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THERMAL MASS:
BLAST RESIDENTIAL PARAMETRIC SIMULATIONS

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ABSTRACT

This report documents an effort to determine the effect of exterior-wall thermal mass on the annual heating and cooling loads of a typical 1200 ft^2 three-bedroom residence. The effects were determined using BLAST* simulations for an extensive set of parametric variations of exterior wall thermal mass configurations. Simulations were conducted for six different climatic conditions representing the full range of heating and cooling severity, humidity, and solar gains found in the continental U.S. The basic wall configuration consisted either of two layers (a low-mass insulating layer and a thermally massive layer with varying thermophysical properties) or of just a massive layer alone. For the two-layer wall, variations also included placement of the insulating layer either external to or internal to the thermally massive layer. Three hundred and thirteen simulations were performed for each climate, with each simulation yielding annual heating and cooling sensible loads. The complete simulation results are presented as a tabular data base. Several important aspects of behavior were observed in the data: (1) For a particular value of wall thermal resistance, increasing the wall thermal mass always reduces both the heating and cooling loads. (2) The relative sensitivity of changes in the loads due to incremental changes in the exterior wall's thermal resistance or thermal mass varies widely, and is dependent on the particular values for each, the load type, the wall type, and the climate. (3) The relative importance of exterior wall mass for reducing heating loads, as opposed to cooling loads, is strongly dependent on climate. (4) For walls with thermally massive layers, the loads changed when the position of the insulation and massive layers were interchanged. (5) It was generally true that the loads were lower when the insulation layer was outside the mass layer.

A non-linear empirical model that represents the energy use results in the data base as a function of wall thermal mass and thermal resistance was developed. Using this model, least squares fits to the data were carried out separately for heating and cooling loads, for each of the generic wall types, in each climate. The resulting regression coefficients are presented in tabular form. In general, the agreement between the model predictions and the data is quite good, both qualitatively and quantitatively. The shapes of the simulation data curves are all accurately reproduced, and the relative error for individual curve fits ranges from a low of about 0.1% to a high of 3.7%, with overall averages of about 1% for both heating and cooling.

In another part of the effort, selected architectural, engineering, and building use assumptions were varied to determine their effect on the wall thermal mass energy impacts for a limited number of wall configurations. The results indicate that the marginal benefits (in terms of load reduction) of additional thermal mass in the external walls are a decresaing function of how much thermal mass is already present in other parts of the structure.

* BLAST (Building Loads Analysis and System Thermodynamics) is trademarked by the Construction Engineering Research Laboratory, U.S. Department of the Army, Champaign, Illinois.

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1. INTRODUCTION

The Thermal Mass Analysis Project that LBL carried out for ORNL had two major phases: a validation phase in which simulation predictions are compared with measured data collected by other participants in the program, and a parametric simulation phase in which predictions of the effects of various thermal mass configurations in models which represent realistic buildings were developed and analyzed. This report describes the results from the completed second phase of the effort. A companion report contains the results of the first phase [1].‡

All the energy performance simulations for both phases of the project used the building analysis computer program BLAST-3.0.* BLAST is a computerized, comprehensive energy analysis simulation tool that employs a detailed heat balance technique for calculating thermal loads. The program uses an hourly time increment, and correctly accounts for the effects of structural thermal mass on the dynamics of building energy consumption [1]. The general capabilities and characteristics of the BLAST program are described in references [2-5].

The second phase, described in this report, consisted of the determination by simulation of the annual sensible heating and cooling loads for an extensive set of parametric variations of wall thermal mass configurations for a typical residence. The general approach was to select a single-family detached residence which had average current practice thermal integrity, design, and use characteristics as a prototypical reference building. The simulated energy performance of this prototypical building in a range of U.S. climates was used as a baseline reference. The baseline configuration was then modified to reflect the incorporation of thermal mass into the exterior walls in varying ways and amounts. The energy performance of these modified configurations was then

‡ Numbers in brackets indicate references cited at the end of this report.

* BLAST (Building Loads Analysis and System Thermodynamics) is trademarked by the Construction Engineering Research Laboratory, U.S. Department of the Army, Champaign, Illinois.

simulated and compared to the baseline energy performance. All the results are contained in a data base, which is presented as an appendix to this report. Finally, a non-linear empirical model that represents the energy use results in the data base as a function of wall thermal mass and thermal resistance was determined by non-linear least squares fits to the data. The form of this model, and empirically determined fitting coefficients are presented and discussed. In a related effort, other architectural, engineering, and building use assumptions were also selectively varied to determine their effect on the wall thermal mass energy impacts for a limited number of wall configurations.

2. PARAMETRIC PLAN

2.1. Baseline Residential Prototype

The specific house design used for this effort was a 1200 ft^2 three-bedroom residence based on plans developed by the Tennessee Valley Authority (TVA) for a passive solar demonstration project. Choices for layout, materials, and constructions were taken from detailed blueprints. The TVA design is similar to one developed by S. R. Hastings of NBS [6]. Figure 1 shows a plan view of the basic TVA design. Insulation levels, window areas, and window thermal integrity of the design were modified to reflect thermal integrity requirements of typical energy performance standards for most U. S. locations [7]. In addition, the present thermal models are compatible with the modified Hastings Ranch prototype which was used to develop proposed energy budgets for the DOE Building Energy Performance Standards (BEPS) effort with respect to window areas and orientation, internal loads, infiltration rates, and interior temperatures [8].

The BLAST thermal model of the prototype consists of an unconditioned attic and a conditioned space representing the occupied part of the house. The conditioned space has been further subdivided into three thermal zones in a manner consistent with the original TVA design. BLAST requires the specification of thermostat setpoints separately for each of the conditioned zones, which is somewhat different than the single thermostat typically found in residences. The loads impact of this assumption is minimized by the fact that BLAST also models interzone air mixing (with associated heat transfer) to represent open doors between rooms. Figure 2 shows how the thermal model was subdivided. Another important feature of the thermal model includes the separate simulation of heat flows through the stud and insulated cavity portions of the external walls.

Details of materials, constructions, internal loads, infiltration rates, and temperature controls that were assumed are described below.

- *Materials*: The ranges of thermophysical properties for the materials used in the model and its parametric variations are chosen to be consistent with values measured or assumed for test cells constructed by the National Bureau of Standards [9] and the New Mexico Research and Development Institute [10-12] in a related project that directly measured the energy performance of thermally massive constructions. Values not specified from these sources are taken from the ASHRAE **Handbook** [13] and, although typical for the materials, should not be considered definitive.

- *Exterior Walls*: The exterior walls were assumed to be of uniform construction (except for the windows). Variations of the exterior wall construction for the thermal mass parametrics will be discussed in the next section.
- *Floor*: The base case floor consisted of two inches of insulation (R-10) in a massless slab-on-grade configuration, in order to determine the maximum effects of wall thermal mass by minimizing the amount of thermal mass present in other parts of the house structure. A realistic concrete slab was modeled as one of the configurational variations described in the last section of this report.
- *Ceiling*: The ceiling consisted of surface gypsum board, nominal R-19 insulation, and was thermally connected to an unconditioned, naturally ventilated attic.
- *Windows*: The baseline case consists of double glazing. Window areas are consistent with BEPS assumptions: 44 square feet on the North, South, East and West facades, respectively. The windows are assumed to have interior shades with an effective solar absorption of 0.5. (The solar energy absorbed by the shade is assumed to appear as an immediate convective load in the zone air; solar energy transmitted through the shades is distributed onto the interior surfaces in the zone.)
- *Interior Partitions*: Gypsum board faced wood-frame cavity walls were assumed throughout the prototype. The same amount of internal partitioning contained in the TVA design has been included so that the thermal storage effect will be the same.

- *Furniture*: The thermal mass of furniture and contents was approximated by an internal surface construction of two-inch thick wood, with the amount and surface area chosen to be representative of 8,500 *lb* of contents. The effect of sunlight incidence on furniture in increasing the instantaneous convective load in the conditioned space was accounted for by increasing the shade solar absorptance (described in the window description above) by an appropriate amount.

- *Temperature Schedules*: Interior temperature in the occupied zones were maintained in the range from 70 °F to 78 °F (BEPS consistent). Night setback to 60 °F was assumed from 11 pm to 7 am. In the simulation, the temperature was allowed to float between those limits without causing any load. The attic temperature was allowed to float totally unconstrained.

- *Internal Loads*: Internal loads were based on the assumed maximum values and the schedules for typical energy performance standard assumptions, as seen in reference [8]. The specific profiles made for this study differ slightly from the typical profiles given in [8] on an hourly basis, but have the same daily totals. Table 1 below shows the actual hourly values used for each zone and the sum of all zones. Typical energy performance standard building total internal loads are shown for comparison. The same internal loads are assumed for all days of the annual simulation analyses.

- *Infiltration*: For the conditioned space, an annual average air exchange rate of 1.0 air change per hour was assumed, with the actual hourly values dependent on wind and temperature difference conditions at that time. Wind and temperature-difference dependence were assumed to be those defined by the Achenbach-Coblentz equation [14]. For the attic, an average rate of 2.0 air changes per hour was assumed.

- *Natural Ventilation*: The house was assumed to be vented at a rate of 5 air changes per hour when the outside air temperature was less than the cooling thermostat setpoint and ventilation cooling could beneficially offset mechanical cooling. Note that this limits this study to the effects of thermal mass on the sensible loads, and does not take into account the potential impact of latent loads in determining the actual number of cooling hours in hot, humid climates such as Miami. The analysis done is consistent with the scope of this study, which was limited to basic space loads, instead of actual building energy use if the equipment were also to be modeled, in the belief that a fundamental understanding of mass correlations based on sensible loads as the most basic house energy performance quantities could subsequently be expanded to impacts on energy use in a straightforward manner.

TABLE 1. PROTOTYPE INTERNAL LOAD PROFILES (Btu/hr)

Hour	East Zone	South Zone	North Zone	Total	Ref. [8]
1	905	486	0	1392	1078
2	905	486	0	1392	1078
3	905	486	0	1392	1078
4	905	486	0	1392	1078
5	905	486	0	1392	1078
6	905	486	0	1392	1801
7	1361	540	53	1956	2263
8	3134	599	791	4525	4526
9	1023	104	103	1231	2641
10	1023	103	207	1336	1616
11	1023	103	207	1336	1616
12	1959	103	207	2271	2155
13	1959	103	207	2271	1616
14	1023	103	207	1336	1348
15	1023	103	207	1336	1401
16	1023	103	207	1336	1401
17	1023	103	207	1336	2048
18	4453	53	53	4561	2209
19	3461	549	549	4561	2371
20	2400	549	549	3500	3718
21	2400	549	549	3500	3718
22	2400	549	549	3500	3880
23	2333	495	686	3515	3880
24	905	486	0	1392	3503
Total	39353	8212	5538	53103	53100

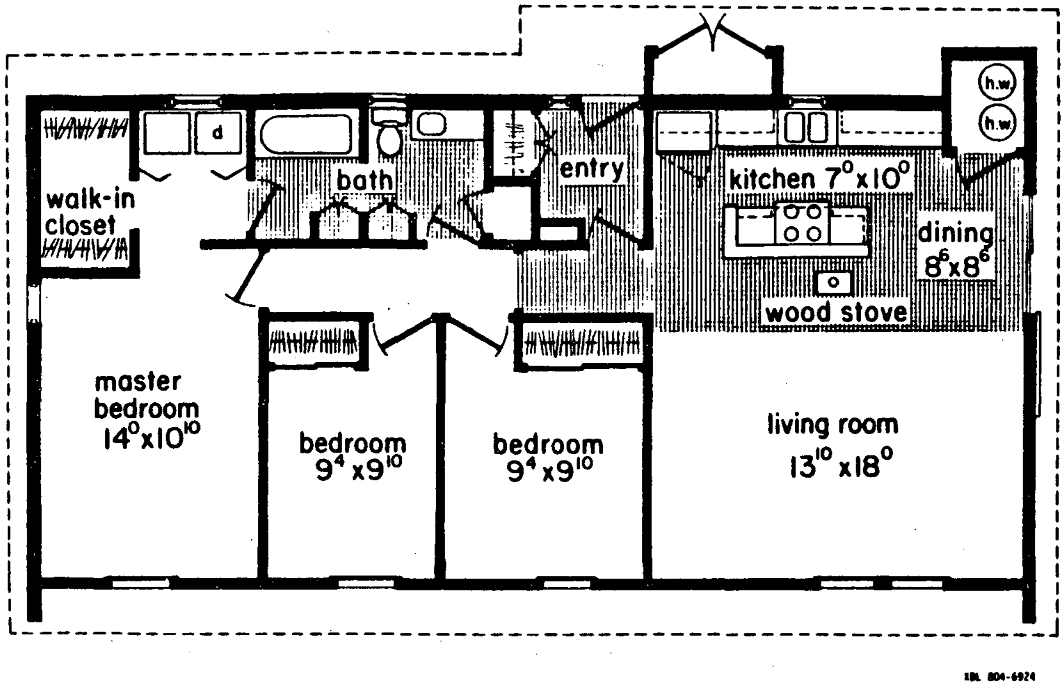

Figure 1. Architectural floor plan for baseline prototype residence.

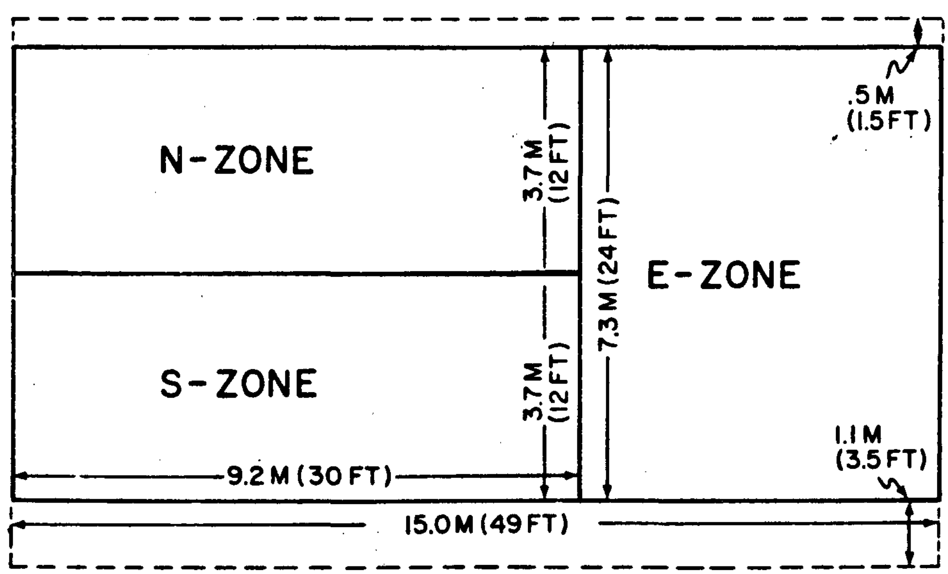

Figure 2. Plan view of the three-conditioned-zone thermal model based on prototype design. Zone 1, not shown, is the unconditioned attic.

2.2. Parametric Variations

The residential prototype was systematically changed in two major ways to explore the effect of thermal mass. The first of these concentrated on variations in the construction of the exterior walls, with other assumptions about the configuration and operation of the house left unchanged. The second part of the effort focussed on a limited number of wall designs, and examined the effect on space loads for selected changes in other aspects of the building configuration or the operating assumptions. These various parametrics are described in detail in the next two subsections.

2.2.1. Exterior Wall Variations

These parametric variations concentrated on a combination of systematic changes to the values of the thermophysical properties of the exterior walls. The basic wall configuration consisted either of two layers, a low-mass insulating layer, and a thermally massive layer with varying thermophysical properties, or of just the massive layer alone. Parametric variations were performed separately for different generic wall types, consisting of the insulating layer either external to or internal to the thermally massive layer. Parametric variations of the composite wall were formed by combinations of variations in each of the layers individually over the following ranges:

Insulation Layer	Thermal Resistance:	0, 5, 20 $hr \cdot ft^2 \cdot {}^\circ F/Btu$
Thermal Mass Layer†	Thermal Conductivity:	0.0 - 1.0 $Btu/hr \cdot ft \cdot {}^\circ F$
	Density:	0 - 150 lb/ft^3
	Specific Heat:	0.3 $Btu/lb \cdot {}^\circ F$
	Thickness:	0 - 1.5 ft

Sufficient intermediate values were used for each parameter to allow the thermal mass and thermal resistance effects to be distinguished in the subsequent development of correlations.

† The specific combinations of thickness and thermal conductivity that were chosen led to thermal resistances for the thermally massive wall layer in the range 0.3 to 21.4 $hr \cdot ft^2 \cdot {}^\circ F/Btu$.

2.2.2. Configuration and Operation Variations

Parametric variations for assumptions other than the walls have been selected based on their expected importance in affecting the influence of a particular amount and configuration of exterior wall mass. They were separately performed for two external wall configurations, representative light frame and masonry block constructions. In each case, the wall was designed to represent the multiple layers that would be seen in typical actual construction practice. To make the effects of the varying mass more apparent and to facilitate comparisons, both walls had the same thermal resistance (R-13.8). Finally the variations were made only one at a time to the baseline configuration. The actual variations chosen were:

1. *Reduced Thermostat deadband*: The heating and cooling thermostat settings were changed from the baseline values of 70 °F and 78 °F, to 72 °F and 76 °F, respectively.
2. *No Night setback*: The night setback assumption was removed.
3. *No Natural ventilation*: The natural ventilation cooling assumption was removed.
4. *Reduced infiltration*: The annual average infiltration rate was assumed to be 0.5 air changes per hour, one-half of the baseline value.
5. *Window solar gains*: While leaving the total window area constant in order to not change the overall envelope U-value, the window shades were removed. (This causes a redistribution of the half of the solar gains that were an immediate convective load into transmitted gains that are absorbed by the interior surfaces of the house.)
6. *Thermally massive floor*: A four-inch concrete slab was added to the floor construction above the insulating layer. (While not typical construction practice in all regions of the U.S., this variation was simulated the same way in all cities for consistency of results.)

2.3. Climate Site Selection and Weather Data

Six climates representing actual cities in the continental U.S. were used for both the wall and configuration variation phases of the parametric study. The particular cities chosen represent the full range of selected climatic parameters representing heating and cooling severity, humidity, and solar gains. Table 2 shows the six selected cities and their associated climate parameters.

The parametric simulations used detailed hourly weather data for the selected cities. For this project, ASHRAE Typical Meteorological Year (TMY) weather data were used [15], with the addition of an hourly sky emissivity parameter for simulating long-wavelength radiation from external building surfaces [16].

TABLE 2. CLIMATE CHARACTERISTICS OF SIMULATION LOCATIONS

Climate City	Climate Parameter†			
	HDD	CDD	LEH	$\overline{K}_T$
Minneapolis	8158	585	1770	0.490
Denver	6016	625	5	0.620
Washington	5008	940	3734	0.470
Atlanta	3094	1588	4931	0.500
Phoenix	1552	3506	968	0.690
Miami	205	4037	27753	0.500

† HDD, CDD: annual heating and cooling degree days, base 65 °F; LEH: annual latent enthalpy hours, a measure of the moisture removal or addition needed to maintain comfort; K_T: annual average fraction of horizontal solar insolation transmitted through the atmosphere.

3. WALL PARAMETRICS

3.1. BLAST Simulation Results

For each of the six cities for which simulations were performed, there were five generic wall configurations: the thermally massive single-layer homogeneous wall (73 simulations), and the four two-layer configurations where the thermally massive layer was combined with R-5 or R-20 insulating layers on either the inside or outside, respectively (60 simulations for each). Thus, a total of 313 simulations were performed for each climate. Each simulation yielded annual heating and cooling sensible loads. All of the simulation results are presented in tables in Appendix 1. For each city, there are five tables, one for each of the generic wall configurations. In each table, simulation results for each configuration are presented along with the values of the thermophysical properties of the thermally massive layer that completely define the particular wall configuration. The configurations in each table are arranged in increasing order of first the thermal resistance, and then the mass (as represented by the product of the thickness and density) of the thermally massive layer.

An examination of the results clearly shows regular variations of the loads, both with variations in the wall thermal resistance, and with the thermal layer mass. Additionally, the same pattern of variation was observed for all generic wall types, and for all climates. In general, the data tended to form families of curves: data for one generic wall type in one climate would separate into a series of related curves, where each curve is produced by the data points at various thermal mass levels, for a particular thermal resistance. Figure 3 shows a sample set of data for one generic wall type in one climate. (The lines connecting the data points on this figure are only meant to aid the eye in connecting points of equal thermal resistance, and are not a curve fit of any kind.)

Three types of behavior were observed in all the data. First, for a fixed wall thermal resistance, both the annual heating and cooling loads always decreased with increasing mass. This was true for all generic wall types in all cities. Second, for a fixed wall mass, the annual heating and cooling loads varied smoothly with increasing thermal resistance. This variation was almost always a decrease with increasing resistance at low mass levels. However, at intermediate and high mass levels in some climates, the variation sometimes exhibited more complex behavior, showing first a decrease and then a minimum and subsequent increase, or just an increase in load for increasing resistance (see, *e.g.*, Fig. 8). This suggests caution in applying existing design intuition in regimes of simultaneously high thermal resistance and high thermal mass. Third, for other than massless walls, the loads for different generic wall types with the insulation layer position inverted, but with the same total resistance were different. It was generally true that the loads were lower when the insulation layer was outside the mass layer.

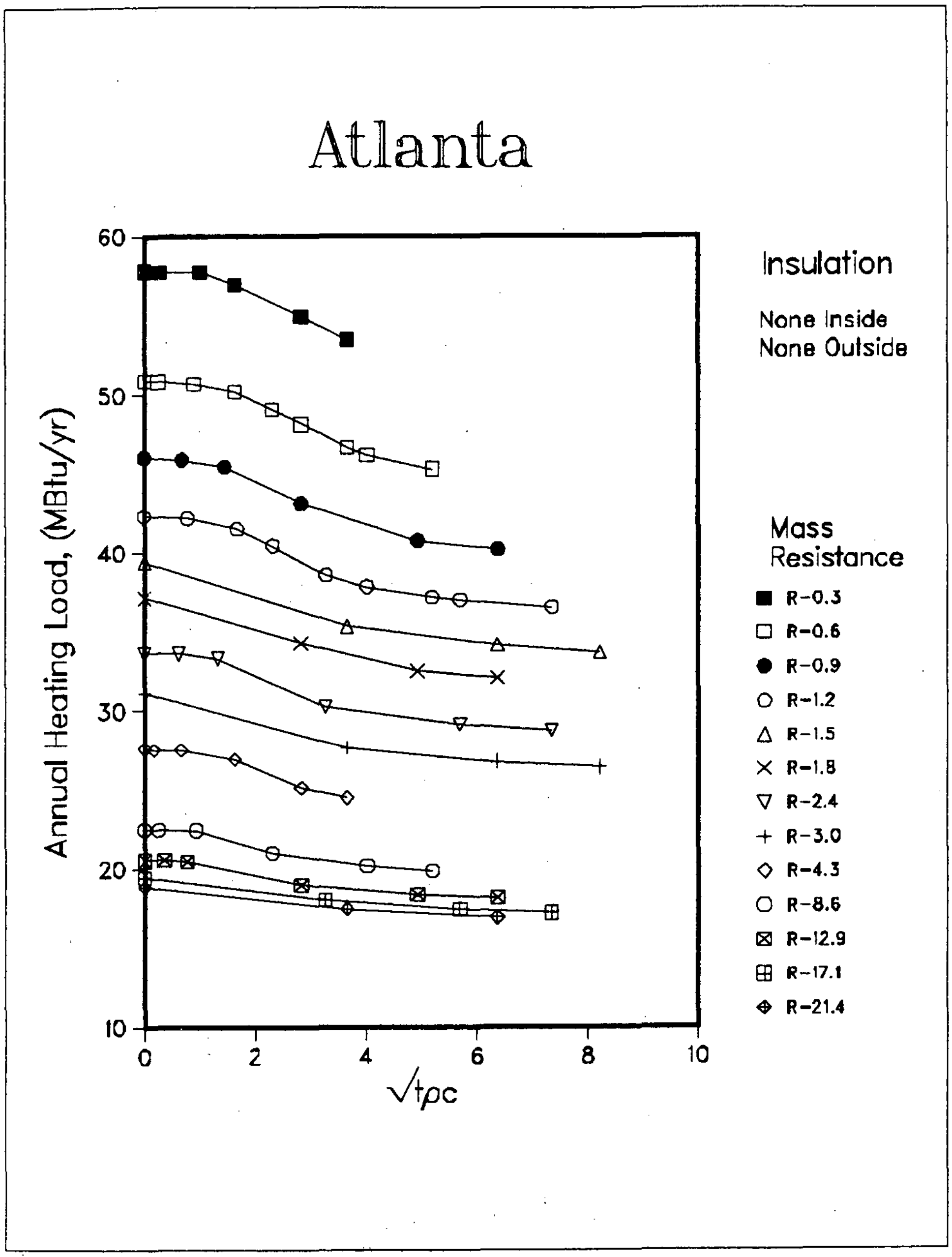

Figure 3. Sample data set of BLAST annual heating simulation results for a single-layer wall type. The straight lines connecting the data points with the same thermal resistance are meant only as an aid for the eye.

3.2. An Empirical Model For Representation Of The Results

Since both the annual heating and cooling loads showed a regular variation with both wall thermal resistance and with massiveness, an effort was made to see whether or not a simple analytical model could be found and fitted to the data base, and that could subsequently be used to predict the observed variations in the data base.

The effort began with a search for a thermal mass characterization parameter for the wall configurations, analogous to the thermal resistance. Ideally, such a parameter should be able to explain the observed simulation results for all of the generic wall types (and in particular the differences due to the inside or outside position of the insulation layer) in the same analytic form of a representational model.

Models of the dynamic heat transmission performance of isolated walls under simple sinusoidal temperature boundary conditions were studied. Details of the analytical development of time-dependent heat transmission under these conditions is generally available in the literature [17-19]. The analytical development results in a complex-variable transmission matrix that relates four quantities (temperature and heat flux at the inside and outside boundaries of a wall) such that if any two of the quantities are known, the remaining two can be derived. The transmission matrix can be calculated for either single-layer or multi-layer walls, based solely on the thermophysical properties of the layers and their location within the wall.

For homogeneous walls, the transmission matrix elements are analytical expressions that all depend on a key dimensionless quantity:

$$\sqrt{(\frac{\pi}{24})\cdot R_m \cdot (t \cdot \rho \cdot c)}\ ,$$

where R_m, t, ρ, and c are the thermal resistance, thickness, density, and specific heat, respectively, of the wall layer material. (This entire quantity is variously called **k** l, ϕ, or γ, in references [17-19].) Since we were interested in separating thermal resistance effects from thermal mass effects, we concentrated on the applicability of the following expression as the thermal mass variable:

$$\mu = \sqrt{t \cdot \rho \cdot c} \ . \tag{1}$$

In particular, we attempted to see whether or not this quantity would explain the differences in loads for different insulation positions, but the same thermal resistance. The multilayer wall transmission matrix can be used to calculate an "effective" μ. The complication is that *four* effective μs can be backed out of the transmission matrix (one from each of the matrix elements), and all of them are different.‡ In this effort, all four were calculated for all of the multilayer wall configurations, and none of them seemed to "collapse" the data for the different generic wall types (particularly the insulation inside/outside difference) into a consistent set of data that could be represented by a single analytical expression, and only one set of regression coefficients.

Another unsatisfying aspect of the effective μ is that if the boundary conditions are air temperatures, not surface temperatures, then the properties of the inside and outside air film coefficients become a necessary part of the transmission matrix calculation, which means that the wall characterization is dependent on conditions that are not a physical part of the wall (which may be a fact of life). However, effective μs were calculated assuming reasonable values for the film coefficients, and these still did not collapse the data. For these reasons, it was decided to calculate an overall μ_T for an N-layer wall by the simple additive formula:

$$\mu_T = \sqrt{\sum_{i=1}^{N} \mu_i^2} = \sqrt{\sum_{i=1}^{N} t_i \rho_i c_i} \ , \tag{2}$$

and to use it in the same analytical model, but with separate regressions to the data for the different generic wall types. (This particular form was motivated by some early developments of Mackey and Wright [20].) Values of μ were calculated using Eq. (2) for

‡ For each of the four elements of the multi-layer wall transmission matrix, a numerical value can be calculated from the thermophysical properties and ordering of the wall layers. An effective μ can be calculated for each by equating the numerical value for a particular multi-layer wall matrix element to the analytical expression for the corresponding single-layer matrix element, which contains the variable μ. The resulting equation can then be solved numerically for μ.

all wall configurations, and are presented in the data base tables in Appendix 1.

The general shape of the variation of both the heating and cooling loads with μ was the same for the full range of resistances simulated. By trial and error the following analytical form, of similar shape to the data, was chosen as the basis of the nonlinear regression model:*

$$F(x) = \frac{1}{\sqrt{½(cosh(2x) + cos(2x))}}.$$

$F(x)$ varies from 1 at $x = 0$ to 0 as $x \rightarrow \infty$ in a smooth, S-shaped curve. When enough parameters are introduced to allow a curve of this general shape to take on arbitrary, specified values for the load at zero mass (L_0) and infinite mass (L_∞), and a further arbitrary "stretching" factor β, the final form used for the model becomes:

$$L(\mu) = L_\infty + \frac{(L_0 - L_\infty)}{\sqrt{½(cosh(2\sqrt{\pi/24\beta\mu}) + cos(2\sqrt{\pi/24\beta\mu}))}}. \quad (3)$$

This model was then used in a series of least-square fits to the data. Although the model represented by Eq. (3) fits well the individual curves formed by the data points of a particular resistance, it was found by examining the various values of L_0, L_∞, and β obtained from the fits for various resistances in a family of such curves, that L_0 and L_∞ were smooth inverse functions of R, and that β was not strongly dependent on R and could reasonably be assumed to be a constant.† Therefore, if the following forms are assumed for L_0 and L_∞:

$$L_0(R) = a_0 + \frac{b_0}{c_0 + R}, \quad (4)$$

$$L_\infty(R) = a_\infty + \frac{b_\infty}{c_\infty + R}, \quad (5)$$

then an entire family of data curves including the data for all simulated values of R for

* This analytical form arises from a particular combination of the transmission matrix elements described above that determines the temperature wave amplitude reduction ratio from outside to inside under floating interior temperature conditions (*i.e.*, no zone heating or cooling).

† At zero mass, the dependence of L_0 on R is equivalent to the fact that loads are simply linearly dependent on the thermal conductance of the exterior walls, all other things being equal, and should not be a surprising result. However, the similar dependence of L_∞ on R is, at this time, empirical.

a generic wall type can be regressed simultaneously to determine the seven regression parameters a_0, b_0, c_0, a_∞, b_∞, c_∞, and β, and $L(\mu)$ in Eq. (3) becomes more generally a function of two parameters $L(\mu,R)$. Here, R is the total thermal resistance of all the wall layers in the case of multilayered walls.

