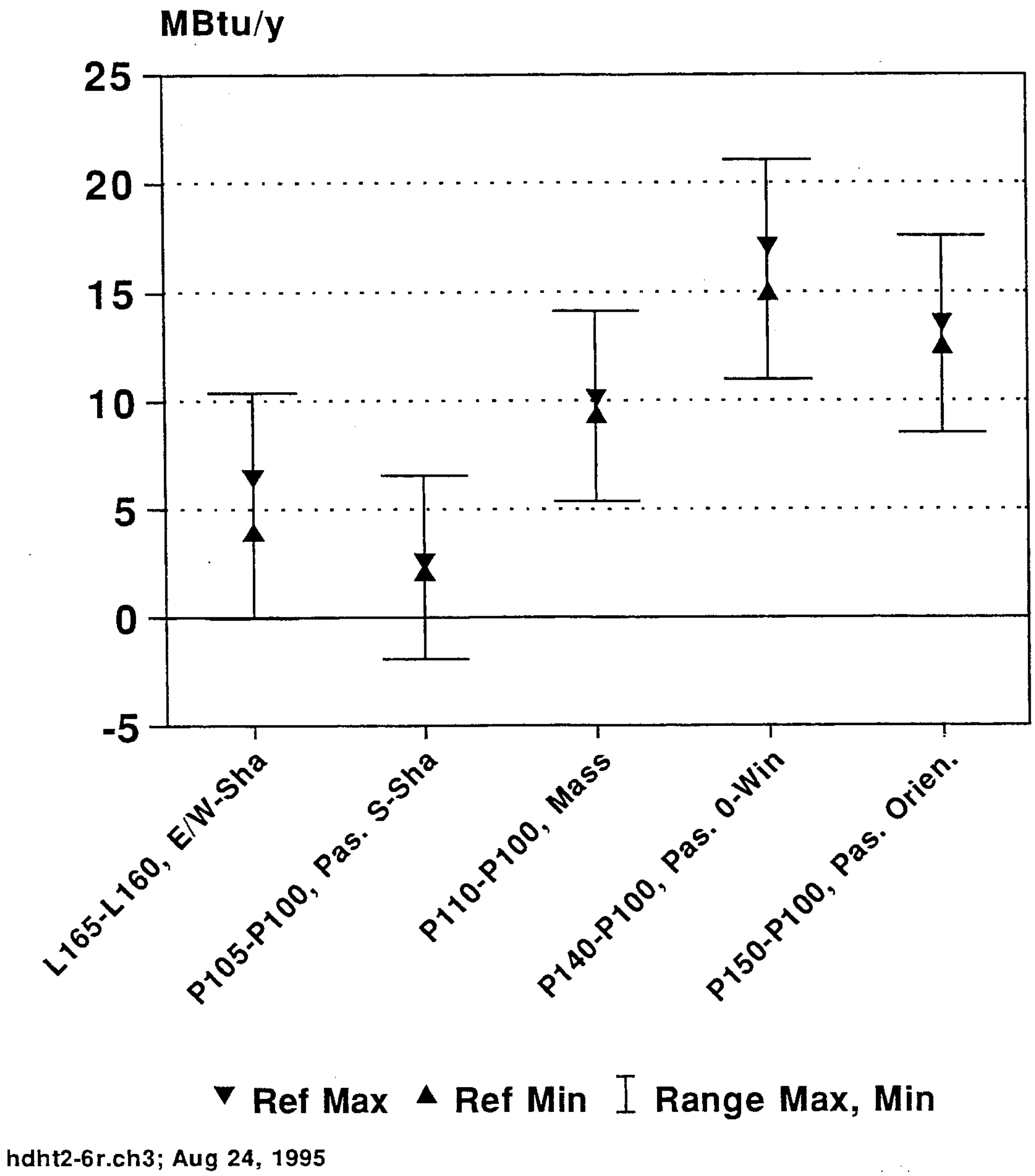
