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Expanded NBSLD Output for Analysis of Thermal Performance of Building Envelope Components

Stephen R. Petersen and
James P. Barnett

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234

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U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, *Secretary*

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PREFACE

This is one of a series of reports planned to document NBS research efforts in developing the energy and cost data needed to formulate energy budgets for Building Energy Conservation Criteria (BECC). The work described in this report was jointly supported by the Department of Energy and the Department of Housing and Urban Development.

The Applied Economics Group, Building Economics and Regulatory Technology Division, in the Center for Building Technology, was given the lead role in developing this report to assure that the thermal analysis of building design modifications was compatible with the need for accurate incremental load reduction data for economic analysis. Existing methodologies based on steady-state analysis and degree-day data do not provide an adequate basis for the economic analysis of alternative component specifications. More accurate load calculation methodologies, such as the NBS Load Determination (NBSLD) program, provide only the total load and do not make the individual load components available to the user. These additional data can be of considerable use in the building envelope design process, both from an economic and technical viewpoint.

The NBSLD Program was selected to serve as the basis for these load component calculations because of its national recognition, sophistication, state of readiness, and the availability of support from the Thermal Analysis Group, Building Thermal Performance Division in the Center for Building Technology. Dr. Tamami Kusuda, Chief of the Thermal Analysis Group and author of the original version of the NBSLD program, provided invaluable assistance in developing the modified version of NBSLD described in this report. In addition, P. R. Achenbach, Bradley Peavy, S. Robert Hastings, and Patricia Christopher provided many helpful comments in preparing the final manuscript.

ABSTRACT

The NBS Load Determination Program (NBSLD) for the calculation of space heating and cooling loads in buildings is a potentially useful tool for the improved thermal design of building envelopes. However, its usefulness is limited because only the net heating and cooling loads are determined. In order to design buildings which are to be, from inception, more energy efficient than existing buildings, the thermal performance of the individual envelope elements (e.g., walls, windows, ceilings and floors) must be known and the interrelationships among these elements understood. The NBSLD-XO subroutine will produce an expanded output of an NBSLD heating and/or cooling load analysis which provides thermal performance data for each envelope element on an hourly, daily, monthly, and yearly basis. This report outlines the NBSLD-XO program, format, and output and provides several examples of its use based on a prototypical single-family residential building. A considerable amount of information about the thermal performance of the various building envelope elements and their interrelationships is provided as exemplary of the use of the NBSLD-XO computer program.

Key Words: Building design; thermal performance; HVAC loads; energy conservation; computer analysis; thermal insulation.

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SI CONVERSION

The NBS Load Determination (NBSLD) program for analysis of building energy performance is currently structured to use customary units of measurement only. In order to maintain compatibility with NBSLD, the subroutine discussed in this report must also be formatted in customary units. Since the United States is a signatory to the Eleventh General Conference on Weights and Measures, which defined and gave official status to the Metric SI system, the following conversion factors are provided to assist users of SI units:

Energy: 1 Btu = 1.055 kilojoules

Temperature: 1°C = 5/9 (°F-32)

Length: 1 ft = 0.3048 meters

Weight: 1 lb = 0.4536 kilograms

1. INTRODUCTION

Dynamic simulation models for the calculation of heating and cooling loads in buildings have considerably advanced the state-of-the-art in load estimation at the design stage. In addition, the availability of weather tapes from the National Climatic Center, which contain representative hour-by-hour climatic data for an entire year at a given location, provide a much more accurate basis for estimating annual heating and cooling requirements than the more traditional methods (e.g., degree-day and bin methods). These tools can be of considerable value in determining the thermal performance of alternative building envelope designs over time and thus provide a sound basis for evaluating energy conservation improvements in new and existing buildings.

However, the usefulness of a dynamic simulation model and improved climatic data for the design process itself is limited when only the total heating and cooling loads are determined. The design process for buildings of improved thermal performance requires information about the components of those loads as well as their interrelationships. That is, the individual contributions to the overall thermal performance of the envelope by each envelope element (e.g., walls, windows, ceilings, and floors) and its relationship to the total heating and cooling loads encountered must be understood by the designer. Similarly, the effects of design changes to each envelope element, both on its own performance and on the overall envelope performance, should be understood. This component performance information is needed if a systematic approach to the design of more energy conserving buildings is to be undertaken.

The National Bureau of Standards Load Determination Program, NBSLD[1], is a research-oriented computer program for the dynamic simulation of heating and cooling loads imposed on building heating, ventilating and air conditioning (HVAC) systems. Its primary purpose is to provide highly sophisticated calculations of these heating and cooling loads for use in HVAC system design analysis and to integrate these loads over time in order to determine annual space heating and cooling requirements. Response factors for the building envelope elements, solar gains, internal heat gains, and hour-by-hour weather data are all utilized in the calculations. As a result, HVAC system sizing requirements and annual heating and cooling requirements can be determined with considerably more accuracy than with more conventional steady-state calculation methods and degree-day data. However, the usefulness of NBSLD for building envelope design purposes is limited because only the overall load imposed on the HVAC system is determined by the program.

The purpose of this report is to describe a subroutine for expanding the output capability of NBSLD and to demonstrate its potential use in the building envelope design process. The expanded version of NBSLD, NBSLD-XO,

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[1] Tamami Kusuda, <u>NBSLD, The Computer Program for Heating and Cooling Loads in Buildings</u>, Building Science Series 69, National Bureau of Standards, 1975.

makes available all of the components of the total heating and cooling loads in a building as calculated on an hourly, daily, monthly, and yearly basis. This information is of considerable importance to building researchers and designers for several reasons:

1. Complex heat transfer mechanisms within the building envelope can be better observed and understood.

2. The designer can more systematically choose to utilize those building envelope elements which contribute least to the load and avoid those which contribute most.

3. The effects of wall and window orientation with respect to solar heat gain can be readily quantified for each building exposure. Thus, differential design by orientation can be better evaluated and more effectively accomplished.

4. Fewer computer runs are needed to analyze the individual effects of several design modifications made simultaneously.

These features are especially desirable when information as to the most cost-effective combination of energy-related modifications to a building envelope design must be developed. Information as to both the relative and absolute cost-effectiveness of individual design modifications vis-a-vis other design modifications can be readily generated once their energy-saving potentials can be quantified. Until now, most of these cost-effectiveness data have been based on conventional, steady-state, energy-estimating methods which do not provide accurate energy-savings data, especially in terms of the saving potential due to a combination of design modifications.

This report is intended primarily to make available to current NBSLD users the subroutine for expanding the output of NBSLD along with examples of its use. The data generated for this report are meant to be demonstrative of the program capabilities and limitations rather than to provide energy data typical of residential buildings. However, some design implications from the examples analyzed will be useful to designers of single-family housing.

In section 2, data from an expanded output run are shown in complete detail. In order to demonstrate its potential use for design analysis and to give a better understanding of the interdependent relationships that occur, several variations of a simple residential-type building are examined in section 3, and preliminary design implications from these case studies are discussed in sections 4 and 5. Limitations of NBSLD and NBSLD-XO with respect to their modeling of heating and cooling requirements are discussed in section 6. Conclusions and recommendations for future research are presented in section 7. Appendix A contains detailed instructions for interfacing the expanded output subroutine with exisiting versions of NBSLD; appendix B lists the expanded output subroutine; appendix C lists the main NBSLD program and shows the modifications needed to interface with the expanded output subroutine; and appendix D lists the data used in generating the results of the case study in section 3.

2. NBSLD-XO OUTPUT FORMAT

The expanded-output version of NBSLD, NBSLD-XO, provides load component data in two primary formats, depending on the type of information required. Format A provides detailed hourly calculations of surface fluxes, loads, and temperatures, as well as the coincident climate profile. Data in Format A are generated for a single 24-hour day. Format B provides the components of the total monthly and yearly heating and cooling loads, using a weather tape to simulate climate conditions during those time periods. In addition, the number of monthly and yearly hours during which heating and cooling loads occurred are provided.

2.1 FORMAT A: DETAILED HOURLY CALCULATIONS

Detailed hourly calculations are provided in four parts, including (1) the coincident hourly climate profile, (2) the inside surface heat fluxes, (3) the inside and outside surface temperatures, and (4) the inside surface loads. These calculations are based on a 24-hour "design" day. Weather data for this 24-hour day can be simulated for a design day or can be taken directly from a specified 24-hour period in a compatable record of hourly climate observations. Tables 1 through 4 show sample printouts of the four parts for a specified design heating day. Tables 5 through 8 are identical in format to tables 1 through 4 but are based on a specified design cooling day.

In table 1, the hourly climate profile used in the component analysis and the calculated net hourly heating or cooling load are printed out as follows:

- TIME - 24-hour clock basis,
- WIND - average wind speed (mph),
- CLOUD - cloud cover modifier (0 = total coverage, 1.0 clear sky),
- HSOLAR - hourly solar heat gain in Btu per ft^2 on the horizontal plane when CLOUD = 1.0,
- DBOUT - dry-bulb outdoor temperature (°F),
- WBOUT - wet-bulb outdoor temperature (°F),
- DBIN - dry-bulb indoor temperature (°F),
- RHIN - relative humidity indoors (%),
- QLS - total hourly sensible load: (+) = heating, (-) = cooling, in Btu, and
- QLL - total hourly latent load: (+) = heating, (-) = cooling, in Btu.

Daily total heating and/or cooling loads and the maximum hourly loads are provided with this first table.

All conductive heat transfer to or from the interior of the building is calculated at the inside surface of the building envelope elements (e.g., walls, windows, ceiling, floor, etc.). These heat gains or losses are referred to as inside surface fluxes. In table 2, hourly inside surface heat fluxes in Btu for all elements of the building envelope plus infiltration losses (gains),

Table 1. Hourly Climate Profile and Net Hourly Heating Loads for Model House
(January 21 Design Heating Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE

HEATING LOAD IN BTU PER HOUR

SENSIBLE LOAD =		30526.
LATENT LOAD =		1269.
TOTAL LOAD =		31795.

TIME	WIND	CLOUD	HSOLAR	DBOUT	WBOUT	DBIN	RHIN	QLS	QLL
1	7.5	1.	0.	20.9	20.8	68.0	20.0	24242.	157.
2	7.5	1.	0.	19.8	19.7	68.0	20.0	24858.	227.
3	7.5	1.	0.	18.9	18.9	68.0	20.0	25359.	281.
4	7.5	1.	0.	18.2	18.2	68.0	20.0	25750.	320.
5	7.5	1.	0.	18.0	18.0	68.0	20.0	25952.	333.
6	7.5	1.	0.	18.4	18.4	68.0	20.0	25874.	307.
7	7.5	1.	0.	19.5	19.5	68.0	20.0	24500.	241.
8	7.5	1.	13.	21.5	21.5	68.0	20.0	18730.	192.
9	7.5	1.	64.	24.4	23.5	68.0	20.0	12923.	201.
10	7.5	1.	109.	27.7	25.6	68.0	20.0	8129.	201.
11	7.5	1.	139.	31.4	27.9	68.0	20.0	6999.	201.
12	7.5	1.	154.	34.9	30.0	68.0	20.0	5101.	201.
13	7.5	1.	150.	37.6	31.5	68.0	20.0	4229.	201.
14	7.5	1.	128.	39.3	32.4	68.0	20.0	4172.	321.
15	7.5	1.	91.	40.0	32.8	68.0	20.0	4600.	321.
16	7.5	1.	42.	39.3	32.4	68.0	20.0	5610.	201.
17	7.5	1.	0.	37.8	31.7	68.0	20.0	12780.	201.
18	7.5	1.	0.	35.4	30.3	68.0	20.0	13122.	81.
19	7.5	1.	0.	32.5	28.6	68.0	20.0	14860.	81.
20	7.5	1.	0.	29.7	26.8	68.0	20.0	17308.	161.
21	7.5	1.	0.	27.2	25.3	68.0	20.0	18109.	161.
22	7.5	1.	0.	25.0	23.9	68.0	20.0	18593.	81.
23	7.5	1.	0.	23.3	22.8	68.0	20.0	20941.	81.
24	7.5	1.	0.	22.0	21.9	68.0	20.0	23540.	83.

MAX COOLING LOAD = 0. MONTH = 0 DAY = 0 HOUR = 0
MAX HEATING LOAD = 26285. MONTH = 1 DAY = 21 HOUR = 5
TOTAL COOLING CONSUMPTION PER DAY = 0. BTU
TOTAL HEATING CONSUMPTION PER DAY = 391122. BTU

Table 2. Hourly Inside Surface Fluxes by Envelope Element, Internal and Air Infiltration Loads (Btu, January 21 Design Heating Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE
INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	1.0000	2.0000	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	3.0000
	.0000	.0000	.0000	.0000	.0000	90.0000	90.0000	90.0000	90.0000	180.0000	180.0000	180.0000	180.0000
	.1170	.0702	.1324	1.1300	1.1300	.0702	.1324	1.1300	1.1300	.0702	.1324	1.1300	1.1300
	1600.0000	224.0000	48.0000	48.0000	48.0000	224.0000	48.0000	48.0000	48.0000	224.0000	48.0000	48.0000	48.0000
	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	SOUTH SOLAR WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	WEST SOLAR WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	NORTH SOLAR WINDOW
1	7095.5	608.8	124.6	1978.3	.0	608.8	151.4	1978.5	.0	608.8	177.6	1978.5	.0
2	7246.3	633.1	150.1	2024.3	.0	633.1	171.1	2024.5	.0	633.1	191.4	2024.5	.0
3	7369.5	651.8	171.7	2061.0	.0	651.8	188.1	2061.1	.0	651.8	204.0	2061.1	.0
4	7462.1	667.0	190.4	2088.2	.0	666.9	203.1	2088.3	.0	666.9	215.5	2088.3	.0
5	7494.4	679.3	206.9	2095.8	.0	679.3	216.9	2095.9	.0	679.3	226.5	2095.9	.0
6	7434.6	687.2	222.0	2074.0	.0	687.2	229.8	2074.1	.0	687.2	237.3	2074.1	.0
7	7314.3	705.0	241.5	2036.8	.0	705.0	247.5	2036.8	.0	705.0	253.4	2036.8	.0
8	6979.8	798.3	305.3	2052.6	-2360.2	841.5	310.1	2052.7	-184.2	841.6	314.8	2052.8	-184.2
9	5412.3	672.2	355.0	2039.5	-6722.2	890.1	361.8	2040.2	-550.3	890.4	365.4	2040.5	-550.3
10	3651.5	320.1	350.8	1957.9	-9378.6	797.3	371.0	1960.1	-789.2	797.2	373.7	1960.1	-789.2
11	2033.7	-51.8	294.6	1785.5	-11018.1	638.8	345.1	1789.3	-939.8	637.9	346.9	1788.7	-939.8
12	978.6	-281.3	232.4	1626.6	-11734.0	549.2	325.6	1632.2	-1006.1	548.5	326.7	1630.6	-1006.1
13	666.0	-412.2	165.6	1509.8	-11533.5	444.2	306.2	1516.5	-2074.7	486.0	307.0	1514.4	-987.5
14	1077.6	-459.3	98.1	1432.2	-10415.1	250.4	280.8	1438.4	-5107.7	437.8	284.5	1436.9	-884.2
15	2119.5	-441.1	29.2	1391.6	-8356.4	7.7	237.0	1396.2	-7162.5	385.2	252.9	1396.2	-696.3
16	3641.8	-352.0	-38.6	1387.3	-5114.5	-182.4	170.1	1389.9	-6716.0	327.1	210.3	1391.3	-411.2
17	4695.2	-285.6	-143.6	1296.9	-59.6	-287.3	43.2	1298.1	-121.9	141.5	114.4	1299.9	-4.5
18	5166.4	194.0	-112.1	1408.4	.0	182.1	40.5	1409.4	.0	347.9	134.2	1410.2	.0
19	5559.1	363.8	-80.0	1526.8	.0	359.1	40.0	1527.6	.0	408.1	134.8	1527.9	.0
20	5925.8	428.7	-44.0	1636.0	.0	427.3	49.6	1636.6	.0	440.3	132.7	1636.8	.0
21	6284.7	500.5	2.8	1745.5	.0	500.0	75.7	1745.9	.0	503.4	143.8	1746.1	.0
22	6618.0	550.3	45.2	1848.5	.0	550.1	102.0	1848.9	.0	551.0	156.3	1849.0	.0
23	6821.6	553.4	70.4	1904.1	.0	553.3	114.7	1904.4	.0	553.5	157.4	1904.5	.0
24	6945.6	563.8	92.9	1933.8	.0	563.8	127.5	1934.0	.0	563.8	160.9	1934.1	.0
T	125994.0	7293.9	2931.1	42841.4	-76692.4	11717.5	4708.8	42879.6	-24652.4	13493.3	5422.4	42879.0	-6453.4
H	125994.0	7293.9	2931.1	42841.4	-76692.4	11717.5	4708.8	42879.6	-24652.4	13493.3	5422.4	42879.0	-6453.4
NL+	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NL-	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
C	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TC+	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TC-	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

(continued)

a Identification number for each envelope element type.
b Compass orientation for walls and windows only (0 = north).
c U-value of envelope element (Btu/h • ft^2 • °F).
d Area in square feet of envelope element.

Table 2. (continuation from right side of previous page)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE
INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	2.0000	2.0000	3.0000	3.0000	5.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	-90.0000	-90.0000	-90.0000	-90.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	.0702	.1324	1.1300	1.1300	.3122	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	224.0000	48.0000	48.0000	48.0000	1600.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	EAST SOLAR WINDOW	SLAB FLOOR	LIGHTS	EQUIP	OCPS	OCPL	INFILS	INFILL	TOTAL SENSBL	TOTAL LATENT
1	608.8	170.0	1978.6	.0	1941.3	.0	-1324.2	-960.0	-240.0	6516.6	396.7	24241.8	156.7
2	633.1	185.5	2024.5	.0	1898.9	.0	-1324.2	-960.0	-240.0	6668.7	467.1	24858.1	227.1
3	651.8	199.4	2061.2	.0	1868.3	.0	-1324.2	-960.0	-240.0	6790.3	521.0	25358.6	281.0
4	666.9	211.9	2088.3	.0	1849.1	.0	-1324.2	-960.0	-240.0	6881.6	560.1	25750.2	320.1
5	679.3	223.7	2095.9	.0	1855.6	.0	-1324.2	-960.0	-240.0	6912.0	572.8	25952.3	332.8
6	687.2	235.1	2074.1	.0	1903.4	.0	-1324.2	-960.0	-240.0	6851.2	547.2	25874.1	307.2
7	705.0	251.7	2036.8	.0	2164.7	-931.1	-1748.0	-960.0	-240.0	6699.1	480.7	24500.4	240.7
8	771.8	313.2	2052.4	-3940.2	5370.3	-3003.4	-2436.6	-643.2	-160.8	6425.4	352.8	18730.4	192.0
9	600.0	359.4	2039.0	-7355.9	9084.3	-1261.4	-3337.1	-480.0	-120.0	6030.0	321.4	12922.9	201.4
10	317.8	349.5	1957.9	-6485.7	10454.8	-480.6	-4661.3	-480.0	-120.0	5573.8	321.4	8129.0	201.4
11	159.2	292.7	1787.0	-3768.7	10176.4	-1081.2	-1853.9	-480.0	-120.0	5056.8	321.4	6999.2	201.4
12	214.5	244.3	1630.4	-1189.6	9751.3	-390.4	-3072.2	-480.0	-120.0	4570.2	321.4	5101.0	201.4
13	333.2	210.2	1515.6	-987.5	10019.4	-270.3	-2224.7	-480.0	-120.0	4205.3	321.4	4229.0	201.4
14	388.1	189.8	1438.6	-884.2	10531.1	.0	-1324.2	.0	.0	3962.0	321.4	4171.5	321.4
15	371.0	170.3	1397.5	-696.3	10251.5	.0	-1324.2	.0	.0	3870.7	321.4	4600.0	321.4
16	322.7	142.3	1391.9	-411.2	8592.4	-540.6	-3072.2	-480.0	-120.0	3962.0	321.4	5610.3	201.4
17	139.9	60.0	1300.0	-4.5	3216.1	-540.6	-3072.2	-480.0	-120.0	4174.8	321.4	12780.1	201.4
18	347.5	91.5	1410.3	.0	3230.3	-390.4	-5297.0	-960.0	-240.0	4509.4	321.4	13122.5	81.4
19	408.0	101.4	1528.0	.0	3044.9	-660.8	-4873.2	-960.0	-240.0	4904.8	321.4	14860.4	81.4
20	440.3	106.6	1636.9	.0	2730.9	-931.1	-3601.9	-643.2	-160.8	5300.1	321.4	17308.3	160.6
21	503.4	123.5	1746.2	.0	2689.5	-1591.8	-3601.9	-643.2	-160.8	5634.7	321.4	18108.6	160.6
22	551.0	140.4	1849.1	.0	2689.2	-2132.4	-3601.9	-960.0	-240.0	5938.8	321.4	18593.4	81.4
23	553.5	145.1	1904.5	.0	2361.5	-1081.2	-2701.5	-960.0	-240.0	6182.1	321.4	20941.3	81.4
24	563.8	151.2	1934.1	.0	1990.3	.0	-1324.2	-960.0	-240.0	6364.6	322.8	23540.1	82.8
T	11617.6	4668.7	42879.0	-25723.8	119665.5	-15287.5	-61074.1	-16809.6	-4202.4	133985.0	9041.5	386283.5	4839.1
H	11617.6	4668.7	42879.0	-25723.8	119665.5	-15287.5	-61074.1	-16809.6	-4202.4	133985.0	9041.5	386283.5	4839.1
NL+	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NL-	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
C	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TC+	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TC-	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

solar gains, and internal heat gains are made available.[1] Since these add up algebraically to the hourly net heating or cooling load, these will be referred to as "load components". Because of the number of building envelope elements typically evaluated, table 2 usually requires two (or more) pages of printout. These pages are intended to be read across, with one column for each load component listed. The top four numbers above each column heading in table 2, in order and where appropriate, correspond to the identification number for each envelope element type (assigned in the NBSLD program itself), compass orientation in degrees for walls and windows, U-values for the envelope elements at winter design conditions,[2] and the area of each envelope element in square feet. Outward heat flux is indicated by (+); inward heat flux is indicated by (-). Conduction/convection (CD/CV) fluxes for windows are shown separately from solar gains. Component titles are self-explanatory except as follows:

OCPS - occupant loads, sensible (Btu/hr),
OCPL - occupant loads, latent (Btu/hr),
INFILS - infiltration loads, sensible (Btu/hr),
INFILL - infiltration loads, latent (Btu/hr),
TOTAL SENSBL - total sensible heating or cooling requirements (Btu/hr), and
TOTAL LATENT - total latent heating or cooling requirements (Btu/hr).

The hourly total sensible and total latent loads printed out in table 2 are the same as the hourly total sensible and total latent loads shown in table 1. Inside surface fluxes through the various envelope elements, solar gains, infiltration losses (gains) and internal heat gains by source, algebraically summed over the entire 24-hour period, are shown in row "T" at the bottom of table 2. Note that a summation of row "T" load components is identically equivalent to the daily sum of the total hourly sensible and latent loads. These 24-hour load component totals are not necessarily meaningful, however, because they may include sources of heat gain and loss which occurred in hours when there was no net heating or cooling load.[3] (That is, even when the indoor temperature is within the desired control range during mild climate conditions there is heat gain and/or heat loss through the various elements of the building envelope). As a result, the 24-hour sums of individual load components in row "T" may overstate the impact of envelope heat gains and losses on the actual daily heating or cooling loads. Moreover, on

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[1] All solar gains are treated as radiation to inside room surfaces. Internal heat gains (lights, equipment, and occupants) have both radiation and convection components.