3.3. Regression Results

The regression procedure described above was carried out separately for heating and cooling loads, for each of the generic wall types, in each climate. The actual least-square fitting routines used were from the Numerical Algorithms Group software library [21] (details of the numerical methodology used in this library is described in reference [22]). Values for the empirically fitted coefficients are presented in Tables 3 and 4 for heating and cooling, respectively. The residual presented in the tables is normalized by the size of the data at each point of comparison in order to facilitate comparisons between fits for different data sets and is calculated from:

$$residual = \sqrt{\frac{1}{M} \cdot \sum_{i=1}^{M} \frac{(L_i^{data} - L_i^{model})^2}{L_i^{data}}} , \qquad (6)$$

where M is the number of data points used in the regression.

This residual is directly related to the quantity that is minimized in the least-squares fitting procedure.

TABLE 3

LEAST-SQUARE-FIT COEFFICIENTS FOR ANNUAL HEATING DATA

Location	R_{in}	R_{out}	a_0	b_0	c_0	a_∞	b_∞	c_∞	β	residual†
Atlanta	0	0	15.9314	64.2415	1.2338	14.4956	46.8428	0.9556	1.3962	0.0248
	0	5	16.1665	60.8162	1.0359	15.1429	35.7408	-0.0725	1.9034	0.0231
	0	20	16.9222	25.0520	-8.1642	5.7952	3239.2632	282.9977	2.0125	0.0337
	5	0	16.2132	60.1136	0.6504	15.8694	39.0165	-0.6041	1.6216	0.0168
	20	0	16.8493	26.7248	-8.8478	15.9852	34.8796	-6.0667	1.7233	0.0105
Denver	0	0	30.8964	121.2755	1.2065	27.7528	86.8409	0.9254	1.4173	0.0471
	0	5	31.2040	116.1757	0.9669	28.9840	68.6093	0.0579	2.0778	0.0293
	0	20	32.0603	64.7397	-6.4020	18.7489	3379.5690	249.8157	2.3069	0.0414
	5	0	31.3802	112.2922	0.5012	30.6171	75.9145	-0.4301	1.7678	0.0292
	20	0	32.1250	58.3760	-8.2411	31.2284	55.5623	-7.0011	1.9281	0.0151
Miami	0	0	0.5648	4.2204	0.9925	0.3235	0.0357	-4.3512*	0.9402	0.0826
	0	5	0.6657	3.3662	-0.0004	2.9654	-1186.2252	441.4991	1.5145	0.0308
	0	20	0.7094	0.9351	-12.6737	0.5586	-4.4470	-5.4773	1.5890	0.0263
	5	0	0.6101	3.2909	-0.9259	0.5553	-0.0404	-17.3405*	1.1032	0.0505
	20	0	0.6321	3.6074	-4.3679	0.6007	0.1258	-19.3504	1.4980	0.0104
Minne-apolis	0	0	61.0258	163.4436	1.2080	58.6036	153.5281	1.1664	1.2734	0.0133
	0	5	61.4601	154.9795	1.0317	58.7955	150.9418	1.0442	1.6796	0.0222
	0	20	62.8498	81.4226	-5.3635	57.1179	255.1081	9.0597	1.8152	0.0260
	5	0	61.2456	161.9715	0.9991	59.9590	154.9757	0.9059	1.4044	0.0104
	20	0	62.4166	93.4299	-5.6313	58.9382	210.6106	2.9244	1.2521	0.0076
Phoenix	0	0	4.9733	32.6933	1.2095	4.0425	8.4072	0.4202	1.4210	0.1012
	0	5	5.4011	26.4309	0.2421	4.4773	4.4912	-1.1877	2.1200	0.0403
	0	20	5.7276	8.3152	-12.4365	4.5596	-1.3703	-17.6192	2.3282	0.0512
	5	0	5.4655	25.0209	-0.3735	5.0191	8.5302	-2.1553	1.8245	0.0460
	20	0	5.6817	9.3710	-12.3480	5.2384	6.5192	-11.9537	2.0061	0.0192
Washing-ton	0	0	27.5996	97.6486	1.2430	25.5923	79.0034	1.0607	1.2769	0.0195
	0	5	27.9049	92.7980	1.0571	26.0243	72.9220	0.6580	1.7867	0.0260
	0	20	29.0028	38.0947	-7.8222	23.6505	280.7526	30.6683	1.8963	0.0345
	5	0	28.0483	90.8579	0.6624	26.7460	80.2359	0.4186	1.4995	0.0168
	20	0	28.7958	43.8203	-8.0218	26.4147	104.5749	0.3225	1.5070	0.0109

† See text for definition.
* See text for discussion of singularities.

TABLE 4

LEAST-SQUARE-FIT COEFFICIENTS FOR ANNUAL COOLING DATA

Location	R_{in}	R_{out}	a_0	b_0	c_0	a_∞	b_∞	c_∞	β	residual†
Atlanta	0	0	16.2598	26.3387	1.1793	13.7842	3.9123	0.1373	1.4577	0.0856
	0	5	16.8265	16.6722	-0.5527	17.1264	-177.5011	49.9251	1.9234	0.0330
	0	20	16.9243	4.3532	-13.2304	15.3490	-16.0481	-13.9377	2.0759	0.0420
	5	0	16.5631	9.0329	-2.1461	15.8704	-0.0128	-5.9681*	1.4940	0.0538
	20	0	16.5768	4.0132	-15.4750	16.3452	-0.0122	-22.0651	1.7066	0.0203
Denver	0	0	12.2904	15.2797	0.9025	30.9928	-3422.0604	138.8511	1.4129	0.1641
	0	5	12.6616	8.9690	-1.4493	11.3487	-43.7365	5.7151	2.0994	0.0451
	0	20	12.8770	-0.2530	-27.1811*	10.8145	-20.5797	-14.0879	2.2047	0.0598
	5	0	12.4268	3.7633	-3.1653	22.5919	-3295.2737	263.4478	1.8579	0.0619
	20	0	12.2956	2.3078	-16.8612	17.3384	-3258.2991	559.6005	2.1518	0.0247
Miami	0	0	35.5967	54.2178	1.1699	33.6588	27.7076	0.7264	1.5972	0.0490
	0	5	36.2959	43.0483	0.2927	34.7220	11.1142	-1.3610	1.8760	0.0226
	0	20	36.2984	27.0289	-5.4435	35.3094	-10.1267	-14.7416	2.0426	0.0282
	5	0	35.8875	33.8318	0.2568	35.6213	10.9852	-2.7312	1.8272	0.0212
	20	0	34.5895	72.8429	3.6657	36.5389	-0.0134	-21.5641	1.1419	0.0249
Minne-apolis	0	0	9.9376	13.8387	1.0830	7.5985	0.9565	-0.0798*	1.3890	0.0913
	0	5	10.2704	7.7542	-1.0455	9.4310	-33.6124	10.5818	1.8469	0.0418
	0	20	10.2827	1.0481	-15.7742	9.0265	-13.3786	-13.9445	1.9512	0.0493
	5	0	10.0714	4.4066	-2.4744	9.2345	-0.0042	-9.2903	1.5041	0.0399
	20	0	10.0433	1.7398	-16.6459	9.7484	-0.0393	-28.0321*	1.7208	0.0172
Phoenix	0	0	39.3127	67.9850	1.1705	37.4054	33.9086	0.7624	1.7087	0.0665
	0	5	40.0198	54.3918	0.2270	38.3426	21.2082	-0.3661	2.2561	0.0201
	0	20	40.2555	27.1127	-8.9026	38.8723	-3.7933	-17.3402	2.4411	0.0258
	5	0	39.7153	42.1412	0.0009	39.3707	16.7806	-2.0861	2.0539	0.0305
	20	0	39.7011	27.5100	-8.8706	39.9093	6.5638	-14.7018	2.5320	0.0127
Washing-ton	0	0	12.5459	19.6133	0.9830	10.2702	0.4757	-14.3038*	1.2030	0.1640
	0	5	13.1256	12.6027	-0.9326	12.1393	-43.8398	12.3478	1.9257	0.0330
	0	20	13.7924	1.7826	-36.9205*	10.0161	0.4680	-23.6863*	2.3607	0.1279
	5	0	12.9142	7.4029	-2.2239	11.9533	-0.0330	-9.2497*	1.5806	0.0521
	20	0	12.8402	3.9161	-15.1847	12.5476	-0.0409	-24.0794*	1.8774	0.0198

† See text for definition.
* See text for discussion of singularities.

A number of observations about the model, its predictive capability, and its limitations can be made:

- *Predictive Error*: An additional, perhaps more intuitive, measure of the ability of the model to fit the data than the residual defined in Eq. (6) is the absolute (or percentage) relative error:

$$\Delta_{abs} = \frac{1}{M} \cdot \sum_{i=1}^{M} \frac{|L_i^{data} - L_i^{model}|}{L_i^{data}} . \qquad (7)$$

Average values for the absolute relative error, for all generic wall types for a particular location, are shown in Table 5; they range from a low of about 0.1% to a high of 3.7%, with overall averages of about 1% for both heating and cooling. The worst individual cases were Miami, no insulation inside or outside, at 6.4% for heating, and Denver, no insulation inside or outside, at 3.6% for cooling.

TABLE 5. RESIDUAL ERROR SUMMARY

Location	Average Δ_{abs} (%)	
	Heating	Cooling
Atlanta	0.37	0.87
Denver	0.37	1.63
Miami	3.68	0.36
Minneapolis	0.14	1.18
Phoenix	1.51	0.36
Washington	0.28	1.68
Average	1.06	1.01

- *Range of applicability of coefficients*: Because of the asymptotic nature of the behavior of loads as a function of μ it is probably acceptable to apply the model for any value found in an actual wall (very few walls would have values greater than those covered in this study). However, for thermal resistance, the model and the fitted coefficients for the different generic wall types must be used with care. They should be used with the general constraint that they are valid only for interpolation within the range of parameter values represented in the BLAST simulation data base from which they were derived, and not for extrapolation beyond those values. For example, the fits for walls without either inside or outside insulation should only be used to predict loads for wall resistances between R-0 and R-22, *etc.* In the case of two-layered walls, work to determine how to interpolate for insulation layers with resistances significantly different than the R-5 or R-20 values used in the parametric study was outside the scope of the study and has not yet been determined at this time.

- *Zero-mass coefficients*: The behavior of loads for zero-mass walls is represented by the coefficients a_0, b_0, c_0 that define $L_0(R)$ through Eq. (5). Note that the asymptotic values a_0 are almost the same for all generic wall types for a particular location. This consistency is to be expected on theoretical grounds: a_0 is just the load that occurs because of heat transfer through the windows, doors, roof, and floor that remains as the wall $R \rightarrow \infty$.

- *Infinite-mass coefficients*: It appears that similar behavior occurs in the limit $R \rightarrow \infty$, and that there is probable consistency of asymptotic values a_∞. There are some notable exceptions, however (*e.g.*, Atlanta, heating, R-0 inside, R-20 outside), which are probably due to idiosyncrasies of the regression procedure. In those cases it is important to note that the numerical values calculated for L_∞ from the coefficients at the high end of the *valid* range of wall R agree closely with the asymptotic value determined for the other generic wall types. This suggests that there is, in fact, a uniform asymptotic value for L_∞ as $R \rightarrow \infty$.

- *Model Singularities*: For some particular generic wall types, the regression produced negative values for some c_0 and c_∞ that are in the valid range of R. When used in Eqs. (4) and (5), these values have the potential to cause a singularity when calculating L_0 or L_∞. These cases seem to arise only when the related value of b_0 or b_∞ is very small, *i.e.*, $L_0(R)$ or $L_\infty(R)$ is almost a straight, flat line as a function of R, except very near the singularity. In these cases, the coefficients should be used to calculate the value of $L_0(R)$ or $L_\infty(R)$ only at the maximum and minimum valid values of R for the wall, and a simple linear interpolation should then be used for intermediate values of R. These cases are marked with an asterisk (*) in Tables 3 and 4.

- *Empiricity of model*: Finally, it must be stressed that the model presented here is empirical, and is not meant to imply by its analytical form an underlying physical model. We make no more claim than that the empirical model presented is a concise analytical representation that can, with the coefficients determined by nonlinear regression, reproduce the actual BLAST simulation results in the data base with reasonable accuracy.

As a final aspect of the quality of the predictive model we have developed, figures 4 - 9 show selected graphical comparisons between the actual data from the BLAST simulation data base and the seven-parameter nonlinear model predictions, using the coefficients derived from the regression procedure. (In all figures, the model predictions are shown as the solid, smooth lines.) In general the agreement is quite good, both qualitatively and quantitatively. The shapes of the curves are all accurately reproduced, including the complex behavior as a function of R at intermediate and high values of μ. Note that the scale of the ordinate changes from figure to figure, and that the actual differences are approximately the same from figure to figure. Graphical comparisons for other locations show the same general quality of agreement.

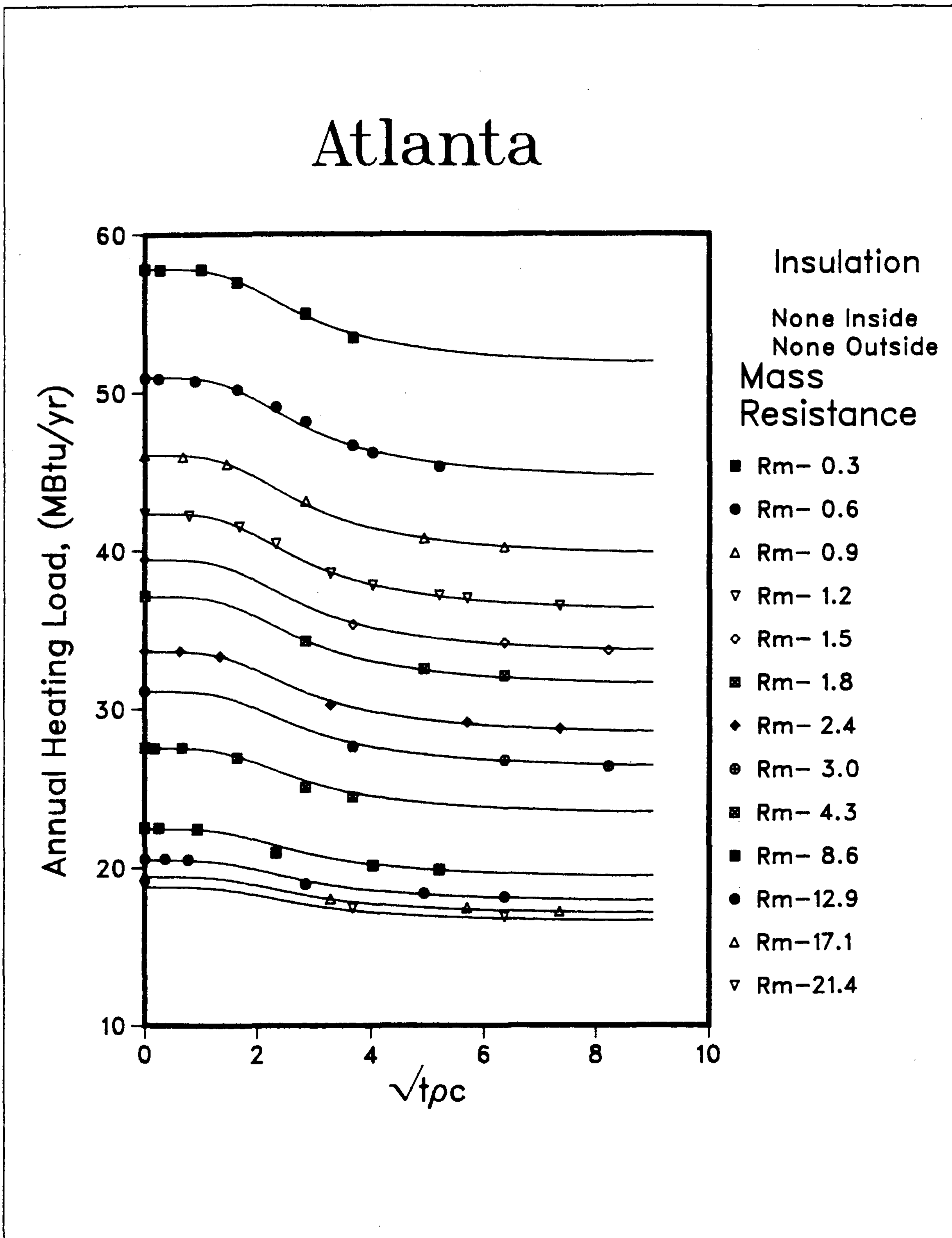

Figure 4. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Heating, *Rin* =0, *Rout* =0.

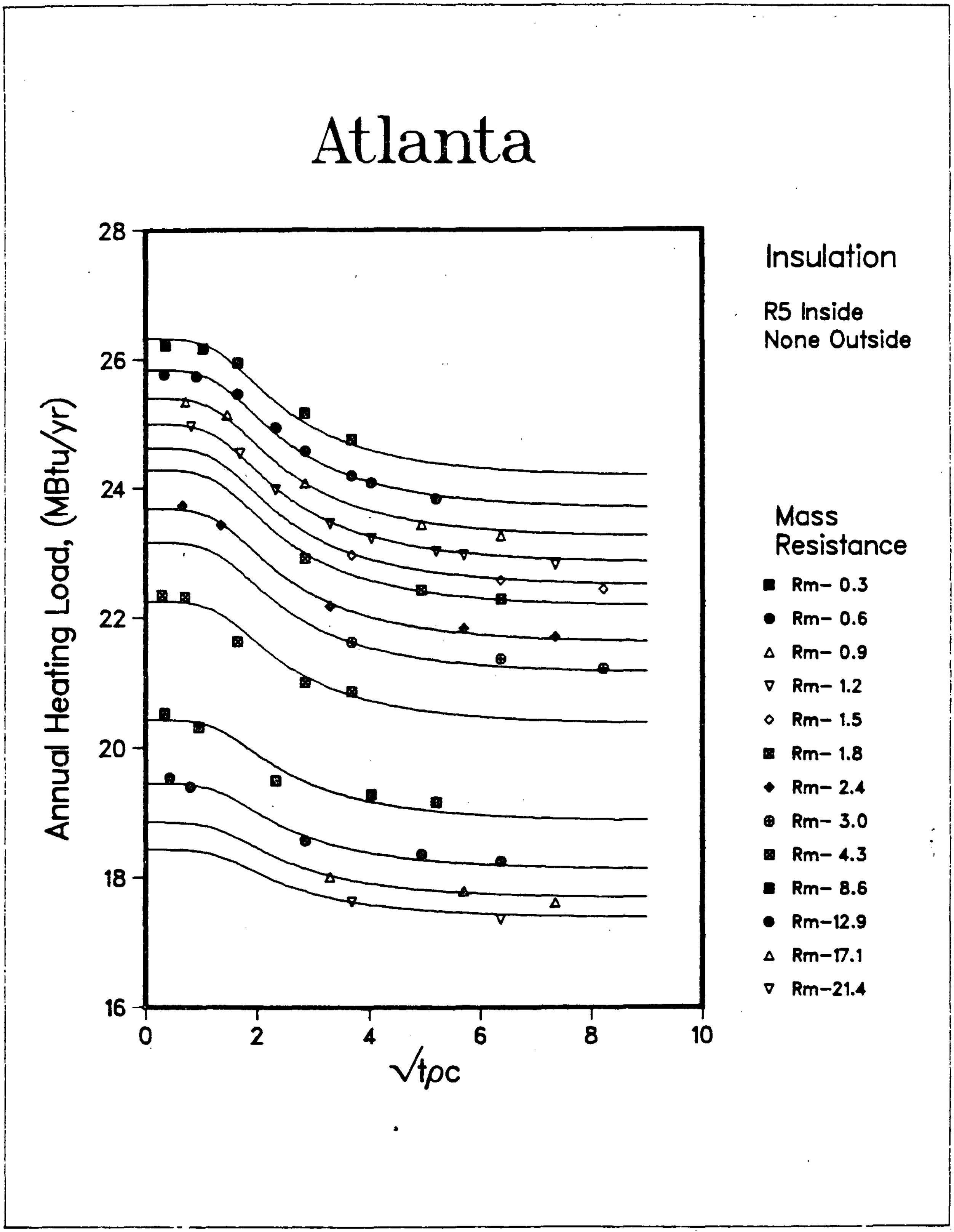

Figure 5. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Heating, *Rin* =5, *Rout* =0.

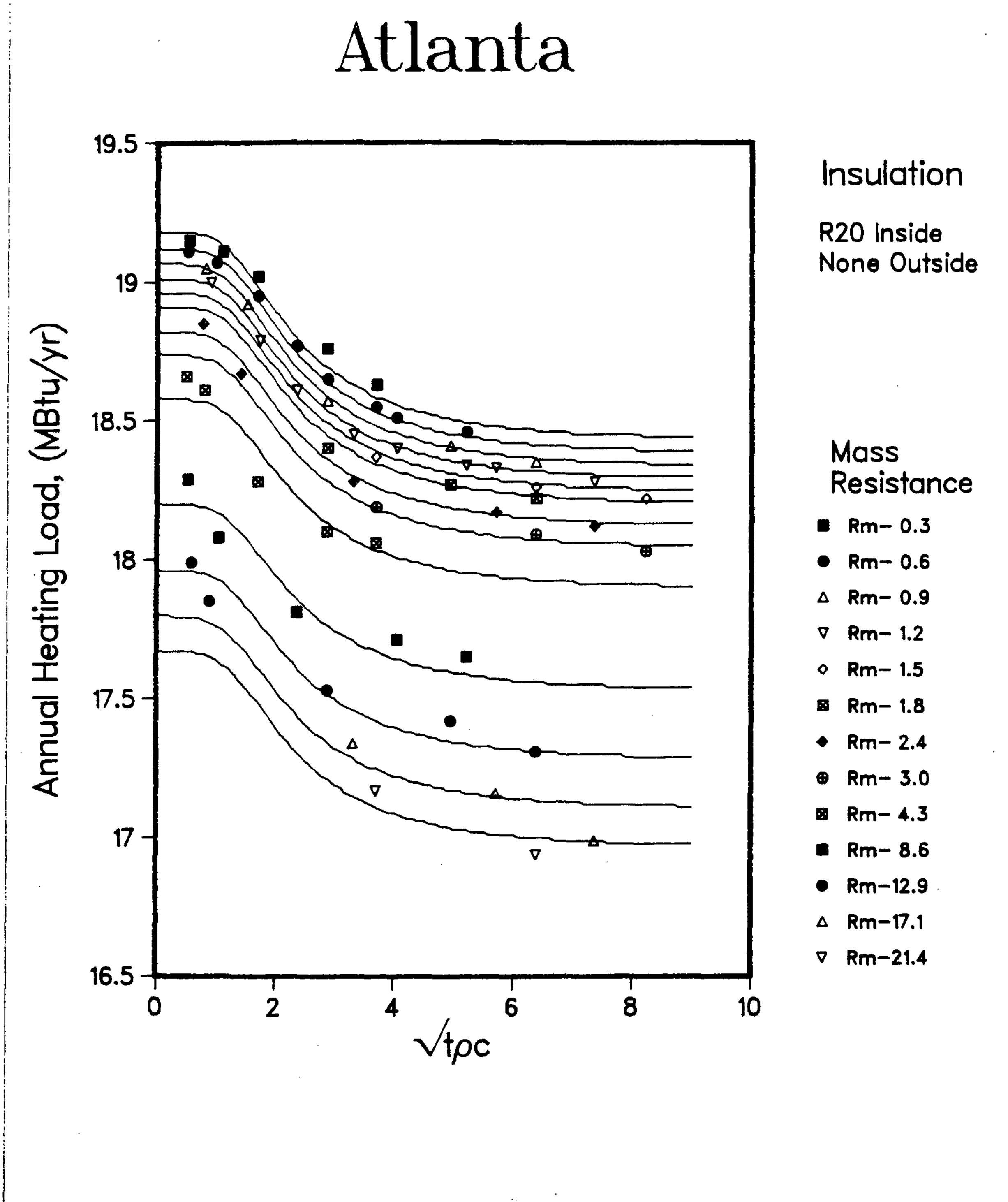

Figure 6. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Heating, Rin =20, $Rout$ =0.

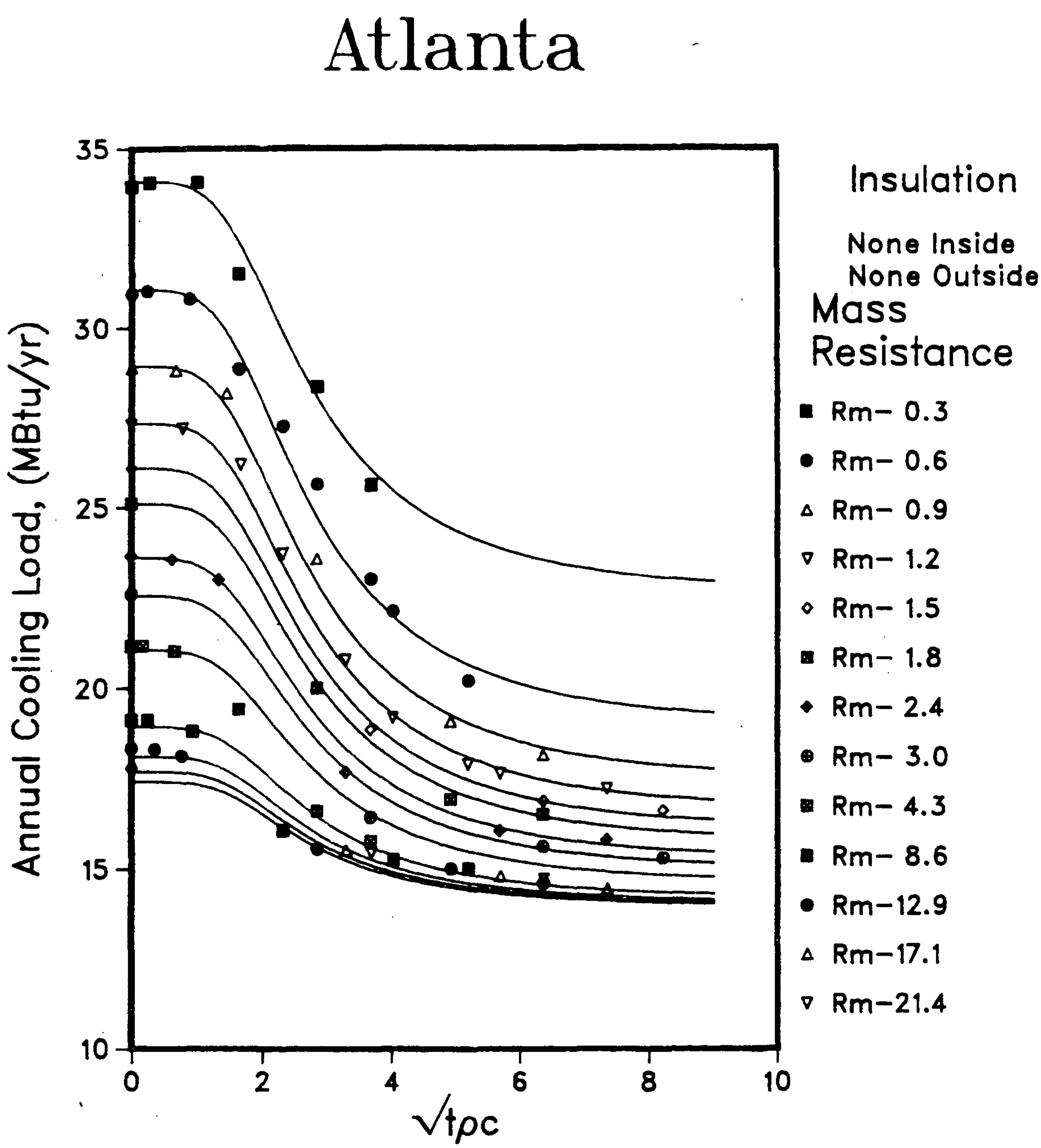

Figure 7. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Cooling, $Rin = 0$, $Rout = 0$.

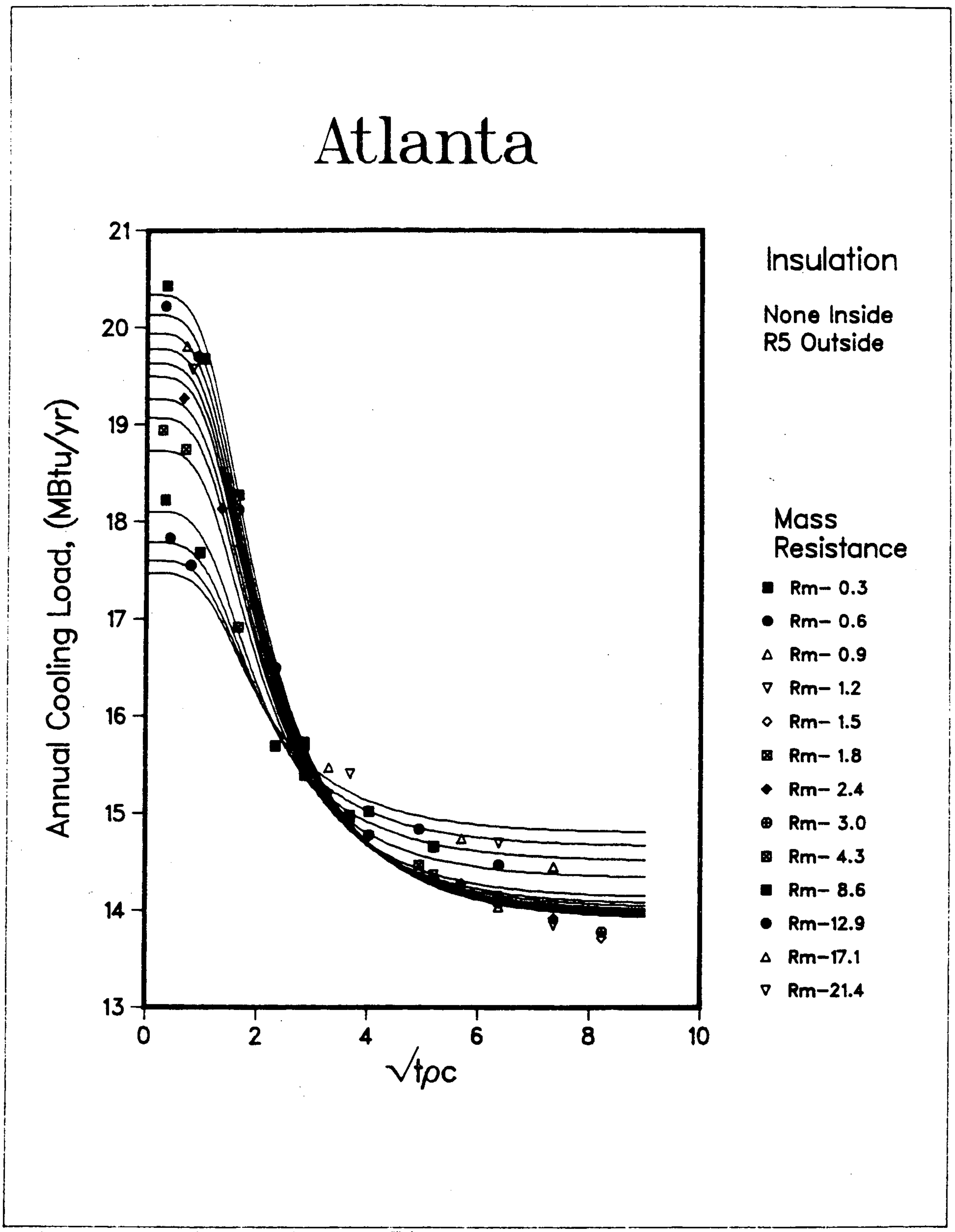

Figure 8. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Cooling, $Rin=0$, $Rout=5$.