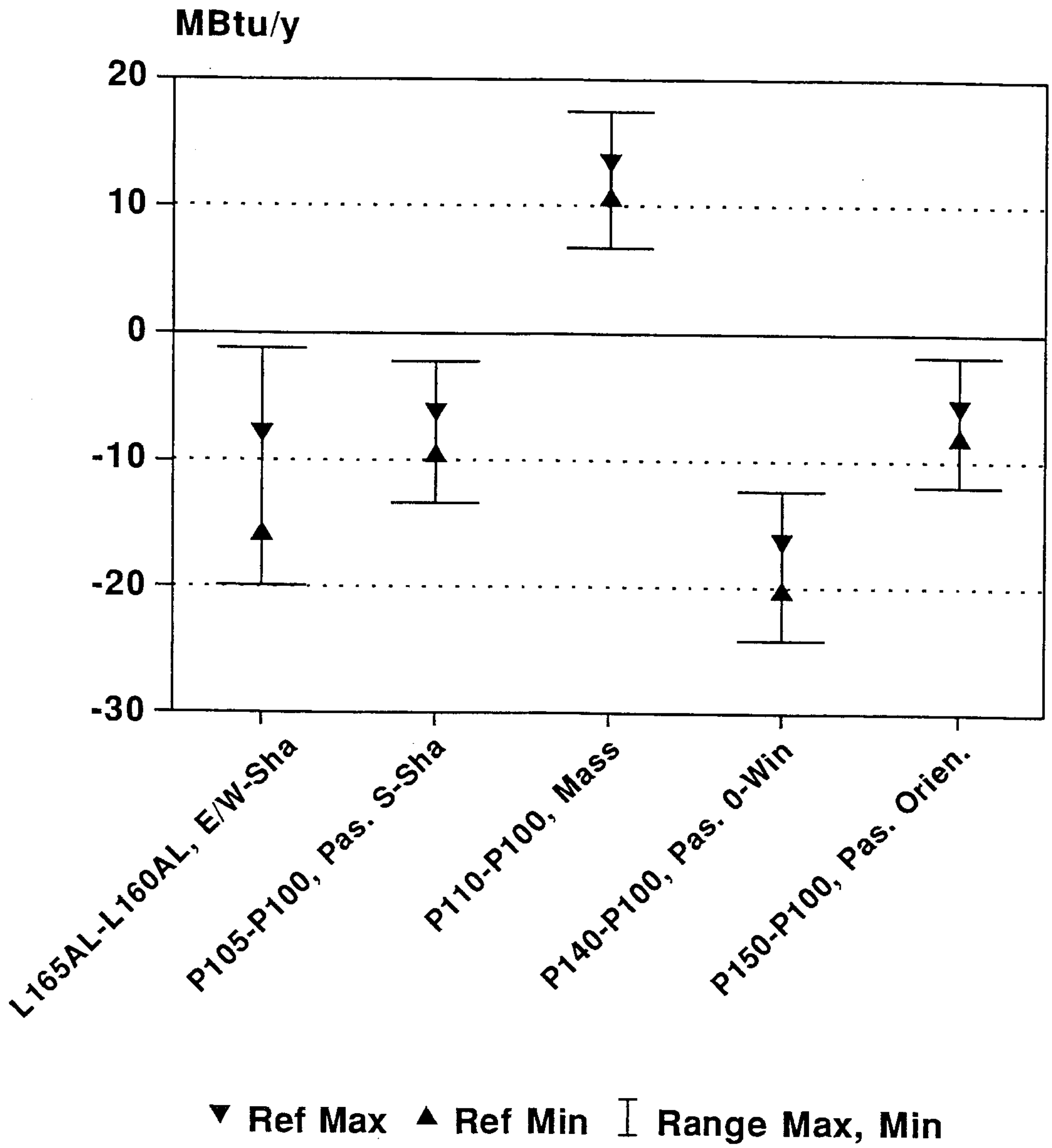