[2] Winter design conditions assume a 15 mph wind speed and heat flow from inside to outside.

[3] These heat losses or gains during non-load hours may have some indirect effect on loads that occur in later hours, if they have an effect on the thermal storage of the interior building mass. However, this effect will show up in terms of reduced loads in those later hours.

some days both cooling and heating loads may occur during the same 24-hour period. In such a case the heating and cooling loads tend to cancel each other out if simply summed over 24-hours.

Thus, a more meaningful approach to the summation of these load components is required. This has been done by providing several additional rows for summing heat fluxes, infiltration, solar and internal gains during heating load hours, no load hours, and cooling load hours, respectively. A check is made each hour to determine whether there is a net heating or cooling load in that hour. If there is a net heating load, all of the load components for that hour are added to the "H" row, immediately below the "T" row in table 2. Heat transfer outward or inward which occurs when there is no net heating or cooling load present are accounted for in rows "NL+" (heat loss) and "NL-" (heat gain) in table 2, respectively. The wider the band between maximum heating and minimum air conditioning setpoints, the greater will be these NL values.

If there is a net cooling load, all of the load components for that hour are added to the "C" row in table 2. This "C" row is then further disaggregated into two parts: load components during cooling hours when the outdoor dry-bulb temperature (t_o) for that hour is equal to or greater than the indoor dry-bulb temperature, t_i (i.e., the air conditioner thermostat setpoint), are added to the "TC+" row; load components during cooling hours when t_o is less than t_i are added to the "TC-" row. This distinction is made because sensible cooling loads which occur during hours when the outdoor temperature is below the thermostat setpoint could potentially be eliminated by increased ventilation. In addition, this distinction avoids a problem in summing the performance of building envelope elements over all potential cooling hours. This problem arises because the desirable heat loss that occurs through some building envelope elements, occuring when t_o is less than t_i, will cancel out undesirable heat gains through those same elements when t_o is greater than t_i. As a result, the actual thermal performance of those elements during all cooling hours is difficult to assess unless these effects are treated separately.

Note that the sum of H, TC+, TC-, NL+, and NL- values for each load component are identical to the corresponding values of row "T". These rows of disaggregated daily load components are summed for each of the 12 months of the year to serve as the basis of the data provided in Format B: Monthly and Yearly Load Components, shown in table 9.

In table 3, hourly inside and outside surface temperatures are provided for each envelope element as a part of Format A. (Exception: the outside ceiling temperature is the attic air temperature.) These surface temperatures are quite useful in understanding and tracking the changes in the fluxes through individual envelope elements due to design modifications.

Surface loads, shown in table 4, represent the convective heat exchange between the interior envelope surfaces and the air in the conditioned space. Surface loads are shown in table 4. Surface loads are used in NBSLD for the calculation of actual heating and cooling loads rather than fluxes through

Table 3. Hourly Inside and Outside Surface Temperatures (°F) by Envelope Element (January 21 Design Heating Day)

INSIDE SURFACE TEMPERATURES

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	SLAB FLOOR
1	60.20	60.77	60.85	34.41	60.77	60.47	34.41	60.77	60.10	34.41	60.77	60.21	34.41	59.58
2	60.02	60.56	60.36	33.63	60.57	60.06	33.63	60.57	59.77	33.63	60.57	59.86	33.63	59.41
3	59.88	60.40	59.95	33.00	60.40	59.71	33.00	60.40	59.49	33.00	60.41	59.55	33.00	59.28
4	59.76	60.27	59.60	32.53	60.27	59.42	32.53	60.27	59.24	32.53	60.28	59.29	32.53	59.17
5	59.70	60.19	59.31	32.37	60.19	59.17	32.37	60.19	59.03	32.37	60.19	59.07	32.37	59.10
6	59.72	60.16	59.10	32.68	60.16	58.99	32.68	60.16	58.88	32.68	60.16	58.91	32.68	59.08
7	59.99	60.37	59.08	33.47	60.37	58.99	33.47	60.37	58.91	33.47	60.37	58.93	33.47	59.30
8	62.06	62.06	60.14	34.95	61.93	60.07	34.95	61.93	60.01	34.95	62.13	60.03	34.95	62.56
9	64.93	64.78	61.77	37.06	64.13	61.69	37.06	64.13	61.64	37.06	64.99	61.70	37.06	66.59
10	66.87	67.27	63.25	39.45	65.84	62.99	39.46	65.84	62.95	39.46	67.28	63.26	39.45	68.40
11	67.64	68.66	64.30	42.11	66.61	63.64	42.11	66.60	63.60	42.11	68.04	64.35	42.11	68.51
12	68.16	69.59	65.42	44.61	67.13	64.17	44.61	67.11	64.13	44.61	68.13	65.30	44.61	68.36
13	68.52	70.21	66.59	46.49	67.69	64.68	46.49	67.53	64.64	46.49	68.02	66.04	46.49	68.84
14	68.61	70.48	67.68	47.74	68.41	65.17	47.74	67.81	65.09	47.74	67.99	66.47	47.74	69.58
15	68.11	70.20	68.43	48.20	68.90	65.54	48.20	67.74	65.31	48.20	67.81	66.51	48.20	69.50
16	66.78	69.11	68.59	47.71	68.63	65.65	47.71	67.10	65.10	47.71	67.12	66.08	47.71	67.95
17	63.34	65.88	67.05	46.50	65.90	64.41	46.50	64.62	63.42	46.50	64.63	64.20	46.50	62.44
18	63.00	64.28	66.47	44.78	64.33	64.31	44.78	63.83	62.98	44.78	63.84	63.60	44.78	62.10
19	62.52	63.41	65.66	42.74	63.44	63.96	42.74	63.29	62.62	42.75	63.29	63.09	42.75	61.67
20	61.93	62.72	64.66	40.70	62.74	63.33	40.70	62.70	62.15	40.70	62.70	62.53	40.70	61.15
21	61.65	62.35	63.84	38.98	62.35	62.80	38.98	62.35	61.83	38.98	62.35	62.13	38.98	60.92
22	61.43	62.10	63.14	37.42	62.11	62.34	37.42	62.11	61.56	37.42	62.11	61.79	37.42	60.76
23	60.93	61.62	62.31	36.15	61.62	61.68	36.15	61.63	61.07	36.15	61.63	61.25	36.15	60.29
24	60.40	61.05	61.45	35.19	61.06	60.96	35.19	61.06	60.49	35.19	61.06	60.62	35.19	59.77

OUTSIDE SURFACE TEMPERATURES

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	SLAB FLOOR
1	25.02	21.76	22.96	33.03	21.76	22.83	33.03	21.76	22.72	33.03	21.76	22.75	33.03	56.00
2	24.09	20.67	21.81	32.22	20.67	21.71	32.22	20.67	21.62	32.22	20.67	21.65	32.22	56.00
3	23.34	19.77	20.86	31.57	19.77	20.79	31.57	19.77	20.72	31.57	19.77	20.74	31.57	56.00
4	22.76	19.09	20.13	31.08	19.09	20.07	31.08	19.09	20.02	31.08	19.09	20.03	31.08	56.00
5	22.54	18.82	19.81	30.91	18.82	19.76	30.91	18.82	19.72	30.91	18.82	19.73	30.91	56.00
6	22.86	19.16	20.09	31.24	19.16	20.05	31.24	19.16	20.02	31.24	19.16	20.03	31.24	56.00
7	23.72	20.15	21.00	32.06	20.15	20.97	32.06	20.15	20.94	32.06	20.15	20.95	32.06	56.00
8	27.45	34.11	34.58	33.52	22.85	23.54	33.52	22.85	23.52	33.52	40.98	41.27	33.52	56.00
9	38.10	59.35	58.91	35.65	27.40	27.90	35.65	27.40	27.89	35.65	62.91	62.20	35.65	56.00
10	48.76	77.59	76.17	38.09	31.98	32.25	38.09	31.98	32.24	38.09	65.48	64.24	38.09	56.00
11	57.55	90.59	88.61	40.87	36.54	36.60	40.87	36.54	36.58	40.87	58.88	57.91	40.87	56.00
12	63.31	98.50	96.30	43.48	40.71	40.61	43.48	40.47	40.37	43.48	47.59	47.23	43.48	56.00
13	65.22	100.84	98.72	45.44	53.93	53.54	45.44	43.14	42.98	45.44	44.17	44.32	45.44	56.00
14	63.27	97.54	95.77	46.74	69.48	68.54	46.74	44.48	44.33	46.74	44.65	44.94	46.74	56.00
15	57.60	88.21	87.00	47.23	79.58	78.19	47.23	44.30	44.22	47.23	44.33	44.63	47.23	56.00
16	48.72	71.20	70.80	46.74	77.10	75.74	46.74	42.33	42.39	46.74	42.33	42.70	46.74	56.00
17	40.06	42.60	43.34	45.60	43.46	43.15	45.60	38.84	39.11	45.60	38.84	39.34	45.60	56.00
18	37.38	36.89	38.45	43.80	37.00	37.85	43.80	36.30	36.78	43.80	36.30	36.96	43.80	56.00
19	34.95	33.60	35.23	41.68	33.62	34.73	41.68	33.49	34.13	41.68	33.49	34.28	41.68	56.00
20	32.55	30.69	32.26	39.56	30.70	31.85	39.56	30.67	31.44	39.56	30.67	31.55	39.56	56.00
21	30.49	28.24	29.71	37.77	28.24	29.40	37.77	28.23	29.09	37.77	28.23	29.18	37.77	56.00
22	28.62	26.03	27.43	36.14	26.03	27.18	36.14	26.03	26.95	36.14	26.03	27.02	36.14	56.00
23	27.11	24.24	25.57	34.83	24.24	25.38	34.83	24.24	25.19	34.83	24.24	25.25	34.83	56.00
24	25.96	22.88	24.14	33.85	22.88	23.99	33.85	22.88	23.84	33.85	22.88	23.89	33.85	56.00

Table 4. Hourly Inside Surface Loads by Envelope Element
(Btu, January 21 Design Heating Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE

SURFACE LOADS

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW
1	8886.0	878.3	186.0	873.9	878.0	195.9	873.9	877.9	205.6	873.9	877.8	202.8	873.9
2	9087.3	902.8	198.8	894.3	902.5	206.5	894.3	902.5	214.1	894.3	902.4	211.9	894.3
3	9252.2	922.4	209.5	910.6	922.2	215.6	910.6	922.1	221.5	910.6	922.1	219.7	910.6
4	9382.0	938.1	218.6	922.8	937.9	223.3	922.8	937.9	227.9	922.8	937.9	226.6	922.8
5	9451.6	948.7	226.0	927.0	948.5	229.7	927.0	948.5	233.3	927.0	948.5	232.2	927.0
6	9432.2	951.5	231.6	918.9	951.4	234.5	918.9	951.4	237.3	918.9	951.3	236.5	918.9
7	9126.3	926.7	232.1	898.3	926.6	234.3	898.3	926.6	236.5	898.3	926.6	235.9	898.3
8	6763.4	721.7	204.5	859.8	737.5	206.2	859.8	737.3	207.9	859.8	712.1	207.4	859.8
9	3494.1	390.9	162.0	804.9	470.4	164.3	804.8	470.1	165.5	804.8	365.1	163.9	804.9
10	1290.6	88.6	123.7	742.7	261.8	130.4	742.6	261.7	131.4	742.6	87.8	123.3	742.7
11	414.5	-80.4	96.2	673.6	168.9	113.4	673.5	169.7	114.4	673.5	-4.9	94.9	673.6
12	-181.5	-192.9	67.2	608.5	105.1	99.7	608.4	107.7	100.7	608.5	-15.9	70.2	608.5
13	-594.9	-268.1	36.8	559.7	37.6	86.4	559.6	57.1	87.5	559.6	-2.0	51.1	559.6
14	-698.2	-301.6	8.3	527.2	-49.5	73.7	527.0	22.8	75.6	527.1	1.2	39.8	527.0
15	-119.6	-267.1	-11.3	515.2	-109.0	64.0	515.1	31.3	69.9	515.1	23.5	38.7	515.0
16	1394.0	-135.0	-15.2	528.0	-76.8	61.2	527.9	109.8	75.5	527.9	106.9	50.1	527.9
17	5305.2	257.5	24.6	559.3	254.7	93.4	559.3	410.6	119.2	559.3	409.7	98.9	559.3
18	5701.2	451.7	39.8	604.0	445.6	96.0	604.0	505.7	130.5	604.0	505.3	114.6	604.0
19	6246.6	557.3	60.8	657.1	554.2	105.1	657.0	571.7	140.1	657.0	571.5	127.6	657.0
20	6910.9	640.7	86.9	710.3	639.1	121.4	710.3	643.5	152.1	710.3	643.3	142.4	710.3
21	7236.3	686.4	108.3	755.0	685.4	135.2	755.0	686.4	160.4	755.0	686.2	152.8	755.0
22	7479.0	715.9	126.4	795.6	715.2	147.4	795.6	715.3	167.5	795.6	715.1	161.5	795.6
23	8052.9	774.6	148.1	828.5	774.0	164.4	828.5	773.9	180.3	828.5	773.9	175.6	828.5
24	8657.6	843.4	170.4	853.5	842.9	183.1	853.5	842.8	195.5	853.5	842.7	191.9	853.5
T	131969.8	11352.1	2940.3	17928.4	12924.2	3585.1	17927.7	13584.2	3850.1	17927.7	12888.3	3570.4	17927.7

(continued)

Table 4. (continuation from right side of previous page)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE

SURFACE LOADS

	SLAB FLOOR	HOURLY TOTALS
1	2183.4	18867.3
2	2225.6	19331.5
3	2260.6	19710.3
4	2289.1	20010.7
5	2307.6	20182.4
6	2311.9	20165.0
7	2256.0	19620.8
8	1409.4	15346.6
9	366.4	9432.1
10	-103.8	5366.0
11	-131.1	3650.0
12	-92.2	2502.1
13	-218.8	1511.2
14	-408.8	871.7
15	-389.4	1391.3
16	12.5	3694.7
17	1440.8	10651.7
18	1530.4	11936.8
19	1639.6	13202.6
20	1774.9	14596.3
21	1834.9	15392.4
22	1876.3	16001.8
23	1998.6	17130.5
24	2133.5	18317.7
T	30507.5	298883.5

those surfaces. Thus all interior surfaces whose temperatures are not equal to the desired room air temperature affect the HVAC load if there is a net load at that time. This even includes partition walls (interior walls that have no net heat loss or gain through them), since their surface temperatures may be somewhat different from the room air temperatures. (Partition walls are used in zoned models examined in section 5.) While individual surface fluxes and surface loads are not equal, the algebraic sum of surface fluxes plus solar gains and all radiative internal heat gains is identical to the sum of the surface loads. Surface loads are provided primarily to help check the consistency of the overall program. Sums of surface loads do not appear to be of any other value at present.

Tables 5-8 provide results corresponding to tables 1-4, based on a 24-hour climate profile that simulates a design cooling day. Again, all heat gain or loss is calculated at the inside surface of each building envelope element.

Table 5. Hourly Climate Profile and Net Hourly Cooling Loads for Model House
(August 21 Design Cooling Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,COOLING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE

TIME	WIND	CLOUD	HSOLAR	DBOUT	WBOUT	DBIN	RHIN	QLS	QLL
1	7.5	1.	0.	71.9	71.8	73.6	98.2	0.	0.
2	7.5	1.	0.	70.4	70.3	72.6	96.5	0.	0.
3	7.5	1.	0.	69.2	69.1	71.8	95.1	0.	0.
4	7.5	1.	0.	68.3	68.2	71.1	94.3	0.	0.
5	7.5	1.	0.	68.0	67.9	70.7	94.5	0.	0.
6	7.5	1.	8.	68.6	68.5	71.4	94.1	0.	0.
7	7.5	1.	63.	70.1	70.0	75.4	86.6	0.	0.
8	7.5	1.	124.	72.8	72.7	78.0	60.0	0.	0.
9	7.5	1.	180.	76.7	74.4	78.0	60.0	-5991.	-3729.
10	7.5	1.	224.	81.2	75.6	78.0	60.0	-9755.	-3729.
11	7.5	1.	253.	86.3	76.9	78.0	60.0	-10830.	-3729.
12	7.5	1.	265.	91.1	78.0	78.0	60.0	-13234.	-3729.
13	7.5	1.	259.	94.7	78.9	78.0	60.0	-14468.	-3729.
14	7.5	1.	235.	97.1	79.4	78.0	60.0	-14790.	-3459.
15	7.5	1.	195.	98.0	79.7	78.0	60.0	-14917.	-3459.
16	7.5	1.	143.	97.1	79.4	78.0	60.0	-15542.	-3729.
17	7.5	1.	83.	95.0	79.0	78.0	60.0	-13111.	-3729.
18	7.5	1.	23.	91.7	78.2	78.0	60.0	-10919.	-3999.
19	7.5	1.	0.	87.8	77.2	78.0	60.0	-6736.	-3999.
20	7.5	1.	0.	83.9	76.3	78.0	60.0	-3586.	-3821.
21	7.5	1.	0.	80.6	75.4	78.0	60.0	-2303.	-3821.
22	7.5	1.	0.	77.6	74.6	78.0	60.0	-1378.	-3999.
23	7.5	1.	0.	75.2	74.0	77.0	94.2	0.	0.
24	7.5	1.	0.	73.4	73.3	74.5	100.0	0.	0.

TOTAL COOLING CONSUMPTION PER DAY = -190224. BTU
TOTAL HEATING CONSUMPTION PER DAY = 0. BTU
MAX COOLING LOAD = -19272. MONTH = 8 DAY = 21 HOUR = 16
MAX HEATING LOAD = 0. MONTH = 0 DAY = 0 HOUR = 0
TOTAL COOLING CONSUMPTION PER DAY = -190224. BTU
TOTAL HEATING CONSUMPTION PER DAY = 0. BTU

Table 6. Hourly Inside Surface Fluxes by Envelope Element, Internal and Air Infiltration Loads (Btu, August 21 Design Cooling Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,COOLING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE
INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	1.0000	2.0000	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	3.0000
	.0000	.0000	.0000	.0000	.0000	90.0000	90.0000	90.0000	90.0000	180.0000	180.0000	180.0000	180.0000
	.1170	.0702	.1324	1.1300	1.1300	.0702	.1324	1.1300	1.1300	.0702	.1324	1.1300	1.1300
	1600.0000	224.0000	48.0000	48.0000	48.0000	224.0000	48.0000	48.0000	48.0000	224.0000	48.0000	48.0000	48.0000
	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	SOUTH SOLAR WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	WEST SOLAR WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	NORTH SOLAR WINDOW
1	821.0	-121.9	-179.4	53.7	.0	-122.0	-217.6	53.4	.0	-121.9	-157.8	53.8	.0
2	919.3	-88.4	-159.5	81.8	.0	-88.4	-189.4	81.5	.0	-88.4	-142.6	81.8	.0
3	999.5	-62.3	-140.2	106.1	.0	-62.2	-163.6	105.9	.0	-62.3	-127.1	106.2	.0
4	1054.1	-39.4	-121.3	122.4	.0	-39.3	-139.5	122.2	.0	-39.4	-111.1	122.4	.0
5	1055.0	-12.8	-100.1	121.3	.0	-12.8	-114.3	121.2	.0	-12.8	-92.1	121.4	.0
6	897.8	89.9	-49.4	145.9	-79.6	89.9	-60.5	145.7	-79.6	81.8	-43.2	145.9	-190.4
7	-277.5	392.8	85.5	326.1	-363.6	393.6	76.6	325.4	-363.6	368.1	89.8	326.0	-382.9
8	-2028.4	399.7	160.9	91.1	-723.0	423.3	153.8	90.7	-555.0	398.3	162.7	91.1	-555.0
9	-4223.5	102.2	143.8	203.8	-1493.7	203.7	139.9	202.2	-697.6	192.4	144.8	204.2	-697.6
10	-6141.9	-122.6	129.4	51.5	-2304.8	91.9	133.5	50.8	-801.8	88.1	135.8	52.5	-801.8
11	-7842.0	-375.6	86.7	-177.2	-2882.2	-52.1	105.8	-176.8	-868.0	-53.7	106.6	-175.7	-868.0
12	-8916.6	-538.0	47.2	-378.3	-3121.8	-135.7	87.3	-376.6	-894.6	-135.0	87.4	-376.4	-894.6
13	-9273.2	-668.9	-5.2	-538.0	-2998.3	-280.3	58.7	-535.6	-1605.1	-226.6	58.7	-535.8	-880.9
14	-8918.7	-740.3	-63.3	-654.7	-2523.5	-525.2	19.9	-653.0	-3165.4	-305.6	23.8	-652.4	-827.4
15	-7861.8	-738.7	-118.5	-706.4	-1767.7	-787.8	-30.9	-706.6	-4312.6	-357.9	-12.5	-704.3	-735.2
16	-6125.7	-656.5	-161.5	-668.0	-941.5	-982.3	-90.2	-670.2	-4832.8	-370.2	-44.1	-666.2	-605.3
17	-4101.3	-579.8	-211.9	-619.4	-432.9	-1126.1	-176.2	-623.5	-4451.1	-415.6	-92.3	-618.2	-432.1
18	-1905.2	-456.9	-240.7	-514.2	-184.4	-1052.2	-252.8	-518.9	-2373.6	-410.2	-129.2	-513.5	-322.7
19	-768.9	-378.3	-258.2	-400.9	.0	-770.0	-316.1	-404.3	.0	-390.6	-163.0	-400.5	.0
20	-255.2	-253.9	-241.2	-256.9	.0	-393.5	-324.9	-258.6	.0	-261.9	-165.5	-256.6	.0
21	196.5	-148.2	-209.8	-114.0	.0	-188.0	-295.1	-115.0	.0	-150.8	-150.9	-113.8	.0
22	612.3	-79.3	-178.9	20.0	.0	-89.7	-253.5	19.3	.0	-80.1	-133.1	20.2	.0
23	755.9	-121.9	-181.6	53.5	.0	-124.5	-242.7	53.0	.0	-122.1	-146.0	53.7	.0
24	668.2	-209.7	-206.4	4.3	.0	-210.3	-255.1	3.9	.0	-209.8	-178.7	4.4	.0
T	-60660.3	-5408.8	-2173.6	-3646.5	-19816.9	-5840.1	-2346.9	-3663.7	-25000.8	-2686.2	-1079.5	-3629.9	-8194.2
H	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NL+	7170.8	882.3	246.4	1106.3	.0	906.8	230.3	1103.0	.0	848.2	252.4	1106.7	.0
NL-	-2305.9	-656.3	-1137.8	.0	-1166.2	-659.6	-1382.6	.0	-998.2	-656.7	-998.5	.0	-1128.3
C	-65525.2	-5634.7	-1282.1	-4752.7	-18650.7	-6087.3	-1194.6	-4766.7	-24002.6	-2877.7	-333.4	-4736.7	-7065.9
TC+	-61914.0	-5657.6	-1247.1	-4976.5	-17157.0	-6201.4	-1081.1	-4988.3	-23305.0	-2990.0	-345.1	-4961.1	-6368.2
TC-	-3611.2	22.9	-35.0	223.8	-1493.7	114.1	-113.6	221.6	-697.6	112.3	11.7	224.4	-697.6

(continued)

a Identification number for each envelope element type.
b Compass orientation for walls and windows only (0 = north).
c U-value of envelope element (Btu/h • ft^2 • °F).
d Area in square feet of envelope element.