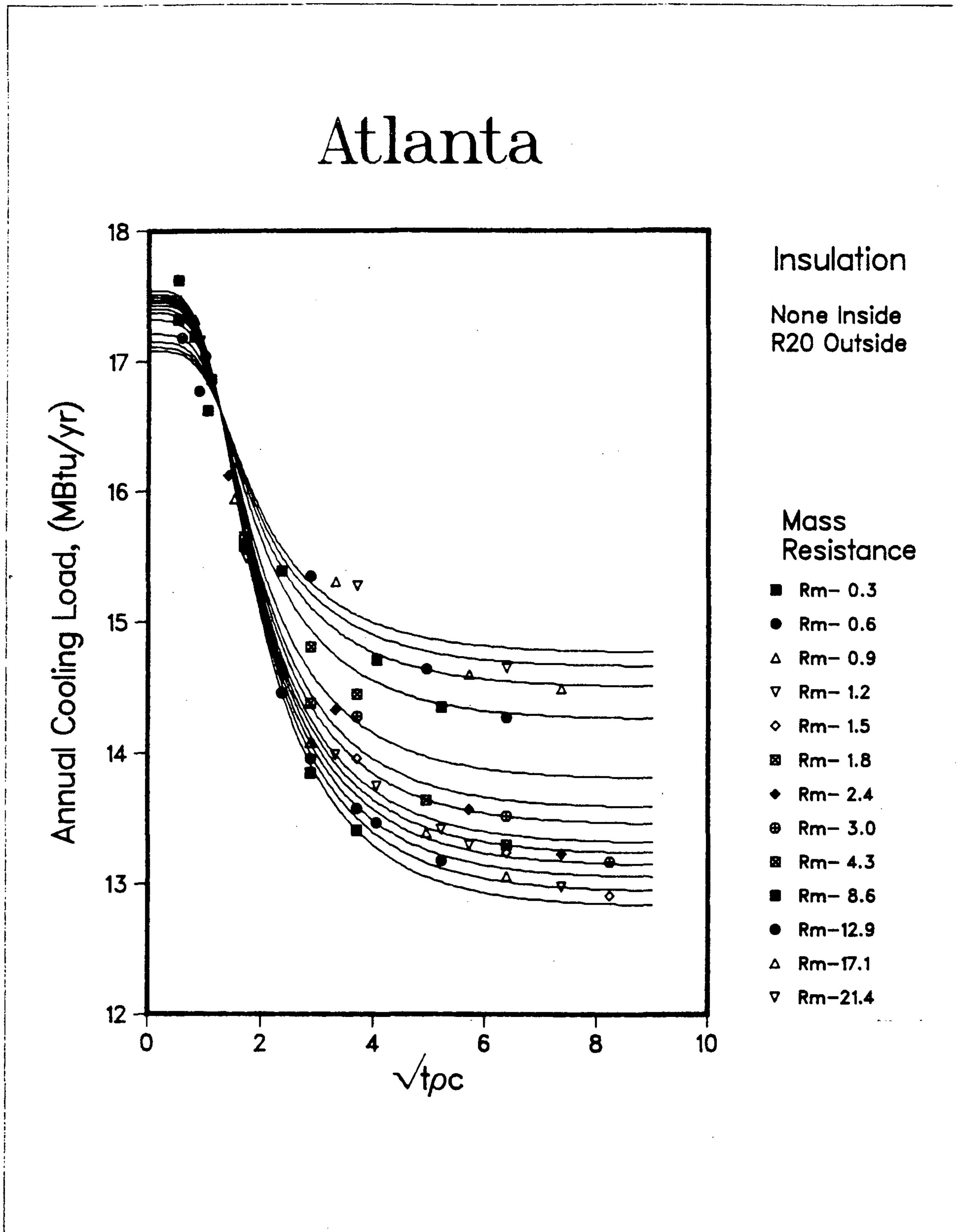

Figure 9. Comparison between BLAST simulation data and empirical model predictions: Atlanta, Cooling, $Rin=0$, $Rout=20$.

4. CONFIGURATION AND OPERATION PARAMETRICS

4.1. BLAST Simulation Results

BLAST simulation results for the configuration and operation parametrics described in Section 2.2.2 are presented in Tables 6 and 7 for annual heating and cooling loads, respectively. The purpose of these variations was to determine how the effect of wall thermal mass, studied extensively with the parametrics discussed in the previous section, changes with variations in the configuration and operation assumptions of the building. For each wall type, the tables are arranged by configuration variation ordered approximately according to decreasing loads. Note that the order is about the same from climate to climate, but is different for heating and cooling. The base case, which represents the set of assumptions used throughout the wall parametric simulations described earlier in this report, is approximately in the middle in each case.

For heating, the loads for the most energy-using configuration are about twice the loads for the least energy-using configuration. Variations for no night setback and reduced floating temperature range (which implies a higher heating setpoint) have higher loads than the base case; removal of window shades and ventilation cooling have little effect, while infiltration reduction and addition of a thermally massive slab to the floor result in somewhat lower loads than the base case. For cooling, the largest loads are about 50% greater than the smallest. Reduced thermostat floating temperature range (which implies a higher cooling setpoint), and removal of ventilation cooling and window shades all cause cooling loads greater than those for the base case, while removal of night setback leaves them largely unchanged, and reduced infiltration and addition of a massive layer to the floor results in smaller cooling loads.

TABLE 6
CONFIGURATION VARIATIONS - BLAST ANNUAL HEATING LOADS (MBtu/yr)

Type	Configuration†	Atlanta	Denver	Miami	Minneapolis	Phoenix	Washington
Frame	S	27.22	49.44	1.97	83.64	12.61	42.88
	T	23.33	42.62	1.34	76.88	8.89	38.04
	B	19.76	37.92	0.83	71.44	6.66	33.63
	W	19.27	37.22	0.80	70.42	6.55	32.88
	V	18.98	36.33	0.65	70.90	5.66	32.91
	F	17.98	34.00	0.50	69.73	4.79	31.56
	I	12.69	25.58	0.50	46.98	4.43	22.22
Masonry	S	25.81	46.97	1.26	82.42	10.74	41.25
	T	21.95	39.83	0.90	75.34	7.51	36.22
	B	18.34	35.04	0.45	69.96	5.27	31.78
	W	17.65	34.15	0.42	68.84	5.04	30.90
	V	17.69	33.72	0.31	69.46	4.37	31.16
	F	17.60	33.27	0.31	69.36	4.38	31.05
	I	11.45	23.13	0.24	45.75	3.40	20.64

TABLE 7
CONFIGURATION VARIATIONS - BLAST ANNUAL COOLING LOADS (MBtu/yr)

Type	Configuration†	Atlanta	Denver	Miami	Minneapolis	Phoenix	Washington
Frame	T	21.13	15.52	44.99	17.76	48.35	16.58
	V	20.66	15.63	41.72	12.68	46.51	16.26
	W	19.58	13.63	42.93	11.69	45.80	15.21
	B	17.35	12.22	38.76	10.32	47.88	13.31
	S	17.41	12.52	38.82	10.40	43.75	13.45
	I	17.37	12.56	38.23	10.40	40.43	13.32
	F	14.60	8.94	36.19	8.25	39.98	10.68
Masonry	T	18.61	12.77	41.92	10.95	45.04	14.11
	V	18.40	12.79	39.20	10.92	43.44	14.04
	W	16.74	10.69	39.55	9.63	42.50	12.51
	B	14.71	9.55	35.63	8.42	39.94	10.89
	S	14.79	9.84	35.69	8.51	40.16	11.00
	I	14.78	9.80	35.10	8.46	37.39	10.90
	F	12.73	7.07	33.73	6.83	37.82	8.91

† B - base case; F - concrete floor; I - ½ base infiltration; S - no night setback; T - reduced floating temperature range; V - no natural ventilation cooling; W - no window shades.

4.2. Discussion

What we are really interested in is the effect these configuration variations have on the size of the wall thermal mass effect that was explored in the previous sections of this report. The configuration impact can be determined by examining the *differences* in load between the low-mass frame construction and the high-mass masonry construction, for each of the variations. These differences are shown in separate bar charts for heating and cooling in Figures 10 and 11. (Note that the order of the variations in each bar set is different for heating and cooling, and reflects the order of their presentation in Tables 6 and 7, respectively.)

For heating, the most obvious feature of Figure 10 is that consistently across all climates, the thermal mass load reduction is approximately the same for all variations except one, the concrete floor, which shows only one-fourth to one-third the load reduction of the other variations. This result clearly indicates that the marginal benefits of thermal mass addition are a decreasing function of how much mass is already present in the structure. There are two other notable features: First, in Miami and Phoenix, the removal of night setback causes a larger load reduction than any of the other variations, while in all of the other climates it causes about the same load reductions as all the other variations. Second, with the exception of Miami and Phoenix, in all other climates the shadeless window variation shows slightly larger load reductions than other configurational variations. This effect is probably due to the increased fraction of the solar gains transmitted through the windows that is incident on and stored in the zone surfaces. However, these features are almost second order effects compared to the most obvious characteristic of all configurations but the massive floor: in a particular location they all lead to about the same absolute load reductions, independent of the size of the load itself.

For cooling, it is also true that the most obvious feature of the load reductions shown in Figure 11 is the smaller reduction, across all climates, for the massive slab floor configuration, although the decreased effectiveness is not so pronounced as it was for heating. Like heating, there is a slightly greater reduction (in all climates but one) for the unshaded window configuration. There is also a slightly smaller reduction in most climates for the unventilated configuration. However, the most obvious general characteristic of all variations but the massive floor is that they all lead to about the same cooling load reduction in any particular climate.

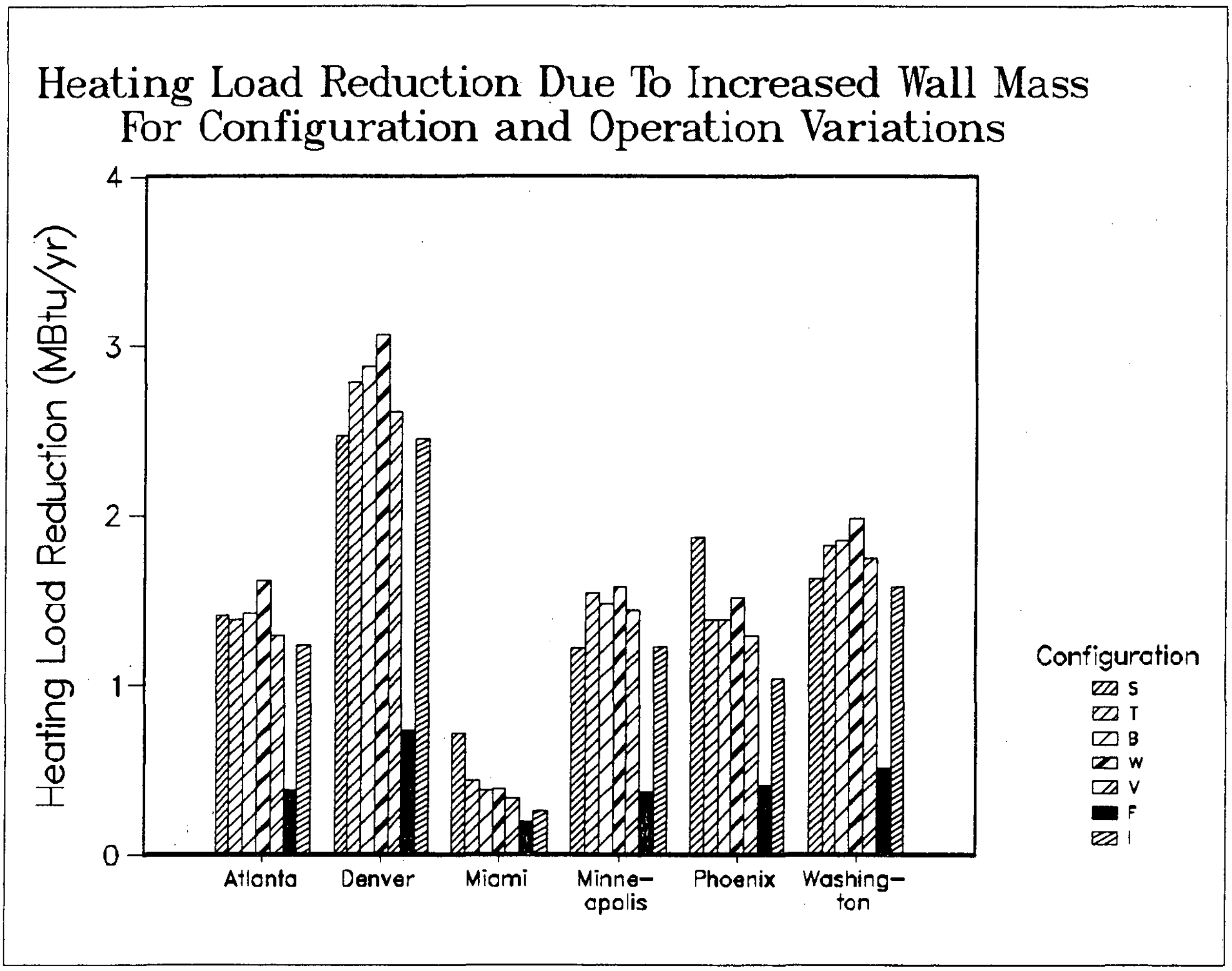

Figure 10. Heating load reduction due to increasing the exterior wall mass from frame construction to masonry construction. B - base case; F - concrete floor; I - ½ base infiltration; S - no night setback; T - reduced floating temperature range; V - no natural ventilation cooling; W - no window shades.

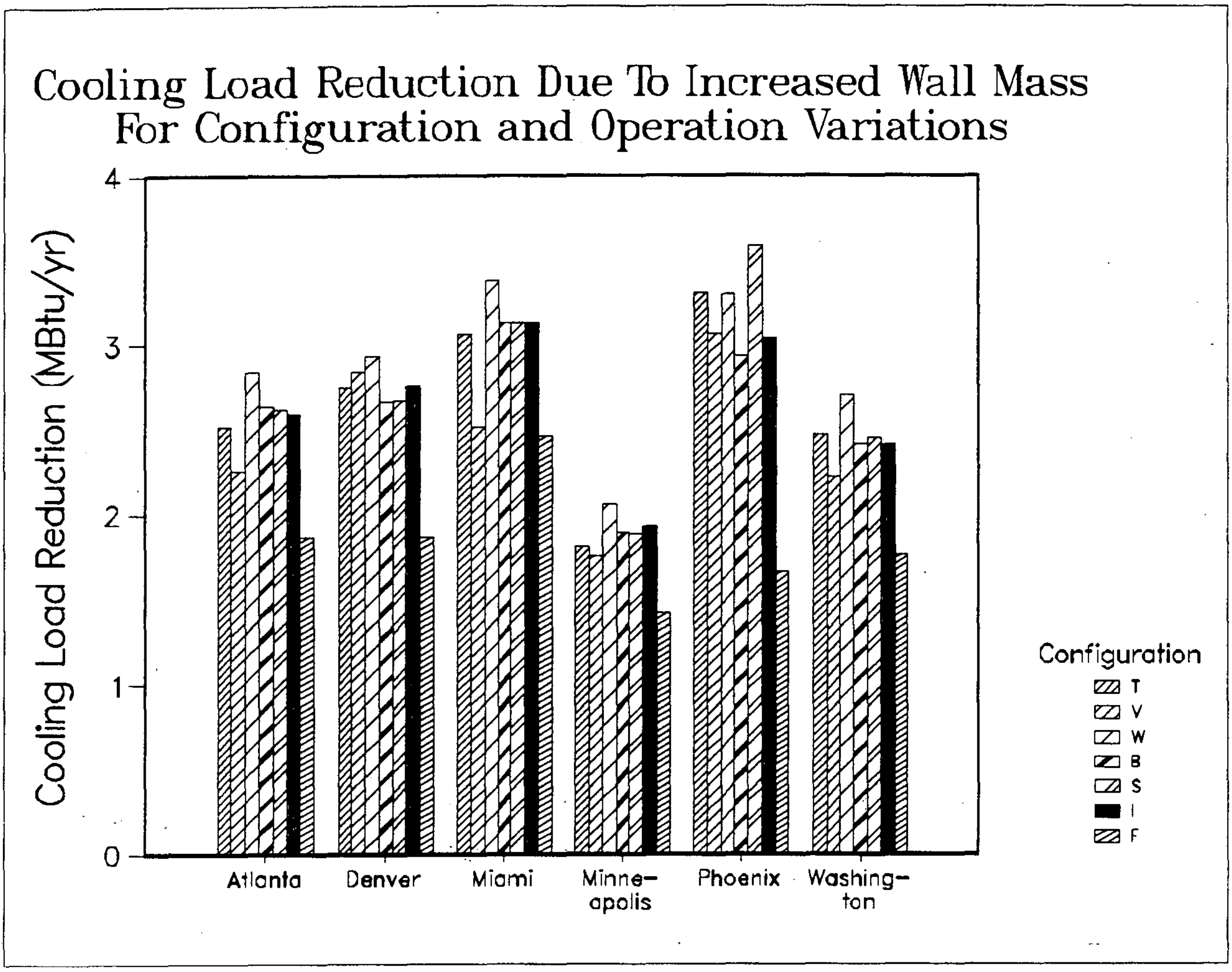

Figure 11. Cooling load reduction due to increasing the exterior wall mass from frame construction to masonry construction. B - base case; F - concrete floor; I - ½ base infiltration; S - no night setback; T - reduced floating temperature range; V - no natural ventilation cooling; W - no window shades.

5. CONCLUDING DISCUSSION

The work completed in this study has led to an extensive data base of BLAST-simulated annual heating and cooling loads for a comprehensive set of parametric variations in the exterior wall thermal mass for a typical residence. Additionally, we also explored the sensitivity of the exterior wall mass effects on heating and cooling load due to selected variations in the configuration and operation assumptions for the residence. The simulations were repeated in each of six locations that span the range of U.S. climates. The data indicates that:

- For a particular value of wall thermal resistance, increasing the wall thermal mass always reduces both the heating and cooling loads. There is a very uniform general pattern to the data.
- The relative sensitivity of changes to the loads due to incremental changes in either thermal resistance or thermal mass of the exterior walls varies widely, and is dependent on the particular values for each, the load type, the wall type, and the climate.
- The relative importance of exterior wall mass for reducing heating loads is strongly dependent on climate. The mass effect on cooling loads, however, is only weakly dependent on climate.
- Assumptions about aspects of the building configuration other than the exterior walls, and about its operation do not appreciably affect the size of load reductions due to the exterior wall mass, *except* for assumptions related to the thermal mass level of the building. The more thermal mass that is already present in the structure, the smaller the incremental load reductions will be from the addition of yet more thermal mass to the exterior walls of the structure.

A simple analytical model was developed that fits the simulation data quite well (within a few percent or less, on the average). This model is a function of only the thermal resistance and thermal mass level of the exterior walls, and has seven fitting parameters determined by least-square-fit regressions to the data. It must be stressed that the model is empirical, not physical; the analytical form of the model does not necessarily imply anything about the actual physical processes that actually determine the very complex behavior being examined. Separate regressions were performed for heating and for cooling, for each climate, and for each generic wall type. This model makes it convenient to explore characteristics of the data base, without having to deal with all the numbers themselves. Thus, it is expected that the data base, and the model that has been developed to represent it, will ultimately lead to an increased, quantitative understanding of the effect of exterior wall thermal mass on the energy performance of residential buildings.

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APPENDIX 1. BLAST Residential Thermal Mass Parametric Simulation Data Base

This Appendix contains the BLAST residential thermal mass simulation data base in the form of thirty tables: five tables corresponding to the generic wall types defined in the text for each of the six climates for which simulations were performed. The tables are numbered according to the following convention:

TABLE A1-XXX-Y

where **XXX** is a three-letter abbreviation for the location, and **Y** is an integer between 1 and 5 which identifies the generic wall type.

Y	Generic Wall Type	
	R_{in}	R_{out}
1	0	0
2	0	20
3	0	5
4	20	0
5	5	0

Additionally, the location and generic wall type are explicitly identified in the title banner for each table.

TABLE A1-Atl-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Atlanta Insulation: None Inside; None Outside

Heat $(MBtu/yr)$	Cool $(MBtu/yr)$	wall thickness (ft)	thermal conductivity $(Btu/hr \cdot ft \cdot {}^\circ F)$	density (lb/ft^3)	specific heat $(Btu/lb \cdot {}^\circ F)$	R_{mass} $(hr \cdot ft^2 \cdot {}^\circ F/Btu)$	$\sqrt{t \rho c}$
57.80	33.93	0.0000	0.0000	0.0	0.0	0.3	0.0000
57.75	34.04	0.1130	0.3768	2.2	0.3	0.3	0.2731
57.75	34.04	0.1130	0.3768	30.0	0.3	0.3	1.0085
56.96	31.52	0.3000	1.0000	30.0	0.3	0.3	1.6432
54.97	28.37	0.3000	1.0000	90.0	0.3	0.3	2.8460
53.47	25.63	0.3000	1.0000	150.0	0.3	0.3	3.6742
50.91	30.94	0.0000	0.0000	0.0	0.0	0.6	0.0000
50.87	31.03	0.0884	0.1473	2.2	0.3	0.6	0.2415
50.72	30.81	0.0884	0.1473	30.0	0.3	0.6	0.8920
50.19	28.86	0.3000	0.5000	30.0	0.3	0.6	1.6432
49.09	27.27	0.6000	1.0000	30.0	0.3	0.6	2.3238
48.15	25.65	0.3000	0.5000	90.0	0.3	0.6	2.8460
46.66	23.03	0.3000	0.5000	150.0	0.3	0.6	3.6742
46.19	22.14	0.6000	1.0000	90.0	0.3	0.6	4.0249
45.30	20.20	0.6000	1.0000	150.0	0.3	0.6	5.1962
46.06	28.88	0.0000	0.0000	0.0	0.0	0.9	0.0000
45.92	28.81	0.7065	0.7849	2.2	0.3	0.9	0.6829
45.47	28.17	0.7065	0.7849	10.0	0.3	0.9	1.4559
43.13	23.57	0.9000	1.0000	30.0	0.3	0.9	2.8460
40.78	19.07	0.9000	1.0000	90.0	0.3	0.9	4.9295
40.21	18.15	0.9000	1.0000	150.0	0.3	0.9	6.3640
42.35	27.30	0.0000	0.0000	0.0	0.0	1.2	0.0000
42.22	27.20	0.9419	0.7849	2.2	0.3	1.2	0.7885
41.53	26.20	0.9419	0.7849	10.0	0.3	1.2	1.6810
40.46	23.72	0.6000	0.5000	30.0	0.3	1.2	2.3238
38.60	20.78	1.2000	1.0000	30.0	0.3	1.2	3.2863
37.84	19.18	0.6000	0.5000	90.0	0.3	1.2	4.0249
37.19	17.90	0.6000	0.5000	150.0	0.3	1.2	5.1962
37.02	17.64	1.2000	1.0000	90.0	0.3	1.2	5.6921
36.52	17.22	1.2000	1.0000	150.0	0.3	1.2	7.3485
39.46	26.09	0.0000	0.0000	0.0	0.0	1.5	0.0000
35.35	18.86	1.5000	1.0000	30.0	0.3	1.5	3.6742
34.16	16.88	1.5000	1.0000	90.0	0.3	1.5	6.3640
33.68	16.61	1.5000	1.0000	150.0	0.3	1.5	8.2158
37.16	25.11	0.0000	0.0000	0.0	0.0	1.8	0.0000
34.29	20.00	0.9000	0.5000	30.0	0.3	1.8	2.8460
32.52	16.92	0.9000	0.5000	90.0	0.3	1.8	4.9295
32.07	16.51	0.9000	0.5000	150.0	0.3	1.8	6.3640
33.65	23.66	0.0000	0.0000	0.0	0.0	2.4	0.0000
33.64	23.57	0.5961	0.2484	2.2	0.3	2.4	0.6272
33.31	23.01	0.5961	0.2484	10.0	0.3	2.4	1.3373

30.26	17.69	1.2000	0.5000	30.0	0.3	2.4	3.2863
29.15	16.06	1.2000	0.5000	90.0	0.3	2.4	5.6921
28.74	15.82	1.2000	0.5000	150.0	0.3	2.4	7.3485
31.13	22.61	0.0000	0.0000	0.0	0.0	3.0	0.0000
27.64	16.45	1.5000	0.5000	30.0	0.3	3.0	3.6742
26.76	15.63	1.5000	0.5000	90.0	0.3	3.0	6.3640
26.39	15.31	1.5000	0.5000	150.0	0.3	3.0	8.2158
27.58	21.17	0.0000	0.0000	0.0	0.0	4.3	0.0000
27.53	21.18	0.0495	0.0115	2.2	0.3	4.3	0.1807
27.55	21.04	0.0495	0.0115	30.0	0.3	4.3	0.6675
26.93	19.44	0.3000	0.0700	30.0	0.3	4.3	1.6432
25.09	16.62	0.3000	0.0700	90.0	0.3	4.3	2.8460
24.48	15.79	0.3000	0.0700	150.0	0.3	4.3	3.6742
22.51	19.13	0.0000	0.0000	0.0	0.0	8.6	0.0000
22.51	19.12	0.0985	0.0115	2.2	0.3	8.6	0.2550
22.43	18.81	0.0985	0.0115	30.0	0.3	8.6	0.9415
20.96	16.08	0.6000	0.0700	30.0	0.3	8.6	2.3238
20.15	15.26	0.6000	0.0700	90.0	0.3	8.6	4.0249
19.87	15.01	0.6000	0.0700	150.0	0.3	8.6	5.1962
20.54	18.34	0.0000	0.0000	0.0	0.0	12.9	0.0000
20.55	18.31	0.1979	0.0154	2.2	0.3	12.9	0.3614
20.49	18.13	0.1979	0.0154	10.0	0.3	12.9	0.7705
18.97	15.55	0.9000	0.0700	30.0	0.3	12.9	2.8460
18.38	15.01	0.9000	0.0700	90.0	0.3	12.9	4.9295
18.14	14.61	0.9000	0.0700	150.0	0.3	12.9	6.3640
19.49	17.93	0.0000	0.0000	0.0	0.0	17.1	0.0000
18.05	15.53	1.2000	0.0700	30.0	0.3	17.1	3.2863
17.47	14.81	1.2000	0.0700	90.0	0.3	17.1	5.6921
17.22	14.45	1.2000	0.0700	150.0	0.3	17.1	7.3485
18.85	17.68	0.0000	0.0000	0.0	0.0	21.4	0.0000
17.48	15.45	1.5000	0.0700	30.0	0.3	21.4	3.6742
16.90	14.72	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Atl-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Atlanta Insulation: None Inside; R20 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t \rho c}$
19.02	17.62	0.1130	0.3768	2.2	0.3	0.3	0.5360
18.61	16.86	0.1130	0.3768	30.0	0.3	0.3	1.1089
17.91	15.58	0.3000	1.0000	30.0	0.3	0.3	1.7067
17.12	13.85	0.3000	1.0000	90.0	0.3	0.3	2.8832
16.90	13.41	0.3000	1.0000	150.0	0.3	0.3	3.7031
18.98	17.62	0.0884	0.1473	2.2	0.3	0.6	0.5206
18.78	17.04	0.0884	0.1473	30.0	0.3	0.6	1.0041
17.84	15.57	0.3000	0.5000	30.0	0.3	0.6	1.7067
17.34	14.46	0.6000	1.0000	30.0	0.3	0.6	2.3691
17.16	13.96	0.3000	0.5000	90.0	0.3	0.6	2.8832
16.89	13.58	0.3000	0.5000	150.0	0.3	0.6	3.7031
16.79	13.47	0.6000	1.0000	90.0	0.3	0.6	4.0513
16.59	13.18	0.6000	1.0000	150.0	0.3	0.6	5.2166
18.91	17.32	0.7065	0.7849	2.2	0.3	0.9	0.8240
17.98	15.94	0.7065	0.7849	10.0	0.3	0.9	1.5272
17.13	14.08	0.9000	1.0000	30.0	0.3	0.9	2.8832
16.64	13.39	0.9000	1.0000	90.0	0.3	0.9	4.9510
16.42	13.06	0.9000	1.0000	150.0	0.3	0.9	6.3807
18.80	17.16	0.9419	0.7849	2.2	0.3	1.2	0.9134
17.70	15.49	0.9419	0.7849	10.0	0.3	1.2	1.7431
17.25	14.59	0.6000	0.5000	30.0	0.3	1.2	2.3691
17.00	13.99	1.2000	1.0000	30.0	0.3	1.2	3.3185
16.81	13.75	0.6000	0.5000	90.0	0.3	1.2	4.0513
16.60	13.42	0.6000	0.5000	150.0	0.3	1.2	5.2166
16.52	13.30	1.2000	1.0000	90.0	0.3	1.2	5.7108
16.28	12.98	1.2000	1.0000	150.0	0.3	1.2	7.3629
16.90	13.96	1.5000	1.0000	30.0	0.3	1.5	3.7031
16.42	13.24	1.5000	1.0000	90.0	0.3	1.5	6.3807
16.18	12.91	1.5000	1.0000	150.0	0.3	1.5	8.2288
17.05	14.38	0.9000	0.5000	30.0	0.3	1.8	2.8832
16.64	13.64	0.9000	0.5000	90.0	0.3	1.8	4.9510
16.42	13.30	0.9000	0.5000	150.0	0.3	1.8	6.3807
18.71	17.30	0.5961	0.2484	2.2	0.3	2.4	0.7785
17.93	16.12	0.5961	0.2484	10.0	0.3	2.4	1.4146
16.93	14.33	1.2000	0.5000	30.0	0.3	2.4	3.3185
16.52	13.57	1.2000	0.5000	90.0	0.3	2.4	5.7108
16.28	13.23	1.2000	0.5000	150.0	0.3	2.4	7.3629
16.82	14.28	1.5000	0.5000	30.0	0.3	3.0	3.7031
16.40	13.52	1.5000	0.5000	90.0	0.3	3.0	6.3807
16.15	13.17	1.5000	0.5000	150.0	0.3	3.0	8.2288
18.54	17.47	0.0495	0.0115	2.2	0.3	4.3	0.4954
18.46	17.19	0.0495	0.0115	30.0	0.3	4.3	0.8113
17.48	15.65	0.3000	0.0700	30.0	0.3	4.3	1.7067