Figure 4-9. HERS BESTEST Tier 2 example range setting—delta annual heating load for Colorado Springs, CO



L165AL-L160AL output is for Las Vegas, NV; other output is for Colo. Springs, CO.
hdct2-6r.ch3; Oct 12, 1995

Figure 4-10. HERS BESTEST Tier 2 example range setting—delta annual cooling load for Colorado Springs, CO

Table 4-4. HERS BESTEST Tier 2 Example Range-Setting Procedure Annual Heating and Cooling Loads

ANNUAL HEATING LOADS, COLORADO SPRINGS hers4.wk3, Range: i:A60..j113; 25-Sep-95

HEATING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L165AC	78.04	64.72	69.87	84.65	55.08	82.04	60.72	84.65	55.08
P100AC	14.40	10.02	12.24	16.76	7.72	18.40	6.02	18.40	6.02
P105AC	16.97	12.10	14.55	19.58	9.53	20.97	8.10	20.97	8.10
P110AC	23.79	20.19	22.12	25.87	18.37	27.79	16.19	27.79	16.19
P140AC	29.42	25.82	28.21	32.49	23.93	33.42	21.82	33.42	21.82
P150AC	27.99	22.58	25.22	30.82	19.63	31.99	18.58	31.99	18.58

ANNUAL SENSIBLE COOLING LOADS, COLORADO SPRINGS, CO (except L165AL = Las Vegas, NV)

COOLING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L165AL	59.59	52.88	55.75	62.90	48.60	63.59	48.88	63.59	48.60
P100AC	23.03	18.11	20.41	25.52	15.29	27.03	14.11	27.03	14.11
P105AC	13.63	11.95	13.01	14.91	11.11	17.63	7.95	17.63	7.95
P110AC	36.49	30.18	32.51	39.65	25.36	40.49	26.18	40.49	25.36
P140AC	2.84	1.67	2.08	3.44	0.72	6.84	-2.33	6.84	-2.33
P150AC	15.03	12.42	13.83	16.55	11.11	19.03	8.42	19.03	8.42

DELTA ANNUAL HEATING LOADS, COLORADO SPRINGS

HEATING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L165AC-L160AC	6.43	3.96	4.98	7.65	2.31	10.43	-0.04	10.43	-0.04
P105AC-P100AC	2.57	2.08	2.31	2.82	1.80	6.57	-1.92	6.57	-1.92
P110AC-P100AC	10.17	9.39	9.88	10.75	9.01	14.17	5.39	14.17	5.39
P140AC-P100AC	17.09	15.02	15.97	18.13	13.81	21.09	11.02	21.09	11.02
P150AC-P100AC	13.60	12.56	12.98	14.11	11.86	17.60	8.56	17.60	8.56

DELTA SENSIBLE COOLING LOADS, COLORADO SPRINGS, CO (except L165AL = Las Vegas, NV)

SENSIBLE COOLING LOAD (MBtu/y) CASE	REF MAX	REF MIN	REF MEAN	REF 90% CONF MAX	REF 90% CONF MIN	REF MAX + 4 MBtu	REF MIN - 4 MBtu	EXAMPLE RANGE MAX	EXAMPLE RANGE MIN
L165AL-L160AL	-7.84	-15.81	-10.55	-1.15	-19.95	-3.84	-19.81	-1.15	-19.95
P105AC-P100AC	-6.16	-9.41	-7.40	-3.77	-11.02	-2.16	-13.41	-2.16	-13.41
P110AC-P100AC	13.45	10.78	12.10	14.86	9.34	17.45	6.78	17.45	6.78
P140AC-P100AC	-16.44	-20.19	-18.33	-14.45	-22.20	-12.44	-24.19	-12.44	-24.19
P150AC-P100AC	-5.69	-8.00	-6.58	-4.01	-9.15	-1.69	-12.00	-1.69	-12.00

Table 4-5. HERS BESTEST Tier 2 Reference Results and Example Range Fuel Cost Summary