Table 6. (continuation from right side of previous page)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,COOLING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE
INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	2.0000	2.0000	3.0000	3.0000	5.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	-90.0000	-90.0000	-90.0000	-90.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	.0702	.1324	1.1300	1.1300	.3122	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	224.0000	48.0000	48.0000	48.0000	1600.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	EAST SOLAR WINDOW	SLAB FLOOR	LIGHTS	EQUIP	OCPS	OCPL	INFILS	INFILL	TOTAL SENSBL	TOTAL LATENT
1	-121.8	-165.8	53.6	.0	2021.8	.0	-1324.2	-764.0	-436.0	238.9	436.4	.0	.4
2	-88.4	-148.9	81.7	.0	1554.3	.0	-1324.2	-791.1	-408.9	309.0	409.2	.0	.3
3	-62.2	-132.0	106.1	.0	1173.9	.0	-1324.2	-820.9	-379.1	359.5	379.4	.0	.3
4	-39.4	-114.9	122.3	.0	880.8	.0	-1324.2	-846.0	-354.0	390.3	354.3	.0	.3
5	-12.8	-95.1	121.3	.0	729.8	.0	-1324.2	-866.3	-333.7	373.2	334.0	.0	.3
6	50.3	-45.6	145.6	-1098.3	1673.6	.0	-1324.2	-879.0	-321.0	383.6	321.3	.0	.3
7	159.6	85.3	324.4	-4032.0	5273.9	-931.1	-1748.0	-858.7	-341.3	730.3	341.6	.0	.3
8	-111.6	144.7	90.1	-4833.0	8224.1	-3003.4	-2436.6	-494.8	-309.2	3220.8	309.2	.0	.0
9	-485.8	94.8	199.0	-4553.1	9078.9	-1261.4	-3337.1	-330.0	-270.0	179.7	-3459.4	-5990.5	-3729.4
10	-587.2	43.9	47.4	-3600.3	9694.8	-480.6	-4661.3	-330.0	-270.0	-442.4	-3459.4	-9755.1	-3729.4
11	-601.1	-22.5	-179.7	-2103.4	9661.3	-1081.2	-1853.9	-330.0	-270.0	-1147.4	-3459.4	-10830.3	-3729.4
12	-477.4	-64.0	-378.7	-925.4	9760.8	-390.4	-3072.2	-330.0	-270.0	-1810.9	-3459.4	-13234.0	-3729.4
13	-369.4	-95.3	-536.6	-880.9	9978.3	-270.3	-2224.7	-330.0	-270.0	-2308.6	-3459.4	-14468.1	-3729.4
14	-350.2	-115.9	-652.9	-827.4	10106.9	.0	-1324.2	.0	.0	-2640.4	-3459.4	-14789.9	-3459.4
15	-370.8	-130.1	-705.2	-735.2	9954.7	.0	-1324.2	.0	.0	-2764.8	-3459.4	-14916.8	-3459.4
16	-373.6	-139.1	-667.8	-605.3	9641.3	-540.6	-3072.2	-330.0	-270.0	-2640.4	-3459.4	-15542.3	-3729.4
17	-413.9	-167.7	-620.3	-432.1	8696.7	-540.6	-3072.2	-330.0	-270.0	-2350.1	-3459.4	-13110.6	-3729.4
18	-393.0	-188.1	-515.8	-184.4	7478.1	-390.4	-5297.0	-660.0	-540.0	-1893.9	-3459.4	-10919.1	-3999.4
19	-357.8	-207.6	-402.0	.0	6031.1	-660.8	-4873.2	-660.0	-540.0	-1354.8	-3459.4	-6736.0	-3999.4
20	-247.6	-197.6	-257.4	.0	5576.0	-931.1	-3601.9	-442.2	-361.8	-815.6	-3459.4	-3585.7	-3821.2
21	-146.3	-174.3	-114.3	.0	5416.8	-1591.8	-3601.9	-442.2	-361.8	-359.4	-3459.4	-2302.7	-3821.2
22	-78.8	-150.7	19.8	.0	5312.8	-2132.4	-3601.9	-660.0	-540.0	55.3	-3459.4	-1378.5	-3999.4
23	-121.7	-159.4	53.4	.0	4447.5	-1081.2	-2701.5	-660.0	-540.0	245.6	540.4	-.0	.4
24	-209.6	-189.1	4.2	.0	2842.1	.0	-1324.2	-690.7	-509.3	156.6	432.2	.0	-77.1
T	-5810.9	-2335.2	-3661.8	-24810.9	145210.7	-15287.5	-61074.1	-12846.0	-8166.0	-13885.7	-44573.2	-137559.4	-52739.1
H	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NL+	209.8	230.0	1102.7	.0	28822.0	.0	.0	.0	.0	6408.0	3858.0	.0	2.8
NL-	-767.7	-1050.9	.0	-9963.3	.0	-5015.7	-16155.8	-7671.6	-3932.4	.0	.0	-.0	-77.1
C	-5253.1	-1514.3	-4764.5	-14847.6	116388.6	-10271.8	-44918.4	-5174.4	-4233.6	-20293.6	-48431.1	-137559.4	-52664.7
TC+	-4688.5	-1458.4	-4983.4	-10294.5	101997.0	-6877.9	-37979.3	-4184.4	-3423.6	-20528.6	-41512.4	-130190.5	-44936.0
TC-	-564.6	-55.9	218.9	-4553.1	14391.7	-3393.9	-6939.0	-990.0	-810.0	235.0	-6918.7	-7369.0	-7728.7

Table 7. Hourly Inside and Outside Surface Temperatures (°F) by Envelope Element
(August 21 Design Cooling Day)

INSIDE SURFACE TEMPERATURES

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	SLAB FLOOR
1	73.03	73.76	75.94	72.62	73.75	76.48	72.62	73.76	75.64	72.62	73.75	75.75	72.62	72.40
2	72.09	72.73	74.73	71.29	72.72	75.15	71.29	72.73	74.49	71.29	72.73	74.58	71.29	71.68
3	71.29	71.86	73.67	70.16	71.86	74.00	70.16	71.87	73.49	70.16	71.86	73.56	70.16	71.07
4	70.65	71.15	72.76	69.29	71.15	73.02	69.29	71.16	72.62	69.29	71.15	72.67	69.29	70.56
5	70.24	70.66	72.05	68.89	70.66	72.25	68.89	70.66	71.94	68.89	70.66	71.98	68.89	70.21
6	71.05	71.13	72.11	69.24	71.13	72.26	69.24	71.15	72.02	69.24	71.25	72.05	69.24	71.00
7	75.49	74.43	74.41	70.66	74.42	74.53	70.66	74.51	74.35	70.66	75.12	74.39	70.65	74.63
8	80.22	78.17	77.09	73.72	78.07	77.17	73.72	78.17	77.07	73.72	79.67	77.26	73.72	77.85
9	82.81	80.34	78.60	77.18	80.00	78.63	77.18	80.07	78.59	77.18	82.06	79.22	77.17	79.05
10	85.06	82.14	79.92	80.41	81.47	79.85	80.41	81.51	79.84	80.41	83.50	81.08	80.41	79.98
11	86.31	83.29	80.91	84.03	82.31	80.64	84.03	82.33	80.64	84.03	83.94	82.43	84.03	80.22
12	87.48	84.33	82.01	87.45	83.13	81.47	87.46	83.13	81.47	87.46	84.14	83.59	87.45	80.54
13	88.06	85.02	83.05	90.01	83.87	82.17	90.01	83.70	82.17	90.01	84.12	84.35	90.01	80.96
14	88.03	85.27	83.91	91.71	84.64	82.75	91.71	83.97	82.70	91.71	84.10	84.69	91.71	81.28
15	87.42	85.11	84.54	92.34	85.26	83.29	92.34	83.98	83.07	92.35	84.01	84.73	92.34	81.28
16	86.43	84.68	84.98	91.70	85.65	83.93	91.70	83.84	83.33	91.70	83.82	84.67	91.70	81.09
17	84.34	83.49	84.74	90.18	85.10	84.18	90.18	83.01	83.06	90.18	82.97	84.10	90.18	80.20
18	81.97	82.04	84.08	87.80	83.79	84.18	87.80	81.91	82.50	87.80	81.82	83.31	87.80	78.96
19	79.69	80.43	82.96	84.99	81.57	83.73	84.99	80.47	81.60	84.99	80.35	82.22	84.99	77.41
20	78.53	79.31	81.97	82.20	79.71	83.14	82.20	79.34	80.90	82.20	79.28	81.34	82.20	76.79
21	77.91	78.68	81.22	79.85	78.78	82.42	79.85	78.69	80.38	79.85	78.67	80.71	79.85	76.49
22	77.43	78.25	80.55	77.72	78.27	81.61	77.72	78.25	79.90	77.72	78.24	80.15	77.72	76.27
23	76.07	77.10	79.31	75.96	77.10	80.18	75.96	77.10	78.81	75.96	77.09	79.00	75.96	75.27
24	73.93	75.03	77.33	74.33	75.02	78.02	74.33	75.03	76.94	74.33	75.03	77.08	74.33	73.47

OUTSIDE SURFACE TEMPERATURES

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	SLAB FLOOR
1	68.96	72.20	72.85	72.58	72.20	73.01	72.58	72.20	72.75	72.58	72.20	72.79	72.58	68.00
2	67.53	70.69	71.32	71.23	70.69	71.45	71.23	70.69	71.24	71.23	70.69	71.27	71.23	68.00
3	66.34	69.45	70.05	70.09	69.45	70.15	70.09	69.45	69.99	70.09	69.45	70.02	70.09	68.00
4	65.42	68.51	69.07	69.20	68.51	69.15	69.20	68.51	69.02	69.20	68.51	69.04	69.20	68.00
5	65.01	68.12	68.63	68.81	68.12	68.69	68.81	68.12	68.59	68.81	68.12	68.61	68.81	68.00
6	66.60	69.35	69.76	69.14	69.32	69.78	69.14	71.44	71.77	69.14	79.63	79.79	69.14	68.00
7	76.86	73.80	74.00	70.43	73.44	73.69	70.43	75.62	75.71	70.43	111.62	110.75	70.43	68.00
8	90.28	83.84	83.64	73.47	78.12	78.08	73.47	78.68	78.55	73.47	125.74	123.77	73.47	68.00
9	103.75	97.33	96.53	77.04	83.49	83.15	77.04	83.56	83.19	77.04	128.74	126.48	77.04	68.00
10	115.52	110.27	108.88	80.37	89.09	88.47	80.37	89.10	88.48	80.37	124.79	122.76	80.37	68.00
11	125.20	121.27	119.44	84.16	94.85	94.01	84.16	94.85	94.01	84.16	116.63	115.12	84.16	68.00
12	131.69	128.83	126.77	87.72	100.52	99.51	87.72	99.97	98.97	87.72	105.64	104.76	87.72	68.00
13	134.04	131.80	129.73	90.39	116.61	115.24	90.39	103.57	102.49	90.39	104.33	103.86	90.39	68.00
14	132.25	130.14	128.28	92.17	133.57	131.59	92.17	105.56	104.48	92.17	105.69	105.26	92.17	68.00
15	126.40	124.01	122.56	92.83	146.12	143.66	92.83	105.68	104.69	92.83	105.70	105.25	92.83	68.00
16	116.00	113.97	113.07	92.17	151.28	148.67	92.17	103.89	103.07	92.17	103.65	103.26	92.17	68.00
17	104.88	102.00	101.71	90.61	145.99	143.68	90.61	100.41	99.82	90.61	99.92	99.67	90.61	68.00
18	91.42	94.66	94.86	88.16	121.79	120.42	88.16	97.76	97.39	88.16	94.26	94.23	88.16	68.00
19	83.51	88.56	89.02	85.27	91.82	91.89	85.27	88.89	88.83	85.27	88.50	88.72	85.27	68.00
20	79.80	84.44	86.05	82.38	84.96	85.95	88.38	84.48	84.75	82.38	84.42	84.84	82.38	68.00
21	76.94	81.06	81.74	79.93	81.16	82.26	79.93	81.07	81.49	79.93	81.06	81.58	79.93	68.00
22	74.30	78.06	78.76	77.70	78.07	79.11	77.70	78.05	78.56	77.70	78.04	78.63	77.70	68.00
23	78.33	75.60	76.30	75.92	75.61	76.57	75.92	75.60	76.14	75.92	75.60	76.20	75.92	68.00
24	70.81	73.74	74.41	74.32	73.74	74.62	74.32	73.74	74.29	74.32	73.74	74.34	74.32	68.00

Table 8. Hourly Inside Surface Loads by Envelope Element
(Btu, August 21 Design Cooling Day)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,COOLING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE

SURFACE LOADS

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW
1	684.2	-15.5	-60.2	26.3	-15.0	-74.3	26.3	-15.7	-52.2	26.3	-15.3	-55.1	26.3
2	624.3	-11.2	-54.5	35.0	-10.7	-65.5	35.0	-11.3	-48.3	35.0	-11.0	-50.6	35.0
3	578.4	-7.8	-48.7	42.7	-7.4	-57.3	42.7	-7.9	-43.9	42.7	-7.7	-45.7	42.7
4	543.4	-3.8	-42.7	47.7	-3.6	-49.4	47.7	-3.9	-38.9	47.7	-3.8	-40.3	47.7
5	527.4	4.8	-35.1	47.1	5.0	-40.3	47.1	4.7	-32.1	47.1	4.9	-33.2	47.1
6	374.1	29.8	-19.1	55.4	30.2	-23.1	55.5	26.9	-16.8	55.4	15.7	-17.6	55.5
7	-119.5	115.3	25.2	123.0	117.0	22.2	123.0	106.3	26.8	123.0	31.9	25.8	123.0
8	-575.6	-20.1	23.6	111.3	-8.5	21.6	111.4	-20.6	24.3	111.3	-202.7	19.1	111.4
9	-1246.6	-283.6	-15.5	21.4	-243.0	-16.4	21.4	-250.8	-15.3	21.4	-493.1	-31.9	21.5
10	-1831.0	-502.7	-50.0	-62.7	-421.7	-48.1	-62.7	-426.3	-48.0	-62.7	-667.7	-80.1	-62.6
11	-2155.0	-642.3	-75.6	-157.0	-523.0	-68.7	-157.0	-525.5	-68.8	-157.0	-721.5	-115.2	-156.9
12	-2456.0	-768.6	-104.4	-246.0	-622.5	-90.2	-246.0	-622.6	-90.2	-246.0	-745.5	-145.5	-245.9
13	-2607.6	-852.1	-131.3	-312.5	-712.3	-108.6	-312.6	-691.9	-108.5	-312.6	-743.5	-165.3	-312.6
14	-2599.2	-882.4	-153.7	-356.7	-805.6	-123.5	-356.8	-725.2	-122.3	-356.8	-740.9	-173.9	-356.8
15	-2441.3	-863.5	-170.3	-373.2	-881.5	-137.7	-373.2	-726.1	-131.8	-373.2	-729.3	-175.1	-373.2
16	-2184.0	-811.6	-181.7	-356.5	-928.5	-154.3	-356.5	-708.5	-138.7	-356.5	-707.0	-173.4	-356.5
17	-1644.0	-667.1	-175.5	-316.8	-862.5	-160.7	-316.8	-608.4	-131.6	-316.9	-603.9	-158.7	-316.8
18	-1030.3	-490.9	-158.2	-255.1	-703.3	-160.9	-255.0	-474.8	-117.1	-255.1	-464.4	-138.0	-255.0
19	-438.8	-294.8	-128.9	-181.9	-434.0	-149.1	-181.8	-300.1	-93.7	-181.9	-285.2	-109.7	-181.8
20	-137.4	-159.0	-103.4	-109.2	-207.7	-133.8	-109.2	-162.5	-75.4	-109.2	-155.7	-87.0	-109.2
21	22.7	-82.1	-83.7	-48.1	-95.0	-114.9	-48.1	-83.5	-61.9	-48.1	-80.9	-70.4	-48.1
22	148.8	-29.8	-66.5	7.4	-32.4	-93.9	7.4	-30.4	-49.5	7.4	-29.2	-55.9	7.4
23	233.9	-14.6	-60.8	26.4	-14.6	-83.3	26.4	-14.9	-47.7	26.4	-14.3	-52.5	26.4
24	156.9	-60.2	-72.8	5.4	-59.7	-90.7	5.4	-60.5	-62.6	5.4	-60.0	-66.4	5.4
T	-17572.1	-7313.8	-1943.7	-2226.6	-7440.4	-2000.9	-2226.2	-6333.5	-1544.2	-2226.9	-7429.9	-1996.6	-2226.2

(continued)

Table 8. (continuation from right side of previous page)

1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,COOLING MODE,DIURNAL TEMP CLE,WASH D.C.,RUN AS 1 SPACE
SURFACE LOADS

	SLAB FLOOR	HOURLY TOTALS
1	319.1	805.2
2	247.6	748.7
3	190.3	713.0
4	146.9	694.8
5	127.8	722.0
6	96.0	718.0
7	195.7	1038.6
8	40.0	-253.4
9	-1195.4	-3706.0
10	-2250.6	-6576.8
11	-2526.9	-8050.3
12	-2897.3	-9526.7
13	-3375.6	-10747.0
14	-3733.8	-11487.4
15	-3740.6	-11489.8
16	-3516.7	-10930.5
17	-2509.4	-8789.1
18	-1093.5	-5851.5
19	677.6	-2284.2
20	1376.1	-282.5
21	1716.8	874.7
22	1972.8	1763.4
23	1938.8	1975.7
24	1205.4	850.9
T	-16588.8	-79069.8

2.2 FORMAT B: MONTHLY AND YEARLY LOAD COMPONENTS

Format B provides monthly and yearly heating and cooling load components for a specified building design using actual hourly weather data from the location examined. (Test Reference Year[1] tapes are typically used with NBSLD.) A sample of this output is shown in table 9. Several pages are generally required to display the output. The monthly load components are the sum of the daily heating and cooling load components, as noted above. The sum of these monthly load components provides the yearly heating and cooling load components. Heat gains and losses during non-load periods, integrated on an annual basis, appear in the NL+ and NL- rows of table 9.

Included in Format B are the number of actual heating and cooling load hours calculated monthly and annually, shown in table 10. Cooling hours are further broken down into hours where the outdoor temperature is greater than or equal to the indoor temperature (+) and hours when the outdoor temperature is less than the indoor temperature (-). Monthly and annual heating and cooling hours may change as the thermal efficiency of the building envelope is improved. The month, day, and hour of the maximum hourly cooling and heating loads are also provided in table 10.

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[1] For an explanation of the methodology used to select a Test Reference Year, see Stamper, E., "Weather Data," ASHRAE Journal, February 1977, p. 47.

Table 9. Monthly and Annual Inside Surface Fluxes by Envelope Element, Internal and Air Infiltration Loads (Heating and Cooling, Million Btu)

INSIDE SURFACE FLUXES, INTERNAL & AIR INFILTRATION LOADS

	CEILNG	SOUTH INSUL WALL	SOUTH STUD WALL	SOUTH CD/CV WINDOW	SOUTH SOLAR WINDOW
	1.0000	2.0000	2.0000	3.0000	3.0000
	.0000	.0000	.0000	.0000	.0000
	.1170	.0702	.1324	1.1300	1.1300
	1600.0000	224.0000	48.0000	48.0000	48.0000
1 H	.3452181+07	.2910994+06	.1161453+06	.1144615+07	-.1066379+07
2 H	.2231937+07	.1852447+06	.7158936+05	.7833245+06	-.8733458+06
3 H	.1915067+07	.1710166+06	.5817181+05	.7182361+06	-.7622541+06
4 H	.8431616+06	.8021228+05	.1735929+05	.3306288+06	-.2486543+06
5 H	.2982892+06	.2376481+05	-.6788151+04	.1149578+06	-.4235818+05
6 H	.5372561+05	.3883977+04	.9576958+02	.1525790+05	-.9180243+02
7 H	.2797614+04	.1265068+03	-.1029767+03	.6211273+03	-.8000378-17
8 H	.1006270+05	.2524099+03	-.3528399+03	.2088611+04	.0000000
9 H	.1583784+06	.1160770+05	.7394291+03	.4221820+05	-.2915720+04
10 H	.1123038+07	.8573456+05	.1321322+05	.3568647+06	-.4032241+06
11 H	.1665672+07	.1167336+06	.3756278+05	.5424718+06	-.7589998+06
12 H	.2579277+07	.2061469+06	.7883714+05	.8755912+06	-.9989135+06
TH	.1433359+08	.1175823+07	.3864696+06	.4926876+07	-.5157137+07
NL+	.9605041+06	.1620637+06	.1148967+06	.5622731+06	.0000000
NL-	-.1820932+07	-.2390790+06	-.1413905+06	-.5225766+05	-.3109362+07
1C+	.0000000	.0000000	.0000000	.0000000	.0000000
1C-	.0000000	.0000000	.0000000	.0000000	.0000000
2C+	.0000000	.0000000	.0000000	.0000000	.0000000
2C-	.0000000	.0000000	.0000000	.0000000	.0000000
3C+	.0000000	.0000000	.0000000	.0000000	.0000000
3C-	.0000000	.0000000	.0000000	.0000000	.0000000
4C+	-.2034847+06	-.1574784+05	.5622409+03	-.8530332+04	-.1736055+06
4C-	-.2056453+05	-.1206470+04	.3810372+03	.1474878+04	-.2388240+05
5C+	-.4352682+06	-.2619800+05	.1247143+03	-.3024798+05	-.1211636+06
5C-	-.1444990+05	-.7224301+03	.1568917+02	.6193616+02	-.3743658+04
6C+	-.1010387+07	-.5611260+05	-.9911061+04	-.6704083+05	-.1950261+06
6C-	-.5492143+05	.1339707+04	.1284577+04	.4361357+04	-.1397606+05
7C+	-.1217633+07	-.7429490+05	-.1321395+05	-.9140619+05	-.2565826+06
7C-	-.9153639+05	.2865111+04	.2243211+04	.5717305+04	-.2195734+05
8C+	-.8336865+06	-.6676754+05	-.1126136+05	-.4985678+05	-.2754969+06
8C-	-.1164287+06	-.1947441+04	.2315236+04	.6599590+04	-.4670388+05
9C+	-.3456244+06	-.3863044+05	-.6485559+04	-.2604588+05	-.2143110+06
9C-	-.7850125+05	-.6405999+04	.2729567+03	.4597028+04	-.4898690+05
10C+	.0000000	.0000000	.0000000	.0000000	.0000000
10C-	.0000000	.0000000	.0000000	.0000000	.0000000
11C+	.0000000	.0000000	.0000000	.0000000	.0000000
11C-	.0000000	.0000000	.0000000	.0000000	.0000000
12C+	.0000000	.0000000	.0000000	.0000000	.0000000
12C-	.0000000	.0000000	.0000000	.0000000	.0000000
TC	-.4424386+07	-.2838278+06	-.3367227+05	-.2503159+06	-.1395436+07
TC+	-.4045984+07	-.2777613+06	-.4018498+05	-.2731280+06	-.1236186+07
TC-	-.3784028+06	-.6076523+04	.6512707+04	.2281209+05	-.1592502+06