16.92	14.81	0.3000	0.0700	90.0	0.3	4.3	2.8832
16.76	14.45	0.3000	0.0700	150.0	0.3	4.3	3.7031
18.19	17.32	0.0985	0.0115	2.2	0.3	8.6	0.5270
17.83	16.62	0.0985	0.0115	30.0	0.3	8.6	1.0484
16.98	15.39	0.6000	0.0700	30.0	0.3	8.6	2.3691
16.49	14.71	0.6000	0.0700	90.0	0.3	8.6	4.0513
16.33	14.35	0.6000	0.0700	150.0	0.3	8.6	5.2166
17.90	17.18	0.1979	0.0154	2.2	0.3	12.9	0.5859
17.67	16.77	0.1979	0.0154	10.0	0.3	12.9	0.8980
16.71	15.35	0.9000	0.0700	30.0	0.3	12.9	2.8832
16.20	14.64	0.9000	0.0700	90.0	0.3	12.9	4.9510
15.99	14.27	0.9000	0.0700	150.0	0.3	12.9	6.3807
16.51	15.31	1.2000	0.0700	30.0	0.3	17.1	3.3185
15.96	14.60	1.2000	0.0700	90.0	0.3	17.1	5.7108
15.44	14.49	1.2000	0.0700	150.0	0.3	17.1	7.3629
16.34	15.28	1.5000	0.0700	30.0	0.3	21.4	3.7031
15.67	14.65	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Atl-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Atlanta Insulation: None Inside; R5 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
25.75	20.43	0.1130	0.3768	2.2	0.3	0.3	0.3575
25.48	19.68	0.1130	0.3768	30.0	0.3	0.3	1.0345
24.42	18.27	0.3000	1.0000	30.0	0.3	0.3	1.6593
23.02	15.73	0.3000	1.0000	90.0	0.3	0.3	2.8554
22.63	14.96	0.3000	1.0000	150.0	0.3	0.3	3.6815
25.34	20.22	0.0884	0.1473	2.2	0.3	0.6	0.3340
25.23	19.70	0.0884	0.1473	30.0	0.3	0.6	0.9213
24.04	18.12	0.3000	0.5000	30.0	0.3	0.6	1.6593
23.13	16.49	0.6000	1.0000	30.0	0.3	0.6	2.3352
22.69	15.67	0.3000	0.5000	90.0	0.3	0.6	2.8554
22.29	14.95	0.3000	0.5000	150.0	0.3	0.6	3.6815
22.15	14.78	0.6000	1.0000	90.0	0.3	0.6	4.0315
21.83	14.33	0.6000	1.0000	150.0	0.3	0.6	5.2013
24.93	19.81	0.7065	0.7849	2.2	0.3	0.9	0.7208
24.05	18.45	0.7065	0.7849	10.0	0.3	0.9	1.4740
22.32	15.62	0.9000	1.0000	30.0	0.3	0.9	2.8554
21.57	14.43	0.9000	1.0000	90.0	0.3	0.9	4.9349
21.30	14.04	0.9000	1.0000	150.0	0.3	0.9	6.3681
24.53	19.57	0.9419	0.7849	2.2	0.3	1.2	0.8215
23.27	17.71	0.9419	0.7849	10.0	0.3	1.2	1.6967
22.40	16.28	0.6000	0.5000	30.0	0.3	1.2	2.3352
21.80	15.19	1.2000	1.0000	30.0	0.3	1.2	3.2944
21.55	14.77	0.6000	0.5000	90.0	0.3	1.2	4.0315
21.22	14.37	0.6000	0.5000	150.0	0.3	1.2	5.2013
21.14	14.25	1.2000	1.0000	90.0	0.3	1.2	5.6968
20.88	13.85	1.2000	1.0000	150.0	0.3	1.2	7.3521
21.37	14.93	1.5000	1.0000	30.0	0.3	1.5	3.6815
20.76	14.08	1.5000	1.0000	90.0	0.3	1.5	6.3681
20.49	13.72	1.5000	1.0000	150.0	0.3	1.5	8.2191
21.41	15.49	0.9000	0.5000	30.0	0.3	1.8	2.8554
20.81	14.47	0.9000	0.5000	90.0	0.3	1.8	4.9349
20.54	14.10	0.9000	0.5000	150.0	0.3	1.8	6.3681
23.39	19.27	0.5961	0.2484	2.2	0.3	2.4	0.6683
22.69	18.13	0.5961	0.2484	10.0	0.3	2.4	1.3570
20.76	15.12	1.2000	0.5000	30.0	0.3	2.4	3.2944
20.23	14.28	1.2000	0.5000	90.0	0.3	2.4	5.6968
19.92	13.92	1.2000	0.5000	150.0	0.3	2.4	7.3521
20.27	14.95	1.5000	0.5000	30.0	0.3	3.0	3.6815
19.76	14.15	1.5000	0.5000	90.0	0.3	3.0	6.3681
19.44	13.78	1.5000	0.5000	150.0	0.3	3.0	8.2191
22.06	18.94	0.0495	0.0115	2.2	0.3	4.3	0.2931
22.04	18.74	0.0495	0.0115	30.0	0.3	4.3	0.7062
20.94	16.91	0.3000	0.0700	30.0	0.3	4.3	1.6593

19.90	15.39	0.3000	0.0700	90.0	0.3	4.3	2.8554
19.62	14.98	0.3000	0.0700	150.0	0.3	4.3	3.6815
20.33	18.22	0.0985	0.0115	2.2	0.3	8.6	0.3438
20.08	17.68	0.0985	0.0115	30.0	0.3	8.6	0.9694
18.78	15.69	0.6000	0.0700	30.0	0.3	8.6	2.3352
18.22	15.02	0.6000	0.0700	90.0	0.3	8.6	4.0315
18.00	14.66	0.6000	0.0700	150.0	0.3	8.6	5.2013
19.38	17.83	0.1979	0.0154	2.2	0.3	12.9	0.4287
19.24	17.55	0.1979	0.0154	10.0	0.3	12.9	0.8043
17.90	15.53	0.9000	0.0700	30.0	0.3	12.9	2.8554
17.37	14.84	0.9000	0.0700	90.0	0.3	12.9	4.9349
17.12	14.47	0.9000	0.0700	150.0	0.3	12.9	6.3681
17.38	15.47	1.2000	0.0700	30.0	0.3	17.1	3.2944
16.82	14.74	1.2000	0.0700	90.0	0.3	17.1	5.6968
16.49	14.45	1.2000	0.0700	150.0	0.3	17.1	7.3521
17.00	15.41	1.5000	0.0700	30.0	0.3	21.4	3.6815
16.40	14.70	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Atl-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Atlanta Insulation: R20 Inside; None Outside

Heat $(MBtu/yr)$	Cool $(MBtu/yr)$	wall thickness (ft)	thermal conductivity $(Btu/hr \cdot ft \cdot {}^\circ F)$	density (lb/ft^3)	specific heat $(Btu/lb \cdot {}^\circ F)$	R_{mass} $(hr \cdot ft^2 \cdot {}^\circ F/Btu)$	$\sqrt{t \rho c}$
19.15	17.30	0.1130	0.3768	2.2	0.3	0.3	0.5360
19.11	17.28	0.1130	0.3768	30.0	0.3	0.3	1.1089
19.02	17.20	0.3000	1.0000	30.0	0.3	0.3	1.7067
18.76	16.89	0.3000	1.0000	90.0	0.3	0.3	2.8832
18.63	16.72	0.3000	1.0000	150.0	0.3	0.3	3.7031
19.11	17.29	0.0884	0.1473	2.2	0.3	0.6	0.5206
19.07	17.27	0.0884	0.1473	30.0	0.3	0.6	1.0041
18.95	17.15	0.3000	0.5000	30.0	0.3	0.6	1.7067
18.77	16.93	0.6000	1.0000	30.0	0.3	0.6	2.3691
18.65	16.79	0.3000	0.5000	90.0	0.3	0.6	2.8832
18.55	16.63	0.3000	0.5000	150.0	0.3	0.6	3.7031
18.51	16.59	0.6000	1.0000	90.0	0.3	0.6	4.0513
18.46	16.50	0.6000	1.0000	150.0	0.3	0.6	5.2166
19.05	17.27	0.7065	0.7849	2.2	0.3	0.9	0.8240
18.92	17.16	0.7065	0.7849	10.0	0.3	0.9	1.5272
18.57	16.72	0.9000	1.0000	30.0	0.3	0.9	2.8832
18.41	16.47	0.9000	1.0000	90.0	0.3	0.9	4.9510
18.35	16.45	0.9000	1.0000	150.0	0.3	0.9	6.3807
19.00	17.25	0.9419	0.7849	2.2	0.3	1.2	0.9134
18.79	17.03	0.9419	0.7849	10.0	0.3	1.2	1.7431
18.61	16.80	0.6000	0.5000	30.0	0.3	1.2	2.3691
18.45	16.57	1.2000	1.0000	30.0	0.3	1.2	3.3185
18.40	16.50	0.6000	0.5000	90.0	0.3	1.2	4.0513
18.34	16.45	0.6000	0.5000	150.0	0.3	1.2	5.2166
18.33	16.44	1.2000	1.0000	90.0	0.3	1.2	5.7108
18.28	16.43	1.2000	1.0000	150.0	0.3	1.2	7.3629
18.37	16.50	1.5000	1.0000	30.0	0.3	1.5	3.7031
18.26	16.44	1.5000	1.0000	90.0	0.3	1.5	6.3807
18.22	16.41	1.5000	1.0000	150.0	0.3	1.5	8.2288
18.40	16.56	0.9000	0.5000	30.0	0.3	1.8	2.8832
18.27	16.44	0.9000	0.5000	90.0	0.3	1.8	4.9510
18.22	16.43	0.9000	0.5000	150.0	0.3	1.8	6.3807
18.85	17.20	0.5961	0.2484	2.2	0.3	2.4	0.7785
18.67	17.00	0.5961	0.2484	10.0	0.3	2.4	1.4146
18.28	16.46	1.2000	0.5000	30.0	0.3	2.4	3.3185
18.17	16.42	1.2000	0.5000	90.0	0.3	2.4	5.7108
18.12	16.42	1.2000	0.5000	150.0	0.3	2.4	7.3629
18.19	16.43	1.5000	0.5000	30.0	0.3	3.0	3.7031
18.09	16.42	1.5000	0.5000	90.0	0.3	3.0	6.3807
18.03	16.40	1.5000	0.5000	150.0	0.3	3.0	8.2288
18.66	17.16	0.0495	0.0115	2.2	0.3	4.3	0.4954
18.61	17.11	0.0495	0.0115	30.0	0.3	4.3	0.8113
18.28	16.66	0.3000	0.0700	30.0	0.3	4.3	1.7067

18.10	16.41	0.3000	0.0700	90.0	0.3	4.3	2.8832
18.06	16.40	0.3000	0.0700	150.0	0.3	4.3	3.7031
18.29	17.04	0.0985	0.0115	2.2	0.3	8.6	0.5270
18.08	16.80	0.0985	0.0115	30.0	0.3	8.6	1.0484
17.81	16.38	0.6000	0.0700	30.0	0.3	8.6	2.3691
17.71	16.38	0.6000	0.0700	90.0	0.3	8.6	4.0513
17.65	16.38	0.6000	0.0700	150.0	0.3	8.6	5.2166
17.99	16.94	0.1979	0.0154	2.2	0.3	12.9	0.5859
17.85	16.77	0.1979	0.0154	10.0	0.3	12.9	0.8980
17.53	16.37	0.9000	0.0700	30.0	0.3	12.9	2.8832
17.42	16.35	0.9000	0.0700	90.0	0.3	12.9	4.9510
17.31	16.34	0.9000	0.0700	150.0	0.3	12.9	6.3807
17.34	16.37	1.2000	0.0700	30.0	0.3	17.1	3.3185
17.16	16.32	1.2000	0.0700	90.0	0.3	17.1	5.7108
16.99	16.30	1.2000	0.0700	150.0	0.3	17.1	7.3629
17.17	16.35	1.5000	0.0700	30.0	0.3	21.4	3.7031
16.94	16.31	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Atl-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Atlanta   Insulation: R5 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
26.21	19.17	0.1130	0.3768	2.2	0.3	0.3	0.3575
26.16	19.11	0.1130	0.3768	30.0	0.3	0.3	1.0345
25.94	18.88	0.3000	1.0000	30.0	0.3	0.3	1.6593
25.16	17.92	0.3000	1.0000	90.0	0.3	0.3	2.8554
24.75	17.32	0.3000	1.0000	150.0	0.3	0.3	3.6815
25.76	19.02	0.0884	0.1473	2.2	0.3	0.6	0.3340
25.73	19.00	0.0884	0.1473	30.0	0.3	0.6	0.9213
25.46	18.70	0.3000	0.5000	30.0	0.3	0.6	1.6593
24.94	18.11	0.6000	1.0000	30.0	0.3	0.6	2.3352
24.57	17.61	0.3000	0.5000	90.0	0.3	0.6	2.8554
24.19	17.02	0.3000	0.5000	150.0	0.3	0.6	3.6815
24.08	16.85	0.6000	1.0000	90.0	0.3	0.6	4.0315
23.83	16.51	0.6000	1.0000	150.0	0.3	0.6	5.2013
25.34	18.91	0.7065	0.7849	2.2	0.3	0.9	0.7208
25.13	18.66	0.7065	0.7849	10.0	0.3	0.9	1.4740
24.07	17.32	0.9000	1.0000	30.0	0.3	0.9	2.8554
23.43	16.41	0.9000	1.0000	90.0	0.3	0.9	4.9349
23.25	16.24	0.9000	1.0000	150.0	0.3	0.9	6.3681
24.96	18.80	0.9419	0.7849	2.2	0.3	1.2	0.8215
24.54	18.31	0.9419	0.7849	10.0	0.3	1.2	1.6967
23.98	17.61	0.6000	0.5000	30.0	0.3	1.2	2.3352
23.45	16.80	1.2000	1.0000	30.0	0.3	1.2	3.2944
23.22	16.48	0.6000	0.5000	90.0	0.3	1.2	4.0315
23.02	16.28	0.6000	0.5000	150.0	0.3	1.2	5.2013
22.96	16.23	1.2000	1.0000	90.0	0.3	1.2	5.6968
22.81	16.16	1.2000	1.0000	150.0	0.3	1.2	7.3521
22.96	16.47	1.5000	1.0000	30.0	0.3	1.5	3.6815
22.57	16.16	1.5000	1.0000	90.0	0.3	1.5	6.3681
22.43	16.12	1.5000	1.0000	150.0	0.3	1.5	8.2191
22.91	16.77	0.9000	0.5000	30.0	0.3	1.8	2.8554
22.42	16.19	0.9000	0.5000	90.0	0.3	1.8	4.9349
22.28	16.14	0.9000	0.5000	150.0	0.3	1.8	6.3681
23.73	18.49	0.5961	0.2484	2.2	0.3	2.4	0.6683
23.43	18.09	0.5961	0.2484	10.0	0.3	2.4	1.3570
22.17	16.34	1.2000	0.5000	30.0	0.3	2.4	3.2944
21.83	16.12	1.2000	0.5000	90.0	0.3	2.4	5.6968
21.70	16.10	1.2000	0.5000	150.0	0.3	2.4	7.3521
21.62	16.18	1.5000	0.5000	30.0	0.3	3.0	3.6815
21.36	16.10	1.5000	0.5000	90.0	0.3	3.0	6.3681
21.21	16.04	1.5000	0.5000	150.0	0.3	3.0	8.2191
22.35	18.13	0.0495	0.0115	2.2	0.3	4.3	0.2931
22.32	18.10	0.0495	0.0115	30.0	0.3	4.3	0.7062
21.63	17.14	0.3000	0.0700	30.0	0.3	4.3	1.6593

21.00	16.21	0.3000	0.0700	90.0	0.3	4.3	2.8554
20.86	16.09	0.3000	0.0700	150.0	0.3	4.3	3.6815
20.53	17.67	0.0985	0.0115	2.2	0.3	8.6	0.3438
20.32	17.39	0.0985	0.0115	30.0	0.3	8.6	0.9694
19.50	16.13	0.6000	0.0700	30.0	0.3	8.6	2.3352
19.28	16.05	0.6000	0.0700	90.0	0.3	8.6	4.0315
19.16	16.01	0.6000	0.0700	150.0	0.3	8.6	5.2013
19.54	17.40	0.1979	0.0154	2.2	0.3	12.9	0.4287
19.40	17.24	0.1979	0.0154	10.0	0.3	12.9	0.8043
18.57	16.05	0.9000	0.0700	30.0	0.3	12.9	2.8554
18.36	15.97	0.9000	0.0700	90.0	0.3	12.9	4.9349
18.25	15.91	0.9000	0.0700	150.0	0.3	12.9	6.3681
18.01	16.06	1.2000	0.0700	30.0	0.3	17.1	3.2944
17.79	15.91	1.2000	0.0700	90.0	0.3	17.1	5.6968
17.61	15.84	1.2000	0.0700	150.0	0.3	17.1	7.3521
17.63	16.03	1.5000	0.0700	30.0	0.3	21.4	3.6815
17.36	15.87	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Den-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Denver Insulation: None Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t \rho c}$
111.30	24.54	0.0000	0.0000	0.0	0.0	0.3	0.0000
111.20	24.61	0.1130	0.3768	2.2	0.3	0.3	0.2731
111.20	24.61	0.1130	0.3768	30.0	0.3	0.3	1.0085
109.70	21.57	0.3000	1.0000	30.0	0.3	0.3	1.6432
105.40	17.12	0.3000	1.0000	90.0	0.3	0.3	2.8460
102.10	13.71	0.3000	1.0000	150.0	0.3	0.3	3.6742
97.85	22.43	0.0000	0.0000	0.0	0.0	0.6	0.0000
97.78	22.49	0.0884	0.1473	2.2	0.3	0.6	0.2415
97.43	22.04	0.0884	0.1473	30.0	0.3	0.6	0.8920
96.40	19.74	0.3000	0.5000	30.0	0.3	0.6	1.6432
94.22	17.47	0.6000	1.0000	30.0	0.3	0.6	2.3238
92.05	15.26	0.3000	0.5000	90.0	0.3	0.6	2.8460
88.88	11.99	0.3000	0.5000	150.0	0.3	0.6	3.6742
87.85	10.94	0.6000	1.0000	90.0	0.3	0.6	4.0249
85.75	8.70	0.6000	1.0000	150.0	0.3	0.6	5.1962
88.35	20.86	0.0000	0.0000	0.0	0.0	0.9	0.0000
88.10	20.67	0.7065	0.7849	2.2	0.3	0.9	0.6829
87.15	19.70	0.7065	0.7849	10.0	0.3	0.9	1.4559
82.43	13.86	0.9000	1.0000	30.0	0.3	0.9	2.8460
77.17	8.41	0.9000	1.0000	90.0	0.3	0.9	4.9295
76.09	7.46	0.9000	1.0000	150.0	0.3	0.9	6.3640
81.31	19.76	0.0000	0.0000	0.0	0.0	1.2	0.0000
80.91	19.47	0.9419	0.7849	2.2	0.3	1.2	0.7885
79.47	18.04	0.9419	0.7849	10.0	0.3	1.2	1.6810
77.42	15.00	0.6000	0.5000	30.0	0.3	1.2	2.3238
73.64	11.22	1.2000	1.0000	30.0	0.3	1.2	3.2863
71.75	9.31	0.6000	0.5000	90.0	0.3	1.2	4.0249
70.29	7.87	0.6000	0.5000	150.0	0.3	1.2	5.1962
69.97	7.61	1.2000	1.0000	90.0	0.3	1.2	5.6921
69.30	7.31	1.2000	1.0000	150.0	0.3	1.2	7.3485
75.80	18.89	0.0000	0.0000	0.0	0.0	1.5	0.0000
67.14	9.58	1.5000	1.0000	30.0	0.3	1.5	3.6742
64.70	7.50	1.5000	1.0000	90.0	0.3	1.5	6.3640
64.20	7.42	1.5000	1.0000	150.0	0.3	1.5	8.2158
71.40	18.23	0.0000	0.0000	0.0	0.0	1.8	0.0000
65.18	11.47	0.9000	0.5000	30.0	0.3	1.8	2.8460
61.40	7.89	0.9000	0.5000	90.0	0.3	1.8	4.9295
60.78	7.61	0.9000	0.5000	150.0	0.3	1.8	6.3640
64.78	17.23	0.0000	0.0000	0.0	0.0	2.4	0.0000
64.62	17.09	0.5961	0.2484	2.2	0.3	2.4	0.6272
63.78	16.23	0.5961	0.2484	10.0	0.3	2.4	1.3373
57.33	9.53	1.2000	0.5000	30.0	0.3	2.4	3.2863

55.19	7.87	1.2000	0.5000	90.0	0.3	2.4	5.6921
54.73	7.79	1.2000	0.5000	150.0	0.3	2.4	7.3485
59.97	16.51	0.0000	0.0000	0.0	0.0	3.0	0.0000
52.24	8.72	1.5000	0.5000	30.0	0.3	3.0	3.6742
50.90	8.05	1.5000	0.5000	90.0	0.3	3.0	6.3640
50.47	7.81	1.5000	0.5000	150.0	0.3	3.0	8.2158
53.19	15.54	0.0000	0.0000	0.0	0.0	4.3	0.0000
53.11	15.54	0.0495	0.0115	2.2	0.3	4.3	0.1807
53.02	15.36	0.0495	0.0115	30.0	0.3	4.3	0.6675
51.45	13.15	0.3000	0.0700	30.0	0.3	4.3	1.6432
47.58	9.71	0.3000	0.0700	90.0	0.3	4.3	2.8460
46.36	8.82	0.3000	0.0700	150.0	0.3	4.3	3.6742
43.45	14.20	0.0000	0.0000	0.0	0.0	8.6	0.0000
43.44	14.19	0.0985	0.0115	2.2	0.3	8.6	0.2550
43.10	13.68	0.0985	0.0115	30.0	0.3	8.6	0.9415
39.85	10.33	0.6000	0.0700	30.0	0.3	8.6	2.3238
38.37	9.55	0.6000	0.0700	90.0	0.3	8.6	4.0249
37.81	9.28	0.6000	0.0700	150.0	0.3	8.6	5.1962
39.64	13.70	0.0000	0.0000	0.0	0.0	12.9	0.0000
39.66	13.64	0.1979	0.0154	2.2	0.3	12.9	0.3614
39.46	13.35	0.1979	0.0154	10.0	0.3	12.9	0.7705
36.24	10.29	0.9000	0.0700	30.0	0.3	12.9	2.8460
35.08	9.70	0.9000	0.0700	90.0	0.3	12.9	4.9295
34.59	9.28	0.9000	0.0700	150.0	0.3	12.9	6.3640
37.61	13.43	0.0000	0.0000	0.0	0.0	17.1	0.0000
34.52	10.53	1.2000	0.0700	30.0	0.3	17.1	3.2863
33.30	9.72	1.2000	0.0700	90.0	0.3	17.1	5.6921
32.87	9.34	1.2000	0.0700	150.0	0.3	17.1	7.3485
36.35	13.26	0.0000	0.0000	0.0	0.0	21.4	0.0000
33.43	10.57	1.5000	0.0700	30.0	0.3	21.4	3.6742
32.26	9.76	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Den-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Denver Insulation: None Inside; R20 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
36.62	13.13	0.1130	0.3768	2.2	0.3	0.3	0.5360
35.86	12.07	0.1130	0.3768	30.0	0.3	0.3	1.1089
33.91	10.51	0.3000	1.0000	30.0	0.3	0.3	1.7067
32.16	8.52	0.3000	1.0000	90.0	0.3	0.3	2.8832
31.73	8.02	0.3000	1.0000	150.0	0.3	0.3	3.7031
36.54	13.13	0.0884	0.1473	2.2	0.3	0.6	0.5206
36.06	12.31	0.0884	0.1473	30.0	0.3	0.6	1.0041
33.79	10.50	0.3000	0.5000	30.0	0.3	0.6	1.7067
32.59	9.22	0.6000	1.0000	30.0	0.3	0.6	2.3691
32.15	8.68	0.3000	0.5000	90.0	0.3	0.6	2.8832
31.75	8.25	0.3000	0.5000	150.0	0.3	0.6	3.7031
31.66	8.14	0.6000	1.0000	90.0	0.3	0.6	4.0513
31.40	7.85	0.6000	1.0000	150.0	0.3	0.6	5.2166
36.26	12.67	0.7065	0.7849	2.2	0.3	0.9	0.8240
34.26	10.95	0.7065	0.7849	10.0	0.3	0.9	1.5272
32.15	8.84	0.9000	1.0000	30.0	0.3	0.9	2.8832
31.46	8.09	0.9000	1.0000	90.0	0.3	0.9	4.9510
31.25	7.82	0.9000	1.0000	150.0	0.3	0.9	6.3807
36.08	12.48	0.9419	0.7849	2.2	0.3	1.2	0.9134
33.52	10.43	0.9419	0.7849	10.0	0.3	1.2	1.7431
32.46	9.42	0.6000	0.5000	30.0	0.3	1.2	2.3691
31.97	8.77	1.2000	1.0000	30.0	0.3	1.2	3.3185
31.74	8.49	0.6000	0.5000	90.0	0.3	1.2	4.0513
31.43	8.16	0.6000	0.5000	150.0	0.3	1.2	5.2166
31.35	8.06	1.2000	1.0000	90.0	0.3	1.2	5.7108
31.09	7.78	1.2000	1.0000	150.0	0.3	1.2	7.3629
31.85	8.75	1.5000	1.0000	30.0	0.3	1.5	3.7031
31.22	8.05	1.5000	1.0000	90.0	0.3	1.5	6.3807
30.96	7.76	1.5000	1.0000	150.0	0.3	1.5	8.2288
32.15	9.24	0.9000	0.5000	30.0	0.3	1.8	2.8832
31.52	8.46	0.9000	0.5000	90.0	0.3	1.8	4.9510
31.19	8.14	0.9000	0.5000	150.0	0.3	1.8	6.3807
35.91	12.70	0.5961	0.2484	2.2	0.3	2.4	0.7785
34.28	11.20	0.5961	0.2484	10.0	0.3	2.4	1.4146
31.97	9.22	1.2000	0.5000	30.0	0.3	2.4	3.3185
31.31	8.43	1.2000	0.5000	90.0	0.3	2.4	5.7108
30.98	8.12	1.2000	0.5000	150.0	0.3	2.4	7.3629
31.84	9.21	1.5000	0.5000	30.0	0.3	3.0	3.7031
31.14	8.43	1.5000	0.5000	90.0	0.3	3.0	6.3807
30.80	8.08	1.5000	0.5000	150.0	0.3	3.0	8.2288
35.71	13.06	0.0495	0.0115	2.2	0.3	4.3	0.4954
35.42	12.57	0.0495	0.0115	30.0	0.3	4.3	0.8113
33.27	10.73	0.3000	0.0700	30.0	0.3	4.3	1.7067

32.09	9.84	0.3000	0.0700	90.0	0.3	4.3	2.8832
31.80	9.47	0.3000	0.0700	150.0	0.3	4.3	3.7031
35.00	12.93	0.0985	0.0115	2.2	0.3	8.6	0.5270
34.11	11.93	0.0985	0.0115	30.0	0.3	8.6	1.0484
32.37	10.60	0.6000	0.0700	30.0	0.3	8.6	2.3691
31.42	9.86	0.6000	0.0700	90.0	0.3	8.6	4.0513
31.09	9.46	0.6000	0.0700	150.0	0.3	8.6	5.2166
34.42	12.79	0.1979	0.0154	2.2	0.3	12.9	0.5859
33.89	12.20	0.1979	0.0154	10.0	0.3	12.9	0.8980
31.90	10.64	0.9000	0.0700	30.0	0.3	12.9	2.8832
30.91	9.85	0.9000	0.0700	90.0	0.3	12.9	4.9510
30.47	9.46	0.9000	0.0700	150.0	0.3	12.9	6.3807
31.53	10.66	1.2000	0.0700	30.0	0.3	17.1	3.3185
30.45	9.85	1.2000	0.0700	90.0	0.3	17.1	5.7108
29.63	9.62	1.2000	0.0700	150.0	0.3	17.1	7.3629
31.19	10.66	1.5000	0.0700	30.0	0.3	21.4	3.7031
29.98	9.90	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Den-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Denver Insulation: None Inside; R5 Outside