"ABSOLUTE" RESULTS

C:hers4.wk3 o:A70..k112 25-Sep-95

CASE	Annual Gas Heating, Note 1 Colorado Springs, CO REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	Annual El. Res. Heating, Note 2 Colorado Springs, CO REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	CASE	Annual Cooling, Note 3 Colorado Springs, CO (Note 4) REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y
L165AC	$524	$50	$111	$1,817	$173	$384	L165AL	$483	$29	$65
P100AC	$92	$16	$46	$318	$57	$161	P100AC	$177	$21	$56
P105AC	$109	$18	$48	$378	$63	$167	P105AC	$113	$7	$42
P110AC	$166	$14	$44	$575	$47	$151	P110AC	$282	$27	$66
P140AC	$212	$14	$44	$734	$47	$151	P140AC	$18	$5	$40
P150AC	$189	$20	$50	$656	$70	$174	P150AC	$120	$11	$46

"DELTA" RESULTS

CASE	Annual Gas Heating, Note 1 Colorado Springs, CO REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	Annual El. Res. Heating, Note 2 Colorado Springs, CO REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y	CASE	Annual Cooling, Note 3 Colorado Springs, CO (Note 4) REF MEAN $/y	REF (MAX-MIN)/2 $/y	RANGE (MAX-MIN)/2 $/y
L165AC-L160AC	$37	$9	$39	$129	$32	$136	L165AL-L160AL	($91)	$35	$81
P105AC-P100AC	$17	$2	$32	$60	$6	$110	P105AC-P100AC	($64)	$14	$49
P110AC-P100AC	$74	$3	$33	$257	$10	$114	P110AC-P100AC	$105	$12	$46
P140AC-P100AC	$120	$8	$38	$415	$27	$131	P140AC-P100AC	($159)	$16	$51
P150AC-P100AC	$97	$4	$34	$338	$13	$117	P150AC-P100AC	($57)	$10	$45

Note 1: Assumes AFUE = 0.8, w/dist eff = 1.0, and $6/MBtu gas.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
Note 2: Assumes AFUE = 1.0, w/dist eff = 1.0, and $26/MBtu electric.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
Note 3: Assumes COP = 3.0, w/dist eff = 1.0, and $26/MBtu electric.
Cost numbers based on 1990 US average fuel costs, increased by roughly 10% for inflation.
Note 4: Except L165AL = Las Vegas, NV
MAX-MIN = difference between maximum and minimum for reference results or example ranges as noted.
RANGE = example range results developed using the algorithm described in the accompanying text.
REF = Reference results using BLAST 3.0, DOE2.1E and SERIRES/SUNCODE 5.7.

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REPORT DOCUMENTATION PAGE

Form Approved
ORB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1995	Technical Report

4. TITLE AND SUBTITLE

Home Energy Rating System Building Energy Simulation Test (HERS BESTEST) Volume 2, Tier 1 and Tier 2 Tests, Reference Results

5. FUNDING NUMBERS

(TA) BE51.4101

6. AUTHOR(S)

Ron Judkoff, Joel Neymark

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

National Renewable Energy laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER

NREL/TP-472-20316

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NA

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

UC-1600

13. ABSTRACT *(Maximum 200 words)*

The Home Energy Rating System (HERS) Building Energy Simulation Test (BESTEST) is a method for evaluating the credibility of software used by HERS to model energy use in buildings. The method provides the technical foundation for "certification of the technical accuracy of building energy analysis tools used to determine energy efficiency ratings," as called for in the Energy Policy Act of 1992 (Title I, Subtitle A, Section 102, Title II, Part 6, Section 271). Certification is accomplished with a uniform set of test cases that facilitate the comparison of a software tool with several of the best public-domain, state-of-the-art building energy simulation programs available in the United States. The HERS BESTEST work is divided into two volumes. Volume 1 contains the test case specifications and is a user's manual for anyone wishing to test a computer program. Volume 2 contains the reference results and suggestions for accrediting agencies on how to use and interpret the results.

14. SUBJECT TERMS

Home Energy Rating System, Building Energy Simulation, Building Energy Simulation Validation

15. NUMBER OF PAGES
50

16. PRICE CODE

A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102