	WEST INSUL WALL	WEST STUD WALL	WEST CD/CV WINDOW	WEST SOLAR WINDOW
	2.0000	2.0000	3.0000	3.0000
	90.0000	90.0000	90.0000	90.0000
	.0702	.1324	1.1300	1.1300
	224.0000	48.0000	48.0000	48.0000
1 H	.3430691+06	.1370402+06	.1145066+07	-.3394169+06
2 H	.2203574+06	.8580393+05	.7835823+06	-.3638568+06
3 H	.1923773+06	.6772649+05	.7183396+06	-.4228582+06
4 H	.8098340+05	.1515042+05	.3305572+06	-.2085784+06
5 H	.2246509+05	-.1183667+05	.1148774+06	-.4877566+05
6 H	.3774501+04	-.2960665+03	.1525407+05	-.2093865+03
7 H	.1265361+03	-.1249443+03	.6209628+03	-.8000378-17
8 H	.2524809+03	-.4039728+03	.2088200+04	.0000000
9 H	.1173873+05	.4552921+03	.4221419+05	-.1084055+04
10 H	.9708833+05	.1947080+05	.3569311+06	-.1723861+06
11 H	.1512494+06	.5509728+05	.5427756+06	-.2707044+06
12 H	.2500696+06	.9829013+05	.8759846+06	-.2923801+06
TH	.1373552+07	.4663729+06	.4928291+07	-.2120250+07
NL+	.2418981+06	.1438838+06	.5625024+06	.0000000
NL-	-.2234650+06	-.1561363+06	-.5241898+05	-.2139295+07
1C+	.0000000	.0000000	.0000000	.0000000
1C-	.0000000	.0000000	.0000000	.0000000
2C+	.0000000	.0000000	.0000000	.0000000
2C-	.0000000	.0000000	.0000000	.0000000
3C+	.0000000	.0000000	.0000000	.0000000
3C-	.0000000	.0000000	.0000000	.0000000
4C+	-.1309206+05	.2596737+04	-.8530706+04	-.1987063+06
4C-	-.1892298+04	.6087172+03	.1467299+04	-.4747114+05
5C+	-.2909844+05	.2181138+04	-.3030715+05	-.2272578+06
5C-	-.1456789+04	.4420250+02	.5451764+02	-.1106550+05
6C+	-.7185281+05	-.1186081+05	-.6733064+05	-.3733188+06
6C-	-.1093300+04	.1185840+04	.4327808+04	-.3783852+05
7C+	-.9784181+05	-.1610128+05	-.9178191+05	-.4972138+06
7C-	.3195945+04	.2169657+04	.5687535+04	-.2219359+05
8C+	-.7075045+05	-.7168832+04	-.4998352+05	-.3955091+06
8C-	.1738785+03	.2764376+04	.6587186+04	-.4060624+05
9C+	-.2893920+05	-.1387309+04	-.2598319+05	-.1774188+06
9C-	-.2652192+04	.1713339+04	.4622163+04	-.4313076+05
10C+	.0000000	.0000000	.0000000	.0000000
10C-	.0000000	.0000000	.0000000	.0000000
11C+	.0000000	.0000000	.0000000	.0000000
11C-	.0000000	.0000000	.0000000	.0000000
12C+	.0000000	.0000000	.0000000	.0000000
12C-	.0000000	.0000000	.0000000	.0000000
TC	-.3152995+06	-.2325423+05	-.2511706+06	-.2071670+07
TC+	-.3115748+06	-.3174036+05	-.2739171+06	-.1889424+07
TC-	-.3724756+04	.8486131+04	.2274651+05	-.1822457+06

(continued)

a Identification number for each envelope element type.
b Compass orientation for walls and windows only (0 = north).
c U-value of envelope element (Btu/h • ft^2 • °F).
d Area in square feet of envelope component.

Table 9. (continuation from right side of previous page, 1)

INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	NORTH INSUL WALL	NORTH STUD WALL	NORTH CD/CV WINDOW	NORTH SOLAR WINDOW	EAST INSUL WALL	EAST STUD WALL	EAST CD/CV WINDOW	EAST SOLAR WINDOW	SLAB FLOOR
	2.0000	2.0000	3.0000	3.0000	2.0000	2.0000	3.0000	3.0000	5.0000
	180.0000	180.0000	180.0000	180.0000	-90.0000	-90.0000	-90.0000	-90.0000	.0000
	.0702	.1324	1.1300	1.1300	.0702	.1324	1.1300	1.1300	.3122
	224.0000	48.0000	48.0000	48.0000	224.0000	48.0000	48.0000	48.0000	1600.0000
1 H	.3630003+06	.1450380+06	.1145052+07	-.8735045+05	.3413637+06	.1363356+06	.1145056+07	-.3371315+06	.3059870+07
2 H	.2447829+06	.9723536+05	.7836937+06	-.9357232+05	.2189931+06	.8755519+05	.7835845+06	-.4038934+06	.3146350+07
3 H	.2146625+06	.7985987+05	.7185192+06	-.1280642+06	.1849793+06	.6901191+05	.7183136+06	-.5847199+06	.3269851+07
4 H	.9130862+05	.2495128+05	.3307099+06	-.8203257+05	.7686872+05	.2018650+05	.3305614+06	-.3730844+06	.2225912+07
5 H	.2548362+05	-.4205617+04	.1149765+06	-.3297226+05	.1757535+05	-.6652121+04	.1148788+06	-.1315967+06	.1649974+07
6 H	.3845748+04	.1624185+03	.1525803+05	-.3776680+03	.3865110+04	.1189554+03	.1525627+05	-.8980360+03	-.3091574+04
7 H	.1265056+03	-.1020225+03	.6211318+03	-.5225826-16	.1265192+03	-.1021264+03	.6210621+03	-.1009768-15	-.1259951+04
8 H	.2523836+03	-.3211829+03	.2088750+04	.0000000	.2524286+03	-.3307373+03	.2088519+04	.0000000	-.4208010+04
9 H	.1174658+05	.1606121+04	.4222258+05	-.1084248+04	.1106014+05	.1384596+04	.4221530+05	-.1160323+05	-.5425796+05
10 H	.1061121+06	.3009073+05	.3570261+06	-.5782117+05	.9129420+05	.2414075+05	.3569265+06	-.3353154+06	.2811223+07
11 H	.1679675+06	.6334669+05	.5428055+06	-.7137069+05	.1485740+06	.5533605+05	.5427654+06	-.3197032+06	.3347936+07
12 H	.2669018+06	.1060314+06	.8759724+06	-.7880197+05	.2483338+06	.9867209+05	.8759795+06	-.3336473+06	.3344462+07
TH	.1496190+07	.5436931+06	.4928945+07	-.6334476+06	.1343286+07	.4856566+06	.4928247+07	-.2831593+07	.2279276+08
NL+	.2671165+06	.1516338+06	.5631908+06	.0000000	.1213875+06	.1039566+06	.5621824+06	.0000000	.1490002+08
NL-	-.1312508+06	-.1066693+06	-.5220482+05	-.7293935+06	-.1770804+06	-.1216436+06	-.5230852+05	-.2273151+07	-.1489477+05
1C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
1C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
2C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
2C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
3C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
3C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
4C+	-.3618151+04	.3538241+04	-.8464951+04	-.4983316+05	-.1080477+05	-.4794176+03	-.8534132+04	-.9382332+05	.7273223+06
4C-	.4695803+03	.8210188+03	.1484034+04	-.8214166+04	-.4755105+03	.4633051+03	.1472802+04	-.1887055+05	.1159812+06
5C+	-.1298360+05	.3703129+04	-.3017531+05	-.6241972+05	-.2203181+05	-.3892565+04	-.3030288+05	-.8293211+05	.1328298+07
5C-	-.3108600+03	.2009452+03	.6451955+02	-.2569861+04	-.6733170+03	-.1053635+03	.5726152+02	-.2938446+04	.5149187+05
6C+	-.4285890+05	-.6019047+04	-.6696668+05	-.1430692+06	-.7589700+05	-.2246387+05	-.6739412+05	-.2725779+06	.2135427+07
6C-	.1205602+04	.1501303+04	.4361714+04	-.1444308+05	-.2562457+04	.6838061+03	.4319273+04	-.4632922+05	.1699037+06
7C+	-.5450410+05	-.7048873+04	-.9129392+05	-.1748141+06	-.9011840+05	-.2731397+05	-.9179712+05	-.3099600+06	.2785781+07
7C-	.2649599+04	.2230572+04	.5716315+04	-.1659505+05	-.6205704+04	.1097971+04	.5642194+04	-.7374798+05	.2226526+06
8C+	-.3168426+05	.1720730+03	-.4965547+05	-.1126062+06	-.5622620+05	-.1546774+05	-.4995662+05	-.1944229+06	.1960057+07
8C-	.2730423+04	.3176903+04	.6623569+04	-.1971952+05	-.5564876+04	.1487418+04	.6556812+04	-.6880221+05	.2795679+06
9C+	-.1246963+05	.1712810+04	-.2589717+05	-.4729880+05	-.2221835+05	-.3743571+04	-.2596432+05	-.8312896+05	.1025026+07
9C-	.1286115+04	.2108003+04	.4638270+04	-.1119987+05	-.1730725+04	.7656510+03	.4622049+04	-.2680932+05	.2017381+06
10C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
10C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
11C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
11C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
12C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
12C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
TC	-.1500882+06	.6097079+04	-.2495651+06	-.6627827+06	-.2945091+06	-.6896835+05	-.2512788+06	-.1274343+07	.1100325+08
TC+	-.1581186+06	-.3941806+04	-.2724535+06	-.5900412+06	-.2772965+06	-.7336113+05	-.2739492+06	-.1036845+07	.9961912+07
TC-	.8030459+04	.1003875+05	.2288842+05	-.7274154+05	-.1721259+05	.4392788+04	.2267039+05	-.2374977+06	.1041335+07

(continued)

Table 9. (continuation from right side of previous page, 2)

INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS

	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

	LIGHTS	EQUIP	OCPS	OCPL	INFILS	INFILL	TOTAL SENSBL	TOTAL LATENT
1 H	-.4734316+06	-.1888633+07	-.5203863+06	-.1303856+06	.2555799+07	.3078011+06	.1080800+08	.1774158+06
2 H	-.4240552+06	-.1675430+07	-.4661939+06	-.1167420+06	.1645135+07	.1467505+06	.7068823+07	.3000871+05
3 H	-.4311733+06	-.1635226+07	-.4812132+06	-.1207547+06	.1468904+07	.1622239+06	.6119528+07	.4146938+05
4 H	-.2602179+06	-.9730006+06	-.3468090+06	-.8761497+05	.6732917+06	.9449764+05	.2979467+07	.6882766+04
5 H	-.1469282+06	-.6114824+06	-.2769253+06	-.7037866+05	.2375708+06	.7056548+05	.1414292+07	.1868709+03
6 H	-.6667637+04	-.5233412+05	-.3099808+05	-.7809916+04	.2482783+05	.7813594+04	.6036181+05	.3678371+01
7 H	.0000000	-.2648488+04	-.1905389+04	-.4946109+03	.8899773+03	.4947617+03	.4320455+03	.1508217+00
8 H	.0000000	-.7945464+04	-.5690685+04	-.1509315+04	.2960697+04	.1509936+04	.3134283+04	.6218204+00
9 H	-.2195515+05	-.9921234+05	-.5543033+05	-.1418167+05	.7174839+05	.1418606+05	.2017926+06	.4388550+01
10 H	-.3806856+06	-.1303531+07	-.4274735+06	-.1076784+06	.7151004+06	.1078264+06	.3463819+07	.1481364+03
11 H	-.4291009+06	-.1662718+07	-.4794202+06	-.1201357+06	.1100693+07	.1345678+06	.5088970+07	.1443233+05
12 H	-.4654425+06	-.1837411+07	-.5133574+06	-.1284146+06	.1885013+07	.1913873+06	.8145612+07	.6297301+05
TH	-.3039658+07	-.1174957+08	-.3605803+07	-.9061000+06	.1038193+08	.1239624+07	.4535423+08	.3335258+06
NL+	.0000000	.0000000	.0000000	.0000000	.1380356+07	.7729261+06	.2906878+02	.2215159+03
NL-	-.1682730+07	-.6424327+07	-.1498092+07	-.7781627+06	-.4095699+05	-.4213153+03	-.6387939+01	-.5878892+04
1C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
1C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
2C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
2C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
3C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
3C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
4C+	-.1808071+05	-.1322125+06	-.1430877+05	-.1149123+05	-.2043426+05	.7245157+04	-.2482719+06	-.4246075+04
4C-	-.2733130+04	-.2579627+05	-.2663872+04	-.2136128+04	.1045361+04	.1615339+04	-.2810010+05	-.5207894+03
5C+	-.3889454+05	-.2989082+06	-.3295543+05	-.2664857+05	-.4528033+05	-.9304177+04	-.2260108+06	-.3595275+05
5C-	-.1982270+04	-.1631469+05	-.1984903+04	-.1615097+04	.2864248+03	.1467833+04	-.5980616+04	-.1472646+03
6C+	-.2009901+06	-.8842764+06	-.1062087+06	-.8675132+05	-.1530755+06	-.2288155+06	-.1769210+07	-.3155668+06
6C-	-.2222545+05	-.8067294+05	-.9331020+04	-.7480980+04	.3337028+04	-.6470732+04	-.8558171+05	-.1395171+05
7C+	-.2640622+06	-.1172590+07	-.1445673+06	-.1180526+06	-.2015139+06	-.6085033+05	-.2199871+07	-.1789029+06
7C-	-.3021460+05	-.9433913+05	-.1038890+05	-.8223095+04	.4273934+04	-.6952363+04	-.1010367+06	-.1517546+05
8C+	-.1600832+06	-.8056164+06	-.9479166+05	-.7754033+05	-.1177778+06	-.2954801+05	-.1488540+07	-.1070883+06
8C-	-.2534903+05	-.1116602+06	-.1225065+05	-.9757354+04	.4878674+04	.3948780+04	-.1255709+06	-.5808574+04
9C+	-.7920069+05	-.4162891+06	-.4810080+05	-.3935520+05	-.5795381+05	-.1454288+06	-.6602523+06	-.1847840+06
9C-	-.1372572+05	-.7940166+05	-.8073034+04	-.6530966+04	.3368118+04	-.6074527+04	-.9088568+05	-.1260549+05
10C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
10C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
11C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
11C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
12C+	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
12C-	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
TC	-.8576417+06	-.4118078+07	-.4856250+06	-.3955829+06	-.5788460+06	-.4791673+06	-.7029312+07	-.8747501+06
TC+	-.7813116+06	-.3700093+07	-.4400327+06	-.3598392+06	-.5960356+06	-.4667017+06	-.6598156+07	-.8265409+06
TC-	-.9823081+05	-.4081849+06	-.4469238+05	-.3574362+05	.1718954+06	-.1246567+05	-.4371557+06	-.4820929+05

Table 10. Monthly and Annual Load Hours, Maximum Loads (Btu)

MONTH	MONTHLY HEATING HOURS	MONTHLY COOLING HOURS(+)	MONTHLY COOLING HOURS(-)	MONTHLY LOAD HOURS
1	743	0	0	743
2	657	0	0	657
3	653	0	0	653
4	438	45	7	490
5	324	100	4	428
6	33	283	22	338
7	2	376	29	407
8	6	260	36	302
9	61	139	26	226
10	554	0	0	554
11	657	0	0	657
12	720	0	0	720
TOTALS	4848	1203	124	6175

MAX COOLING LOAD = -15766. MONTH = 6 DAY = 16 HOUR = 10
MAX HEATING LOAD = 29949. MONTH = 1 DAY = 18 HOUR = 4

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a Cooling hours when $t_o \geq 78°F$.
b Cooling hours when $t_o < 78°F$.

3. NBSLD-XO ANALYSES OF A SINGLE-FAMILY RESIDENTIAL BUILDING

To illustrate the use of the expanded output version of NBSLD, a 1600 sq. ft., one-story frame house on a concrete slab located in the Washington, D.C. area was modeled, as shown in figure 1. The house design is square and symmetrical, so that the performance of each wall and window orientation is readily comparable. Window to gross wall area is 15 percent. Studs make up 17.6 percent of the opaque wall area (representative of 2x4 or 2x6 construction, 24 in. on center); the remainder of the wall area is insulated with a suitable building insulation material. No partition walls or interior zoning are used in this basic design. Four envelopes design combinations are analyzed using low and high insulation levels, each with and without storm windows. Table 11 provides the specific envelope parameters used in the four cases. Appendix D provides a listing of the data actually used in the NBSLD analysis for both the low and high insulation levels, including the thermo-physical properties and response factors for the roof, walls, and slab floor.

Window and ceiling fluxes are calculated in NBSLD using steady-state procedures. Floor and opaque wall fluxes are calculated using thermal response factors.

NBSLD does not presently have the capability of simulating a pitched-roof attic. Thus, attic temperature calculations are based on flat-roof construction over an attic area. In addition, NBSLD presently assumes linear heat flow normal to the slab floor, ignoring the horizontal heat flow component. In effect, this simulates well-insulated slab edges. Where the floor itself is to be insulated, insulation is assumed to be placed uniformly under the entire slab. The ground temperature under the floor is assumed to be constant at 68°F from June to October and constant at 56°F from November to May.

Two design days are examined in some detail. The winter design day has a dry-bulb temperature ranging from 18° to 40°F, and insolation based on a clear January 21st day. The summer design day has a dry-bulb temperature range from 68° to 98°F and insolation based on a clear August 21st day. Indoor dry-bulb temperatures are assumed to be maintained at 68°F during heating hours and 78°F during cooling hours. Thus, whenever the interior air temperature is between 68° and 78°F there is no heating or cooling load. Hourly internal equipment and occupant loads and solar gains through windows are shown in tables 2 and 6. The same equipment and occupant loading schedules are used in both winter and summer periods. Infiltration is assumed to be 0.5 air changes per hour at a wind speed of 15 mph and an indoor-outdoor temperature differential of 70°F. (The air change rate is modeled in NBSLD as a function of wind speed and temperature differential.) Windows are assumed to be opened only when doing so will eliminate potential cooling loads in any given hour. A maximum ventilation rate of 12 times the natural air leakage rate is assumed with all windows open. However, only the actual amount of air needed to offset the cooling load is brought in, so that the inside temperature remains at the upper bound of acceptability (i.e., 78°F). (If a lower indoor temperature were achieved, the hourly heat fluxes through each building envelope element would have to be recalculated.)

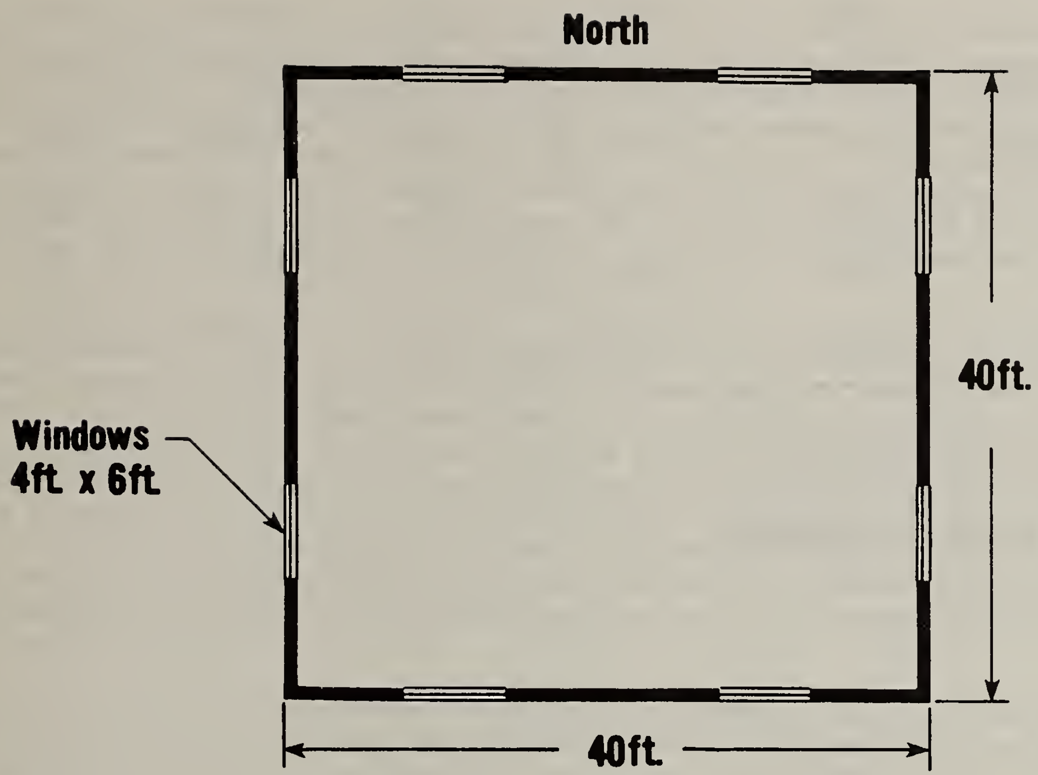

Figure 1. 1600 Square-Foot Symmetrical One-Story House (Unpartitioned) Used in NBSLD-XO Analysis

Table 11. Envelope Parameters for Four Variations of the Model House

		U-Value[a]			
Element	Area (ft^2)	Case 1	Case 2	Case 3	Case 4
Ceiling	1600	0.1170	0.1170	0.0340	0.0340
Wall (insulated)	896	0.0702	0.0702	0.0450	0.0450
Wall (studded)	192	0.1324	0.1324	0.1022	0.1022
Windows	192	1.1300	0.5600	1.1300	0.5600
Floor	1600	0.3122	0.3122	0.0757	0.0757
Total Shell	4480	0.2214[b]	0.1970[b]	0.1010[b]	0.0766[b]

[a] Winter design conditions.

[b] Weighted by area of elements.

Results of the first case (low insulation, no storm windows) are shown in detail in tables 1-4 for the heating design day and in tables 5-8 for the cooling design day, as described in section 2.1. (Tables 1 and 5 contain the hourly outdoor temperature profile for each day.) Table 9 contains the monthly and annual load components for the first case. Partial results of the three remaining cases (low insulation with storm windows, high insulation without storm windows, and high insulation with storm windows) are tabulated along with the results of the first case in tables 12-19.

Table 12 contains the 5 a.m. load components for the four case studies on the January 21st design heating day. Outdoor and indoor dry-bulb temperatures are 18° and 68°F, respectively, and the building elements have reached near steady-state thermal performance in the first two cases. In the second two cases, the insulation under the slab floor has resulted in a more dynamic performance mode for that element, so that at 5 a.m. it is releasing energy which was stored up during the previous day. Because there has been no solar radiation on the building for 12 hours at this point the thermal performance of all four wall orientations is nearly identical.

Table 13 provides the 1 p.m. load components for the same four case studies on the January 21st design heating day. Outdoor air dry-bulb temperature is 37.6°F. In the first three cases, indoor air temperature is 68°F. In the fourth case, where there is no net heating load at 1 p.m., indoor dry-bulb temperature floats up to 71.5°F at that hour. Solar gain through the windows is at a near peak condition and the building is in a dynamic performance mode. Note that the insulated portion of the south wall is shown to provide a net heat gain due to solar radiation at that time of day. Windows are assumed to be completely unshaded on the design heating day, with transmission of sunlight at 80 percent.