Heat ($MBtu/yr$)	Cool ($MBtu/yr$)	wall thickness (ft)	thermal conductivity ($Btu/hr \cdot ft \cdot {}^\circ F$)	density (lb/ft^3)	specific heat ($Btu/lb \cdot {}^\circ F$)	R_{mass} ($hr \cdot ft^2 \cdot {}^\circ F/Btu$)	$\sqrt{t \rho c}$
49.71	15.05	0.1130	0.3768	2.2	0.3	0.3	0.3575
48.87	14.00	0.1130	0.3768	30.0	0.3	0.3	1.0345
46.64	12.13	0.3000	1.0000	30.0	0.3	0.3	1.6593
43.62	9.15	0.3000	1.0000	90.0	0.3	0.3	2.8554
42.84	8.31	0.3000	1.0000	150.0	0.3	0.3	3.6815
48.87	14.87	0.0884	0.1473	2.2	0.3	0.6	0.3340
48.41	14.17	0.0884	0.1473	30.0	0.3	0.6	0.9213
45.83	12.02	0.3000	0.5000	30.0	0.3	0.6	1.6593
43.77	10.10	0.6000	1.0000	30.0	0.3	0.6	2.3352
42.87	9.17	0.3000	0.5000	90.0	0.3	0.6	2.8554
42.15	8.38	0.3000	0.5000	150.0	0.3	0.6	3.6815
41.94	8.20	0.6000	1.0000	90.0	0.3	0.6	4.0315
41.49	7.77	0.6000	1.0000	150.0	0.3	0.6	5.2013
47.97	14.43	0.7065	0.7849	2.2	0.3	0.9	0.7208
45.93	12.54	0.7065	0.7849	10.0	0.3	0.9	1.4740
42.19	9.22	0.9000	1.0000	30.0	0.3	0.9	2.8554
40.95	7.98	0.9000	1.0000	90.0	0.3	0.9	4.9349
40.65	7.64	0.9000	1.0000	150.0	0.3	0.9	6.3681
47.16	14.20	0.9419	0.7849	2.2	0.3	1.2	0.8215
44.45	11.71	0.9419	0.7849	10.0	0.3	1.2	1.6967
42.40	10.05	0.6000	0.5000	30.0	0.3	1.2	2.3352
41.17	8.82	1.2000	1.0000	30.0	0.3	1.2	3.2944
40.75	8.39	0.6000	0.5000	90.0	0.3	1.2	4.0315
40.35	7.98	0.6000	0.5000	150.0	0.3	1.2	5.2013
40.22	7.88	1.2000	1.0000	90.0	0.3	1.2	5.6968
39.94	7.60	1.2000	1.0000	150.0	0.3	1.2	7.3521
40.42	8.63	1.5000	1.0000	30.0	0.3	1.5	3.6815
39.61	7.84	1.5000	1.0000	90.0	0.3	1.5	6.3681
39.29	7.59	1.5000	1.0000	150.0	0.3	1.5	8.2191
40.52	9.32	0.9000	0.5000	30.0	0.3	1.8	2.8554
39.47	8.26	0.9000	0.5000	90.0	0.3	1.8	4.9349
39.14	7.95	0.9000	0.5000	150.0	0.3	1.8	6.3681
45.03	14.14	0.5961	0.2484	2.2	0.3	2.4	0.6683
43.46	12.48	0.5961	0.2484	10.0	0.3	2.4	1.3570
39.29	9.07	1.2000	0.5000	30.0	0.3	2.4	3.2944
38.45	8.24	1.2000	0.5000	90.0	0.3	2.4	5.6968
38.14	7.95	1.2000	0.5000	150.0	0.3	2.4	7.3521
38.39	9.01	1.5000	0.5000	30.0	0.3	3.0	3.6815
37.64	8.28	1.5000	0.5000	90.0	0.3	3.0	6.3681
37.27	7.93	1.5000	0.5000	150.0	0.3	3.0	8.2191
42.56	14.06	0.0495	0.0115	2.2	0.3	4.3	0.2931
42.41	13.74	0.0495	0.0115	30.0	0.3	4.3	0.7062
39.95	11.29	0.3000	0.0700	30.0	0.3	4.3	1.6593

37.77	9.64	0.3000	0.0700	90.0	0.3	4.3	2.8554
37.19	9.26	0.3000	0.0700	150.0	0.3	4.3	3.6815
39.24	13.59	0.0985	0.0115	2.2	0.3	8.6	0.3438
38.52	12.73	0.0985	0.0115	30.0	0.3	8.6	0.9694
35.85	10.42	0.6000	0.0700	30.0	0.3	8.6	2.3352
34.72	9.75	0.6000	0.0700	90.0	0.3	8.6	4.0315
34.29	9.37	0.6000	0.0700	150.0	0.3	8.6	5.2013
37.36	13.32	0.1979	0.0154	2.2	0.3	12.9	0.4287
36.97	12.82	0.1979	0.0154	10.0	0.3	12.9	0.8043
34.27	10.53	0.9000	0.0700	30.0	0.3	12.9	2.8554
33.11	9.78	0.9000	0.0700	90.0	0.3	12.9	4.9349
32.70	9.39	0.9000	0.0700	150.0	0.3	12.9	6.3681
33.26	10.61	1.2000	0.0700	30.0	0.3	17.1	3.2944
32.10	9.79	1.2000	0.0700	90.0	0.3	17.1	5.6968
31.43	9.46	1.2000	0.0700	150.0	0.3	17.1	7.3521
32.53	10.62	1.5000	0.0700	30.0	0.3	21.4	3.6815
31.30	9.82	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Den-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Denver Insulation: R20 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
36.87	12.82	0.1130	0.3768	2.2	0.3	0.3	0.5360
36.77	12.76	0.1130	0.3768	30.0	0.3	0.3	1.1089
36.56	12.60	0.3000	1.0000	30.0	0.3	0.3	1.7067
35.98	12.13	0.3000	1.0000	90.0	0.3	0.3	2.8832
35.73	11.95	0.3000	1.0000	150.0	0.3	0.3	3.7031
36.78	12.81	0.0884	0.1473	2.2	0.3	0.6	0.5206
36.70	12.76	0.0884	0.1473	30.0	0.3	0.6	1.0041
36.41	12.53	0.3000	0.5000	30.0	0.3	0.6	1.7067
36.02	12.23	0.6000	1.0000	30.0	0.3	0.6	2.3691
35.79	12.03	0.3000	0.5000	90.0	0.3	0.6	2.8832
35.55	11.87	0.3000	0.5000	150.0	0.3	0.6	3.7031
35.49	11.83	0.6000	1.0000	90.0	0.3	0.6	4.0513
35.37	11.77	0.6000	1.0000	150.0	0.3	0.6	5.2166
36.65	12.78	0.7065	0.7849	2.2	0.3	0.9	0.8240
36.38	12.54	0.7065	0.7849	10.0	0.3	0.9	1.5272
35.63	11.95	0.9000	1.0000	30.0	0.3	0.9	2.8832
35.28	11.75	0.9000	1.0000	90.0	0.3	0.9	4.9510
35.22	11.76	0.9000	1.0000	150.0	0.3	0.9	6.3807
36.54	12.75	0.9419	0.7849	2.2	0.3	1.2	0.9134
36.10	12.37	0.9419	0.7849	10.0	0.3	1.2	1.7431
35.71	12.06	0.6000	0.5000	30.0	0.3	1.2	2.3691
35.37	11.83	1.2000	1.0000	30.0	0.3	1.2	3.3185
35.26	11.77	0.6000	0.5000	90.0	0.3	1.2	4.0513
35.18	11.76	0.6000	0.5000	150.0	0.3	1.2	5.2166
35.16	11.76	1.2000	1.0000	90.0	0.3	1.2	5.7108
35.14	11.76	1.2000	1.0000	150.0	0.3	1.2	7.3629
35.22	11.77	1.5000	1.0000	30.0	0.3	1.5	3.7031
35.09	11.76	1.5000	1.0000	90.0	0.3	1.5	6.3807
35.05	11.77	1.5000	1.0000	150.0	0.3	1.5	8.2288
35.28	11.83	0.9000	0.5000	30.0	0.3	1.8	2.8832
35.06	11.77	0.9000	0.5000	90.0	0.3	1.8	4.9510
35.03	11.77	0.9000	0.5000	150.0	0.3	1.8	6.3807
36.26	12.73	0.5961	0.2484	2.2	0.3	2.4	0.7785
35.86	12.37	0.5961	0.2484	10.0	0.3	2.4	1.4146
35.04	11.76	1.2000	0.5000	30.0	0.3	2.4	3.3185
34.92	11.78	1.2000	0.5000	90.0	0.3	2.4	5.7108
34.89	11.79	1.2000	0.5000	150.0	0.3	2.4	7.3629
34.88	11.77	1.5000	0.5000	30.0	0.3	3.0	3.7031
34.80	11.80	1.5000	0.5000	90.0	0.3	3.0	6.3807
34.71	11.77	1.5000	0.5000	150.0	0.3	3.0	8.2288
35.92	12.74	0.0495	0.0115	2.2	0.3	4.3	0.4954
35.79	12.65	0.0495	0.0115	30.0	0.3	4.3	0.8113
35.07	11.99	0.3000	0.0700	30.0	0.3	4.3	1.7067

34.71	11.78	0.3000	0.0700	90.0	0.3	4.3	2.8832
34.67	11.80	0.3000	0.0700	150.0	0.3	4.3	3.7031
35.18	12.65	0.0985	0.0115	2.2	0.3	8.6	0.5270
34.72	12.25	0.0985	0.0115	30.0	0.3	8.6	1.0484
34.15	11.84	0.6000	0.0700	30.0	0.3	8.6	2.3691
34.09	11.88	0.6000	0.0700	90.0	0.3	8.6	4.0513
34.00	11.87	0.6000	0.0700	150.0	0.3	8.6	5.2166
34.59	12.57	0.1979	0.0154	2.2	0.3	12.9	0.5859
34.26	12.27	0.1979	0.0154	10.0	0.3	12.9	0.8980
33.72	11.91	0.9000	0.0700	30.0	0.3	12.9	2.8832
33.58	11.89	0.9000	0.0700	90.0	0.3	12.9	4.9510
33.42	11.89	0.9000	0.0700	150.0	0.3	12.9	6.3807
33.36	11.96	1.2000	0.0700	30.0	0.3	17.1	3.3185
33.13	11.93	1.2000	0.0700	90.0	0.3	17.1	5.7108
32.90	11.91	1.2000	0.0700	150.0	0.3	17.1	7.3629
33.05	11.98	1.5000	0.0700	30.0	0.3	21.4	3.7031
32.76	11.95	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Den-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Denver Insulation: R5 Inside; None Outside

Heat $(MBtu/yr)$	Cool $(MBtu/yr)$	wall thickness (ft)	thermal conductivity $(Btu/hr \cdot ft \cdot {}^{\circ}F)$	density (lb/ft^3)	specific heat $(Btu/lb \cdot {}^{\circ}F)$	R_{mass} $(hr \cdot ft^2 \cdot {}^{\circ}F/Btu)$	$\sqrt{t \rho c}$
50.48	13.86	0.1130	0.3768	2.2	0.3	0.3	0.3575
50.32	13.74	0.1130	0.3768	30.0	0.3	0.3	1.0345
49.82	13.32	0.3000	1.0000	30.0	0.3	0.3	1.6593
48.08	11.96	0.3000	1.0000	90.0	0.3	0.3	2.8554
47.17	11.29	0.3000	1.0000	150.0	0.3	0.3	3.6815
49.61	13.78	0.0884	0.1473	2.2	0.3	0.6	0.3340
49.49	13.70	0.0884	0.1473	30.0	0.3	0.6	0.9213
48.85	13.12	0.3000	0.5000	30.0	0.3	0.6	1.6593
47.75	12.25	0.6000	1.0000	30.0	0.3	0.6	2.3352
46.94	11.66	0.3000	0.5000	90.0	0.3	0.6	2.8554
46.11	11.01	0.3000	0.5000	150.0	0.3	0.6	3.6815
45.88	10.85	0.6000	1.0000	90.0	0.3	0.6	4.0315
45.42	10.54	0.6000	1.0000	150.0	0.3	0.6	5.2013
48.77	13.69	0.7065	0.7849	2.2	0.3	0.9	0.7208
48.21	13.18	0.7065	0.7849	10.0	0.3	0.9	1.4740
45.95	11.43	0.9000	1.0000	30.0	0.3	0.9	2.8554
44.71	10.50	0.9000	1.0000	90.0	0.3	0.9	4.9349
44.48	10.42	0.9000	1.0000	150.0	0.3	0.9	6.3681
48.01	13.60	0.9419	0.7849	2.2	0.3	1.2	0.8215
47.04	12.74	0.9419	0.7849	10.0	0.3	1.2	1.6967
45.85	11.81	0.6000	0.5000	30.0	0.3	1.2	2.3352
44.70	10.92	1.2000	1.0000	30.0	0.3	1.2	3.2944
44.28	10.62	0.6000	0.5000	90.0	0.3	1.2	4.0315
43.98	10.46	0.6000	0.5000	150.0	0.3	1.2	5.2013
43.90	10.45	1.2000	1.0000	90.0	0.3	1.2	5.6968
43.79	10.46	1.2000	1.0000	150.0	0.3	1.2	7.3521
43.79	10.67	1.5000	1.0000	30.0	0.3	1.5	3.6815
43.28	10.49	1.5000	1.0000	90.0	0.3	1.5	6.3681
43.18	10.51	1.5000	1.0000	150.0	0.3	1.5	8.2191
43.70	11.02	0.9000	0.5000	30.0	0.3	1.8	2.8554
42.88	10.52	0.9000	0.5000	90.0	0.3	1.8	4.9349
42.75	10.53	0.9000	0.5000	150.0	0.3	1.8	6.3681
45.68	13.45	0.5961	0.2484	2.2	0.3	2.4	0.6683
44.94	12.77	0.5961	0.2484	10.0	0.3	2.4	1.3570
42.32	10.70	1.2000	0.5000	30.0	0.3	2.4	3.2944
41.88	10.60	1.2000	0.5000	90.0	0.3	2.4	5.6968
41.79	10.63	1.2000	0.5000	150.0	0.3	2.4	7.3521
41.33	10.65	1.5000	0.5000	30.0	0.3	3.0	3.6815
41.05	10.70	1.5000	0.5000	90.0	0.3	3.0	6.3681
40.90	10.66	1.5000	0.5000	150.0	0.3	3.0	8.2191
43.06	13.33	0.0495	0.0115	2.2	0.3	4.3	0.2931
42.98	13.21	0.0495	0.0115	30.0	0.3	4.3	0.7062
41.44	11.78	0.3000	0.0700	30.0	0.3	4.3	1.6593

40.12	10.81	0.3000	0.0700	90.0	0.3	4.3	2.8554
39.91	10.75	0.3000	0.0700	150.0	0.3	4.3	3.6815
39.61	13.07	0.0985	0.0115	2.2	0.3	8.6	0.3438
39.06	12.52	0.0985	0.0115	30.0	0.3	8.6	0.9694
37.27	11.06	0.6000	0.0700	30.0	0.3	8.6	2.3352
37.07	11.06	0.6000	0.0700	90.0	0.3	8.6	4.0315
36.92	11.03	0.6000	0.0700	150.0	0.3	8.6	5.2013
37.65	12.89	0.1979	0.0154	2.2	0.3	12.9	0.4287
37.32	12.56	0.1979	0.0154	10.0	0.3	12.9	0.8043
35.65	11.23	0.9000	0.0700	30.0	0.3	12.9	2.8554
35.40	11.17	0.9000	0.0700	90.0	0.3	12.9	4.9349
35.13	11.10	0.9000	0.0700	150.0	0.3	12.9	6.3681
34.65	11.36	1.2000	0.0700	30.0	0.3	17.1	3.2944
34.27	11.21	1.2000	0.0700	90.0	0.3	17.1	5.6968
33.97	11.16	1.2000	0.0700	150.0	0.3	17.1	7.3521
33.92	11.39	1.5000	0.0700	30.0	0.3	21.4	3.6815
33.48	11.26	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Mia-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Miami Insulation: None Inside; None Outside

Heat	Cool	wall thickness	thermal conductivity	density	specific heat	R_{mass}	$\sqrt{t\rho c}$
(MBtu/yr)	(MBtu/yr)	(ft)	(Btu/hr·ft·°F)	(lb/ft³)	(Btu/lb·°F)	(hr·ft²·°F/Btu)	
3.78	72.42	0.0000	0.0000	0.0	0.0	0.3	0.0000
3.78	72.60	0.1130	0.3768	2.2	0.3	0.3	0.2731
3.78	72.60	0.1130	0.3768	30.0	0.3	0.3	1.0085
3.66	68.90	0.3000	1.0000	30.0	0.3	0.3	1.6432
3.08	65.73	0.3000	1.0000	90.0	0.3	0.3	2.8460
2.62	63.29	0.3000	1.0000	150.0	0.3	0.3	3.6742
3.22	66.15	0.0000	0.0000	0.0	0.0	0.6	0.0000
3.22	66.30	0.0884	0.1473	2.2	0.3	0.6	0.2415
3.21	65.97	0.0884	0.1473	30.0	0.3	0.6	0.8920
3.14	63.09	0.3000	0.5000	30.0	0.3	0.6	1.6432
2.87	61.49	0.6000	1.0000	30.0	0.3	0.6	2.3238
2.58	59.95	0.3000	0.5000	90.0	0.3	0.6	2.8460
2.13	57.60	0.3000	0.5000	150.0	0.3	0.6	3.6742
1.97	56.84	0.6000	1.0000	90.0	0.3	0.6	4.0249
1.58	55.20	0.6000	1.0000	150.0	0.3	0.6	5.1962
2.84	61.74	0.0000	0.0000	0.0	0.0	0.9	0.0000
2.84	61.66	0.7065	0.7849	2.2	0.3	0.9	0.6829
2.78	60.89	0.7065	0.7849	10.0	0.3	0.9	1.4559
2.22	55.76	0.9000	1.0000	30.0	0.3	0.9	2.8460
1.37	51.77	0.9000	1.0000	90.0	0.3	0.9	4.9295
1.07	50.98	0.9000	1.0000	150.0	0.3	0.9	6.3640
2.53	58.41	0.0000	0.0000	0.0	0.0	1.2	0.0000
2.53	58.26	0.9419	0.7849	2.2	0.3	1.2	0.7885
2.44	57.18	0.9419	0.7849	10.0	0.3	1.2	1.6810
2.21	54.20	0.6000	0.5000	30.0	0.3	1.2	2.3238
1.71	51.46	1.2000	1.0000	30.0	0.3	1.2	3.2863
1.41	50.03	0.6000	0.5000	90.0	0.3	1.2	4.0249
1.12	48.96	0.6000	0.5000	150.0	0.3	1.2	5.1962
1.03	48.73	1.2000	1.0000	90.0	0.3	1.2	5.6921
0.78	48.30	1.2000	1.0000	150.0	0.3	1.2	7.3485
2.30	55.82	0.0000	0.0000	0.0	0.0	1.5	0.0000
1.35	48.39	1.5000	1.0000	30.0	0.3	1.5	3.6742
0.81	46.71	1.5000	1.0000	90.0	0.3	1.5	6.3640
0.59	46.41	1.5000	1.0000	150.0	0.3	1.5	8.2158
2.12	53.77	0.0000	0.0000	0.0	0.0	1.8	0.0000
1.54	48.30	0.9000	0.5000	30.0	0.3	1.8	2.8460
0.93	45.60	0.9000	0.5000	90.0	0.3	1.8	4.9295
0.73	45.26	0.9000	0.5000	150.0	0.3	1.8	6.3640
1.85	50.72	0.0000	0.0000	0.0	0.0	2.4	0.0000
1.86	50.66	0.5961	0.2484	2.2	0.3	2.4	0.6272
1.85	50.01	0.5961	0.2484	10.0	0.3	2.4	1.3373
1.12	44.63	1.2000	0.5000	30.0	0.3	2.4	3.2863

0.71	43.22	1.2000	0.5000	90.0	0.3	2.4	5.6921
0.52	42.99	1.2000	0.5000	150.0	0.3	2.4	7.3485
1.66	48.54	0.0000	0.0000	0.0	0.0	3.0	0.0000
0.89	42.42	1.5000	0.5000	30.0	0.3	3.0	3.6742
0.56	41.67	1.5000	0.5000	90.0	0.3	3.0	6.3640
0.41	41.35	1.5000	0.5000	150.0	0.3	3.0	8.2158
1.40	45.52	0.0000	0.0000	0.0	0.0	4.3	0.0000
1.39	45.53	0.0495	0.0115	2.2	0.3	4.3	0.1807
1.42	45.41	0.0495	0.0115	30.0	0.3	4.3	0.6675
1.31	43.57	0.3000	0.0700	30.0	0.3	4.3	1.6432
0.89	40.94	0.3000	0.0700	90.0	0.3	4.3	2.8460
0.75	40.22	0.3000	0.0700	150.0	0.3	4.3	3.6742
1.06	41.26	0.0000	0.0000	0.0	0.0	8.6	0.0000
1.06	41.27	0.0985	0.0115	2.2	0.3	8.6	0.2550
1.06	40.95	0.0985	0.0115	30.0	0.3	8.6	0.9415
0.76	38.24	0.6000	0.0700	30.0	0.3	8.6	2.3238
0.57	37.46	0.6000	0.0700	90.0	0.3	8.6	4.0249
0.48	37.17	0.6000	0.0700	150.0	0.3	8.6	5.1962
0.93	39.64	0.0000	0.0000	0.0	0.0	12.9	0.0000
0.93	39.62	0.1979	0.0154	2.2	0.3	12.9	0.3614
0.93	39.44	0.1979	0.0154	10.0	0.3	12.9	0.7705
0.63	36.89	0.9000	0.0700	30.0	0.3	12.9	2.8460
0.48	36.32	0.9000	0.0700	90.0	0.3	12.9	4.9295
0.43	35.95	0.9000	0.0700	150.0	0.3	12.9	6.3640
0.86	38.78	0.0000	0.0000	0.0	0.0	17.1	0.0000
0.57	36.39	1.2000	0.0700	30.0	0.3	17.1	3.2863
0.46	35.68	1.2000	0.0700	90.0	0.3	17.1	5.6921
0.42	35.33	1.2000	0.0700	150.0	0.3	17.1	7.3485
0.83	38.26	0.0000	0.0000	0.0	0.0	21.4	0.0000
0.54	36.00	1.5000	0.0700	30.0	0.3	21.4	3.6742
0.46	35.30	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Mia-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Miami Insulation: None Inside; R20 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t \rho c}$
0.84	38.25	0.1130	0.3768	2.2	0.3	0.3	0.5360
0.79	37.45	0.1130	0.3768	30.0	0.3	0.3	1.1089
0.69	36.23	0.3000	1.0000	30.0	0.3	0.3	1.7067
0.50	34.59	0.3000	1.0000	90.0	0.3	0.3	2.8832
0.42	34.11	0.3000	1.0000	150.0	0.3	0.3	3.7031
0.84	38.23	0.0884	0.1473	2.2	0.3	0.6	0.5206
0.82	37.62	0.0884	0.1473	30.0	0.3	0.6	1.0041
0.68	36.20	0.3000	0.5000	30.0	0.3	0.6	1.7067
0.56	35.14	0.6000	1.0000	30.0	0.3	0.6	2.3691
0.50	34.69	0.3000	0.5000	90.0	0.3	0.6	2.8832
0.42	34.25	0.3000	0.5000	150.0	0.3	0.6	3.7031
0.39	34.11	0.6000	1.0000	90.0	0.3	0.6	4.0513
0.32	33.80	0.6000	1.0000	150.0	0.3	0.6	5.2166
0.83	37.88	0.7065	0.7849	2.2	0.3	0.9	0.8240
0.71	36.52	0.7065	0.7849	10.0	0.3	0.9	1.5272
0.50	34.80	0.9000	1.0000	30.0	0.3	0.9	2.8832
0.34	33.97	0.9000	1.0000	90.0	0.3	0.9	4.9510
0.28	33.64	0.9000	1.0000	150.0	0.3	0.9	6.3807
0.82	37.70	0.9419	0.7849	2.2	0.3	1.2	0.9134
0.66	36.08	0.9419	0.7849	10.0	0.3	1.2	1.7431
0.56	35.26	0.6000	0.5000	30.0	0.3	1.2	2.3691
0.46	34.64	1.2000	1.0000	30.0	0.3	1.2	3.3185
0.40	34.34	0.6000	0.5000	90.0	0.3	1.2	4.0513
0.33	33.99	0.6000	0.5000	150.0	0.3	1.2	5.2166
0.31	33.87	1.2000	1.0000	90.0	0.3	1.2	5.7108
0.26	33.55	1.2000	1.0000	150.0	0.3	1.2	7.3629
0.43	34.57	1.5000	1.0000	30.0	0.3	1.5	3.7031
0.30	33.80	1.5000	1.0000	90.0	0.3	1.5	6.3807
0.26	33.48	1.5000	1.0000	150.0	0.3	1.5	8.2288
0.50	35.03	0.9000	0.5000	30.0	0.3	1.8	2.8832
0.35	34.21	0.9000	0.5000	90.0	0.3	1.8	4.9510
0.30	33.85	0.9000	0.5000	150.0	0.3	1.8	6.3807
0.82	37.79	0.5961	0.2484	2.2	0.3	2.4	0.7785
0.71	36.60	0.5961	0.2484	10.0	0.3	2.4	1.4146
0.47	34.93	1.2000	0.5000	30.0	0.3	2.4	3.3185
0.33	34.12	1.2000	0.5000	90.0	0.3	2.4	5.7108
0.30	33.77	1.2000	0.5000	150.0	0.3	2.4	7.3629
0.44	34.84	1.5000	0.5000	30.0	0.3	3.0	3.7031
0.33	34.03	1.5000	0.5000	90.0	0.3	3.0	6.3807
0.29	33.70	1.5000	0.5000	150.0	0.3	3.0	8.2288
0.81	37.92	0.0495	0.0115	2.2	0.3	4.3	0.4954
0.80	37.58	0.0495	0.0115	30.0	0.3	4.3	0.8113
0.64	36.13	0.3000	0.0700	30.0	0.3	4.3	1.7067

0.52	35.31	0.3000	0.0700	90.0	0.3	4.3	2.8832
0.45	34.95	0.3000	0.0700	150.0	0.3	4.3	3.7031
0.79	37.61	0.0985	0.0115	2.2	0.3	8.6	0.5270
0.72	36.91	0.0985	0.0115	30.0	0.3	8.6	1.0484
0.57	35.70	0.6000	0.0700	30.0	0.3	8.6	2.3691
0.46	35.02	0.6000	0.0700	90.0	0.3	8.6	4.0513
0.42	34.67	0.6000	0.0700	150.0	0.3	8.6	5.2166
0.77	37.35	0.1979	0.0154	2.2	0.3	12.9	0.5859
0.73	36.93	0.1979	0.0154	10.0	0.3	12.9	0.8980
0.54	35.53	0.9000	0.0700	30.0	0.3	12.9	2.8832
0.45	34.84	0.9000	0.0700	90.0	0.3	12.9	4.9510
0.42	34.49	0.9000	0.0700	150.0	0.3	12.9	6.3807
0.52	35.42	1.2000	0.0700	30.0	0.3	17.1	3.3185
0.45	34.71	1.2000	0.0700	90.0	0.3	17.1	5.7108
0.40	35.06	1.2000	0.0700	150.0	0.3	17.1	7.3629
0.52	35.31	1.5000	0.0700	30.0	0.3	21.4	3.7031
0.44	34.83	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Mia-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Miami　　　Insulation: None Inside; R5 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\,\rho c}$
1.27	44.03	0.1130	0.3768	2.2	0.3	0.3	0.3575
1.26	43.21	0.1130	0.3768	30.0	0.3	0.3	1.2720
1.10	41.79	0.3000	1.0000	30.0	0.3	0.3	1.6593
0.75	39.37	0.3000	1.0000	90.0	0.3	0.3	2.8554
0.62	38.62	0.3000	1.0000	150.0	0.3	0.3	3.6815
1.25	43.63	0.0884	0.1473	2.2	0.3	0.6	0.3340
1.25	43.03	0.0884	0.1473	30.0	0.3	0.6	1.1817
1.07	41.44	0.3000	0.5000	30.0	0.3	0.6	1.6593
0.85	39.92	0.6000	1.0000	30.0	0.3	0.6	2.3352
0.73	39.16	0.3000	0.5000	90.0	0.3	0.6	2.8554
0.61	38.42	0.3000	0.5000	150.0	0.3	0.6	3.6815
0.56	38.25	0.6000	1.0000	90.0	0.3	0.6	4.0315
0.44	37.75	0.6000	1.0000	150.0	0.3	0.6	5.2013
1.24	43.00	0.7065	0.7849	2.2	0.3	0.9	0.7208
1.10	41.61	0.7065	0.7849	10.0	0.3	0.9	1.6494
0.71	38.95	0.9000	1.0000	30.0	0.3	0.9	2.8554
0.46	37.68	0.9000	1.0000	90.0	0.3	0.9	4.9349
0.36	37.26	0.9000	1.0000	150.0	0.3	0.9	6.3681
1.20	42.58	0.9419	0.7849	2.2	0.3	1.2	0.8215
1.00	40.76	0.9419	0.7849	10.0	0.3	1.2	1.8511
0.81	39.40	0.6000	0.5000	30.0	0.3	1.2	2.3352
0.63	38.35	1.2000	1.0000	30.0	0.3	1.2	3.2944
0.54	37.92	0.6000	0.5000	90.0	0.3	1.2	4.0315
0.43	37.45	0.6000	0.5000	150.0	0.3	1.2	5.2013
0.39	37.31	1.2000	1.0000	90.0	0.3	1.2	5.6968
0.31	36.91	1.2000	1.0000	150.0	0.3	1.2	7.3521
0.57	37.96	1.5000	1.0000	30.0	0.3	1.5	3.6815
0.36	37.01	1.5000	1.0000	90.0	0.3	1.5	6.3681
0.29	36.65	1.5000	1.0000	150.0	0.3	1.5	8.2191
0.68	38.41	0.9000	0.5000	30.0	0.3	1.8	2.8554
0.44	37.30	0.9000	0.5000	90.0	0.3	1.8	4.9349
0.36	36.90	0.9000	0.5000	150.0	0.3	1.8	6.3681
1.13	41.78	0.5961	0.2484	2.2	0.3	2.4	0.6683
1.02	40.64	0.5961	0.2484	10.0	0.3	2.4	1.5457
0.60	37.80	1.2000	0.5000	30.0	0.3	2.4	3.2944
0.39	36.85	1.2000	0.5000	90.0	0.3	2.4	5.6968
0.33	36.52	1.2000	0.5000	150.0	0.3	2.4	7.3521
0.55	37.38	1.5000	0.5000	30.0	0.3	3.0	3.6815
0.36	36.53	1.5000	0.5000	90.0	0.3	3.0	6.3681
0.31	36.18	1.5000	0.5000	150.0	0.3	3.0	8.2191
1.03	40.89	0.0495	0.0115	2.2	0.3	4.3	0.2931
1.04	40.68	0.0495	0.0115	30.0	0.3	4.3	1.0230
0.83	38.85	0.3000	0.0700	30.0	0.3	4.3	1.6593