Table 14 provides the components of the daily heating load, integrated over the hours when a net heating load actually occurs. In addition, the number of heating hours when a net heating load occurs is recorded. Note that the storm windows and upgraded insulation significantly reduce the number of heating load hours. This results from their lowering of the "balance point" temperature, above which no net heating loads occur. As the number of heating hours decreases, the solar gains and internal heat gains reported decrease as well since they are only reported for those hours. In addition, the heat loss through the slab has been reversed in the last case. This is due to the heat storage capability of the insulated slab and the higher indoor temperature in the afternoon hours when the temperature floats above the heating setpoint. The slab can then store more heat and release it later as the room temperature falls back to that set point. Even when the surface temperature of the floor is lower than the room air temperature, heat release from the slab floor can occur by radiation exchange to other envelope elements with still lower surface temperatures (e.g., windows).

Table 15 contains the 4 p.m. hourly cooling load components for four cases calculated for a clear August 21st design cooling day. Outdoor and indoor dry-bulb temperatures are 97.1° and 78°F respectively. (See table 5 for the hourly temperature profile for that day.) Net cooling loads for this

Table 12. Hourly Heating Load Components[a] (Btu, 5 a.m., January 21 Design Heating Day, Δt = 50°F)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	7494	7646	2633	2697
South Face				
Insulated Wall	679	692	457	468
Stud Wall	207	213	111	114
CD/CV[b] Window	2096	1137	2278	1229
Solar Window	0	0	0	0
West Face				
Insulated Wall	679	692	457	468
Stud Wall	217	223	141	144
CD/CV Window	2096	1137	2278	1229
Solar Window	0	0	0	0
North Face				
Insulated Wall	679	692	457	468
Stud Wall	226	232	161	164
CD/CV Window	2096	1137	2278	1229
Solar Window	0	0	0	0
East Face				
Insulated Wall	679	692	457	468
Stud Wall	224	229	151	154
CD/CV Window	2096	1137	2278	1229
Solar Window	0	0	0	0
Slab Floor	1856	2456	-1176	-1136
Lights	0	0	0	0
Equipment	-1324	-1324	-1324	-1324
Occupant (Sensible)	-960	-960	-960	-960
Occupant (Latent)	-240	-240	-240	-240
Infiltration (Sensible)	6912	6912	6912	6912
Infiltration (Latent)	573	573	573	573
Total Sensible Load	25952	22944	17588	13552
Total Latent Load	333	333	333	333
Total Load	26285	23277	17921	13885

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[a] Positive values indicate heat flow outward, negative values indicate heat flow inward, consistent with NBSLD notation.

[b] CD/CV is conduction/convection component of heat transfer.

Table 13. Hourly Heating Load Components[a] (Btu, 1 p.m., January 21 Design Heating Day, Δt = 30.4°F[b])

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	666	782	309	494
South Face				
Insulated Wall	-412	-407	-203	-113
Stud Wall	166	167	209	257
CD/CV[c] Window	1510	800	1617	924
Solar Window	-11534	-11534	-11534	-11534
West Face				
Insulated Wall	444	449	340	430
Stud Wall	306	308	253	302
CD/CV Window	1516	803	1621	926
Solar Window	-2075	-2075	-2075	-2075
North Face				
Insulated Wall	486	491	350	440
Stud Wall	307	309	259	308
CD/CV Window	1514	802	1620	925
Solar Window	-988	-988	-988	-988
East Face				
Insulated Wall	333	338	199	289
Stud Wall	210	212	225	273
CD/CV Window	1516	802	1620	925
Solar Window	-988	-988	-988	-988
Slab Floor	10019	10442	6048	7442
Lights	-270	-270	-270	-270
Equipment	-2225	-2225	-2225	-2225
Occupant (Sensible)	-480	-480	-480	-480
Occupant (Latent)	-120	-120	-120	-163
Infiltration (Sensible)	4205	4205	4205	4694
Infiltration (Latent)	321	321	321	163
Total Sensible Load	4229	1944	114	0
Total Latent Load	201	201	201	0
Total Load	4430	2145	315	0

[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] Case IV: Δt = 33.9°F because interior temperature rises to 71.5°F.

[c] CD/CV is conduction/convection component of heat transfer.

Table 14. Daily Heating Load Components[a] (Btu, January 21[b])

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	125994	129146	43521	40443
South Face				
Insulated Wall	7294	7548	5773	5754
Stud Wall	2931	3033	2212	1061
CD/CV[c] Window	42841	23061	43559	18654
Solar Window	-76692	-76692	-57921	-9142
West Face				
Insulated Wall	11718	11971	7739	5891
Stud Wall	4709	4811	3439	2077
CD/CV Window	42880	23078	43578	18656
Solar Window	-24652	-24652	-12382	-856
North Face				
Insulated Wall	13493	13747	8622	6478
Stud Wall	5422	5524	3979	2577
CD/CV Window	42879	23078	43579	18657
Solar Window	-6453	-6453	-4873	-739
East Face				
Insulated Wall	11618	11872	7506	6340
Stud Wall	4669	4771	3490	2214
CD/CV Window	42879	23078	43578	18657
Solar Window	-25724	-25724	-24143	-11301
Slab Floor	119665	131855	27877	-7654
Lights	-15288	-15288	-15288	-12524
Equipment	-61074	-61074	-58426	-43541
Occupant (Sensible)	-16810	-16810	-16808	-14335
Occupant (Latent)	-4202	-4202	-4203	-3677
Infiltration (Sensible)	133985	133985	126152	102784
Infiltration (Latent)	9042	9042	8399	6792
Total Sensible Load	386284	323865	220764	150150
Total Latent Load	4839	4839	4195	3115
Total Load	391123	328704	224959	153265
Heating Hours	24	24	22	17

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a Positive values indicate heat flow outward, negative values indicate heat flow inward.

b See table 1 for weather profile.

c CD/CV is conduction/convection component of heat transfer.

Table 15. Hourly Cooling Load Components[a] (Btu, 4 p.m., August 21 Design Cooling Day Δt = 19.1°F)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	-6126	-6188	-2069	-2087
South Face				
Insulated Wall	-657	-660	-433	-435
Stud Wall	-162	-165	-40	-44
CD/CV[b] Window	-668	-374	-680	-380
Solar Window	-942	-942	-942	-942
West Face				
Insulated Wall	-982	-986	-554	-556
Stud Wall	-90	-94	-2	-7
CD/CV Window	-670	-375	-681	-380
Solar Window	-4833	-4833	-4833	4833
North Face				
Insulated Wall	-370	-374	-219	-221
Stud Wall	-44	-48	+12	+7
CD/CV Window	-666	-373	-679	-379
Solar Window	-605	-605	-605	-605
East Face				
Insulated Wall	-374	-378	-226	-228
Stud Wall	-139	-143	-69	-73
CD/CV Window	-668	-374	-680	-380
Solar Window	-605	-605	-605	-605
Slab Floor	+9641	+9464	+3724	+3468
Lights	-541	-541	-541	-541
Equipment	-3072	-3072	-3072	-3072
Occupant (Sensible)	-330	-330	-330	-330
Occupant (Latent)	-270	-270	-270	-270
Infiltration (Sensible)	-2640	-2640	-2640	-2640
Infiltration (Latent)	-3459	-3459	-3459	-3459
Total Sensible Load	-15542	-14635	-16167	-15264
Total Latent Load	-3729	-3729	-3729	-3729
Total Load	-19271	-18364	-19896	-18993

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[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] CD/CV is conduction/convection component of heat transfer.

design day are at a maximum during this hour. Likewise, total solar gain is also at its peak level. Windows are assumed to be 50 percent shaded during summer months, with net transmission of sunlight at 40 percent. Note that in the two cases with upgraded insulation, the heat gain through the ceiling, walls, and windows has been significantly reduced, while the total sensible load has increased. This is because the heat sink effect of the earth has been largely removed as insulation is added beneath the floor, and this is more than enough to offset the reductions in heat gain due to the insulation of the other envelope elements. (Note that the simulation of floor slab performance has not been well validated and thus these particular results may not be accurate representations of the actual performance of such construction.)

Table 16 provides the daily cooling load components, integrated over those twelve hours when the outdoor dry-bulb temperature is greater than the indoor dry-bulb temperature on the August 21st design day. Again, net cooling loads are increased in the better-insulated cases because of the reduced heat sink effect of the earth.

Tables 17, 18 and 19 provide the annual heating load and cooling load components, respectively, for each of the four cases examined. Total heating and cooling hours in each case are shown at the bottom of the tables. Note that heating load hours decrease significantly as storm windows and insulation are added, while cooling load hours increase, due primarily to the reduced heat sink effect of the earth after the floor is insulated. Changes in solar gain and internal heat gains are due to the changes in heating and cooling hours.

Table 16. Daily Load Components[a] (Btu, August 21 Design Cooling Day,[b] $t_o \geq t_i$)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	-61914	-62366	-20519	-20637
South Face				
Insulated Wall	-5658	-5705	-3645	-3683
Stud Wall	-1247	-1279	-533	-574
CD/CV[c] Window	-4977	-2809	-4874	-2758
Solar Window	-17157	-17157	-17157	-17157
West Face				
Insulated Wall	-6021	-6249	-3939	-3977
Stud Wall	-1081	-1113	-390	-431
CD/CV Window	-4988	-2814	-4882	-2762
Solar Window	-23305	-23305	-23305	-23305
North Face				
Insulated Wall	-2990	-3038	-1903	-1940
Stud Wall	-345	-377	-34	-74
CD/CV Window	-4961	-2802	-4864	-2754
Solar Window	-6368	-6368	-6368	-6368
East Face				
Insulated Wall	-4689	-4736	-3208	-3246
Stud Wall	-1458	-1490	-766	-807
CD/CV Window	-4983	-2812	-4880	-2761
Solar Window	-10295	-10295	-10295	-10295
Slab Floor	+101997	+100670	+32816	+30685
Lights	-6878	-6878	-6878	-6878
Equipment	-37979	-37979	-37979	-37979
Occupant (Sensible)	-4184	-4184	-4184	-4184
Occupant (Latent)	-3424	-3424	-3424	-3424
Infiltration (Sensible)	-20529	-20529	-20529	-20529
Infiltration (Latent)	-41512	-41512	-41512	-41512
Total Sensible Load	-130191	-123612	-148317	-142414
Total Latent Load	-44936	-44936	-44936	-44936
Total Load	-175127	-168548	-193253	-187350
Cooling Hours Over 78°	12	12	12	12

[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] See table 1 for weather profile.

[c] CD/CV is conduction/convection component of heat transfer.

Table 17. Annual Heating Load Components[a] (Million Btu)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	14.333	14.612	4.626	4.105
South Face				
Insulated Wall	1.176	1.201	0.748	0.670
Stud Wall	0.386	0.384	0.274	0.237
CD/CV[b] Window	4.927	2.560	4.654	2.065
Solar Window	-5.157	-4.586	-3.143	-1.884
West Face				
Insulated Wall	1.374	1.374	0.829	0.724
Stud Wall	0.466	0.458	0.328	0.280
CD/CV Window	4.928	2.560	4.655	2.066
Solar Window	-2.120	-1.872	-1.111	-0.690
North Face				
Insulated Wall	1.496	1.486	0.875	0.754
Stud Wall	0.544	0.534	0.371	0.313
CD/CV Window	4.929	2.560	4.655	2.066
Solar Window	-0.633	-0.550	-0.332	-0.182
East Face				
Insulated Wall	1.343	1.356	0.826	0.727
Stud Wall	0.486	0.481	0.338	0.289
CD/CV Window	4.928	2.560	4.655	2.066
Solar Window	-2.832	-2.494	-1.572	-0.884
Slab Floor	22.793	23.104	1.915	1.042
Lights	-3.040	-2.941	-1.984	-1.460
Equipment	-11.750	-11.321	-7.956	-6.058
Occupant (Sensible)	-3.606	-3.536	-2.622	-2.159
Occupant (Latent)	-0.906	-0.889	-0.660	-0.544
Infiltration (Sensible)	10.382	10.187	8.976	7.673
Infiltration (Latent)	1.240	1.215	0.964	0.811
Total Sensible Load	45.354	38.118	20.004	11.759
Total Latent Load	0.334	0.325	0.304	0.268
Total Load	45.688	38.443	20.308	12.027
Heating Hours	4848	4705	3429	2737

[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] CD/CV is conduction/convection component of heat transfer.

Table 18. Annual Cooling Load Components[a] ($t_o \geq t_i$, Million Btu)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	-4.046	-4.061	-1.274	-1.278
South Face				
Insulated Wall	-0.278	-0.280	-0.179	-0.181
Stud Wall	-0.040	-0.042	-0.015	-0.018
CD/CV[b] Window	-0.273	-0.146	-0.227	-0.126
Solar Window	-1.236	-1.234	-1.240	-1.240
West Face				
Insulated Wall	-0.312	-0.314	-0.196	-0.198
Stud Wall	-0.032	-0.033	-0.012	-0.015
CD/CV Window	-0.274	-0.146	-0.227	-0.126
Solar Window	-1.869	-1.866	-1.883	-1.883
North Face				
Insulated Wall	-0.158	-0.161	-0.100	-0.103
Stud Wall	-0.004	-0.005	+0.006	+0.003
CD/CV Window	-0.272	-0.146	-0.226	-0.125
Solar Window	-0.590	-0.589	-0.593	-0.593
East Face				
Insulated Wall	-0.277	-0.280	-0.187	-0.190
Stud Wall	-0.073	-0.075	-0.042	-0.044
CD/CV Window	-0.274	-0.146	-0.227	-0.126
Solar Window	-1.037	-1.034	-1.040	-1.040
Slab Floor	+9.962	+9.816	+3.436	+3.251
Lights	-0.761	-0.758	-0.798	-0.798
Equipment	-3.710	-3.695	-3.931	-3.931
Occupant (Sensible)	-0.441	-0.436	-0.514	-0.514
Occupant (Latent)	-0.360	-0.356	-0.421	-0.421
Infiltration (Sensible)	-0.596	-0.593	-0.610	-0.610
Infiltration (Latent)	-0.467	-0.461	-0.543	-0.543
Total Sensible Load	-6.592	-6.225	-10.080	-9.885
Total Latent Load	-0.827	-0.817	-0.964	-0.964
Total Load	-7.419	-7.042	-11.044	-10.849
Cooling Hours ($t_o \geq t_i$)	1203	1194	1322	1322

[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] CD/CV is conduction/convection component of heat transfer.

Table 19. Annual Cooling Load Components[a] ($t_o < t_i$, Million Btu)

CASE:	I	II	III	IV
INSULATION:	LOW	LOW	HIGH	HIGH
STORM WINDOWS:	NO	YES	NO	YES
LOAD COMPONENT				
Ceiling	-0.376	-0.420	-0.181	-0.202
South Face				
Insulated Wall	-0.006	-0.006	-0.008	-0.007
Stud Wall	+0.006	+0.008	+0.004	+0.006
CD/CV[b] Window	+0.023	+0.013	+0.093	+0.058
Solar Window	-0.159	-0.182	-0.370	-0.448
West Face				
Insulated Wall	-0.004	-0.002	-0.008	-0.005
Stud Wall	+0.008	+0.010	+0.004	+0.007
CD/CV Window	+0.023	+0.013	+0.093	+0.058
Solar Window	-0.202	-0.215	-0.400	-0.484
North Face				
Insulated Wall	+0.008	+0.010	+0.010	+0.015
Stud Wall	+0.010	+0.012	+0.011	+0.015
CD/CV Window	+0.023	+0.013	+0.093	+0.059
Solar Window	-0.073	-0.083	+0.164	-0.195
East Face				
Insulated Wall	-0.017	-0.020	+0.023	-0.023
Stud Wall	+0.004	+0.005	+0.002	+0.003
CD/CV Window	+0.023	+0.013	+0.093	+0.058
Solar Window	-0.237	-0.276	-0.552	-0.672
Slab Floor	+1.041	+1.177	+1.078	+1.263
Lights	-0.096	-0.110	-0.384	-0.459
Equipment	-0.408	-0.457	-1.320	-1.523
Occupant (Sensible)	-0.045	-0.049	-0.183	-0.211
Occupant (Latent)	-0.036	-0.039	-0.150	-0.172
Infiltration (Sensible)	+0.017	+0.021	+0.076	+0.100
Infiltration (Latent)	-0.012	-0.014	-0.098	-0.101
Total Sensible Load	-0.437	-0.526	-2.037	-2.586
Total Latent Load	-0.048	-0.053	-0.248	-0.273
Total Load	-0.485	-0.579	-2.285	-2.859
Cooling Hours ($t_o < t_i$)	124	140	424	495

[a] Positive values indicate heat flow outward, negative values indicate heat flow inward.

[b] CD/CV is conduction/convection component of heat transfer.

4. INTERPRETATION OF EXPANDED OUTPUT DATA

The expanded-output version of NBSLD can provide a considerable amount of information relating to the thermal performance and conservation potential of buildings. In particular, the identification of the components of heating and cooling loads can make it easier to determine the load-reducing potential of individual modifications to the building envelope, especially if several such modifications are made simultaneously. In addition, the interdependent relationships among the envelope elements can be quantified to a larger extent than previously possible. This section of the report will explore each of these features in greater detail.

4.1 DESIGN IMPLICATIONS FROM NBSLD-XO ANALYSIS

In sections 2 and 3, heat fluxes, solar gains, air infiltration and internal loads that resulted in net hourly heating or cooling loads were reported for four variations of a 1600 sq. ft., wood-frame dwelling in the Washington, D.C. climate. A number of preliminary design implications can be inferred directly from these data for the house model used.

In interpreting these expanded-output data it must be recognized that the heating and cooling load components reported in tables 9, 17, 18, and 19 represent sources of heat loss and heat gain only during hours when there is a net heating or cooling load. This is important because as the building envelope becomes better insulated, the number of hours in which heating and cooling loads occur annually may change. As the number of heating and cooling hours change, all of the load components reported, not just those modified, change as well. For example, if internal and solar gains are held constant as the building is better insulated, the number of hours where heating is required will be reduced. As a result, the solar and internal gains during the heating hours eliminated are no longer included in the load components that are shown.

This does not imply that energy conservation features incorporated into the building envelope design are of no energy-saving value during non-load hours. In fact, without one or more such features there may indeed be a net heating or cooling load in some of those hours. However, this does imply that any further thermal improvements to the envelope would have no energy-saving value in those hours. These data are therefore of considerably more use to the envelope design process than a report of total annual or even monthly envelope heat losses. Building envelope heat losses can occur even during some cooling hours, and thus total monthly or annual envelope heat losses are a poor indication of corresponding heating loads.

The heat fluxes through the individual building envelope elements and heat losses or gains due to infiltration during hours with net heating or cooling loads represent an upper bound on the load reduction potential of modifications to the heat transfer attributes of those elements, under certain conditions. These conditions require that: (1) other design parameters and operational procedures be held constant, and (2) that the heat fluxes through those elements be of the same sign as the load incurred, which is the usual case.[1]

While the heat loss through individual envelope elements may represent an upper bound on the heating load reduction potential of improvements to those elements, it is unlikely that this potential could be fully realized over the heating season, even if the heat loss through any given element were reduced to zero. This is because the total heat loss through the envelope elements is generally much greater than the net heating load, due to the offsetting effects of solar and internal heat gains.

On the other hand, reductions in heat gain through any given element during hours when net cooling loads are incurred are likely to be more fully realized in terms of reduced cooling requirements. This is because the total heat gain through the envelope elements is generally considerably less than actual cooling loads.

4.1.1 Heating Season Effects

The annual heating load data reported in table 17 for the four variations of the dwelling unit analyzed provide some preliminary implications for basic envelope design with respect to heating requirements.

(1) Window design. In cases I and II (low insulation) the solar gain through south-facing windows is greater than the conduction/convection losses during heating hours, with and without storm windows. However, the windows on the other three orientations have conductive/convective heat losses greater than solar gains, even with storm windows, during heating hours. This implies that larger windows than modeled on the south side and smaller windows than modeled on the other orientations would reduce heating loads further, as might be expected.

In the well insulated house (cases III and IV), the solar gain through the south-facing windows is less than the conductive/convective losses during heating hours, even with storm windows. This is because the bulk of the heating load has been shifted toward hours when the sun is not shining. This would imply that smaller windows than modeled on the south side would

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[1] However, there are important cases in which the heat gain may have the opposite sign of the load incurred. For example, an insulated slab floor may provide a heat gain (−) during heating hours (as in cases III and IV of table 12) or a heat loss (+) during cooling hours. When usable solar gain (−) is greater than the conduction/convection losses (+) through a window during heating hours, increasing the size of the window may reduce heating loads. In addition, when t_i is greater than t_o, some envelope elements (e.g., floors, windows, and below-grade walls) may have heat fluxes out (+) while net cooling loads (−) are incurred. These cases have a special significance in "passively" heated and cooled houses and deserve special design considerations.

be warranted as well in order to reduce heating loads in a well insulated house. However, these implications for window design must be considered in light of the thermal storage capacity of the building interior. That is, if solar gain through windows during non-heating hours can be stored for use during heating hours, the larger windows may still be justified, especially on the south and west exposures. However, this effect requires further investigation of the interrelationship between window size and thermal storage capacity of the building.

(2) Wall orientation. A comparison of annual heat losses during heating hours through the four opaque walls, by orientation, can be made based on table 17. The opaque wall area consists of the insulated wall and the stud wall portions. In case I (low insulation, no storm windows) the north-facing wall loses approximately 30 percent more heat than the south-facing wall and 11 percent more heat than the east- and west-facing walls per square foot of wall area during heating load hours. This would imply that the north wall, and to some extent, the east and west walls, should be more heavily insulated than the south wall in such a case. In the well insulated house with storm windows (case IV), where the heating load has been shifted toward the hours without solar gains, the north wall loses only 18 percent more heat than the south-facing wall and about 6 percent more than the east and west walls, making the differential wall insulation less attractive.

By comparing the sum of north and south heat losses with east and west heat losses by square foot of wall area, a good idea of the effects of orientation of a rectangular building can be obtained. That is, if the average north and south losses were less than the average east and west losses, per square foot of wall area, the implication would be to design the building so that its longer walls faced north and south. In all four cases analyzed, the advantage of north and south over east and west was approximately 2 percent in terms of reduced heat loss per square foot during actual heating hours. Thus, the advantage of differential orientation from a heating standpoint may be small in this climate, given that all four walls are identically insulated.

(3) Slab floor. Insulation under the slab floor reduced heat loss through the floor surface during heating hours to a considerably greater degree than would be expected by comparison of U-values before and after insulation and the reduced number of heating hours alone. This result is due to the superior thermal storage properties of the insulated floor, which results in a heat release from the floor during some heating load hours. (For an example of this, see table 12, cases III and IV.) This load reduction potential is consistent with other NBS research[1] which showed that insulation on the outside of masonry walls enhances their thermal storage effects and has a greater impact on heating loads than insulation on the inside of the walls. It should be noted that the calculated heat release from the floor is largely due to radiation exchange to other colder surfaces rather than through

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[1] Peavy, Powell, and Burch, Dynamic Thermal Performance of an Experimental Masonry Building, Building Science Series 45, National Bureau of Standards, 1973.

conduction/convection to the inside air, as the floor surface is shown to be colder than the air temperature in the expanded output for the design-day analysis.

4.1.2 Cooling Season Effects

The annual cooling load data ($t_o \geq t_i$) reported in table 18 provide some preliminary implications for basic envelope design with respect to cooling requirements. Cooling load data ($t_o < t_i$) reported in table 19 will be discussed separately.