0.62	37.47	0.3000	0.0700	90.0	0.3	4.3	2.8554
0.53	37.04	0.3000	0.0700	150.0	0.3	4.3	3.6815
0.92	39.44	0.0985	0.0115	2.2	0.3	8.6	0.3438
0.89	38.88	0.0985	0.0115	30.0	0.3	8.6	1.2196
0.64	36.99	0.6000	0.0700	30.0	0.3	8.6	2.3352
0.50	36.31	0.6000	0.0700	90.0	0.3	8.6	4.0315
0.44	35.93	0.6000	0.0700	150.0	0.3	8.6	5.2013
0.86	38.64	0.1979	0.0154	2.2	0.3	12.9	0.4287
0.85	38.34	0.1979	0.0154	10.0	0.3	12.9	1.0930
0.57	36.40	0.9000	0.0700	30.0	0.3	12.9	2.8554
0.46	35.71	0.9000	0.0700	90.0	0.3	12.9	4.9349
0.42	35.32	0.9000	0.0700	150.0	0.3	12.9	6.3681
0.54	36.03	1.2000	0.0700	30.0	0.3	17.1	3.2944
0.46	35.33	1.2000	0.0700	90.0	0.3	17.1	5.6968
0.42	35.20	1.2000	0.0700	150.0	0.3	17.1	7.3521
0.52	35.77	1.5000	0.0700	30.0	0.3	21.4	3.6815
0.45	35.14	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Mia-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Miami Insulation: R20 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t \rho c}$
0.85	37.67	0.1130	0.3768	2.2	0.3	0.3	0.5360
0.85	37.64	0.1130	0.3768	30.0	0.3	0.3	1.1089
0.84	37.56	0.3000	1.0000	30.0	0.3	0.3	1.7067
0.79	37.31	0.3000	1.0000	90.0	0.3	0.3	2.8832
0.76	37.17	0.3000	1.0000	150.0	0.3	0.3	3.7031
0.85	37.64	0.0884	0.1473	2.2	0.3	0.6	0.5206
0.84	37.62	0.0884	0.1473	30.0	0.3	0.6	1.0041
0.83	37.50	0.3000	0.5000	30.0	0.3	0.6	1.7067
0.80	37.31	0.6000	1.0000	30.0	0.3	0.6	2.3691
0.78	37.21	0.3000	0.5000	90.0	0.3	0.6	2.8832
0.75	37.10	0.3000	0.5000	150.0	0.3	0.6	3.7031
0.74	37.06	0.6000	1.0000	90.0	0.3	0.6	4.0513
0.71	36.99	0.6000	1.0000	150.0	0.3	0.6	5.2166
0.85	37.60	0.7065	0.7849	2.2	0.3	0.9	0.8240
0.83	37.49	0.7065	0.7849	10.0	0.3	0.9	1.5272
0.76	37.12	0.9000	1.0000	30.0	0.3	0.9	2.8832
0.71	36.95	0.9000	1.0000	90.0	0.3	0.9	4.9510
0.68	36.90	0.9000	1.0000	150.0	0.3	0.9	6.3807
0.84	37.56	0.9419	0.7849	2.2	0.3	1.2	0.9134
0.81	37.35	0.9419	0.7849	10.0	0.3	1.2	1.7431
0.78	37.16	0.6000	0.5000	30.0	0.3	1.2	2.3691
0.74	36.99	1.2000	1.0000	30.0	0.3	1.2	3.3185
0.72	36.94	0.6000	0.5000	90.0	0.3	1.2	4.0513
0.69	36.89	0.6000	0.5000	150.0	0.3	1.2	5.2166
0.68	36.88	1.2000	1.0000	90.0	0.3	1.2	5.7108
0.66	36.87	1.2000	1.0000	150.0	0.3	1.2	7.3629
0.72	36.91	1.5000	1.0000	30.0	0.3	1.5	3.7031
0.67	36.85	1.5000	1.0000	90.0	0.3	1.5	6.3807
0.65	36.87	1.5000	1.0000	150.0	0.3	1.5	8.2288
0.74	36.94	0.9000	0.5000	30.0	0.3	1.8	2.8832
0.68	36.83	0.9000	0.5000	90.0	0.3	1.8	4.9510
0.66	36.83	0.9000	0.5000	150.0	0.3	1.8	6.3807
0.83	37.47	0.5961	0.2484	2.2	0.3	2.4	0.7785
0.81	37.26	0.5961	0.2484	10.0	0.3	2.4	1.4146
0.71	36.82	1.2000	0.5000	30.0	0.3	2.4	3.3185
0.66	36.79	1.2000	0.5000	90.0	0.3	2.4	5.7108
0.65	36.81	1.2000	0.5000	150.0	0.3	2.4	7.3629
0.69	36.75	1.5000	0.5000	30.0	0.3	3.0	3.7031
0.65	36.76	1.5000	0.5000	90.0	0.3	3.0	6.3807
0.64	36.77	1.5000	0.5000	150.0	0.3	3.0	8.2288
0.82	37.37	0.0495	0.0115	2.2	0.3	4.3	0.4954
0.82	37.33	0.0495	0.0115	30.0	0.3	4.3	0.8113
0.76	36.89	0.3000	0.0700	30.0	0.3	4.3	1.7067

0.70	36.69	0.3000	0.0700	90.0	0.3	4.3	2.8832
0.68	36.66	0.3000	0.0700	150.0	0.3	4.3	3.7031
0.80	37.14	0.0985	0.0115	2.2	0.3	8.6	0.5270
0.76	36.88	0.0985	0.0115	30.0	0.3	8.6	1.0484
0.69	36.50	0.6000	0.0700	30.0	0.3	8.6	2.3691
0.65	36.53	0.6000	0.0700	90.0	0.3	8.6	4.0513
0.63	36.53	0.6000	0.0700	150.0	0.3	8.6	5.2166
0.78	36.95	0.1979	0.0154	2.2	0.3	12.9	0.5859
0.75	36.76	0.1979	0.0154	10.0	0.3	12.9	0.8980
0.66	36.39	0.9000	0.0700	30.0	0.3	12.9	2.8832
0.63	36.40	0.9000	0.0700	90.0	0.3	12.9	4.9510
0.63	36.40	0.9000	0.0700	150.0	0.3	12.9	6.3807
0.65	36.33	1.2000	0.0700	30.0	0.3	17.1	3.3185
0.63	36.32	1.2000	0.0700	90.0	0.3	17.1	5.7108
0.62	36.30	1.2000	0.0700	150.0	0.3	17.1	7.3629
0.63	36.25	1.5000	0.0700	30.0	0.3	21.4	3.7031
0.62	36.25	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Mia-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Miami Insulation: R5 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t \rho c}$
1.33	41.81	0.1130	0.3768	2.2	0.3	0.3	0.3575
1.33	41.73	0.1130	0.3768	30.0	0.3	0.3	1.0345
1.30	41.55	0.3000	1.0000	30.0	0.3	0.3	1.6593
1.13	40.71	0.3000	1.0000	90.0	0.3	0.3	2.8554
1.03	40.27	0.3000	1.0000	150.0	0.3	0.3	3.6815
1.29	41.53	0.0884	0.1473	2.2	0.3	0.6	0.3340
1.31	41.48	0.0884	0.1473	30.0	0.3	0.6	0.9213
1.26	41.22	0.3000	0.5000	30.0	0.3	0.6	1.6593
1.15	40.67	0.6000	1.0000	30.0	0.3	0.6	2.3352
1.08	40.27	0.3000	0.5000	90.0	0.3	0.6	2.8554
0.97	39.82	0.3000	0.5000	150.0	0.3	0.6	3.6815
0.94	39.69	0.6000	1.0000	90.0	0.3	0.6	4.0315
0.85	39.41	0.6000	1.0000	150.0	0.3	0.6	5.2013
1.28	41.26	0.7065	0.7849	2.2	0.3	0.9	0.7208
1.25	41.02	0.7065	0.7849	10.0	0.3	0.9	1.4740
1.02	39.88	0.9000	1.0000	30.0	0.3	0.9	2.8554
0.82	39.13	0.9000	1.0000	90.0	0.3	0.9	4.9349
0.73	38.98	0.9000	1.0000	150.0	0.3	0.9	6.3681
1.25	41.03	0.9419	0.7849	2.2	0.3	1.2	0.8215
1.18	40.57	0.9419	0.7849	10.0	0.3	1.2	1.6967
1.06	39.92	0.6000	0.5000	30.0	0.3	1.2	2.3352
0.93	39.30	1.2000	1.0000	30.0	0.3	1.2	3.2944
0.86	39.03	0.6000	0.5000	90.0	0.3	1.2	4.0315
0.77	38.83	0.6000	0.5000	150.0	0.3	1.2	5.2013
0.74	38.80	1.2000	1.0000	90.0	0.3	1.2	5.6968
0.67	38.75	1.2000	1.0000	150.0	0.3	1.2	7.3521
0.86	38.86	1.5000	1.0000	30.0	0.3	1.5	3.6815
0.68	38.60	1.5000	1.0000	90.0	0.3	1.5	6.3681
0.62	38.57	1.5000	1.0000	150.0	0.3	1.5	8.2191
0.92	38.98	0.9000	0.5000	30.0	0.3	1.8	2.8554
0.74	38.49	0.9000	0.5000	90.0	0.3	1.8	4.9349
0.67	38.45	0.9000	0.5000	150.0	0.3	1.8	6.3681
1.17	40.30	0.5961	0.2484	2.2	0.3	2.4	0.6683
1.11	39.94	0.5961	0.2484	10.0	0.3	2.4	1.3570
0.82	38.38	1.2000	0.5000	30.0	0.3	2.4	3.2944
0.66	38.20	1.2000	0.5000	90.0	0.3	2.4	5.6968
0.61	38.20	1.2000	0.5000	150.0	0.3	2.4	7.3521
0.76	38.03	1.5000	0.5000	30.0	0.3	3.0	3.6815
0.62	38.00	1.5000	0.5000	90.0	0.3	3.0	6.3681
0.58	37.97	1.5000	0.5000	150.0	0.3	3.0	8.2191
1.06	39.54	0.0495	0.0115	2.2	0.3	4.3	0.2931
1.07	39.48	0.0495	0.0115	30.0	0.3	4.3	0.7062
0.94	38.56	0.3000	0.0700	30.0	0.3	4.3	1.6593

0.78	37.73	0.3000	0.0700	90.0	0.3	4.3	2.8554
0.71	37.64	0.3000	0.0700	150.0	0.3	4.3	3.6815
0.94	38.48	0.0985	0.0115	2.2	0.3	8.6	0.3438
0.91	38.18	0.0985	0.0115	30.0	0.3	8.6	0.9694
0.72	37.01	0.6000	0.0700	30.0	0.3	8.6	2.3352
0.62	36.95	0.6000	0.0700	90.0	0.3	8.6	4.0315
0.58	36.92	0.6000	0.0700	150.0	0.3	8.6	5.2013
0.88	37.89	0.1979	0.0154	2.2	0.3	12.9	0.4287
0.86	37.71	0.1979	0.0154	10.0	0.3	12.9	0.8043
0.65	36.60	0.9000	0.0700	30.0	0.3	12.9	2.8554
0.57	36.53	0.9000	0.0700	90.0	0.3	12.9	4.9349
0.56	36.50	0.9000	0.0700	150.0	0.3	12.9	6.3681
0.61	36.39	1.2000	0.0700	30.0	0.3	17.1	3.2944
0.56	36.28	1.2000	0.0700	90.0	0.3	17.1	5.6968
0.55	36.21	1.2000	0.0700	150.0	0.3	17.1	7.3521
0.59	36.20	1.5000	0.0700	30.0	0.3	21.4	3.6815
0.56	36.10	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Min-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Minneapolis   Insulation: None Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
169.60	19.83	0.0000	0.0000	0.0	0.0	0.3	0.0000
169.50	19.90	0.1130	0.3768	2.2	0.3	0.3	0.2731
169.50	19.90	0.1130	0.3768	30.0	0.3	0.3	1.0085
168.60	18.32	0.3000	1.0000	30.0	0.3	0.3	1.6432
166.90	16.15	0.3000	1.0000	90.0	0.3	0.3	2.8460
165.60	14.31	0.3000	1.0000	150.0	0.3	0.3	3.6742
151.40	18.12	0.0000	0.0000	0.0	0.0	0.6	0.0000
151.30	18.17	0.0884	0.1473	2.2	0.3	0.6	0.2415
151.20	18.00	0.0884	0.1473	30.0	0.3	0.6	0.8920
150.70	16.78	0.3000	0.5000	30.0	0.3	0.6	1.6432
149.90	15.67	0.6000	1.0000	30.0	0.3	0.6	2.3238
149.10	14.57	0.3000	0.5000	90.0	0.3	0.6	2.8460
147.80	12.75	0.3000	0.5000	150.0	0.3	0.6	3.6742
147.40	12.11	0.6000	1.0000	90.0	0.3	0.6	4.0249
146.50	10.63	0.6000	1.0000	150.0	0.3	0.6	5.1962
138.50	16.92	0.0000	0.0000	0.0	0.0	0.9	0.0000
138.40	16.86	0.7065	0.7849	2.2	0.3	0.9	0.6829
138.10	16.40	0.7065	0.7849	10.0	0.3	0.9	1.4559
136.30	13.40	0.9000	1.0000	30.0	0.3	0.9	2.8460
134.10	10.06	0.9000	1.0000	90.0	0.3	0.9	4.9295
133.40	9.27	0.9000	1.0000	150.0	0.3	0.9	6.3640
128.90	16.03	0.0000	0.0000	0.0	0.0	1.2	0.0000
128.70	15.91	0.9419	0.7849	2.2	0.3	1.2	0.7885
128.20	15.23	0.9419	0.7849	10.0	0.3	1.2	1.6810
127.50	13.66	0.6000	0.5000	30.0	0.3	1.2	2.3238
126.00	11.58	1.2000	1.0000	30.0	0.3	1.2	3.2863
125.30	10.38	0.6000	0.5000	90.0	0.3	1.2	4.0249
124.50	9.38	0.6000	0.5000	150.0	0.3	1.2	5.1962
124.30	9.13	1.2000	1.0000	90.0	0.3	1.2	5.6921
123.70	8.72	1.2000	1.0000	150.0	0.3	1.2	7.3485
121.50	15.33	0.0000	0.0000	0.0	0.0	1.5	0.0000
118.20	10.34	1.5000	1.0000	30.0	0.3	1.5	3.6742
116.80	8.71	1.5000	1.0000	90.0	0.3	1.5	6.3640
116.20	8.39	1.5000	1.0000	150.0	0.3	1.5	8.2158
115.50	14.80	0.0000	0.0000	0.0	0.0	1.8	0.0000
113.10	11.27	0.9000	0.5000	30.0	0.3	1.8	2.8460
111.50	8.95	0.9000	0.5000	90.0	0.3	1.8	4.9295
111.00	8.55	0.9000	0.5000	150.0	0.3	1.8	6.3640
106.50	13.97	0.0000	0.0000	0.0	0.0	2.4	0.0000
106.40	13.91	0.5961	0.2484	2.2	0.3	2.4	0.6272
106.00	13.53	0.5961	0.2484	10.0	0.3	2.4	1.3373
103.70	9.83	1.2000	0.5000	30.0	0.3	2.4	3.2863

102.50	8.51	1.2000	0.5000	90.0	0.3	2.4	5.6921
102.00	8.25	1.2000	0.5000	150.0	0.3	2.4	7.3485
100.10	13.39	0.0000	0.0000	0.0	0.0	3.0	0.0000
97.04	9.07	1.5000	0.5000	30.0	0.3	3.0	3.6742
96.03	8.32	1.5000	0.5000	90.0	0.3	3.0	6.3640
95.54	7.97	1.5000	0.5000	150.0	0.3	3.0	8.2158
90.90	12.59	0.0000	0.0000	0.0	0.0	4.3	0.0000
90.79	12.59	0.0495	0.0115	2.2	0.3	4.3	0.1807
90.76	12.54	0.0495	0.0115	30.0	0.3	4.3	0.6675
90.22	11.42	0.3000	0.0700	30.0	0.3	4.3	1.6432
88.75	9.39	0.3000	0.0700	90.0	0.3	4.3	2.8460
88.21	8.78	0.3000	0.0700	150.0	0.3	4.3	3.6742
77.75	11.50	0.0000	0.0000	0.0	0.0	8.6	0.0000
77.77	11.49	0.0985	0.0115	2.2	0.3	8.6	0.2550
77.64	11.24	0.0985	0.0115	30.0	0.3	8.6	0.9415
76.43	9.34	0.6000	0.0700	30.0	0.3	8.6	2.3238
75.52	8.72	0.6000	0.0700	90.0	0.3	8.6	4.0249
75.12	8.47	0.6000	0.0700	150.0	0.3	8.6	5.1962
72.63	11.07	0.0000	0.0000	0.0	0.0	12.9	0.0000
72.63	11.03	0.1979	0.0154	2.2	0.3	12.9	0.3614
72.56	10.91	0.1979	0.0154	10.0	0.3	12.9	0.7705
71.18	9.09	0.9000	0.0700	30.0	0.3	12.9	2.8460
70.39	8.60	0.9000	0.0700	90.0	0.3	12.9	4.9295
69.87	8.25	0.9000	0.0700	150.0	0.3	12.9	6.3640
69.84	10.82	0.0000	0.0000	0.0	0.0	17.1	0.0000
68.44	9.10	1.2000	0.0700	30.0	0.3	17.1	3.2863
67.42	8.48	1.2000	0.0700	90.0	0.3	17.1	5.6921
66.92	8.19	1.2000	0.0700	150.0	0.3	17.1	7.3485
68.13	10.69	0.0000	0.0000	0.0	0.0	21.4	0.0000
66.68	9.05	1.5000	0.0700	30.0	0.3	21.4	3.6742
65.62	8.45	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Min-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Minneapolis Insulation: None Inside; R20 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t \rho c}$
68.54	10.63	0.1130	0.3768	2.2	0.3	0.3	0.5360
67.99	10.09	0.1130	0.3768	30.0	0.3	0.3	1.1089
67.27	9.12	0.3000	1.0000	30.0	0.3	0.3	1.7067
66.60	7.86	0.3000	1.0000	90.0	0.3	0.3	2.8832
66.35	7.47	0.3000	1.0000	150.0	0.3	0.3	3.7031
68.42	10.63	0.0884	0.1473	2.2	0.3	0.6	0.5206
68.06	10.20	0.0884	0.1473	30.0	0.3	0.6	1.0041
67.15	9.11	0.3000	0.5000	30.0	0.3	0.6	1.7067
66.72	8.31	0.6000	1.0000	30.0	0.3	0.6	2.3691
66.50	7.94	0.3000	0.5000	90.0	0.3	0.6	2.8832
66.25	7.61	0.3000	0.5000	150.0	0.3	0.6	3.7031
66.18	7.50	0.6000	1.0000	90.0	0.3	0.6	4.0513
65.97	7.23	0.6000	1.0000	150.0	0.3	0.6	5.2166
68.18	10.41	0.7065	0.7849	2.2	0.3	0.9	0.8240
67.23	9.40	0.7065	0.7849	10.0	0.3	0.9	1.5272
66.39	8.04	0.9000	1.0000	30.0	0.3	0.9	2.8832
65.91	7.40	0.9000	1.0000	90.0	0.3	0.9	4.9510
65.72	7.13	0.9000	1.0000	150.0	0.3	0.9	6.3807
68.02	10.30	0.9419	0.7849	2.2	0.3	1.2	0.9134
66.89	9.06	0.9419	0.7849	10.0	0.3	1.2	1.7431
66.48	8.43	0.6000	0.5000	30.0	0.3	1.2	2.3691
66.18	7.94	1.2000	1.0000	30.0	0.3	1.2	3.3185
66.02	7.73	0.6000	0.5000	90.0	0.3	1.2	4.0513
65.80	7.43	0.6000	0.5000	150.0	0.3	1.2	5.2166
65.71	7.32	1.2000	1.0000	90.0	0.3	1.2	5.7108
65.47	7.04	1.2000	1.0000	150.0	0.3	1.2	7.3629
66.01	7.91	1.5000	1.0000	30.0	0.3	1.5	3.7031
65.54	7.25	1.5000	1.0000	90.0	0.3	1.5	6.3807
65.27	6.99	1.5000	1.0000	150.0	0.3	1.5	8.2288
66.12	8.26	0.9000	0.5000	30.0	0.3	1.8	2.8832
65.70	7.62	0.9000	0.5000	90.0	0.3	1.8	4.9510
65.46	7.32	0.9000	0.5000	150.0	0.3	1.8	6.3807
67.76	10.41	0.5961	0.2484	2.2	0.3	2.4	0.7785
67.02	9.56	0.5961	0.2484	10.0	0.3	2.4	1.4146
65.86	8.21	1.2000	0.5000	30.0	0.3	2.4	3.3185
65.41	7.56	1.2000	0.5000	90.0	0.3	2.4	5.7108
65.15	7.26	1.2000	0.5000	150.0	0.3	2.4	7.3629
65.62	8.18	1.5000	0.5000	30.0	0.3	3.0	3.7031
65.16	7.51	1.5000	0.5000	90.0	0.3	3.0	6.3807
64.55	7.21	1.5000	0.5000	150.0	0.3	3.0	8.2288
67.32	10.56	0.0495	0.0115	2.2	0.3	4.3	0.4954
67.18	10.32	0.0495	0.0115	30.0	0.3	4.3	0.8113
66.22	9.25	0.3000	0.0700	30.0	0.3	4.3	1.7067

65.48	8.61	0.3000	0.0700	90.0	0.3	4.3	2.8832
65.33	8.34	0.3000	0.0700	150.0	0.3	4.3	3.7031
66.38	10.47	0.0985	0.0115	2.2	0.3	8.6	0.5270
66.07	9.92	0.0985	0.0115	30.0	0.3	8.6	1.0484
65.09	9.08	0.6000	0.0700	30.0	0.3	8.6	2.3691
64.41	8.52	0.6000	0.0700	90.0	0.3	8.6	4.0513
64.15	8.22	0.6000	0.0700	150.0	0.3	8.6	5.2166
65.65	10.38	0.1979	0.0154	2.2	0.3	12.9	0.5859
65.46	10.06	0.1979	0.0154	10.0	0.3	12.9	0.8980
64.31	9.04	0.9000	0.0700	30.0	0.3	12.9	2.8832
63.51	8.47	0.9000	0.0700	90.0	0.3	12.9	4.9510
63.11	8.16	0.9000	0.0700	150.0	0.3	12.9	6.3807
63.68	9.01	1.2000	0.0700	30.0	0.3	17.1	3.3185
62.81	8.43	1.2000	0.0700	90.0	0.3	17.1	5.7108
61.87	8.27	1.2000	0.0700	150.0	0.3	17.1	7.3629
63.16	9.00	1.5000	0.0700	30.0	0.3	21.4	3.7031
62.07	8.45	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Min-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Minneapolis Insulation: None Inside; R5 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
86.23	12.21	0.1130	0.3768	2.2	0.3	0.3	0.3575
85.66	11.65	0.1130	0.3768	30.0	0.3	0.3	1.0345
84.86	10.63	0.3000	1.0000	30.0	0.3	0.3	1.6593
83.85	8.79	0.3000	1.0000	90.0	0.3	0.3	2.8554
83.44	8.20	0.3000	1.0000	150.0	0.3	0.3	3.6815
85.09	12.09	0.0884	0.1473	2.2	0.3	0.6	0.3340
84.75	11.68	0.0884	0.1473	30.0	0.3	0.6	0.9213
83.75	10.56	0.3000	0.5000	30.0	0.3	0.6	1.6593
83.09	9.36	0.6000	1.0000	30.0	0.3	0.6	2.3352
82.74	8.77	0.3000	0.5000	90.0	0.3	0.6	2.8554
82.34	8.22	0.3000	0.5000	150.0	0.3	0.6	3.6815
82.21	8.06	0.6000	1.0000	90.0	0.3	0.6	4.0315
81.87	7.69	0.6000	1.0000	150.0	0.3	0.6	5.2013
83.96	11.82	0.7065	0.7849	2.2	0.3	0.9	0.7208
83.05	10.81	0.7065	0.7849	10.0	0.3	0.9	1.4740
81.71	8.76	0.9000	1.0000	30.0	0.3	0.9	2.8554
80.95	7.81	0.9000	1.0000	90.0	0.3	0.9	4.9349
80.64	7.44	0.9000	1.0000	150.0	0.3	0.9	6.3681
82.96	11.65	0.9419	0.7849	2.2	0.3	1.2	0.8215
81.79	10.31	0.9419	0.7849	10.0	0.3	1.2	1.6967
81.12	9.27	0.6000	0.5000	30.0	0.3	1.2	2.3352
80.60	8.48	1.2000	1.0000	30.0	0.3	1.2	3.2944
80.34	8.13	0.6000	0.5000	90.0	0.3	1.2	4.0315
80.00	7.78	0.6000	0.5000	150.0	0.3	1.2	5.2013
79.86	7.64	1.2000	1.0000	90.0	0.3	1.2	5.6968
79.59	7.31	1.2000	1.0000	150.0	0.3	1.2	7.3521
79.63	8.30	1.5000	1.0000	30.0	0.3	1.5	3.6815
78.90	7.53	1.5000	1.0000	90.0	0.3	1.5	6.3681
78.54	7.21	1.5000	1.0000	150.0	0.3	1.5	8.2191
79.16	8.75	0.9000	0.5000	30.0	0.3	1.8	2.8554
78.47	7.92	0.9000	0.5000	90.0	0.3	1.8	4.9349
78.14	7.57	0.9000	0.5000	150.0	0.3	1.8	6.3681
79.98	11.54	0.5961	0.2484	2.2	0.3	2.4	0.6683
79.29	10.67	0.5961	0.2484	10.0	0.3	2.4	1.3570
77.57	8.53	1.2000	0.5000	30.0	0.3	2.4	3.2944
76.93	7.78	1.2000	0.5000	90.0	0.3	2.4	5.6968
76.59	7.45	1.2000	0.5000	150.0	0.3	2.4	7.3521
76.23	8.41	1.5000	0.5000	30.0	0.3	3.0	3.6815
75.62	7.69	1.5000	0.5000	90.0	0.3	3.0	6.3681
75.19	7.36	1.5000	0.5000	150.0	0.3	3.0	8.2191
76.58	11.39	0.0495	0.0115	2.2	0.3	4.3	0.2931
76.52	11.21	0.0495	0.0115	30.0	0.3	4.3	0.7062
75.56	9.88	0.3000	0.0700	30.0	0.3	4.3	1.6593

74.58	8.83	0.3000	0.0700	90.0	0.3	4.3	2.8554
74.20	8.51	0.3000	0.0700	150.0	0.3	4.3	3.6815
72.05	10.99	0.0985	0.0115	2.2	0.3	8.6	0.3438
71.80	10.57	0.0985	0.0115	30.0	0.3	8.6	0.9694
70.61	9.16	0.6000	0.0700	30.0	0.3	8.6	2.3352
69.87	8.63	0.6000	0.0700	90.0	0.3	8.6	4.0315
69.54	8.32	0.6000	0.0700	150.0	0.3	8.6	5.2013
69.53	10.76	0.1979	0.0154	2.2	0.3	12.9	0.4287
69.41	10.55	0.1979	0.0154	10.0	0.3	12.9	0.8043
68.11	9.10	0.9000	0.0700	30.0	0.3	12.9	2.8554
67.25	8.52	0.9000	0.0700	90.0	0.3	12.9	4.9349
66.69	8.21	0.9000	0.0700	150.0	0.3	12.9	6.3681
66.43	9.07	1.2000	0.0700	30.0	0.3	17.1	3.2944
65.43	8.47	1.2000	0.0700	90.0	0.3	17.1	5.6968
64.75	8.21	1.2000	0.0700	150.0	0.3	17.1	7.3521
65.26	9.04	1.5000	0.0700	30.0	0.3	21.4	3.6815
64.19	8.45	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Min-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Minneapolis Insulation: R20 Inside; None Outside

Heat ($MBtu/yr$)	Cool ($MBtu/yr$)	wall thickness (ft)	thermal conductivity ($Btu/hr \cdot ft \cdot {}^\circ F$)	density (lb/ft^3)	specific heat ($Btu/lb \cdot {}^\circ F$)	R_{mass} ($hr \cdot ft^2 \cdot {}^\circ F/Btu$)	$\sqrt{t \rho c}$
68.80	10.44	0.1130	0.3768	2.2	0.3	0.3	0.5360
68.77	10.42	0.1130	0.3768	30.0	0.3	0.3	1.1089
68.69	10.36	0.3000	1.0000	30.0	0.3	0.3	1.7067
68.46	10.13	0.3000	1.0000	90.0	0.3	0.3	2.8832
68.35	10.02	0.3000	1.0000	150.0	0.3	0.3	3.7031
68.68	10.44	0.0884	0.1473	2.2	0.3	0.6	0.5206
68.66	10.42	0.0884	0.1473	30.0	0.3	0.6	1.0041
68.56	10.33	0.3000	0.5000	30.0	0.3	0.6	1.7067
68.41	10.17	0.6000	1.0000	30.0	0.3	0.6	2.3691
68.31	10.07	0.3000	0.5000	90.0	0.3	0.6	2.8832
68.19	9.95	0.3000	0.5000	150.0	0.3	0.6	3.7031
68.16	9.92	0.6000	1.0000	90.0	0.3	0.6	4.0513
68.08	9.85	0.6000	1.0000	150.0	0.3	0.6	5.2166
68.56	10.43	0.7065	0.7849	2.2	0.3	0.9	0.8240
68.48	10.33	0.7065	0.7849	10.0	0.3	0.9	1.5272
68.18	10.01	0.9000	1.0000	30.0	0.3	0.9	2.8832
67.96	9.84	0.9000	1.0000	90.0	0.3	0.9	4.9510
67.89	9.81	0.9000	1.0000	150.0	0.3	0.9	6.3807
68.45	10.40	0.9419	0.7849	2.2	0.3	1.2	0.9134
68.30	10.24	0.9419	0.7849	10.0	0.3	1.2	1.7431
68.14	10.07	0.6000	0.5000	30.0	0.3	1.2	2.3691
67.98	9.91	1.2000	1.0000	30.0	0.3	1.2	3.3185
67.91	9.86	0.6000	0.5000	90.0	0.3	1.2	4.0513
67.83	9.81	0.6000	0.5000	150.0	0.3	1.2	5.2166
67.81	9.80	1.2000	1.0000	90.0	0.3	1.2	5.7108
67.73	9.78	1.2000	1.0000	150.0	0.3	1.2	7.3629
67.83	9.86	1.5000	1.0000	30.0	0.3	1.5	3.7031
67.66	9.79	1.5000	1.0000	90.0	0.3	1.5	6.3807
67.57	9.78	1.5000	1.0000	150.0	0.3	1.5	8.2288
67.81	9.91	0.9000	0.5000	30.0	0.3	1.8	2.8832
67.64	9.80	0.9000	0.5000	90.0	0.3	1.8	4.9510
67.55	9.78	0.9000	0.5000	150.0	0.3	1.8	6.3807
68.07	10.38	0.5961	0.2484	2.2	0.3	2.4	0.7785
67.93	10.22	0.5961	0.2484	10.0	0.3	2.4	1.4146
67.56	9.84	1.2000	0.5000	30.0	0.3	2.4	3.3185
67.39	9.79	1.2000	0.5000	90.0	0.3	2.4	5.7108
67.28	9.77	1.2000	0.5000	150.0	0.3	2.4	7.3629
67.34	9.80	1.5000	0.5000	30.0	0.3	3.0	3.7031
67.15	9.78	1.5000	0.5000	90.0	0.3	3.0	6.3807
67.00	9.75	1.5000	0.5000	150.0	0.3	3.0	8.2288
67.54	10.37	0.0495	0.0115	2.2	0.3	4.3	0.4954
67.50	10.33	0.0495	0.0115	30.0	0.3	4.3	0.8113
67.24	10.00	0.3000	0.0700	30.0	0.3	4.3	1.7067