(1) Slab Floor. The slab floor on grade is the factor which has the greatest impact of all of the envelope modifications made in the NBSLD-XO analysis of the 1600 sq. ft. house. Before the underside of the floor was insulated, it provided a major heat sink effect. After the slab was insulated, its heat sink effect was greatly reduced, although not entirely eliminated, so that the number of cooling hours and the cooling loads increased significantly. Thus, for cooling purposes, insulation of the entire slab decreased the energy efficiency of the dwelling.

(2) Other envelope elements. Increasing the insulating effect of the attic, walls, and windows all served to reduce cooling loads during hours when $t_o \geq t_i$. The increased attic insulation was particularly effective in reducing heat gain. Solar gains through windows between the months of May and October, the prime cooling period, are assumed to be halved by shading on all orientations. Note that solar gains through the western windows during cooling hours were approximately 50 percent greater than the southern windows and 80 percent greater than eastern windows.

In general, western and eastern walls transmitted more heat to the interior during cooling hours than southern or northern walls. In table 17 the average eastern and western wall heat transmission is approximately 45 percent greater than the average heat transmission through the northern and southern walls during cooling hours. This implies that a rectangular building shape with the long walls facing north and south is substantially more energy efficient than one with long walls facing east and west.

Finally, some consideration should be given to cooling loads that occur when the outdoor temperature is lower than the indoor temperature. These loads are of some concern because they potentially can be increased by further insulation of the building envelope. In table 19 the reported cooling loads ($t_o < t_i$) increased from 485,000 Btu to 2,859,000 Btu as a result of the upgraded insulation and addition of storm windows. Most of this increased cooling load was due to the greatly increased number of hours when such loads occur. As the walls, windows and floor become better insulated, the conductive heat loss pathways for the internally generated and solar heat gains are reduced. While this may only amount to a small reduction in envelope heat loss during hours when t_o is less than t_i, its impact can be greatly multiplied when new cooling hours are incurred because of the need to mechanically remove solar and internal loads when windows are closed up. In the data presented in table 19, the increased cooling loads were due largely to the need to remove solar and internal heat gains mechanically.

For this reason, the design of a well insulated house must include increased consideration for alternative means of reducing internally generated and solar heat gains during cooling periods. Adequate natural cross-ventilation, direct venting of equipment loads, reduction in lighting usage, and solar shading should all be considered. In addition, the potential for whole-house ventilating as a supplement to mechanical air conditioning should be investigated. As a result of these actions, the cooling loads during hours when t_o is less than t_i can be largely eliminated. This not only reduces air conditioning costs but reduces potentially negative effects of high insulation levels, making higher insulation levels more energy efficient and cost effective.

4.2 INTERDEPENDENCE AMONG ENVELOPE ELEMENTS

Two distinct types of interdependence characterize the thermal relationships among the elements of the building envelope. The first is associated directly with the amount of heat flux through the envelope elements themselves; the second concerns the relationship between these fluxes and the resulting thermal load.

I. Radiation exchange among the various inside surfaces of a building can significantly affect the heat flux through the various elements of the building envelope. This exchange mechanism creates a thermal link among all of the inside surfaces whenever one or more surfaces are at a different temperature than the others. If one surface is warmer than another it radiates energy to that other surface, raising the latter surface temperature and lowering the former until they reach equilibrium (although not necessarily an equal temperature). As a result, on a cold day, the inside-outside temperature differential of the latter is increased and that of the former is decreased, altering the amount of heat flux through the two elements. In general, as the overall envelope is better insulated, inside surface temperatures approach the room temperature and the effects of radiation exchange become less significant.

II. The shifting "balance point" gives rise to the second type of interdependence which characterizes the load reduction potentials of the individual envelope components. The heating balance point is defined as the outdoor dry-bulb air temperature below which heating loads occur. The cooling balance point is defined as the outdoor dry-bulb air temperature above which building cooling loads occur.[1]

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[1] It must be recognized that the balance point is not entirely inherent in building design and construction, but is somewhat dependent on the amount of solar gain and internal heat release as well as the indoor temperature requirements and occupant-induced air infiltration. As these factors change through the day or year the balance point will change as well. Thus, an average seasonal balance point may be of more general interest than the balance point calculated under given operational conditions.

When an envelope modification reduces net heat flux in any given hour, it can reduce the net heating or cooling load by a corresponding amount only if there is a heating or cooling load in that hour at least as great as the reduction in flux. Whether or not such a load exists depends not only on the climate but on the overall thermal integrity of the envelope, the amount of solar heat gain through the windows, and the magnitude of internal heat release. Thus, the whole building and its mode of operation is, in essence, an interdependent system with respect to heating and cooling loads. As a result, the load reduction potential of a given design modification depends to some extent on the degree to which these other factors prevail.

While a modification to the building envelope that reduces heat flux cannot reduce building heating or cooling loads in hours when such loads do not exist, the benefit of the reduced flux is often realized as a reduction in the number of hours when such loads do occur. This load-hour reduction potential is especially typical of the heating season, because the reduced heat loss allows the internally generated heat (from lights, equipment and occupants) and solar gains to satisfy the minimum acceptable indoor temperature at a lower outdoor temperature without using the heating system. For example, in table 17, the lesser insulated house without storm windows required heating in 4,848 hours while the better insulated house with storm windows required heating in only 2,737 hours.

In the case of cooling loads, reductions in envelope heat gains do not necessarily reduce net cooling load hours. This is because the internally generated heat and solar heat gains add to the net load rather than offset it. In cooling hours where t_o is greater than t_i, one would expect that insulating the walls, windows, and ceiling of a building would have little impact on the number of cooling hours, since internal and solar heat gains must still be removed.[1] However, insulating the floor may significantly increase cooling load hours because of the reduced heat sink effect. These effects can be verified by examining table 18, which provides annual cooling loads and the number of cooling hours when t_o is equal to or exceeds t_i. In hours where t_o is less than t_i, increased insulation of the walls, windows, and floor of the envelope may actually increase the number of cooling hours incurred, because conductive heat loss pathways for the internally generated and solar heat gains are reduced. This effect can be clearly observed in table 19, which provides both the number of annual cooling hours when t_o is less than t_i and the components of the associated cooling loads. Note that these calculations were based on the assumption that up to twelve times the normal hourly air changes with windows closed could be brought in through openable windows and doors if that would eliminate the cooling load in that hour. Had the house been closed up at all times, the number of cooling hours where t_o is less than t_i would have been considerably greater.

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[1] Only a wood-frame structure with relatively little thermal response (or heat storage effects) was examined in the computer analysis made in this report. The use of more massive construction materials in the walls might, in some cases, reduce the number of cooling hours.

In estimating the load reduction potential of various modifications to the building envelope, interdependent relationships due both to radiation exchange and the shifting balance point should be considered. While interdependence due to radiation exchange decreases as the overall building envelope is insulated, the effects of the shifting balance point in both heating and cooling operations can be significant regardless of the level of insulation.

Before leaving this subsection, the relationship between heating and cooling loads and actual energy use must be considered. In particular, it must be stressed that while hourly heating and cooling loads and daily, monthly, and annual heating and cooling requirements are calculated, they are not estimates of actual energy use. Moreover, they are not directly additive in any meaningful sense. In order to estimate the actual energy use corresponding to these loads, the conversion performance of the HVAC equipment must be known under part- and full-load conditions.

After converting reductions in heating requirements and cooling requirements to their respective energy savings, the total annual energy savings due to a given design modification can be calculated by direct addition of the two. However, this total energy savings may not be entirely meaningful from a design standpoint. If the objective of the design process is not only to reduce energy use but to reduce energy-related costs, the dollar value of the heating and cooling energy savings must be estimated separately and the results summed in dollar terms. Thus, if an additional heating energy unit is more costly than an additional cooling energy unit, more weight would be given to the reduction in heating requirements, and vice-versa.

5. EFFECTS OF THERMAL ZONING

The four case studies examined in section 3 provide an analysis of a simple residential model formulated as a single thermal zone. The single-zone design may provide a satisfactory approximation of an actual residence from the thermal design standpoint. However, the lack of interior partitions (e.g., walls) and other massive elements within (e.g., furniture) leads to several undesirable consequences:

(1) There are no surfaces other than the envelope elements themselves for which heat transmission by radiation exchange is considered. As a result, the four envelope walls "see" one another directly, thus minimizing the effect of radiation exchange when they are (close to) the same temperature. Because interior surfaces are likely to be closer to the indoor air temperature than the envelope surfaces, they will radiate heat to the envelope surfaces during heating periods, raise their temperature, and thereby increase the rate of conductive heat loss through the envelope if the room air temperature is held constant. During cooling periods, the inside surfaces of the warmer exterior walls will radiate to the cooler interior surfaces, increasing the rate of conductive heat gain if indoor air temperature is held constant. As pointed out earlier, the change in surface temperatures can also have an effect on occupant comfort that will allow an adjustment in the thermostat setting to reduce heating and cooling loads. However, this consideration is not made in NBSLD.

(2) In the one-room case, the solar radiation entering through the windows is evenly distributed to the inside envelope surfaces since no partitions are modeled. This raises the temperature of these surfaces, increasing conductive losses in winter and reducing conductive gains in summer. In either case, partition walls and floors and other interior objects would receive a substantial amount of the direct radiation from the sun as it enters through the windows. If, as an alternative modeling procedure, most of the direct solar radiation is assumed to fall on the floor, when this is not in fact the case, the performance characteristics and optimal design characteristics of that element and the other envelope elements determined through the use of NBSLD analysis will be distorted.

During heating periods the solar radiation on the inside envelope surfaces does offset to some degree the lack of partition walls and other bodies which radiate to those envelope surfaces. However, during cooling periods, when partition walls and other interior objects would otherwise receive radiation from these envelope surfaces, the lack of partition walls and other interior objects, together with the solar radiation on the inside envelope surfaces, reinforce each other in underestimating the conductive heat gain to the building interior.

(3) The thermal storage capacity of the interior partitions and other massive elements inside the building is not accounted for. This is especially significant during periods when heating or cooling loads occur only part of the day. Heat that is stored during the day when there is no heating load and released at a later time when there is a heating load provides a net benefit, even though on a 24-hour basis the net flux may be zero. The same

case can be made for cooling loads. (In the past, thermal storage capacity has often been modeled by increasing the mass of the floor. However, this is inconsistent with the purpose of NBSLD-XO as an aid to envelope design which includes the floor.)

(4) The room temperatures cannot be maintained at different levels in different parts of the building and internal heat loads (e.g., lights, equipment, occupant) cannot be isolated by zone when modeling a building as a single-zone.

These undesirable consequences of a single-zone analysis are largely avoided if the building can be divided into several thermally-coupled zones. However, NBSLD at present has a limited zone-modeling capacity. While two or more zones in a single building can be modeled, each is entirely independent so that no means of heat transfer among the zones (i.e., "coupling") is allowed for. Thus, it is possible to have a heating load in one zone and a cooling load in another simultaneously. In large buildings, this may be realistic. In smaller buildings, especially single-family housing units, this is not generally realistic.

As an example of the limited zone-modeling capabilities of NBSLD, the 1600 sq. ft. house examined previously was divided into four zones of equal size, as shown in figure 2. Each of these zones was analyzed by NBSLD-XO for the heating design day shown in table 1. The results are tabulated in tables 20 and 21.

The effects of the partitioned walls on heat loss through the envelope can be clearly seen at 5 a.m. on the January 21st design day in table 20. The sun has not been shining for 12 hours, so that all four zones have approximately the same total conductive heat loss through the interior surfaces of the building envelope in cases I and II. In cases III and IV the thermal storage effect of the slab floor results in substantially lower conductive heat loss in zones I and II relative to zones III and IV. Note that the total conductive heat loss summed for the four zones is somewhat more than the conductive heat loss calculated in the single-zone examples (table 12), but that this difference diminishes as the overall building is better insulated. Because the effects of solar gain and internal heat gain are small during this hour, there is a heating load in all four zones, and thus the fact that four zones are not thermally coupled is not significant at this time.

These 5 a.m. results would imply that a partitioned building loses more heat than a non-partitioned building during heating hours, given the same interior temperature in all zones. This is because the partitioned walls absorb heat from the air by conduction/convection and then radiate this heat to the inside surfaces of the interior envelope. This in turn increases the temperature differential across the envelope elements, increasing the rate of heat transmission. However, as stated earlier, this does not imply that partitioned buildings use more energy than non-partitioned buildings. This is because the higher inside surface temperatures of all surfaces in the partitioned buildings increase the mean radiant temperature over that of the single-zone case, allowing equal thermal comfort at a lower thermostat setting in the former over the latter.

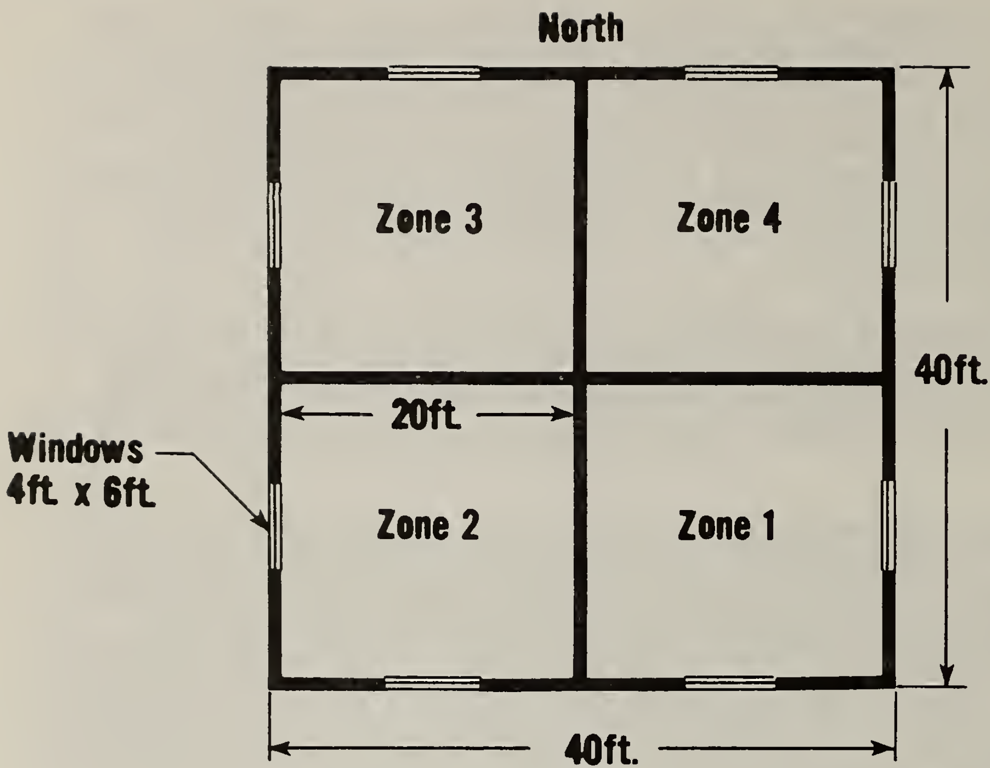

Figure 2. Zoning of 1600 Square-Foot Symmetrical House by Partition Walls.

Table 20. Total Conductive Heat Loss[a] (Btu, 5 a.m., January 21 Design Heating Day)

	Zone 1	Zone 2	Zone 3	Zone 4	Total	Single[b] Zone
Case 1	5670	5661	5692	5701	22724	21325
Case 2	4835	4828	4862	4870	19395	18316
Case 3	3155	3141	3568	3591	13455	12960
Case 4	2065	2067	2564	2594	9290	8924

[a] Does not include internal heat gain nor infiltration heat loss.

[b] From table 12.

In table 21, results of the 24-hour design heating day are tabulated for each of the four zones for the same four cases examined in section 3. These heating loads are very similar in zones I and II and in zones III and IV. As might be expected, heating loads in zones III and IV are substantially greater than in zones I and II. Comparison of the sum of the daily loads in the four zones with the daily load calculated for the same building modeled as a single zone (table 14) shows that the former are not only greater than the latter but as the building becomes better insulated, this difference increases. This increasing difference results from the fact that excess heat in one zone is not available to make up simultaneous heat deficits in other zones. In some hours, windows are actually opened in zones I and II in order to avoid air conditioning loads, while heating is required in zones III and IV.

In order to make a more realistic model, some means of transferring this excess heat (or cooling effect during hours requiring air conditioning) from one zone to another as needed must be incorporated into the program. It has been suggested that rather than analyzing each zone independently for some extended period of time, the several zones should be analyzed sequentially each hour. At the end of each hour the heating and/or cooling loads would be balanced by means of "coupling coefficients" which simulate heat transfer by air movement among the zones. However, this procedure would require some major modifications of NBSLD.

Table 21. Heating Loads, Heating Hours, and Hours of Window Opening by Zone (January 21 Design Heating Day)

	Zone 1	Zone 2	Zone 3	Zone 4	Total	Single Zone[a]
Design Day Heating Load[b]						
(10^3 Btu)						
Case 1	89.93	91.92	114.12	113.76	409.74	391.12
Case 2	75.58	76.84	97.54	97.17	347.13	328.70
Case 3	47.10	48.16	73.11	72.62	241.00	224.96
Case 4	31.18	32.21	52.88	52.33	168.60	153.27
Heating Hours						
Case 1	19	19	24	24	-	24
Case 2	18	19	24	24	-	24
Case 3	16	17	24	24	-	22
Case 4	14	14	22	24	-	17
Hours of Window Opening[c]						
Case 1	0	0	0	0	-	0
Case 2	0	0	0	0	-	0
Case 3	0	2	0	0	-	0
Case 4	5	4	0	0	-	0

[a] From table 14.
[b] See table 1 for weather data.
[c] If windows are not opened, air conditioning loads result.

6. LIMITATIONS OF NBSLD

NBSLD was originally developed to calculate, with considerable accuracy, the hour-by-hour heating and cooling loads imposed by a building on its HVAC equipment. The purpose of the NBSLD-XO subroutine, however, is to identify the individual components of the HVAC loads for use in envelope design analysis. While the overall load may be computed with acceptable accuracy, several of the component loads are calculated using algorithms which are not entirely acceptable by themselves. Thus, the value of the results discussed in this report is limited by the degree of accuracy of many individual algorithms in the main NBSLD program. Research to improve certain of these algorithms is needed if the thermal performance of individual building components is to be better understood in the design of new buildings and retrofit of existing buildings.

Component algorithms which may have significant shortcomings are identified in the following:

1. Attic. NBSLD does not model an attic with a sloped roof and gable endwalls. Only a flat roof (of area equal to the attic itself) can be modeled, with gable walls of equal height on the four sides. No solar gain on gable walls is calculated. In addition, no radiation exchange between the roof, attic floor, and gable walls is calculated.

2. Slab Floors. While the heat storage capacity of a slab floor is calculated using thermal response factors, only heat flow perpendicular to the floor surface is calculated. Thus NBSLD does not calculate the horizontal heat flow component through the edge of a slab on grade, which is known to be significant. In addition, the modeling of the earth beneath the slab as a semi-infinite heat sink is not addressed in the existing NBSLD program. Similar inadequacies are encountered on the modeling of basement walls and floors below grade.

3. Windows. The effects of the absorption of solar radiation (and other radiation exchange) on the window glass temperature is not calculated. Because this may be significant on sunny days, this could have a significant impact on heat losses and gains through single- and multiple-glazed windows, especially for heat absorbing or reflecting glass.

4. Partition Walls and Floors. The 1600 sq. ft. house used as an example in sections 2 and 3 was modeled as an open space rather than as several partitioned spaces. The presence of partition walls may have several effects on heating and cooling loads due to (a) heat storage effects, (b) radiation exchange, (c) reception of solar gain, and (d) indoor temperature zoning.

5. Multi-Zone Problems. NBSLD is essentially a one-room model and does not determine the effects of room-to-room heat exchange. This may be a significant problem if there is an appreciable temperature gradient between adjacent rooms (e.g., one space requiring heating and another space requiring cooling).

In addition to the problems associated with individual components, other limitations of NBSLD should be kept in mind. For example, NBSLD computes HVAC loads only; actual energy use must be estimated using equipment simulation techniques. This may require additional computational software in many cases, especially where part-load equipment performance must be simulated. Algorithms to improve simulation of ventilation with outside air must be improved. This is especially important for buildings which are well insulated. Daylighting effects of windows must be considered if the energy performance improvements for a building are to include the reduction of artificial lighting. And finally, a better index of thermal comfort than dry-bulb air temperature and relative humidity must be established for use in the NBSLD program. Such an index should recognize mean radiant temperatures inside rooms as well.

7. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The determination of cost-effective thermal designs for a building envelope requires more than an estimate of the total heating and cooling requirements of the building. It also requires that the thermal performance of each element of the building envelope be accurately calculated under actual load conditions and that the interrelationships among the envelope elements be understood. The thermal design of the building envelope begins with the design of its individual elements. Only when the individual elements of the envelope can be optimally designed can the overall envelope design be optimized with respect to cost. Most current data on individual envelope element performance are based on steady-state models, often using degree day data as the basis of the temperature differential driving forces and the length of the heating and cooling seasons. These steady-state models do not accurately estimate how the various elements actually perform and interrelate during heating and cooling days. In addition, they provide poor insight into the differential performance of those elements sensitive to building orientation, such as walls and windows.

NBSLD, the NBS Load Determination Program, was designed to provide a dynamic thermal analysis of building envelopes, using actual hour-by-hour weather data. However, in its present form it provides only the net hourly space heating or cooling loads, without making available the intermediate calculations related to the components of those loads. The purpose of this report is to develop a subroutine for use with NBSLD which provides, in expanded output form, each component of the heating and cooling load on an hourly, daily, monthly or annual basis as specified by the user. This subroutine is called NBSLD-XO. In addition to the load components, the climate profile, inside and outside surface temperatures and surface loads are printed out by hour for a design-day analysis, and the number of heating and cooling load hours per month and per year is made available in the annual analysis.

In order to demonstrate the usefulness of NBSLD-XO in the design process, a prototypical 1600 sq. ft., one-story house was modeled, and the results reported for four different variations in energy conservation design. Analysis of these data can provide quantitative information as to the contributions of each element to the total heating or cooling load, the extent to which the various elements are thermally linked by radiation exchange, the effects of solar gains and internal heat release on heating and cooling loads, the differential impact of element orientation on the performance of that element, the impact of the overall thermal performance of the envelope on the hours of heating and cooling loads annually, and the effects of thermal improvements to the building envelope on all of these factors.

NBSLD-XO can serve as a useful research tool in evaluating and understanding the thermal performance of individual envelope elements under actual heating and cooling load conditions for a wide range of building designs. However, its usefulness is limited to the accuracy of the algorithms which model the performance of the various envelope elements. In some cases these algorithms are in need of considerable improvement. Algorithm improvements are likely to require major investments in time, manpower, and computer time. However, the data that can potentially be provided by such an upgrading will be invaluable to the determination of optimal envelope designs for new buildings. In the years to come, billions of dollars will be spent to conserve energy in buildings through improved envelope design. Accurate data will both assure that this increased investment will be properly allocated and encourage additional investment through improved confidence in the calculation of potential energy savings.

REFERENCES

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APPENDIX A. IMPLEMENTATION OF NBSLD-XO SUBROUTINE

Implementation of NBSLD-XO requires a new subroutine, PRTOUT, two new arrays in the main NBSLD program, and two data cards for titling at the end of the standard NBSLD data deck. PRTOUT is a Fortran callable subroutine (written in Fortran IV) which enables NBSLD to print out in tabular form the various load components that contribute to the overall space heating and cooling loads of a building. An explanation of the PRTOUT subroutine and the new arrays is provided in this appendix. A listing of PRTOUT is provided in appendix B.

PRTOUT is called once every 24-hours in the main program of NBSLD. The parameters passed via the call are:

- RUNTYP - Variable indicating a weather tape (=1) or design day (=2) calculation,
- NEXP - Number of different type surfaces bounding the space,
- ND - Day loop index (runs from 1 to 366),
- NEND - Last day of calculation (an integer between 1 and 366),
- LDAY - Day of month for which calculation was made,
- MONTH - Month of year for which calculation was made,
- YEAR - Year for which calculation was made,
- UCELNG - U-value of ceiling,
- ITYPE - Array identifying each envelope element as a floor, partition, wall, door, etc.,
- AZW - Array indicating in degrees the direction normal to the surface points (i.e., 0-south, 90-west, 180-north, 270-east),
- UE - Array containing input U-values of surfaces,
- A - Array containing areas of surfaces,
- QLITE - Array containing hourly heat gain of lights,
- QEQUP - Array containing hourly heat gain of equipment,
- QPEOPL - Array containing hourly latent heat gain of occupants,
- AIRLK - Array containing hourly sensible air infiltration load,
- AIRLAT - Array containing hourly latent air infiltration load,
- CALDB - Array containing hourly calculated space temperature,
- DB - Array containing hourly ambient dry-bulb temperature,
- H24 - Array containing hourly inside surface coefficients,
- TEMPSI - Array containing hourly inside surface temperatures,
- TEMPSO - Array containing hourly outside surface temperatures,
- QIGAIN - Array containing hourly inside surface fluxes, and
- QGLAS - Array containing hourly solar heat gains through windows.

The arrays UE, QIGAIN, H24, TEMPSO and TEMPSI are newly defined arrays and are needed only for PRTOUT and not for any other routines in NBSLD. QIGAIN, TEMPSO and TEMPSI are storage arrays which hold hourly values of variables which are calculated in NBSLD and later printed out in PRTOUT. UE was defined because it became apparent that it was more meaningful to print the input U-values for surfaces rather than the values modified by wind speed each hour. The array H24 was needed because in PRTOUT the surface loads are calculated by the expression

$$L_i = (T_A - T_i)\, h_i\, A_i,$$

where

L_i = surface load of i^{th} surface,
T_A = air temperature of space,
T_i = inside surface temperature of i^{th} surface,
h_i = inside surface coefficient of i^{th} surface, and
A_i = area of i^{th} surface.

The array H24 stores the hourly h_i values for the various surfaces.

Since PRTOUT is extensively populated with comment cards, a detailed explanation of the subroutine is not needed here. Most simply stated, the above defined arrays and variables are passed into PRTOUT where they are either sorted directly into tables or two or more of the values are used in a simple calculation and the result stored in a table. The titles for columns of the tables are then chosen and the resulting tables with titles printed out. In other words, PRTOUT is basically a sorting routine in which a few simple calculations are performed. In addition, it selects titles and prints out predetermined energy components and energy related parameters in tabular form.

In order to use PRTOUT with NBSLD, all that is necessary is to dimension and properly load arrays UE, QIGAIN, H24, TEMPSO, and TEMPSI and then to call PRTOUT. Appendix D shows the proper places to do this in the main NBSLD program. The only change in the standard NBSLD data deck is the two additional titling cards that appear after the NAME ROOM data card.

It is important for the user to note two limitations of the PRTOUT subroutine:

1. The column heading indicating the direction normal to the surface can only be south ($-45° \leq AZW < 45°$), west ($45° \leq AZW < 135°$), north ($135° \leq AZW < 225°$), and east ($225° \leq AZW < 315°$). Note that the calculation is done correctly for the azimuth angle and the numerical printout of the angle is correct.

2. Even though PRTOUT usually lists the correct values for the hourly total horizontal solar radiation there are two cases when it does not. The first case is when the roof is a partition (ITYPE=6). The second case is when the absorptivity of the roof is set equal to zero. In both cases PRTOUT lists the hourly total horizontal radiation as zero. This limitation is due to the way NBSLD stores hourly solar radiation. The user can correct this limitation by introducing a new array with appropriate logic in the main NBSLD program.

PRTOUT has two different types of output: one for design day calculations and another for a load calculation for a predetermined period of time, usually an entire calendar year. The design day calculation output consists of a steady-state hourly heating load calculation, a table of the 24-hour values for wind speed, cloud cover modifier, horizontal solar radiation, ambient dry-bulb temperature, indoor relative humidity, sensible and latent heating and cooling loads, daily total heating and cooling loads, and maximum hourly heating and cooling loads. This printout closely resembles the standard NBSLD design-day printout. In addition, PRTOUT outputs a table of hourly inside surface fluxes, internal heat gains, and infiltration loads, a table of hourly inside and outside surface temperatures and a table of the hourly space air loads associated with the various surfaces.

A design day output from PRTOUT is shown in tables 1-4. Note that the columns in tables 2-4 always list the ceiling/roof first, followed by the south, west, north, and east surfaces and floor. In addition, table 2 lists internal heat gains, air infiltration loads, and finally the horizontal totals. Also note that the windows are allotted two columns in table 2, one for conduction/convection heat transfer and one for solar radiation transfer. The surface loads reported in table 4 are the actual heat transfer to or from the air attributable to the respective surfaces.

The output from PRTOUT for a load calculation made with a weather tape consists of a table of monthly totals for the surface fluxes and internal and infiltration loads, a table of monthly heating and cooling hours and the maximum hourly heating and cooling loads. The output from PRTOUT when running with a weather tape is seen in tables 9 and 10. The information displayed in table 9 is somewhat different than the design-day table, but the column headings are the same. Table 9 is divided into two parts; one for heating requirements and one for cooling requirements. The table shows the monthly and annual fluxes for the various envelope surfaces as well as the coincident solar gains, internal gains, and infiltration gains/losses.

APPENDIX B. NBSLD-XO (PRTOUT) SUBROUTINE LISTING

```
      SUBROUTINE PRTOUT(ITYPE,AZW,U,A,QLITE,QEQUP,QOCPS,QPEOPL,AIRLK,
     *AIRLAT,QIGAIN,QGLAS,UC,NS,TI,TO,H24,DB,JTITLE,DBI)
      DIMENSION ITYPE(1),AZW(1),U(1),A(1),QLITE(1),QEQUP(1),QOCPS(1),
     *QPEOPL(1),AIRLK(1),AIRLAT(1),QIGAIN(30,1),QGLAS(30,1),OPMN1(30,40)
     *,IH(3,40),IT(3,40),TI(30,1),TO(30,1),ITT(3,30),SLI(30,25),H24(30,1)
     *,IDATE(2),JTITLE(19),TH(40),TC(40),TT(40),THH(40),TCC(40),WLD(24),
     *SH(40),SC(40),DB(1),TCA(40),TCB(40),DBI(1)
      INTEGER TITLES(3,16)/'EAST  ','      ','CEILNG','SOUTH ','INSUL ',
     *'WALL  ','WEST  ','CD/CV ','WINDOW','NORTH ','      ','DOOR  ',
     *'      ','SLAB  ','FLOOR ','      ','PARTY ','WALL  ','      ',
     *'      ','FLOOR ','      ','CRL SP','FLOOR ','      ','      ',
     *'LIGHTS','      ','      ','EQUIP ','      ','      ','OCPS  ',
     *'      ','      ','OCPL  ','      ','      ','INFILS','      ',
     *'      ','INFILL','TOTAL ','      ','SENSBL','TOTAL ','      ',
     *'LATENT'/,
     *HYPH(130)/130*'------'/
      DEFINE IZ(I,J)=TITLES(I,J)
C     THE FOLLOWING DO-LOOPS SET THE SUMMING ARRAYS INITIALLY TO ZERO
      CALL DATEIM(IDATE)
      DO 106 I=1,3
      DO 106 J=1,30
      IT(I,J)='      '
  106 ITT(I,J)='      '
      K=0
      IXZ=IXZ+1
      DO 107 J=1,40
      TCA(J)=0.0
      TCB(J)=0.0
      TT(J)=0.0
      THH(J)=0.0
  107 TCC(J)=0.0
      DO 562 J=1,30
      SH(J)=0.
      SC(J)=0.
      TH(J)=0.0
  562 TC(J)=0.0
      DO 561 J=1,40
      DO 561 I=1,30
  561 OPMN1(I,J)=0.0
      DO 10   I=1,NS
   10 IF(ITYPE(I).EQ.3)K=K+1
      N=NS+K  @ N=# OF OPAQUE SURFACES + 2 * # OF TRANSPARENT SURFACES
      L=0
C     DO-LOOP 20 LOADS THE ELEMENTS OF OUTPUT ARRAY TABLE WITH HOURLY SURFACE
C     FLUX,SOLAR FLUX,INTERNAL HEAT GAIN,AND AIR INFILTRATION LOAD
      DO 20   I=1,NS
      L=L+1
      OPMN1(1,L)=ITYPE(I)
      OPMN1(2,L)=AZW(I)
      OPMN1(3,L)=U(I)
      OPMN1(4,L)=A(I)
       IF(ITYPE(I).NE.3)GO TO 14
       OPMN1(1,L+1)=ITYPE(I)
       OPMN1(2,L+1)=AZW(I)
       OPMN1(3,L+1)=U(I)
       OPMN1(4,L+1)=A(I)
   14  DO 20   J=1,24
```

```
      WLD(J)=0.
      OPMN1(J,N+7)=0.
      SLI(NS+1,J)=0.
      J4=J+4
      OPMN1(J4,L)=QIGAIN(I,J)*A(I)
      IF(ITYPE(I).NE.3)GO TO 15
      OPMN1(J4,L+1)=-QGLAS(I,J)*A(I)
      IF(J.EQ.24)L=L+1
15    IF(I.GT.1)GO TO 20
      OPMN1(J4,N+1)=-QLITE(J)
      OPMN1(J4,N+2)=-QEQUP(J)
      OPMN1(J4,N+3)=-QOCPS(J)
      OPMN1(J4,N+4)=QPEOPL(J)
      OPMN1(J4,N+5)=AIRLK(J)
      OPMN1(J4,N+6)=AIRLAT(J)
      OPMN1(J4,N+7)=0.
      OPMN1(J4,N+8)=QPEOPL(J)+AIRLAT(J)
20    CONTINUE
      N8=N+8
      N5=N+5
      DO 30   I=1,N8
      DO 30   J=5,28
      IF(OPMN1(1,I).EQ.3..AND.OPMN1(J,I).GT.0.)WLD(J-4)=WLD(J-4)+
     *2.*OPMN1(J,I)/4.
      IF(I.EQ.(N+4).OR.I.GT.N5)GO TO 30
      OPMN1(J,N+7)=OPMN1(J,N+7)+OPMN1(J,I)
30    CONTINUE
1292  FORMAT(2X,13F10.4)
      IF(UC.GT.0.0)OPMN1(3,1)=UC  @ CHECK IF HOUSE HAS ATTIC
      N1=8
C     THE FOLLOWING DO-LOOPS CHOOSE THE CORRECT TITLES FOR COLUMN HEADINGS
      DO 40  I=1,N8
      IF(I.GT.N)GO TO 39
      M(1,I)=OPMN1(2,I)/90.+2.
      M(2,I)=OPMN1(1,I)
      M(3,I)=OPMN1(1,I)
      IF(M(3,I).LT.2.OR.M(3,I).EQ.5)M(1,I)=5
      GO TO 40
39    N1=N1+1
      M(1,I)=N1
      M(2,I)=N1
      M(3,I)=N1
40    CONTINUE
      DO 59 I=1,3
      IWC=0
      MWC=0
      JY=0
      DO 59 J=1,N8
      JY=JY+1
      IF(ITYPE(JY).EQ.2)IWC=IWC+1
      IF(ITYPE(JY).EQ.3)MWC=MWC+1
      IF(ITYPE(JY).EQ.3.AND.MOD(MWC,2).NE.0)JY=JY-1
      TITLES(2,2)='INSUL '
      TITLES(2,3)='CD/CV '
      IF(MOD(IWC,2).EQ.0)TITLES(2,2)='STUD  '
      IF(MOD(MWC,2).EQ.0)TITLES(2,3)='SOLAR '
59    IT(I,J)=IZ(I,M(I,J))
5     FORMAT(3I10,A6)
```

```
      NQ=N8
      DO 92 IC=1,3
      IV1=13
      IF(IC.EQ.2)IV1=18
      L=1-IV1
      K13=0
      LP=IC-2
      DO 50   IV=IV1,39,IV1
      L=L+IV1
      KI=MINO(IV,NQ)
      MC=10
      IF(IC.EQ.2)MC=7
      J10=(KI-K13)*MC
      K13=IV
      IF(LP)41,42,43
41    WRITE(47,4   )
      WRITE(47,722)JTITLE,IDATE
722   FORMAT(1X,21A6)
      WRITE(47,174)
174   FORMAT(20X' INSIDE SURFACE FLUXES,INTERNAL & AIR INFILTRATION LOADS
     *')
C     DO-LOOP 60 PRINTS ITYPE,AZMITH,U-VALUE,AND AREA FOR THE APPROPRIATE COLUMNS
      DO 60   J=1,4
60    WRITE(47,1292)(OPMN1(J,K),K=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
71    FORMAT(2X,130A1)
72    FORMAT(2X,130I1)
C     DO-LOOP 70 PRINTS SURFACE DESCRIPTION
      DO 70  J=1,3
70    WRITE(47,400)(IT(J,K),K=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
400   FORMAT(6X,A6,12A10)
      DO 80    J=5,29
      JH=J-4
      IF(J.LT.29)GO TO 79
C     THE FOLLOWING WRITES PRINT THE VARIOUS SUBTOTALS FOR FLUX TABLE
      WRITE(47,72)(HYPH(K),K=1,J10)
      WRITE(47,1  )(OPMN1(29,K),K=L,KI)
      WRITE(47,792)(TH(K),K=L,KI)
      WRITE(47,7792)(SH(K),K=L,KI)
      WRITE(47,7793)(SC(K),K=L,KI)
      WRITE(47,793)(TC(K),K=L,KI)
      WRITE(47,7790)(TCA(K),K=L,KI)
      WRITE(47,7791)(TCB(K),K=L,KI)
      IF(IXZ.LT.2)GO TO 541
      DO 297 K=L,KI
      TT(K)=TT(K)+OPMN1(29,K)
      THH(K)=THH(K)+TH(K)
297   TCC(K)=TCC(K)+TC(K)
      IF(IXZ.LT.5)GO TO 541
      WRITE(47,998)
      WRITE(47,1)(TT(K),K=L,KI)
      WRITE(47,792)(THH(K),K=L,KI)
      WRITE(47,793)(TCC(K),K=L,KI)
541   CONTINUE
998   FORMAT(1H0)
 792  FORMAT(2H H,13F10.1)
 793  FORMAT(2H C,13F10.1)
```

```
7790  FORMAT(4H TC+,F8.1,12F10.1)
7791  FORMAT(4H TC-,F8.1,12F10.1)
7792  FORMAT(4H NL+,F8.1,12F10.1)
7793  FORMAT(4H NL-,F8.1,12F10.1)
      GO TO 80
79    LD=OPMN1(J,NQ-1)
      INFL6=OPMN1(J,N+5)*(-12.0)+WLD(J-4)
      IF(LD.LT.0.0.AND.INFL6.LT.LD)GO TO 556
      GO TO 555
556   LD=0.0
      OPMN1(J,N+5)=OPMN1(J,N+5)-OPMN1(J,NQ-1)+WLD(JH)
      OPMN1(J,N+6)=-OPMN1(J,N+4)
      OPMN1(J,N+8)=0.0
       OPMN1(J,NQ-1)=0.0
      DO 557 MM=1,N
      IF(OPMN1(1,MM).NE.3.)GO TO 557
      IF(OPMN1(J,MM).GT.0.)OPMN1(J,MM)=OPMN1(J,MM)/4.
557   CONTINUE
555   DO 31   I=L,KI
      OPMN1(29,I)=OPMN1(29,I)+OPMN1(J,I)
31    CONTINUE
      WRITE(47,2    )JH,(OPMN1(J,K),K=L,KI)
      IF(ABS(LD).LT.10.0)GO TO 379
      DO 380 K=L,KI
      IF(LD.LT.0.0)GO TO 671
      TH(K)=TH(K)+OPMN1(J,K)
      GO TO 380
671   IF(DB(JH).GE.DBI(JH))TCA(K)=TCA(K)+OPMN1(J,K)   @ SUMMING COOLING HOURS WHEN AMBIENT
      IF(DB(JH).LT.DBI(JH))TCB(K)=TCB(K)+OPMN1(J,K)   @ TEMPERATURE IS ABOVE OR BELOW SPACE
      TC(K)=TC(K)+OPMN1(J,K)                          @ TEMPERATURE
380   CONTINUE
      GO TO 80
379   DO 381 K=L,KI
      IF(OPMN1(J,K).LE.0.)GO TO 373
      SH(K)=SH(K)+OPMN1(J,K)
      GO TO 381
373   SC(K)=SC(K)+OPMN1(J,K)
381   CONTINUE
80    CONTINUE
      GO TO 50
1     FORMAT(2H T,13F10.1)
2     FORMAT( I3,F9.1,12F10.1)
3     FORMAT(/)
4     FORMAT( 1H1)
42    DO 100 I=1,NS
      SLI(I,25)=0.
      DO 100 J=1,24
      TI(I,J)=TI(I,J)+75.  @ SETTING SURFACE TEMPS BACK TO CORRECT VALUE
      SLI(I,J)=(DBI(J)-TI(I,J))*H24(I,J)*A(I)  @ CALCULATING SURFACE LOADS
      SLI(I,25)=SLI(I,25)+SLI(I,J)
      SLI(NS+1,J)=SLI(NS+1,J)+SLI(I,J)
100   TO(I,J)=TO(I,J)+75.
      WRITE(6,201)(TO(14,J),J=1,18)
      DO 110 I=1,3
      JJ=0
      DO 110 J=1,N
      IF(J.LT.2)GO TO 109
      IF(IT(3,J).EQ.TITLES(3,3).AND.IT(3,J-1).EQ.TITLES(3,3))GO TO 110
```

```
109   JJ=JJ+1
      ITT(I,JJ)=IT(I,J)
110   CONTINUE
      WRITE(47,171)
171   FORMAT(1H1,40X'INSIDE SURFACE TEMPERATURES')
C     THE FOLLOWING DO-LOOPS PRINT THE INSIDE AND OUTSIDE SURFACE TEMPS
      DO 115  J=1,3
115    WRITE(47,500)(ITT(J,K),K=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
      DO 121 J=1,24
121   WRITE(47,201)J,(TI(I,J),I=L,KI)
      WRITE(47,172)
172   FORMAT(40X'OUTSIDE SURFACE TEMPERATURES')
      DO 116  J=1,3
116    WRITE(47,500)(ITT(J,K),K=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
      DO 122 J=1,24
122   WRITE(47,201)J,(TO(I,J),I=L,KI)
      GO TO 50
43    WRITE(47,4)
      WRITE(47,722)JTITLE,IDATE
      WRITE(47,173)
173   FORMAT(40X'SURFACE LOADS')
      ITT(1,NS+1)='HOURLY'
      ITT(3,NS+1)='TOTALS'
C     THE FOLLOWING DO-LOOPS PRINT THE SURFACE LOADS
      DO 135  J=1,3
      SLI(NQ,25)=0.
135    WRITE(47,400)(ITT(J,K),K=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
      DO 136 J=1,24
      SLI(NQ,25)=SLI(NQ,25)+SLI(NQ,J)
136   WRITE(47,2)J,(SLI(I,J),I=L,KI)
      WRITE(47,71)(HYPH(J),J=1,J10)
      WRITE(47,1)(SLI(I,25),I=L,KI)
50    IF(IV.GE.NQ)GO TO 90
90    NQ=NS
      IF(IC.EQ.2)NQ=NS+1
92    CONTINUE
201   FORMAT(I3,18F7.2)
500   FORMAT(3X,18A7)
      RETURN
      END
```