67.05	9.82	0.3000	0.0700	90.0	0.3	4.3	2.8832
66.98	9.79	0.3000	0.0700	150.0	0.3	4.3	3.7031
66.57	10.30	0.0985	0.0115	2.2	0.3	8.6	0.5270
66.41	10.10	0.0985	0.0115	30.0	0.3	8.6	1.0484
66.15	9.80	0.6000	0.0700	30.0	0.3	8.6	2.3691
66.00	9.79	0.6000	0.0700	90.0	0.3	8.6	4.0513
65.87	9.77	0.6000	0.0700	150.0	0.3	8.6	5.2166
65.83	10.23	0.1979	0.0154	2.2	0.3	12.9	0.5859
65.71	10.09	0.1979	0.0154	10.0	0.3	12.9	0.8980
65.41	9.81	0.9000	0.0700	30.0	0.3	12.9	2.8832
65.17	9.78	0.9000	0.0700	90.0	0.3	12.9	4.9510
64.88	9.75	0.9000	0.0700	150.0	0.3	12.9	6.3807
64.81	9.81	1.2000	0.0700	30.0	0.3	17.1	3.3185
64.42	9.76	1.2000	0.0700	90.0	0.3	17.1	5.7108
64.06	9.72	1.2000	0.0700	150.0	0.3	17.1	7.3629
64.32	9.80	1.5000	0.0700	30.0	0.3	21.4	3.7031
63.82	9.75	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Min-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Minneapolis Insulation: R5 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
86.93	11.48	0.1130	0.3768	2.2	0.3	0.3	0.3575
86.87	11.41	0.1130	0.3768	30.0	0.3	0.3	1.0345
86.67	11.27	0.3000	1.0000	30.0	0.3	0.3	1.6593
86.02	10.59	0.3000	1.0000	90.0	0.3	0.3	2.8554
85.67	10.18	0.3000	1.0000	150.0	0.3	0.3	3.6815
85.80	11.37	0.0884	0.1473	2.2	0.3	0.6	0.3340
85.76	11.36	0.0884	0.1473	30.0	0.3	0.6	0.9213
85.51	11.16	0.3000	0.5000	30.0	0.3	0.6	1.6593
85.10	10.72	0.6000	1.0000	30.0	0.3	0.6	2.3352
84.79	10.38	0.3000	0.5000	90.0	0.3	0.6	2.8554
84.46	9.97	0.3000	0.5000	150.0	0.3	0.6	3.6815
84.36	9.88	0.6000	1.0000	90.0	0.3	0.6	4.0315
84.09	9.62	0.6000	1.0000	150.0	0.3	0.6	5.2013
84.72	11.32	0.7065	0.7849	2.2	0.3	0.9	0.7208
84.54	11.15	0.7065	0.7849	10.0	0.3	0.9	1.4740
83.68	10.20	0.9000	1.0000	30.0	0.3	0.9	2.8554
83.08	9.56	0.9000	1.0000	90.0	0.3	0.9	4.9349
82.85	9.43	0.9000	1.0000	150.0	0.3	0.9	6.3681
83.78	11.26	0.9419	0.7849	2.2	0.3	1.2	0.8215
83.41	10.90	0.9419	0.7849	10.0	0.3	1.2	1.6967
82.97	10.40	0.6000	0.5000	30.0	0.3	1.2	2.3352
82.51	9.84	1.2000	1.0000	30.0	0.3	1.2	3.2944
82.29	9.64	0.6000	0.5000	90.0	0.3	1.2	4.0315
82.06	9.47	0.6000	0.5000	150.0	0.3	1.2	5.2013
81.98	9.44	1.2000	1.0000	90.0	0.3	1.2	5.6968
81.78	9.35	1.2000	1.0000	150.0	0.3	1.2	7.3521
81.49	9.64	1.5000	1.0000	30.0	0.3	1.5	3.6815
81.02	9.38	1.5000	1.0000	90.0	0.3	1.5	6.3681
80.84	9.30	1.5000	1.0000	150.0	0.3	1.5	8.2191
80.92	9.85	0.9000	0.5000	30.0	0.3	1.8	2.8554
80.42	9.43	0.9000	0.5000	90.0	0.3	1.8	4.9349
80.23	9.36	0.9000	0.5000	150.0	0.3	1.8	6.3681
80.63	11.09	0.5961	0.2484	2.2	0.3	2.4	0.6683
80.37	10.81	0.5961	0.2484	10.0	0.3	2.4	1.3570
79.32	9.59	1.2000	0.5000	30.0	0.3	2.4	3.2944
78.90	9.37	1.2000	0.5000	90.0	0.3	2.4	5.6968
78.67	9.31	1.2000	0.5000	150.0	0.3	2.4	7.3521
77.98	9.49	1.5000	0.5000	30.0	0.3	3.0	3.6815
77.58	9.34	1.5000	0.5000	90.0	0.3	3.0	6.3681
77.27	9.25	1.5000	0.5000	150.0	0.3	3.0	8.2191
77.07	10.90	0.0495	0.0115	2.2	0.3	4.3	0.2931
77.05	10.86	0.0495	0.0115	30.0	0.3	4.3	0.7062
76.53	10.18	0.3000	0.0700	30.0	0.3	4.3	1.6593

75.99	9.54	0.3000	0.0700	90.0	0.3	4.3	2.8554
75.82	9.45	0.3000	0.0700	150.0	0.3	4.3	3.6815
72.43	10.65	0.0985	0.0115	2.2	0.3	8.6	0.3438
72.27	10.42	0.0985	0.0115	30.0	0.3	8.6	0.9694
71.55	9.55	0.6000	0.0700	30.0	0.3	8.6	2.3352
71.26	9.44	0.6000	0.0700	90.0	0.3	8.6	4.0315
71.09	9.38	0.6000	0.0700	150.0	0.3	8.6	5.2013
69.82	10.51	0.1979	0.0154	2.2	0.3	12.9	0.4287
69.72	10.36	0.1979	0.0154	10.0	0.3	12.9	0.8043
68.98	9.50	0.9000	0.0700	30.0	0.3	12.9	2.8554
68.66	9.39	0.9000	0.0700	90.0	0.3	12.9	4.9349
68.31	9.31	0.9000	0.0700	150.0	0.3	12.9	6.3681
67.36	9.51	1.2000	0.0700	30.0	0.3	17.1	3.2944
66.90	9.35	1.2000	0.0700	90.0	0.3	17.1	5.6968
66.47	9.28	1.2000	0.0700	150.0	0.3	17.1	7.3521
66.21	9.50	1.5000	0.0700	30.0	0.3	21.4	3.6815
65.66	9.34	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Pho-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Phoenix Insulation: None Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t \rho c}$
26.38	85.30	0.0000	0.0000	0.0	0.0	0.3	0.0000
26.37	85.46	0.1130	0.3768	2.2	0.3	0.3	0.2731
26.37	85.46	0.1130	0.3768	30.0	0.3	0.3	1.0085
25.14	80.54	0.3000	1.0000	30.0	0.3	0.3	1.6432
21.50	75.72	0.3000	1.0000	90.0	0.3	0.3	2.8460
18.73	72.39	0.3000	1.0000	150.0	0.3	0.3	3.6742
22.90	77.53	0.0000	0.0000	0.0	0.0	0.6	0.0000
22.88	77.64	0.0884	0.1473	2.2	0.3	0.6	0.2415
22.67	77.19	0.0884	0.1473	30.0	0.3	0.6	0.8920
21.81	73.42	0.3000	0.5000	30.0	0.3	0.6	1.6432
19.99	70.91	0.6000	1.0000	30.0	0.3	0.6	2.3238
18.22	68.63	0.3000	0.5000	90.0	0.3	0.6	2.8460
15.60	65.57	0.3000	0.5000	150.0	0.3	0.6	3.6742
14.81	64.62	0.6000	1.0000	90.0	0.3	0.6	4.0249
13.19	62.73	0.6000	1.0000	150.0	0.3	0.6	5.1962
20.46	72.03	0.0000	0.0000	0.0	0.0	0.9	0.0000
20.36	71.84	0.7065	0.7849	2.2	0.3	0.9	0.6829
19.60	70.69	0.7065	0.7849	10.0	0.3	0.9	1.4559
15.78	63.52	0.9000	1.0000	30.0	0.3	0.9	2.8460
11.67	58.66	0.9000	1.0000	90.0	0.3	0.9	4.9295
11.12	58.02	0.9000	1.0000	150.0	0.3	0.9	6.3640
18.63	67.87	0.0000	0.0000	0.0	0.0	1.2	0.0000
18.50	67.64	0.9419	0.7849	2.2	0.3	1.2	0.7885
17.36	65.95	0.9419	0.7849	10.0	0.3	1.2	1.6810
15.71	61.85	0.6000	0.5000	30.0	0.3	1.2	2.3238
12.73	58.25	1.2000	1.0000	30.0	0.3	1.2	3.2863
11.27	56.55	0.6000	0.5000	90.0	0.3	1.2	4.0249
10.32	55.42	0.6000	0.5000	150.0	0.3	1.2	5.1962
10.19	55.27	1.2000	1.0000	90.0	0.3	1.2	5.6921
9.97	55.28	1.2000	1.0000	150.0	0.3	1.2	7.3485
17.11	64.69	0.0000	0.0000	0.0	0.0	1.5	0.0000
10.66	54.56	1.5000	1.0000	30.0	0.3	1.5	3.6742
9.31	53.10	1.5000	1.0000	90.0	0.3	1.5	6.3640
9.13	53.23	1.5000	1.0000	150.0	0.3	1.5	8.2158
15.88	62.15	0.0000	0.0000	0.0	0.0	1.8	0.0000
11.55	54.47	0.9000	0.5000	30.0	0.3	1.8	2.8460
8.90	51.46	0.9000	0.5000	90.0	0.3	1.8	4.9295
8.72	51.45	0.9000	0.5000	150.0	0.3	1.8	6.3640
14.07	58.36	0.0000	0.0000	0.0	0.0	2.4	0.0000
14.06	58.22	0.5961	0.2484	2.2	0.3	2.4	0.6272
13.67	57.19	0.5961	0.2484	10.0	0.3	2.4	1.3373
9.05	50.08	1.2000	0.5000	30.0	0.3	2.4	3.2863

7.92	48.92	1.2000	0.5000	90.0	0.3	2.4	5.6921
7.77	49.02	1.2000	0.5000	150.0	0.3	2.4	7.3485
12.76	55.63	0.0000	0.0000	0.0	0.0	3.0	0.0000
7.76	47.49	1.5000	0.5000	30.0	0.3	3.0	3.6742
7.25	47.25	1.5000	0.5000	90.0	0.3	3.0	6.3640
7.04	47.18	1.5000	0.5000	150.0	0.3	3.0	8.2158
10.94	51.86	0.0000	0.0000	0.0	0.0	4.3	0.0000
10.92	51.84	0.0495	0.0115	2.2	0.3	4.3	0.1807
10.95	51.60	0.0495	0.0115	30.0	0.3	4.3	0.6675
10.00	48.94	0.3000	0.0700	30.0	0.3	4.3	1.6432
7.40	45.65	0.3000	0.0700	90.0	0.3	4.3	2.8460
6.81	44.92	0.3000	0.0700	150.0	0.3	4.3	3.6742
8.40	46.45	0.0000	0.0000	0.0	0.0	8.6	0.0000
8.41	46.44	0.0985	0.0115	2.2	0.3	8.6	0.2550
8.28	45.89	0.0985	0.0115	30.0	0.3	8.6	0.9415
6.29	42.41	0.6000	0.0700	30.0	0.3	8.6	2.3238
5.73	41.86	0.6000	0.0700	90.0	0.3	8.6	4.0249
5.54	41.69	0.6000	0.0700	150.0	0.3	8.6	5.1962
7.43	44.41	0.0000	0.0000	0.0	0.0	12.9	0.0000
7.45	44.37	0.1979	0.0154	2.2	0.3	12.9	0.3614
7.37	44.06	0.1979	0.0154	10.0	0.3	12.9	0.7705
5.59	40.95	0.9000	0.0700	30.0	0.3	12.9	2.8460
5.23	40.58	0.9000	0.0700	90.0	0.3	12.9	4.9295
5.04	40.21	0.9000	0.0700	150.0	0.3	12.9	6.3640
6.92	43.32	0.0000	0.0000	0.0	0.0	17.1	0.0000
5.39	40.41	1.2000	0.0700	30.0	0.3	17.1	3.2863
4.94	39.77	1.2000	0.0700	90.0	0.3	17.1	5.6921
4.71	39.43	1.2000	0.0700	150.0	0.3	17.1	7.3485
6.62	42.66	0.0000	0.0000	0.0	0.0	21.4	0.0000
5.23	39.95	1.5000	0.0700	30.0	0.3	21.4	3.6742
4.75	39.29	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Pho-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Phoenix Insulation: None Inside; R20 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
6.71	42.61	0.1130	0.3768	2.2	0.3	0.3	0.5360
6.29	41.57	0.1130	0.3768	30.0	0.3	0.3	1.1089
5.45	40.01	0.3000	1.0000	30.0	0.3	0.3	1.7067
4.52	38.31	0.3000	1.0000	90.0	0.3	0.3	2.8832
4.29	37.95	0.3000	1.0000	150.0	0.3	0.3	3.7031
6.69	42.60	0.0884	0.1473	2.2	0.3	0.6	0.5206
6.44	41.74	0.0884	0.1473	30.0	0.3	0.6	1.0041
5.40	39.97	0.3000	0.5000	30.0	0.3	0.6	1.7067
4.78	38.85	0.6000	1.0000	30.0	0.3	0.6	2.3691
4.54	38.45	0.3000	0.5000	90.0	0.3	0.6	2.8832
4.37	38.13	0.3000	0.5000	150.0	0.3	0.6	3.7031
4.32	38.04	0.6000	1.0000	90.0	0.3	0.6	4.0513
4.20	37.86	0.6000	1.0000	150.0	0.3	0.6	5.2166
6.58	42.09	0.7065	0.7849	2.2	0.3	0.9	0.8240
5.60	40.37	0.7065	0.7849	10.0	0.3	0.9	1.5272
4.57	38.56	0.9000	1.0000	30.0	0.3	0.9	2.8832
4.29	38.02	0.9000	1.0000	90.0	0.3	0.9	4.9510
4.13	37.81	0.9000	1.0000	150.0	0.3	0.9	6.3807
6.49	41.85	0.9419	0.7849	2.2	0.3	1.2	0.9134
5.28	39.83	0.9419	0.7849	10.0	0.3	1.2	1.7431
4.78	38.98	0.6000	0.5000	30.0	0.3	1.2	2.3691
4.53	38.48	1.2000	1.0000	30.0	0.3	1.2	3.3185
4.44	38.30	0.6000	0.5000	90.0	0.3	1.2	4.0513
4.31	38.07	0.6000	0.5000	150.0	0.3	1.2	5.2166
4.23	37.97	1.2000	1.0000	90.0	0.3	1.2	5.7108
4.10	37.74	1.2000	1.0000	150.0	0.3	1.2	7.3629
4.51	38.46	1.5000	1.0000	30.0	0.3	1.5	3.7031
4.21	37.92	1.5000	1.0000	90.0	0.3	1.5	6.3807
4.03	37.69	1.5000	1.0000	150.0	0.3	1.5	8.2288
4.66	38.81	0.9000	0.5000	30.0	0.3	1.8	2.8832
4.39	38.23	0.9000	0.5000	90.0	0.3	1.8	4.9510
4.25	37.97	0.9000	0.5000	150.0	0.3	1.8	6.3807
6.49	41.96	0.5961	0.2484	2.2	0.3	2.4	0.7785
5.63	40.45	0.5961	0.2484	10.0	0.3	2.4	1.4146
4.63	38.78	1.2000	0.5000	30.0	0.3	2.4	3.3185
4.34	38.17	1.2000	0.5000	90.0	0.3	2.4	5.7108
4.16	37.90	1.2000	0.5000	150.0	0.3	2.4	7.3629
4.60	38.73	1.5000	0.5000	30.0	0.3	3.0	3.7031
4.28	38.11	1.5000	0.5000	90.0	0.3	3.0	6.3807
4.12	37.81	1.5000	0.5000	150.0	0.3	3.0	8.2288
6.47	42.20	0.0495	0.0115	2.2	0.3	4.3	0.4954
6.33	41.67	0.0495	0.0115	30.0	0.3	4.3	0.8113
5.25	39.89	0.3000	0.0700	30.0	0.3	4.3	1.7067

4.80	39.14	0.3000	0.0700	90.0	0.3	4.3	2.8832
4.66	38.83	0.3000	0.0700	150.0	0.3	4.3	3.7031
6.28	41.81	0.0985	0.0115	2.2	0.3	8.6	0.5270
5.80	40.76	0.0985	0.0115	30.0	0.3	8.6	1.0484
5.04	39.50	0.6000	0.0700	30.0	0.3	8.6	2.3691
4.70	38.90	0.6000	0.0700	90.0	0.3	8.6	4.0513
4.52	38.56	0.6000	0.0700	150.0	0.3	8.6	5.2166
6.14	41.42	0.1979	0.0154	2.2	0.3	12.9	0.5859
5.84	40.81	0.1979	0.0154	10.0	0.3	12.9	0.8980
4.98	39.37	0.9000	0.0700	30.0	0.3	12.9	2.8832
4.59	38.67	0.9000	0.0700	90.0	0.3	12.9	4.9510
4.33	38.34	0.9000	0.0700	150.0	0.3	12.9	6.3807
4.92	39.22	1.2000	0.0700	30.0	0.3	17.1	3.3185
4.46	38.49	1.2000	0.0700	90.0	0.3	17.1	5.7108
4.10	38.61	1.2000	0.0700	150.0	0.3	17.1	7.3629
4.85	39.10	1.5000	0.0700	30.0	0.3	21.4	3.7031
4.32	38.49	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Pho-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Phoenix Insulation: None Inside; R5 Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
10.02	49.95	0.1130	0.3768	2.2	0.3	0.3	0.3575
9.70	48.69	0.1130	0.3768	30.0	0.3	0.3	1.0345
8.43	46.80	0.3000	1.0000	30.0	0.3	0.3	1.6593
6.54	44.04	0.3000	1.0000	90.0	0.3	0.3	2.8554
6.07	43.29	0.3000	1.0000	150.0	0.3	0.3	3.6815
9.81	49.39	0.0884	0.1473	2.2	0.3	0.6	0.3340
9.63	48.56	0.0884	0.1473	30.0	0.3	0.6	0.9213
8.29	46.37	0.3000	0.5000	30.0	0.3	0.6	1.6593
6.91	44.54	0.6000	1.0000	30.0	0.3	0.6	2.3352
6.42	43.72	0.3000	0.5000	90.0	0.3	0.6	2.8554
6.02	43.06	0.3000	0.5000	150.0	0.3	0.6	3.6815
5.93	42.90	0.6000	1.0000	90.0	0.3	0.6	4.0315
5.71	42.60	0.6000	1.0000	150.0	0.3	0.6	5.2013
9.57	48.55	0.7065	0.7849	2.2	0.3	0.9	0.7208
8.56	46.59	0.7065	0.7849	10.0	0.3	0.9	1.4740
6.28	43.45	0.9000	1.0000	30.0	0.3	0.9	2.8554
5.70	42.44	0.9000	1.0000	90.0	0.3	0.9	4.9349
5.51	42.23	0.9000	1.0000	150.0	0.3	0.9	6.3681
9.35	48.02	0.9419	0.7849	2.2	0.3	1.2	0.8215
7.82	45.47	0.9419	0.7849	10.0	0.3	1.2	1.6967
6.63	43.90	0.6000	0.5000	30.0	0.3	1.2	2.3352
5.96	42.84	1.2000	1.0000	30.0	0.3	1.2	3.2944
5.78	42.50	0.6000	0.5000	90.0	0.3	1.2	4.0315
5.62	42.22	0.6000	0.5000	150.0	0.3	1.2	5.2013
5.55	42.13	1.2000	1.0000	90.0	0.3	1.2	5.6968
5.39	41.93	1.2000	1.0000	150.0	0.3	1.2	7.3521
5.78	42.47	1.5000	1.0000	30.0	0.3	1.5	3.6815
5.44	41.87	1.5000	1.0000	90.0	0.3	1.5	6.3681
5.18	41.68	1.5000	1.0000	150.0	0.3	1.5	8.2191
6.01	42.77	0.9000	0.5000	30.0	0.3	1.8	2.8554
5.55	41.95	0.9000	0.5000	90.0	0.3	1.8	4.9349
5.41	41.73	0.9000	0.5000	150.0	0.3	1.8	6.3681
8.84	47.03	0.5961	0.2484	2.2	0.3	2.4	0.6683
7.97	45.36	0.5961	0.2484	10.0	0.3	2.4	1.3570
5.73	42.17	1.2000	0.5000	30.0	0.3	2.4	3.2944
5.38	41.56	1.2000	0.5000	90.0	0.3	2.4	5.6968
5.22	41.32	1.2000	0.5000	150.0	0.3	2.4	7.3521
5.57	41.77	1.5000	0.5000	30.0	0.3	3.0	3.6815
5.23	41.21	1.5000	0.5000	90.0	0.3	3.0	6.3681
5.07	40.92	1.5000	0.5000	150.0	0.3	3.0	8.2191
8.19	45.96	0.0495	0.0115	2.2	0.3	4.3	0.2931
8.15	45.60	0.0495	0.0115	30.0	0.3	4.3	0.7062
6.71	43.14	0.3000	0.0700	30.0	0.3	4.3	1.6593

5.64	41.65	0.3000	0.0700	90.0	0.3	4.3	2.8554
5.45	41.37	0.3000	0.0700	150.0	0.3	4.3	3.6815
7.34	44.15	0.0985	0.0115	2.2	0.3	8.6	0.3438
7.01	43.25	0.0985	0.0115	30.0	0.3	8.6	0.9694
5.55	40.99	0.6000	0.0700	30.0	0.3	8.6	2.3352
5.18	40.49	0.6000	0.0700	90.0	0.3	8.6	4.0315
5.02	40.15	0.6000	0.0700	150.0	0.3	8.6	5.2013
6.89	43.12	0.1979	0.0154	2.2	0.3	12.9	0.4287
6.70	42.61	0.1979	0.0154	10.0	0.3	12.9	0.8043
5.30	40.38	0.9000	0.0700	30.0	0.3	12.9	2.8554
4.92	39.76	0.9000	0.0700	90.0	0.3	12.9	4.9349
4.71	39.41	0.9000	0.0700	150.0	0.3	12.9	6.3681
5.18	39.98	1.2000	0.0700	30.0	0.3	17.1	3.2944
4.73	39.29	1.2000	0.0700	90.0	0.3	17.1	5.6968
4.43	39.09	1.2000	0.0700	150.0	0.3	17.1	7.3521
5.05	39.68	1.5000	0.0700	30.0	0.3	21.4	3.6815
4.55	39.00	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Pho-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Phoenix Insulation: R20 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
6.79	41.97	0.1130	0.3768	2.2	0.3	0.3	0.5360
6.75	41.91	0.1130	0.3768	30.0	0.3	0.3	1.1089
6.63	41.71	0.3000	1.0000	30.0	0.3	0.3	1.7067
6.29	41.29	0.3000	1.0000	90.0	0.3	0.3	2.8832
6.16	41.14	0.3000	1.0000	150.0	0.3	0.3	3.7031
6.77	41.93	0.0884	0.1473	2.2	0.3	0.6	0.5206
6.74	41.88	0.0884	0.1473	30.0	0.3	0.6	1.0041
6.57	41.63	0.3000	0.5000	30.0	0.3	0.6	1.7067
6.34	41.33	0.6000	1.0000	30.0	0.3	0.6	2.3691
6.21	41.17	0.3000	0.5000	90.0	0.3	0.6	2.8832
6.09	41.05	0.3000	0.5000	150.0	0.3	0.6	3.7031
6.06	41.02	0.6000	1.0000	90.0	0.3	0.6	4.0513
6.01	40.97	0.6000	1.0000	150.0	0.3	0.6	5.2166
6.73	41.87	0.7065	0.7849	2.2	0.3	0.9	0.8240
6.58	41.61	0.7065	0.7849	10.0	0.3	0.9	1.5272
6.15	41.07	0.9000	1.0000	30.0	0.3	0.9	2.8832
5.99	40.93	0.9000	1.0000	90.0	0.3	0.9	4.9510
5.97	40.93	0.9000	1.0000	150.0	0.3	0.9	6.3807
6.69	41.78	0.9419	0.7849	2.2	0.3	1.2	0.9134
6.44	41.41	0.9419	0.7849	10.0	0.3	1.2	1.7431
6.22	41.12	0.6000	0.5000	30.0	0.3	1.2	2.3691
6.05	40.94	1.2000	1.0000	30.0	0.3	1.2	3.3185
5.99	40.90	0.6000	0.5000	90.0	0.3	1.2	4.0513
5.96	40.90	0.6000	0.5000	150.0	0.3	1.2	5.2166
5.96	40.90	1.2000	1.0000	90.0	0.3	1.2	5.7108
5.95	40.94	1.2000	1.0000	150.0	0.3	1.2	7.3629
5.99	40.87	1.5000	1.0000	30.0	0.3	1.5	3.7031
5.94	40.91	1.5000	1.0000	90.0	0.3	1.5	6.3807
5.94	40.93	1.5000	1.0000	150.0	0.3	1.5	8.2288
6.04	40.86	0.9000	0.5000	30.0	0.3	1.8	2.8832
5.94	40.84	0.9000	0.5000	90.0	0.3	1.8	4.9510
5.93	40.89	0.9000	0.5000	150.0	0.3	1.8	6.3807
6.62	41.67	0.5961	0.2484	2.2	0.3	2.4	0.7785
6.40	41.30	0.5961	0.2484	10.0	0.3	2.4	1.4146
5.95	40.78	1.2000	0.5000	30.0	0.3	2.4	3.3185
5.92	40.84	1.2000	0.5000	90.0	0.3	2.4	5.7108
5.90	40.86	1.2000	0.5000	150.0	0.3	2.4	7.3629
5.91	40.72	1.5000	0.5000	30.0	0.3	3.0	3.7031
5.89	40.82	1.5000	0.5000	90.0	0.3	3.0	6.3807
5.84	40.81	1.5000	0.5000	150.0	0.3	3.0	8.2288
6.54	41.57	0.0495	0.0115	2.2	0.3	4.3	0.4954
6.48	41.42	0.0495	0.0115	30.0	0.3	4.3	0.8113
6.08	40.79	0.3000	0.0700	30.0	0.3	4.3	1.7067

5.89	40.63	0.3000	0.0700	90.0	0.3	4.3	2.8832
5.88	40.66	0.3000	0.0700	150.0	0.3	4.3	3.7031
6.33	41.24	0.0985	0.0115	2.2	0.3	8.6	0.5270
6.11	40.80	0.0985	0.0115	30.0	0.3	8.6	1.0484
5.80	40.41	0.6000	0.0700	30.0	0.3	8.6	2.3691
5.78	40.52	0.6000	0.0700	90.0	0.3	8.6	4.0513
5.73	40.51	0.6000	0.0700	150.0	0.3	8.6	5.2166
6.19	40.93	0.1979	0.0154	2.2	0.3	12.9	0.5859
6.02	40.66	0.1979	0.0154	10.0	0.3	12.9	0.8980
5.72	40.34	0.9000	0.0700	30.0	0.3	12.9	2.8832
5.64	40.35	0.9000	0.0700	90.0	0.3	12.9	4.9510
5.55	40.34	0.9000	0.0700	150.0	0.3	12.9	6.3807
5.65	40.25	1.2000	0.0700	30.0	0.3	17.1	3.3185
5.52	40.22	1.2000	0.0700	90.0	0.3	17.1	5.7108
5.40	40.17	1.2000	0.0700	150.0	0.3	17.1	7.3629
5.57	40.14	1.5000	0.0700	30.0	0.3	21.4	3.7031
5.41	40.10	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Pho-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Phoenix Insulation: R5 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t \rho c}$
10.34	47.40	0.1130	0.3768	2.2	0.3	0.3	0.3575
10.28	47.26	0.1130	0.3768	30.0	0.3	0.3	1.0345
9.95	46.87	0.3000	1.0000	30.0	0.3	0.3	1.6593
8.80	45.61	0.3000	1.0000	90.0	0.3	0.3	2.8554
8.24	44.98	0.3000	1.0000	150.0	0.3	0.3	3.6815
10.12	47.03	0.0884	0.1473	2.2	0.3	0.6	0.3340
10.07	46.94	0.0884	0.1473	30.0	0.3	0.6	0.9213
9.67	46.41	0.3000	0.5000	30.0	0.3	0.6	1.6593
8.93	45.58	0.6000	1.0000	30.0	0.3	0.6	2.3352
8.42	45.00	0.3000	0.5000	90.0	0.3	0.6	2.8554
7.92	44.42	0.3000	0.5000	150.0	0.3	0.6	3.6815
7.78	44.29	0.6000	1.0000	90.0	0.3	0.6	4.0315
7.55	44.02	0.6000	1.0000	150.0	0.3	0.6	5.2013
9.90	46.67	0.7065	0.7849	2.2	0.3	0.9	0.7208
9.56	46.20	0.7065	0.7849	10.0	0.3	0.9	1.4740
8.11	44.50	0.9000	1.0000	30.0	0.3	0.9	2.8554
7.39	43.73	0.9000	1.0000	90.0	0.3	0.9	4.9349
7.31	43.70	0.9000	1.0000	150.0	0.3	0.9	6.3681
9.68	46.35	0.9419	0.7849	2.2	0.3	1.2	0.8215
9.08	45.54	0.9419	0.7849	10.0	0.3	1.2	1.6967
8.32	44.60	0.6000	0.5000	30.0	0.3	1.2	2.3352
7.59	43.80	1.2000	1.0000	30.0	0.3	1.2	3.2944
7.36	43.53	0.6000	0.5000	90.0	0.3	1.2	4.0315
7.23	43.45	0.6000	0.5000	150.0	0.3	1.2	5.2013
7.20	43.46	1.2000	1.0000	90.0	0.3	1.2	5.6968
7.19	43.50	1.2000	1.0000	150.0	0.3	1.2	7.3521
7.29	43.33	1.5000	1.0000	30.0	0.3	1.5	3.6815
7.11	43.29	1.5000	1.0000	90.0	0.3	1.5	6.3681
7.09	43.35	1.5000	1.0000	150.0	0.3	1.5	8.2191
7.45	43.41	0.9000	0.5000	30.0	0.3	1.8	2.8554
7.04	43.06	0.9000	0.5000	90.0	0.3	1.8	4.9349
7.02	43.14	0.9000	0.5000	150.0	0.3	1.8	6.3681
9.08	45.43	0.5961	0.2484	2.2	0.3	2.4	0.6683
8.66	44.76	0.5961	0.2484	10.0	0.3	2.4	1.3570
7.03	42.77	1.2000	0.5000	30.0	0.3	2.4	3.2944
6.88	42.82	1.2000	0.5000	90.0	0.3	2.4	5.6968
6.85	42.88	1.2000	0.5000	150.0	0.3	2.4	7.3521
6.81	42.44	1.5000	0.5000	30.0	0.3	3.0	3.6815
6.74	42.60	1.5000	0.5000	90.0	0.3	3.0	6.3681
6.67	42.56	1.5000	0.5000	150.0	0.3	3.0	8.2191
8.38	44.44	0.0495	0.0115	2.2	0.3	4.3	0.2931
8.35	44.30	0.0495	0.0115	30.0	0.3	4.3	0.7062
7.42	42.88	0.3000	0.0700	30.0	0.3	4.3	1.6593

6.65	41.98	0.3000	0.0700	90.0	0.3	4.3	2.8554
6.56	41.99	0.3000	0.0700	150.0	0.3	4.3	3.6815
7.47	43.05	0.0985	0.0115	2.2	0.3	8.6	0.3438
7.20	42.50	0.0985	0.0115	30.0	0.3	8.6	0.9694
6.17	41.07	0.6000	0.0700	30.0	0.3	8.6	2.3352
6.12	41.17	0.6000	0.0700	90.0	0.3	8.6	4.0315
6.05	41.15	0.6000	0.0700	150.0	0.3	8.6	5.2013
6.98	42.27	0.1979	0.0154	2.2	0.3	12.9	0.4287
6.83	41.90	0.1979	0.0154	10.0	0.3	12.9	0.8043
5.90	40.64	0.9000	0.0700	30.0	0.3	12.9	2.8554
5.79	40.62	0.9000	0.0700	90.0	0.3	12.9	4.9349
5.65	40.59	0.9000	0.0700	150.0	0.3	12.9	6.3681
5.73	40.39	1.2000	0.0700	30.0	0.3	17.1	3.2944
5.51	40.28	1.2000	0.0700	90.0	0.3	17.1	5.6968
5.33	40.22	1.2000	0.0700	150.0	0.3	17.1	7.3521
5.57	40.18	1.5000	0.0700	30.0	0.3	21.4	3.6815
5.32	40.04	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Was-1

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Washington Insulation: None Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
90.94	27.47	0.0000	0.0000	0.0	0.0	0.3	0.0000
90.87	27.56	0.1130	0.3768	2.2	0.3	0.3	0.2731
90.87	27.56	0.1130	0.3768	30.0	0.3	0.3	1.0085
90.12	25.26	0.3000	1.0000	30.0	0.3	0.3	1.6432
87.98	22.05	0.3000	1.0000	90.0	0.3	0.3	2.8460
86.28	19.41	0.3000	1.0000	150.0	0.3	0.3	3.6742
80.55	24.96	0.0000	0.0000	0.0	0.0	0.6	0.0000
80.49	25.03	0.0884	0.1473	2.2	0.3	0.6	0.2415
80.32	24.76	0.0884	0.1473	30.0	0.3	0.6	0.8920
79.83	23.03	0.3000	0.5000	30.0	0.3	0.6	1.6432
78.75	21.39	0.6000	1.0000	30.0	0.3	0.6	2.3238
77.69	19.77	0.3000	0.5000	90.0	0.3	0.6	2.8460
76.09	17.23	0.3000	0.5000	150.0	0.3	0.6	3.6742
75.53	16.35	0.6000	1.0000	90.0	0.3	0.6	4.0249
74.23	14.43	0.6000	1.0000	150.0	0.3	0.6	5.1962
73.11	23.18	0.0000	0.0000	0.0	0.0	0.9	0.0000
73.01	23.07	0.7065	0.7849	2.2	0.3	0.9	0.6829
72.51	22.47	0.7065	0.7849	10.0	0.3	0.9	1.4559
70.25	18.10	0.9000	1.0000	30.0	0.3	0.9	2.8460
67.36	13.58	0.9000	1.0000	90.0	0.3	0.9	4.9295
66.46	12.57	0.9000	1.0000	150.0	0.3	0.9	6.3640
67.59	21.84	0.0000	0.0000	0.0	0.0	1.2	0.0000
67.48	21.71	0.9419	0.7849	2.2	0.3	1.2	0.7885
66.70	20.77	0.9419	0.7849	10.0	0.3	1.2	1.6810
65.70	18.43	0.6000	0.5000	30.0	0.3	1.2	2.3238
63.87	15.52	1.2000	1.0000	30.0	0.3	1.2	3.2863
62.85	13.90	0.6000	0.5000	90.0	0.3	1.2	4.0249
61.87	12.58	0.6000	0.5000	150.0	0.3	1.2	5.1962
61.57	12.29	1.2000	1.0000	90.0	0.3	1.2	5.6921
60.88	11.80	1.2000	1.0000	150.0	0.3	1.2	7.3485
63.24	20.82	0.0000	0.0000	0.0	0.0	1.5	0.0000
59.01	13.76	1.5000	1.0000	30.0	0.3	1.5	3.6742
57.22	11.66	1.5000	1.0000	90.0	0.3	1.5	6.3640
56.63	11.41	1.5000	1.0000	150.0	0.3	1.5	8.2158
59.82	19.99	0.0000	0.0000	0.0	0.0	1.8	0.0000
56.90	15.03	0.9000	0.5000	30.0	0.3	1.8	2.8460
54.66	11.89	0.9000	0.5000	90.0	0.3	1.8	4.9295
54.00	11.45	0.9000	0.5000	150.0	0.3	1.8	6.3640
54.52	18.77	0.0000	0.0000	0.0	0.0	2.4	0.0000
54.49	18.71	0.5961	0.2484	2.2	0.3	2.4	0.6272
54.09	18.16	0.5961	0.2484	10.0	0.3	2.4	1.3373
51.01	12.96	1.2000	0.5000	30.0	0.3	2.4	3.2863

49.42	11.26	1.2000	0.5000	90.0	0.3	2.4	5.6921
48.89	11.05	1.2000	0.5000	150.0	0.3	2.4	7.3485
50.73	17.90	0.0000	0.0000	0.0	0.0	3.0	0.0000
46.97	11.90	1.5000	0.5000	30.0	0.3	3.0	3.6742
45.76	11.00	1.5000	0.5000	90.0	0.3	3.0	6.3640
45.32	10.74	1.5000	0.5000	150.0	0.3	3.0	8.2158
45.36	16.69	0.0000	0.0000	0.0	0.0	4.3	0.0000
45.29	16.70	0.0495	0.0115	2.2	0.3	4.3	0.1807
45.29	16.60	0.0495	0.0115	30.0	0.3	4.3	0.6675
44.72	15.05	0.3000	0.0700	30.0	0.3	4.3	1.6432
42.77	12.27	0.3000	0.0700	90.0	0.3	4.3	2.8460
42.02	11.43	0.3000	0.0700	150.0	0.3	4.3	3.6742
37.61	14.97	0.0000	0.0000	0.0	0.0	8.6	0.0000
37.62	14.97	0.0985	0.0115	2.2	0.3	8.6	0.2550
37.49	14.68	0.0985	0.0115	30.0	0.3	8.6	0.9415
36.00	12.05	0.6000	0.0700	30.0	0.3	8.6	2.3238
34.94	11.23	0.6000	0.0700	90.0	0.3	8.6	4.0249
34.55	10.97	0.6000	0.0700	150.0	0.3	8.6	5.1962
34.54	14.35	0.0000	0.0000	0.0	0.0	12.9	0.0000
34.56	14.34	0.1979	0.0154	2.2	0.3	12.9	0.3614
34.50	14.15	0.1979	0.0154	10.0	0.3	12.9	0.7705
32.86	11.63	0.9000	0.0700	30.0	0.3	12.9	2.8460
32.01	11.09	0.9000	0.0700	90.0	0.3	12.9	4.9295
31.75	10.73	0.9000	0.0700	150.0	0.3	12.9	6.3640
32.91	14.02	0.0000	0.0000	0.0	0.0	17.1	0.0000
31.27	11.64	1.2000	0.0700	30.0	0.3	17.1	3.2863
30.45	10.97	1.2000	0.0700	90.0	0.3	17.1	5.6921
30.01	10.66	1.2000	0.0700	150.0	0.3	17.1	7.3485
31.90	13.80	0.0000	0.0000	0.0	0.0	21.4	0.0000
30.33	11.60	1.5000	0.0700	30.0	0.3	21.4	3.6742
29.42	10.93	1.5000	0.0700	90.0	0.3	21.4	6.3640

TABLE A1-Was-2

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Washington Insulation: None Inside; R20 Outside

Heat $(MBtu/yr)$	Cool $(MBtu/yr)$	wall thickness (ft)	thermal conductivity $(Btu/hr \cdot ft \cdot {}^{\circ}F)$	density (lb/ft^3)	specific heat $(Btu/lb \cdot {}^{\circ}F)$	R_{mass} $(hr \cdot ft^2 \cdot {}^{\circ}F/Btu)$	$\sqrt{t \rho c}$
32.17	13.77	0.1130	0.3768	2.2	0.3	0.3	0.5360
31.69	13.00	0.1130	0.3768	30.0	0.3	0.3	1.1089
30.84	11.78	0.3000	1.0000	30.0	0.3	0.3	1.7067
30.02	10.05	0.3000	1.0000	90.0	0.3	0.3	2.8832
29.71	9.55	0.3000	1.0000	150.0	0.3	0.3	3.7031
32.11	13.77	0.0884	0.1473	2.2	0.3	0.6	0.5206
31.81	13.17	0.0884	0.1473	30.0	0.3	0.6	1.0041
30.74	11.76	0.3000	0.5000	30.0	0.3	0.6	1.7067
30.27	10.64	0.6000	1.0000	30.0	0.3	0.6	2.3691
29.99	10.14	0.3000	0.5000	90.0	0.3	0.6	2.8832
29.69	9.72	0.3000	0.5000	150.0	0.3	0.6	3.7031
29.57	9.59	0.6000	1.0000	90.0	0.3	0.6	4.0513
29.34	9.32	0.6000	1.0000	150.0	0.3	0.6	5.2166
31.98	13.43	0.7065	0.7849	2.2	0.3	0.9	0.8240
31.00	12.11	0.7065	0.7849	10.0	0.3	0.9	1.5272
29.96	10.24	0.9000	1.0000	30.0	0.3	0.9	2.8832
29.34	9.52	0.9000	1.0000	90.0	0.3	0.9	4.9510
29.15	9.27	0.9000	1.0000	150.0	0.3	0.9	6.3807
31.87	13.29	0.9419	0.7849	2.2	0.3	1.2	0.9134
30.62	11.68	0.9419	0.7849	10.0	0.3	1.2	1.7431
30.09	10.75	0.6000	0.5000	30.0	0.3	1.2	2.3691
29.76	10.13	1.2000	1.0000	30.0	0.3	1.2	3.3185
29.55	9.88	0.6000	0.5000	90.0	0.3	1.2	4.0513
29.28	9.60	0.6000	0.5000	150.0	0.3	1.2	5.2166
29.21	9.49	1.2000	1.0000	90.0	0.3	1.2	5.7108
28.96	9.24	1.2000	1.0000	150.0	0.3	1.2	7.3629
29.62	10.10	1.5000	1.0000	30.0	0.3	1.5	3.7031
29.06	9.46	1.5000	1.0000	90.0	0.3	1.5	6.3807
28.78	9.21	1.5000	1.0000	150.0	0.3	1.5	8.2288
29.80	10.56	0.9000	0.5000	30.0	0.3	1.8	2.8832
29.31	9.83	0.9000	0.5000	90.0	0.3	1.8	4.9510
29.02	9.54	0.9000	0.5000	150.0	0.3	1.8	6.3807
31.69	13.43	0.5961	0.2484	2.2	0.3	2.4	0.7785
30.82	12.27	0.5961	0.2484	10.0	0.3	2.4	1.4146
29.60	10.50	1.2000	0.5000	30.0	0.3	2.4	3.3185
29.13	9.80	1.2000	0.5000	90.0	0.3	2.4	5.7108
28.78	9.52	1.2000	0.5000	150.0	0.3	2.4	7.3629
29.46	10.48	1.5000	0.5000	30.0	0.3	3.0	3.7031
28.95	9.78	1.5000	0.5000	90.0	0.3	3.0	6.3807
28.44	9.49	1.5000	0.5000	150.0	0.3	3.0	8.2288
31.43	13.65	0.0495	0.0115	2.2	0.3	4.3	0.4954
31.33	13.30	0.0495	0.0115	30.0	0.3	4.3	0.8113
30.24	11.84	0.3000	0.0700	30.0	0.3	4.3	1.7067

29.47	11.00	0.3000	0.0700	90.0	0.3	4.3	2.8832
29.29	10.66	0.3000	0.0700	150.0	0.3	4.3	3.7031
30.87	13.52	0.0985	0.0115	2.2	0.3	8.6	0.5270
30.50	12.75	0.0985	0.0115	30.0	0.3	8.6	1.0484
29.51	11.57	0.6000	0.0700	30.0	0.3	8.6	2.3691
28.82	10.94	0.6000	0.0700	90.0	0.3	8.6	4.0513
28.60	10.61	0.6000	0.0700	150.0	0.3	8.6	5.2166
30.43	13.37	0.1979	0.0154	2.2	0.3	12.9	0.5859
30.20	12.93	0.1979	0.0154	10.0	0.3	12.9	0.8980
29.03	11.54	0.9000	0.0700	30.0	0.3	12.9	2.8832
28.34	10.90	0.9000	0.0700	90.0	0.3	12.9	4.9510
27.99	10.56	0.9000	0.0700	150.0	0.3	12.9	6.3807
28.68	11.55	1.2000	0.0700	30.0	0.3	17.1	3.3185
27.91	10.87	1.2000	0.0700	90.0	0.3	17.1	5.7108
27.12	10.73	1.2000	0.0700	150.0	0.3	17.1	7.3629
28.34	11.52	1.5000	0.0700	30.0	0.3	21.4	3.7031
27.44	10.91	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Was-3

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Washington Insulation: None Inside; R5 Outside

Heat ($MBtu/yr$)	Cool ($MBtu/yr$)	wall thickness (ft)	thermal conductivity ($Btu/hr \cdot ft \cdot {}^\circ F$)	density (lb/ft^3)	specific heat ($Btu/lb \cdot {}^\circ F$)	R_{mass} ($hr \cdot ft^2 \cdot {}^\circ F/Btu$)	$\sqrt{t \rho c}$
42.60	16.08	0.1130	0.3768	2.2	0.3	0.3	0.3575
42.22	15.35	0.1130	0.3768	30.0	0.3	0.3	1.0345
41.08	13.98	0.3000	1.0000	30.0	0.3	0.3	1.6593
39.66	11.49	0.3000	1.0000	90.0	0.3	0.3	2.8554
39.16	10.67	0.3000	1.0000	150.0	0.3	0.3	3.6815
41.96	15.90	0.0884	0.1473	2.2	0.3	0.6	0.3340
41.77	15.39	0.0884	0.1473	30.0	0.3	0.6	0.9213
40.52	13.85	0.3000	0.5000	30.0	0.3	0.6	1.6593
39.51	12.26	0.6000	1.0000	30.0	0.3	0.6	2.3352
39.07	11.45	0.3000	0.5000	90.0	0.3	0.6	2.8554
38.57	10.69	0.3000	0.5000	150.0	0.3	0.6	3.6815
38.39	10.48	0.6000	1.0000	90.0	0.3	0.6	4.0315
37.99	10.02	0.6000	1.0000	150.0	0.3	0.6	5.2013
41.29	15.53	0.7065	0.7849	2.2	0.3	0.9	0.7208
40.27	14.19	0.7065	0.7849	10.0	0.3	0.9	1.4740
38.50	11.41	0.9000	1.0000	30.0	0.3	0.9	2.8554
37.54	10.15	0.9000	1.0000	90.0	0.3	0.9	4.9349
37.21	9.81	0.9000	1.0000	150.0	0.3	0.9	6.3681
40.69	15.29	0.9419	0.7849	2.2	0.3	1.2	0.8215
39.38	13.51	0.9419	0.7849	10.0	0.3	1.2	1.6967
38.38	12.10	0.6000	0.5000	30.0	0.3	1.2	2.3352
37.71	10.96	1.2000	1.0000	30.0	0.3	1.2	3.2944
37.40	10.52	0.6000	0.5000	90.0	0.3	1.2	4.0315
37.00	10.13	0.6000	0.5000	150.0	0.3	1.2	5.2013
36.86	10.00	1.2000	1.0000	90.0	0.3	1.2	5.6968
36.58	9.69	1.2000	1.0000	150.0	0.3	1.2	7.3521
37.07	10.71	1.5000	1.0000	30.0	0.3	1.5	3.6815
36.27	9.91	1.5000	1.0000	90.0	0.3	1.5	6.3681
36.01	9.64	1.5000	1.0000	150.0	0.3	1.5	8.2191
37.02	11.33	0.9000	0.5000	30.0	0.3	1.8	2.8554
36.25	10.26	0.9000	0.5000	90.0	0.3	1.8	4.9349
35.90	9.97	0.9000	0.5000	150.0	0.3	1.8	6.3681
38.95	15.10	0.5961	0.2484	2.2	0.3	2.4	0.6683
38.21	13.94	0.5961	0.2484	10.0	0.3	2.4	1.3570
36.03	10.98	1.2000	0.5000	30.0	0.3	2.4	3.2944
35.35	10.18	1.2000	0.5000	90.0	0.3	2.4	5.6968
34.97	9.90	1.2000	0.5000	150.0	0.3	2.4	7.3521
35.22	10.84	1.5000	0.5000	30.0	0.3	3.0	3.6815
34.61	10.13	1.5000	0.5000	90.0	0.3	3.0	6.3681
34.21	9.82	1.5000	0.5000	150.0	0.3	3.0	8.2191
36.91	14.83	0.0495	0.0115	2.2	0.3	4.3	0.2931
36.88	14.64	0.0495	0.0115	30.0	0.3	4.3	0.7062
35.76	12.81	0.3000	0.0700	30.0	0.3	4.3	1.6593

34.56	11.34	0.3000	0.0700	90.0	0.3	4.3	2.8554
34.15	10.93	0.3000	0.0700	150.0	0.3	4.3	3.6815
34.21	14.27	0.0985	0.0115	2.2	0.3	8.6	0.3438
33.96	13.70	0.0985	0.0115	30.0	0.3	8.6	0.9694
32.55	11.76	0.6000	0.0700	30.0	0.3	8.6	2.3352
31.75	11.11	0.6000	0.0700	90.0	0.3	8.6	4.0315
31.46	10.77	0.6000	0.0700	150.0	0.3	8.6	5.2013
32.75	13.94	0.1979	0.0154	2.2	0.3	12.9	0.4287
32.61	13.62	0.1979	0.0154	10.0	0.3	12.9	0.8043
31.08	11.63	0.9000	0.0700	30.0	0.3	12.9	2.8554
30.32	11.00	0.9000	0.0700	90.0	0.3	12.9	4.9349
29.90	10.67	0.9000	0.0700	150.0	0.3	12.9	6.3681
30.18	11.62	1.2000	0.0700	30.0	0.3	17.1	3.2944
29.32	10.94	1.2000	0.0700	90.0	0.3	17.1	5.6968
28.76	10.68	1.2000	0.0700	150.0	0.3	17.1	7.3521
29.55	11.58	1.5000	0.0700	30.0	0.3	21.4	3.6815
28.58	10.93	1.5000	0.0700	90.0	0.3	21.4	6.3681

TABLE A1-Was-4

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Washington Insulation: R20 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft^3)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft^2·°F/Btu)	$\sqrt{t\rho c}$
32.35	13.51	0.1130	0.3768	2.2	0.3	0.3	0.5360
32.32	13.47	0.1130	0.3768	30.0	0.3	0.3	1.1089
32.21	13.34	0.3000	1.0000	30.0	0.3	0.3	1.7067
31.91	13.02	0.3000	1.0000	90.0	0.3	0.3	2.8832
31.78	12.86	0.3000	1.0000	150.0	0.3	0.3	3.7031
32.28	13.50	0.0884	0.1473	2.2	0.3	0.6	0.5206
32.25	13.47	0.0884	0.1473	30.0	0.3	0.6	1.0041
32.11	13.29	0.3000	0.5000	30.0	0.3	0.6	1.7067
31.92	13.08	0.6000	1.0000	30.0	0.3	0.6	2.3691
31.79	12.92	0.3000	0.5000	90.0	0.3	0.6	2.8832
31.67	12.78	0.3000	0.5000	150.0	0.3	0.6	3.7031
31.63	12.74	0.6000	1.0000	90.0	0.3	0.6	4.0513
31.53	12.66	0.6000	1.0000	150.0	0.3	0.6	5.2166
32.20	13.47	0.7065	0.7849	2.2	0.3	0.9	0.8240
32.08	13.30	0.7065	0.7849	10.0	0.3	0.9	1.5272
31.69	12.85	0.9000	1.0000	30.0	0.3	0.9	2.8832
31.46	12.64	0.9000	1.0000	90.0	0.3	0.9	4.9510
31.40	12.62	0.9000	1.0000	150.0	0.3	0.9	6.3807
32.13	13.45	0.9419	0.7849	2.2	0.3	1.2	0.9134
31.92	13.18	0.9419	0.7849	10.0	0.3	1.2	1.7431
31.71	12.94	0.6000	0.5000	30.0	0.3	1.2	2.3691
31.53	12.72	1.2000	1.0000	30.0	0.3	1.2	3.3185
31.45	12.66	0.6000	0.5000	90.0	0.3	1.2	4.0513
31.38	12.62	0.6000	0.5000	150.0	0.3	1.2	5.2166
31.36	12.61	1.2000	1.0000	90.0	0.3	1.2	5.7108
31.29	12.61	1.2000	1.0000	150.0	0.3	1.2	7.3629
31.41	12.65	1.5000	1.0000	30.0	0.3	1.5	3.7031
31.26	12.60	1.5000	1.0000	90.0	0.3	1.5	6.3807
31.20	12.61	1.5000	1.0000	150.0	0.3	1.5	8.2288
31.44	12.71	0.9000	0.5000	30.0	0.3	1.8	2.8832
31.27	12.61	0.9000	0.5000	90.0	0.3	1.8	4.9510
31.20	12.60	0.9000	0.5000	150.0	0.3	1.8	6.3807
31.91	13.41	0.5961	0.2484	2.2	0.3	2.4	0.7785
31.72	13.16	0.5961	0.2484	10.0	0.3	2.4	1.4146
31.25	12.63	1.2000	0.5000	30.0	0.3	2.4	3.3185
31.12	12.60	1.2000	0.5000	90.0	0.3	2.4	5.7108
31.04	12.60	1.2000	0.5000	150.0	0.3	2.4	7.3629
31.13	12.60	1.5000	0.5000	30.0	0.3	3.0	3.7031
30.97	12.60	1.5000	0.5000	90.0	0.3	3.0	6.3807
30.85	12.58	1.5000	0.5000	150.0	0.3	3.0	8.2288
31.60	13.39	0.0495	0.0115	2.2	0.3	4.3	0.4954
31.55	13.30	0.0495	0.0115	30.0	0.3	4.3	0.8113
31.21	12.82	0.3000	0.0700	30.0	0.3	4.3	1.7067

30.97	12.60	0.3000	0.0700	90.0	0.3	4.3	2.8832
30.92	12.59	0.3000	0.0700	150.0	0.3	4.3	3.7031
31.02	13.28	0.0985	0.0115	2.2	0.3	8.6	0.5270
30.82	12.98	0.0985	0.0115	30.0	0.3	8.6	1.0484
30.47	12.58	0.6000	0.0700	30.0	0.3	8.6	2.3691
30.33	12.59	0.6000	0.0700	90.0	0.3	8.6	4.0513
30.21	12.59	0.6000	0.0700	150.0	0.3	8.6	5.2166
30.55	13.18	0.1979	0.0154	2.2	0.3	12.9	0.5859
30.42	12.97	0.1979	0.0154	10.0	0.3	12.9	0.8980
30.02	12.59	0.9000	0.0700	30.0	0.3	12.9	2.8832
29.79	12.57	0.9000	0.0700	90.0	0.3	12.9	4.9510
29.57	12.56	0.9000	0.0700	150.0	0.3	12.9	6.3807
29.66	12.60	1.2000	0.0700	30.0	0.3	17.1	3.3185
29.34	12.56	1.2000	0.0700	90.0	0.3	17.1	5.7108
29.03	12.53	1.2000	0.0700	150.0	0.3	17.1	7.3629
29.37	12.58	1.5000	0.0700	30.0	0.3	21.4	3.7031
28.94	12.55	1.5000	0.0700	90.0	0.3	21.4	6.3807

TABLE A1-Was-5

BLAST RESIDENTIAL THERMAL MASS SIMULATION PARAMETRICS ANNUAL HEATING AND COOLING LOADS

Location: Washington Insulation: R5 Inside; None Outside

Heat (MBtu/yr)	Cool (MBtu/yr)	wall thickness (ft)	thermal conductivity (Btu/hr·ft·°F)	density (lb/ft³)	specific heat (Btu/lb·°F)	R_{mass} (hr·ft²·°F/Btu)	$\sqrt{t\rho c}$
43.20	15.06	0.1130	0.3768	2.2	0.3	0.3	0.3575
43.13	15.01	0.1130	0.3768	30.0	0.3	0.3	1.0345
42.91	14.77	0.3000	1.0000	30.0	0.3	0.3	1.6593
42.04	13.76	0.3000	1.0000	90.0	0.3	0.3	2.8554
41.59	13.19	0.3000	1.0000	150.0	0.3	0.3	3.6815
42.51	14.96	0.0884	0.1473	2.2	0.3	0.6	0.3340
42.48	14.93	0.0884	0.1473	30.0	0.3	0.6	0.9213
42.18	14.60	0.3000	0.5000	30.0	0.3	0.6	1.6593
41.63	13.95	0.6000	1.0000	30.0	0.3	0.6	2.3352
41.25	13.47	0.3000	0.5000	90.0	0.3	0.6	2.8554
40.80	12.91	0.3000	0.5000	150.0	0.3	0.6	3.6815
40.67	12.76	0.6000	1.0000	90.0	0.3	0.6	4.0315
40.34	12.40	0.6000	1.0000	150.0	0.3	0.6	5.2013
41.88	14.87	0.7065	0.7849	2.2	0.3	0.9	0.7208
41.63	14.57	0.7065	0.7849	10.0	0.3	0.9	1.4740
40.53	13.22	0.9000	1.0000	30.0	0.3	0.9	2.8554
39.75	12.31	0.9000	1.0000	90.0	0.3	0.9	4.9349
39.52	12.18	0.9000	1.0000	150.0	0.3	0.9	6.3681
41.30	14.77	0.9419	0.7849	2.2	0.3	1.2	0.8215
40.84	14.21	0.9419	0.7849	10.0	0.3	1.2	1.6967
40.27	13.49	0.6000	0.5000	30.0	0.3	1.2	2.3352
39.67	12.72	1.2000	1.0000	30.0	0.3	1.2	3.2944
39.40	12.43	0.6000	0.5000	90.0	0.3	1.2	4.0315
39.13	12.20	0.6000	0.5000	150.0	0.3	1.2	5.2013
39.05	12.17	1.2000	1.0000	90.0	0.3	1.2	5.6968
38.87	12.14	1.2000	1.0000	150.0	0.3	1.2	7.3521
38.97	12.43	1.5000	1.0000	30.0	0.3	1.5	3.6815
38.46	12.12	1.5000	1.0000	90.0	0.3	1.5	6.3681
38.32	12.10	1.5000	1.0000	150.0	0.3	1.5	8.2191
38.80	12.72	0.9000	0.5000	30.0	0.3	1.8	2.8554
38.20	12.14	0.9000	0.5000	90.0	0.3	1.8	4.9349
38.01	12.13	0.9000	0.5000	150.0	0.3	1.8	6.3681
39.42	14.50	0.5961	0.2484	2.2	0.3	2.4	0.6683
39.09	14.07	0.5961	0.2484	10.0	0.3	2.4	1.3570
37.73	12.33	1.2000	0.5000	30.0	0.3	2.4	3.2944
37.28	12.12	1.2000	0.5000	90.0	0.3	2.4	5.6968
37.15	12.11	1.2000	0.5000	150.0	0.3	2.4	7.3521
36.90	12.18	1.5000	0.5000	30.0	0.3	3.0	3.6815
36.53	12.12	1.5000	0.5000	90.0	0.3	3.0	6.3681
36.30	12.08	1.5000	0.5000	150.0	0.3	3.0	8.2191
37.31	14.22	0.0495	0.0115	2.2	0.3	4.3	0.2931
37.28	14.16	0.0495	0.0115	30.0	0.3	4.3	0.7062
36.55	13.16	0.3000	0.0700	30.0	0.3	4.3	1.6593

35.87	12.24	0.3000	0.0700	90.0	0.3	4.3	2.8554
35.66	12.13	0.3000	0.0700	150.0	0.3	4.3	3.6815
34.51	13.83	0.0985	0.0115	2.2	0.3	8.6	0.3438
34.30	13.48	0.0985	0.0115	30.0	0.3	8.6	0.9694
33.40	12.22	0.6000	0.0700	30.0	0.3	8.6	2.3352
33.11	12.15	0.6000	0.0700	90.0	0.3	8.6	4.0315
32.90	12.12	0.6000	0.0700	150.0	0.3	8.6	5.2013
32.98	13.61	0.1979	0.0154	2.2	0.3	12.9	0.4287
32.84	13.37	0.1979	0.0154	10.0	0.3	12.9	0.8043
31.91	12.20	0.9000	0.0700	30.0	0.3	12.9	2.8554
31.57	12.12	0.9000	0.0700	90.0	0.3	12.9	4.9349
31.20	12.08	0.9000	0.0700	150.0	0.3	12.9	6.3681
30.97	12.23	1.2000	0.0700	30.0	0.3	17.1	3.2944
30.48	12.11	1.2000	0.0700	90.0	0.3	17.1	5.6968
30.08	12.06	1.2000	0.0700	150.0	0.3	17.1	7.3521
30.32	12.21	1.5000	0.0700	30.0	0.3	21.4	3.6815
29.74	12.10	1.5000	0.0700	90.0	0.3	21.4	6.3681

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