APPENDIX C. LISTING OF NBSLD PROGRAM WITH MODIFICATIONS FOR NBSLD-XO (PRTOUT) SUBROUTINE INTERFACE

```
C     .......................NBSLD.......................................
C
C
C     NBSLD IS A RESEARCH PROGRAM OF NBS FOR THE PURPOSE OF
C     STUDYING HEATING AND COOLING LOAD AND ROOM TEMPERATURE
C     OF BUILDING UNDER ACTUAL WEATHER CONDITION
C     A(I)       AREA OF SURFACE I, FT2
C     ABSP(I)    SOLAR HEAT ABSORPTION COEFFICIENT FOR SURFACE I.
C                THIS DATA REQUIRED FOR OPAQUE SURFACES ONLY.
C     AENDW      AREA OF THE ATTIC END WALL, FT2
C     AG         GROUND HEAT TRANSFER AREA, FT2  (MAY=0.)
C     AIRCHG     NO. OF ATTIC AIR CHANGES PER HR, DAYTIME
C     AIRNT      ATTIC NIGHT TIME AIR CHANGE MULTIPLIER
C     ARCHGS     NO. OF AIR CHANGES PER HR IN SUMMER
C     ARCHGW     NO. OF AIR CHANGES PER HR IN WINTER
C     ATCACG     NO. OF ATTIC AIR CHANGES PER HR (DAY OR NIGHT)
C     AVEHTG     AVERAGE HOURLY HEAT GAIN ENTIRE BUILDING, BTU/HR
C     AZW(I)     WALL AZIMUTH ANGLE FOR SURFACE I, DEGREES
C                SOUTH = 0.
C                WEST = 90.
C                NORTH = 180.
C                EAST = -90.
C     BLDMAX     BUILDING MAXIMUM SENSIBLE HEAT GAIN, BTU/HR
C     CFML       SUMMER INFILTRATION RATE, FT3/MIN.
C     CFMV       VENTILATION RATE, FT3/MIN.
C     CFMWT      WINTER INFILTRATION, FT3/MIN.
C     CLDAY      DAILY TOTAL ENERGY CONSUMPTION FOR A GRUOP
C                (NORM OF THEM) OF ROOMS OF THE SAME CONFIG-
C                URATION, BTU
C     CLDSUM     RUNNING TOTAL ENERGY CONSUMPTION FOR COOLING OF
C                ALL THE ROOMS IN A BUILDING OVER A SET TIME
C                PERIOD, BTU
C     CN         CLEARNESS NUMBER
C     CR(L)      RESPONSE FACTOR COMMON RATIO FOR CONSTRUCTION L
C     DAY        DAY OF YEAR
C     DAYSKP     NO. OF DAYS TO BE SKIPPED FROM THE WEATHER TAPE
C                (FROM ITS LAST STARTING POSITION)
C     DB(J)      OUTDOOR DRYBULB TEMPERATURE AT HOUR J, F
C     DBA        DAILY AVERAGE OUTSIDE DRYBULB TEMPERATURE, F
C     DBIN       DESIGN INDOOR DRYBULB TEMPERATURE, F
C     DBM        DRYBULB MEAN, F
C     DBMAX      DESIGN OUTDOOR MAXIMUM DRYBULB TEMPERATURE, F
C     DENWT      DESIGN WINTER OUTDOOR DRYBULB TEMPERATURE, F
C     DENBS(J)   FRACTION OF RANGE TO USE FOR DESIGN PROFILE
C                AT HOUR J
C     DP         OUTDOOR DEW POINT, F
C     DPID       INDOOR DEW POINT, F
C     DPIN       DESIGN INDOOR DEW POINT, F
C     DR(L)      RESPONSE FACTOR COMMON RATIO FOR CONSTRUCTION L
C                (SAME AS CR(L))
C     DST        DAYLIGHT SAVING TIME INDICATOR
C     ELAPS      DAYS ELAPSED SINCE JANUARY 1
C     G(IV,VI)   RADIATION CONFIGURATION FACTORS FOR
C                RADIATION FROM SURFACE VI TO SURFACE IV
C     H(I)       EXTERIOR SURFACE HEAT TRANSFER COEFFICIENT
C                FOR SURFACE I, BTU/HR,FT2,F
C     HI(I)      INTERIOR SURFACE CONVECTION HEAT TRANSFER
```

```
C                COEFFICIENT, BTU/HR,FT2,F
C      HIND      INDOOR ENTHALPY FOR DESIGN CONDITIONS, BTU/LB
C      HLDAY     DAILY TOTAL ENERGY CONSUMPTION FOR HEATING FOR A
C                GROUP (NORM OF THEM) OF ROOMS OF THE SAME
C                CONFIGURATION, BTU
C      HLDSUM    RUNNING TOTAL ENERGY CONSUMPTION FOR HEATING OF
C                ALL THE ROOMS IN A BUILDING, BTU
C      HOUT      OUTDOOR ENTHALPY FOR DESIGN CONDITIONS, BTU/LB
C      HR        INNER SURFACE RADIATIVE HEAT TRANSFER COEFFICIENT
C                (=4.*(535.**3)*SIGMA)
C      HT        CEILING HEIGHT, FT
C      IHT(I)    HEAT TRANSFER INDEX
C                =-1 FOR GLASS SURFACE
C                = 0 OPAQUE
C                = 1 OTHERWISE
C      IMAX      HOUR OF DAY FOR MAXIMUM COOLING LOAD
C      INCLUD    =0  INCLUDE ROOM IN SUMMARY
C                =1  OTHERWISE
C      IRF(I)    RESPONSE FACTOR INDEX FOR SURFACE I
C      IROT      DEGREES OF ROTATION
C      ISKIP     = 1 SKIP RESPONSE FACTOR CALCULATION
C                AND BUILDING DATA INPUT
C                = 0 OTHERWISE
C      ITK AND ITHST      INDICES FOR ROOM TEMPERATURE COMPUTATION
C      ITK=0, ITHST=1      ROOM TEMP PRESCRIBED, EITHER CONSTANT
C                OR WITH NIGHT TIME SET-BACK
C      ITK=1, ITHST=0      ROOM TEMP NOT BEING CONTROLLED. NO A/C.
C      ITK=1, ITHST=1      ROOM TEMP FLOAT WITHIN PRESCRIBED UPPER
C                AND LOWER LIMITS. NO A/C WHEN WITHIN
C                THE LIMITS.
C      ITK=0, ITEST=0      EQUIPMENT CAPACITY PRESCRIBED. ROOM TEMP
C                FLOAT WITHIN PRESCRIBED UPPER AND LOWER
C                LIMITS, AND WHEN EQUIPMENT CAPACITY IS
C                EXCEEDED.
C      ITYPE(I)  TYPE OF SURFACE I
C                = 1  ROOF
C                = 2  EXPOSED WALL
C                = 3  WINDOW
C                = 4  DOOR
C                = 5  GROUND HEAT TRANSFER SURFACE
C                = 6  INTERNAL MASS, FURNISHINGS, PARTY WALLS,
C                PARTITION WALLS, AND FLOOR/CEILINGS
C                = 7  OPEN PASSAGES
C                = 8  EXPOSED FLOOR (EXPOSED UNDERSIDE)
C      LAT       LATITUDE, DEGREES
C      LONG      LONGITUDE, DEGREES
C      LPYR      LEAP YEAR INDICATOR
C      MONTH     MONTH OF YEAR
C      MR(L)     NUMBER OF RESPONSE FACTOR TERMS GENERA-
C                TED BY RESPTK FOR CONSTRUCTION L
C                SAME AS NR(L)
C      NAMEBD    NAME OF ROOM
C      NE        NUMBER OF SURFACES IN EAST WALL
C      NEXP      TOTAL NUMBER OF SURFACES IN ROOM
C                = 2+NS+NW+NN+NE
C      NMAX      HR OF THE DAY WHEN QLMAX OCCURS
C      NN        NUMBER OF SURFACES IN NORTH WALL
C      NOFLR     NUMBER OF FLOORS
```

```
C       NORM       NO. OF ROOMS HAVING THE SAME DATA
C       NR(L)      NUMBER OF RESPONSE FACTOR TERMS CALCU-
C                  LATED BY RESPTK FOR CONSTRUCTION L
C       NS         NUMBER OF SURFACES IN SOUTH WALL
C       NW         NUMBER OF SURFACES IN WEST WALL
C       PB         BAROMETRIC PRESSURE
C                  = 29.921 INCHES OF MERCURY
C       PI         = 3.1415...
C       PV         VAPOR PRESSURE, INCHES OF MERCURY
C       QCU        MAXIMUM NUMBER OF OCCUPANTS
C       QDES(I)    HEAT GAIN OF SURFACE I AT HOUR IMAX, BTU/HR
C       QDESIN(I,J)    HEAT GAIN OF SURFACE I AT HOUR J,
C                  BTU/HR
C       QEQPO      EQUIPMENT MAXIMUM HEAT LOAD, BTU/HR
C       QEQPX      MAXIMUM EQUIPMENT LOAD, WATTS/FT2
C       QEQUP(J)   EQUIPMENT LOAD AT HOUR J, BTU/HR
C       QEQUX(J)   EQUIPMENT USE SCHEDULE
C       QGLAS(I,J)    HEAT GAIN OF GLASS FOR I AT HOUR J,
C                     BTU/HR
C       QGX(I)     HEAT TRANSMISSION OF GLASS FOR SURFACE
C                  I AT HOUR IMAX, BTU/HR
C       QI(I)      INSIDE SURFACE HEAT FLUX OF SURFACE I,
C                  BTU/HR,FT2
C       QISAVE(J,I)    INSIDE SURFACE HEAT FLUX OF SURFACE
C                  I AT HOUR J, BTU/HR,FT2
C       QLDS       SUM OF LATENT AND SENSIBLE LOAD AT HOUR
C                  J, BTU/HR
C       QLITE(J)   LIGHT LOAD AT HOUR J, BTU/HR
C       QLITO      MAXIMUM LIGHT LOAD, BTU/HR
C       QLITX(J)   LIGHT USE SCHEDULE
C       QLITY      MAXIMUM LIGHTING LOAD, WATTS/FT2
C       QLMAX      ABSOLUTE VALUE OF THE MAX COOLING (OR
C                  HEATING) LOAD OF THE DAY, BTU/HR
C       QLL(J)     LATENT HEAT LOAD AT HOUR J, BTU/HR
C       QLS(J)     SENSIBLE HEAT LOAD AT HOUR J, BTU/HR
C       QO(I)      OUTSIDE SURFACE HEAT FLUX OF SURFACE I,
C                  BTU/HR, FT2
C       QOCPS(J)   OCCUPANT LOAD AT HOUR J, BTU/HR
C       QOCUP(J)   OCCUPANT SCHEDULE
C       QPEOPL(J)  PEOPLE LATENT LOAD AT HOUR J, BTU/HR
C       QPLX       MAX OCCUPANT LATENT LOAD, BTU/HR,PERSON
C       QPSX       MAX OCCUPANT SENSIBLE LOAD,BTU/HR,PERSON
C       QSAVE(M,J)    HEAT GAINS AND LOADS AT HOUR J, BTU/HR
C                  M = 1  TIME, HR
C                  M = 2  SENSIBLE HEAT GAIN, BTU/HR
C                  M = 3  LATENT HEAT GAIN, BTU/HR
C                  M = 4  SENSIBLE LOAD, BTU/HR
C                  M = 5  TOTAL LOAD, BTU/HR
C       QSKY(I,J)  HEAT RADIATED TO SKY BY SURFACE I T
C                  HOUR J, BTU/HR, FT2
C       QSUMT      SUM OF TOTAL HEAT GAINS FOR 24 HOURS,
C                  BTU/HR
C       QSUN(I,J)  INCIDENT SOLAR RADIATION FOR SURFACE I
C                  AT HOUR J, BTU/HR,FT2
C       QTL(J)     LATENT HEAT GAIN FROM INFILTRATION AT
C                  HOUR J, BTU/HR
C       QWINT      HEAT LOSS IN WINTER, BTU/HR
C       RANGE      DAILY RANGE OF OUTDOOR DRYBULB, F
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C      RHIN        DESIGN INDOOR RELATIVE HUMIDITY
C      RHOUT       DESIGN OUTDOOR RELATIVE HUMIDITY
C      ROOMNO      ROOM NUMBER
C      S           INFORMATION ARRAY REQUIRED BY SUBROU-
C                  TINE SUN AND GLASS
C      SHADE(I)    SHADING COEFFICIENT FOR SURFACE I
C      SIGMA       = 0.1714E-8
C      SITELD(J)   OVERALL COOLING LOAD AT HOUR J, BTU/HR
C      SITEQL(J)   OVERALL LATENT HEAT GAIN AT HOUR J,
C                  BTU/HR
C      SITEQS(J)   OVERALL SENSIBLE HEAT GAIN AT HOUR J,
C                  BTU/HR
C      SITETH(J)   OVERALL TOTAL HEAT GAIN AT HOUR J,
C                  BTU/HR
C      SITMAX      OVERALL MAXIMUM HEAT GAIN, BTU/HR
C      SOTHTX      OVERALL HEAT GAIN AT HOUR IMAX, BTU/HR
C      SQLLD       TOTAL COOLING LOAD, BTU/HR
C      SQWINT      OVERALL TOTAL HEAT LOSS, BTU/HR
C      TA          ROOM AIR TEMPERATURE, F
C      TASAVE(J)   ROOM AIR TEMPERATURE AT HOUR J, F
C      TCLLD       DAILY RUNNING TOTAL ENERGY CONSUMPTION
C                  FOR COOLING FOR A GROUP (NORM OF THEM)
C                  OF ROOMS HAVING THE SAME CONFIGURATION,
C                  BTU
C      TG          DESIGN SUMMER GROUND TEMPERATURE, F
C      TGW         DESIGN WINTER GROUND TEMPERATURE, F
C      THTLD       DAILY RUNNUNG TOTAL ENERGY CONSUMPTION
C                  FOR HEATING FOR A GRUOP (NORM OF THEM)
C                  OF ROOMS HAVING THE SAME CONFIGURATION,
C                  BTU
C      TI(J)       INSIDE SURFACE TEMPERATURE RELATIVE TO
C                  THE REFERENCE TEMPERATURE AT HOUR J
C      TIF(J)      INSIDE SURFACE TEMPERATURE AT HOUR J, F
C      TIFSAV(J,I)    INSIDE SURFACE TEMPERATURE OF SUR-
C                  FACE I AT HOUR J, F
C      TIM         INDOOR DESIGN MEAN (REFERENCE TEMPERA-
C                  TURE), F
C      TIO         INDOOR DESIGN TEMPERATURE, F
C      TIS(I,J)    INSIDE SURFACE TEMPERATURE RELATIVE TO
C                  THE REFERENCE TEMPERATURE OF SURFACE I
C                  AT HOUR J, F
C      TIX(J)      INDOOR DESIGN DRYBULB TEMPERATURE AT
C                  HOUR J, F
C      TNEW(I)     UPDATED OUTSIDE SURFACE TEMPERATURE OF
C                  SURFACE I AT EVERY TIME INCEMENT, F
C      TNUSAV(J,I)    UPDATED OUTSIDE SURFACE TEMPERATRE
C                  OF SURFACE I AT HOUR J, F
C      TOS(I,J)    OUTSIDE SURFACE TEMPERATURE RELATIVE TO
C                  REFERENCE TEMPERATURE OF SURFACE I AT
C                  HOUR J, F
C      TOTHTX      TOTAL COOLING LOAD FOR A ROOM, BTU/HR
C      TOY(J)      ARRAY USED FOR TEMPORARY STORAGE OF
C                  VALUES WHILE ADVANCING TEMPERATURE AS
C                  REQUIRED BY RESPONSE FACTOR METHOD
C      TSAVE       MAXIMUM TOTAL COOLING LOAD, BTU/HR
C      TSITHT      TOTAL OVERALL HEAT GAIN FOR 24 HOURS,
C                  BTU/HR
C      TV          TEMPERATURE OF VENTILATING AIR, F
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C       TZN       TIME ZONE NUMBER
C       U(I)      OVERALL HEAT TRANSFER COEFFICIENT FOR
C                 SURFACE I
C       UCELNG    OVERALL HEAT TRANSFER COEFFICIENT OF
C                 THE CEILING BETWEEN THE ATTIC AIR AND
C                 THE ROOM AIR BELOW
C       UENDW     OVERALL HEAT TRANSFER COEFFICIENT OF
C                 THE ATTIC ENDWALL
C       UG        GROUND HEAT TRANSFER COEFFICIENT
C       UGLAS     WINTER GLASS HEAT TRANSFER COEFFICIENT
C       UT(I)     U VALUE WITHOUT SURFACE RESISTANCES
C       VIN       INDOOR AIR SPECIFIC VOLUME, FT3/LB
C       VOUT      OUTDOOR AIR SPECIFIC VOLUME, FT3/LB
C       VT(L)     SAME AS UT(I)
C       WA        OUTDOOR AIR HUMIDITY RATIO, LB OF H20
C                 VAPOR PER LB OF DRY AIR (= WOUT)
C       WAZ(I)    WALL AZIMUTH ANGLE MEASURED CLOCKWISE
C                 FROM SOUTH, DEGREES
C       WBID      DESIGN INDOOR WETBULB TEMPERATURE, F
C       WJMAX     DESIGN OUTDOOR WETBULB TEMPERATURE, F
C       WBSAVE(J) INDOOR WETBULB TEMPERATURE AT HOUR J, F
C       WID       DESIGN INDOOR HUMIDITY RATIO, LB OF H20
C                 VAPOR/LB OF DRY AIR
C       WIN       INDOOR HUMIDITY RATIO, LB H20/LB DRY AIR
C       WOUT      DESIGN OUTDOOR HUMIDITY RATIO, LB H20
C                 VAPOR/LB DRY AIR
C       WROT      DEGREES OF ROTATION FOR ROOM
C       WT        WALL TILT ANGLE (= 90. DEGREES WHEN
C                 VERTICAL WALL)
C       WV        VENTILATION AIR HUMIDITY RATIO, LB H20
C                 VAPOR/LB DRY AIR
C       X(L,N)    RESPONSE FACTORS FOR CONSTRUCTION L
C       XX(N,L)   TRANSPOSE OF ARRAY X
C       Y(L,N)    RESPONSE FACTORS FOR CONSTRUCTION L
C       YY(N,L)   TRANSPOSE OF ARRAY Y
C       Z(L,N)    RESPONSE FACTORS FOR CONSTRUCTION L
C       ZBLDG     INPUT ARRAY FOR BUILDING AND EXTERNAL DATA
C       ZROOM     INPUT ARRAY FOR ROOM DATA
C       ZZ(N,L)   TRANSPOSE OF ARRAY Z
C
C
         COMMON /CC/ X(10,100),Y(10,100),Z(10,100),ITYPE(30),IHT(30),
        2 IRF(30),ABSP(30),U(30),H(30),HI(30),A(30),UT(30),TOS(30,48),
        3 TIS(30,48),G(30,30),TOY(48),DB(24),QLITX(24,3),QEQUX(24,3),
        4 QOCUP(24,3),QOCPS(24),QLITE(24),QEQUP(24),QI(30),CR(30),NR(30),
        5 QGLAS(30,24),ITEST,UENDW,AZW(30),SHADE(30),RMDES(24),RMDEW(24),
        6 SHD(30),UCELNG
         DIMENSION XX(100,10),YY(100,10),ZZ(100,10).TNEW(100),TI(48),
        2 XDUM(100),YDUM(100),ZDUM(100),TDUM(100),QO(30).TIF(30),TOC(24),
        3 QSUN(30,24),QSKY(30,24).NAMERM(9).NAMEBD(9),VT(10),DR(10).MR(10),
        4 PR(24),PS(24) ,MDAYS(12)/31,28,31,30,31,30,31,31.30,31,30,31/
         DIMENSION DPT(24).WBT(24),PBT(24),WST(24),TC(24),NTOC(24),HSUN(24)   @ NBSLD-XO MODIF
         DIMENSION SALT(24),IEDAY(12) /15,46,74,105,135,166,196,227,258,288
        2,319,349/,CCZ(24)
         DIMENSION CALDB(24),CALRH(24).PGLAS(30,24),PSUN(30,24),TATTIC(100)
        2,QLS(24),QLL(24),ZBLDG(15),ZROOM(12),UW(30),JTITLE(19),IDATE(2) @ NBSLD-XO MODIF
         DIMENSION HEATG(2),HEATX(2),HEATIS(2),HLCG(2),HLCX(2),HLCIS(2)
         DIMENSION DBPF(24) /.87,.92,.96,.99,
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      2 1.00,.98,.93,.84,.71,.56,.39,.23,.11,.03,
      3 0.0,.03,.10,.21,.34,.47,.58,.68,.76,.82/
        COMMON /SHDW/ SHAW(30,15)
        DIMENSION SHDX(20),SHDF(30,24),AIRLK(24),QSOL(24)
      *,QPEOPL(24),QICAIN(30,24),UE(30),TEMPSI(30,24),TEMPSO(30,24), @ NBSLD-XO MODIF
      *H24(30,24) @ NBSLD-XO MODIFICATION
        DIMENSION V(15),PLAT(24),AIRLAT(24),RALD(24),BASEL(24)
        INTEGER DSTX,DSTY,RUNID,RUNTYP,ASHRAE
        REAL LAT,LONG,NOFLR
        INTEGER YEAR,TAPE2
        LOGICAL LL1,LL2,LL3
        COMMON /SOL/ LAT,LONG,TZN,WAZ,WT,CN,DSX,LPYR,S(35)
        COMMON NSKP
        PI=3.1415927
        WRITE (6,1790)
        WRITE (6,1800)
        WRITE (6,1810)
        WRITE (6,1820)
        WRITE (6,1270)
        CALL DATEIM(IDATE)
        READ (5,1460) RUNID,RUNTYP,ASHRAE,IDETAL,METHOD,IDDAY
        READ (5,1640) NAMEBD
        WRITE (6,1630) NAMEBD
C       READ 24 HOUR PROFILES FOR LIGHTING,EQUIPMENT AND OCCUPANCY
        J3=3
        DO 10 J=1,J3
        IF (J.EQ.1) WRITE (6,1280)
        IF (J.EQ.2) WRITE (6,1290)
        IF (J.EQ.3) WRITE (6,1300)
        READ (5,1460) (QLITX(I,J),I=1,24)
        IF (J.EQ.1) WRITE (6,1310)
        IF (J.EQ.2) WRITE (6,1320)
        IF (J.EQ.3) WRITE (6,1330)
        READ (5,1460) (QEQUX(I,J),I=1,24)
        IF (J.EQ.1) WRITE (6,1340)
        IF (J.EQ.2) WRITE (6,1350)
        IF (J.EQ.3) WRITE (6,1360)
        READ (5,1460) (QOCUP(I,J),I=1,24)
 10     CONTINUE
        IF (RUNTYP.GT.2) RUNTYP=2
        WRITE (6,1370)
        READ (5,1460) RMDBS
        WRITE (6,1380)
        READ (5,1460) RMDBW
        WRITE (6,1390)
        READ (5,1460) RMDBWO,RMDBSO,RHW,RHS
        SIGMA=0.1714E-8
        HR=4.*0.9*SIGMA*(530.**3)
        WRITE (6,1400)
        READ (5,1460) NDAY,NSKIP,TAPE2
        WRITE (6,1410)
        READ (5,1460) ZBLDG
        DO 1260 IJKLMN=1,10
        WRITE (6,1420)
        READ (5,1630) NAMERM
C       IF TAPE2 IS NOT BLANK  B TAPE SHOULD BE ASSIGNED
        IF (NAMERM(1).EQ.4H    ) STOP
        WRITE (6,1430)
```

```
      READ (5,1460) IROT,ISKIP,INCLUD
      IF(INCLUD.EQ.0)GO TO 15
      CLDSUM=0.
      HLDSUM=0.
C     IF ISKIP .NE. 0, RESPONSE FACTOR CALCULATION IS SKIPPED
C     SO NO WALL DATA IS NEEDED
15    IF (ISKIP.NE.0) GO TO 50
      DO 20 I=1,10
      DO 20 J=1,100
      X(I,J)=0.
      Y(I,J)=0.
20    Z(I,J)=0.
      IF (RUNID.EQ.1) GO TO 30
      READ (8) X,Y,Z,MR,DR,VT
      GO TO 40
C     THIS RESPONSE FACTOR ROUTINE REQUIRES MANY CONSTRUCTION DATA
C     PLEASE REFER TO THE INPUT INSTRUCTIONS
30    CONTINUE
      CALL RESFX (X,Y,Z.XX,YY,ZZ,MR,DR,VT,10)
      WRITE (8) X,Y,Z,MR,DR,VT
      END FILE 8
40    PB=29.921
50    IF (IROT.NE.0) GO TO 60
      WROT=0.
      WRITE (6,1440)
      READ (5,1460) ZROOM
      WRITE (6,1450)
      READ (5,1460) IW,IL,ISTART,ILEAVE
      READ (5,1460) TUL,TLL,QCMAX,QHMAX,DBVMAX,DBVMIN
      READ (5,1460) ITEST,ITK
      CALL ROOMX (NEXP,NS,NW,NN,NE,HT)
      ROOMNO=ZROOM(1)
      MONTH=ZBLDG(1)
      AG=A(NEXP)
      NOFLR=1
      QCU=ZROOM(4)
      LAT=ZBLDG(12)
      LONG=ZBLDG(11)
      TZN=ZBLDG(13)
      DAYSKP=NSKIP
      QLITY=ZROOM(2)
      QEQPX=ZROOM(3)
      CFMV=ZROOM(8)
      WBMAX=ZBLDG(6)
      FLCG=ZROOM(5)
      TGS=ZBLDG(8)
      TGW=ZBLDG(9)
      LDAY=ZBLDG(2)
      YEAR=2000
      DBWT=ZBLDG(7)
      DBMAX=ZBLDG(4)
      RHOW=ZBLDG(15)
      ZLF=ZBLDG(14)
      DBIN=RMDBW(12)
      RHIN=RHW
      IF (RUNTYP.EQ.2) CALL PSY1 (DBMAX,WBMAX,PB,DPMAX,PV,WA,HA,VA,RHO)
      UG=ZBLDG(10)
      TV=ZROOM(7)
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      FRAS=ZROOM(6)
      ZNORM=ZROOM(12)
      ARCHGW=ZROOM(10)
      CFMWT=AG*HT*ARCHGW/60.
      ARCHGM=ZROOM(11)
      CFMIN=AG*HT*ARCHGM/60.
      CONST=ARCHGW/0.695
C     THESE AIR CHANGE VALUES ARE FOR THE ATTIC VENTILATION
C     ROOM AIR CHANGE VALUES WILL BE DETERMINED AS A FUNCTION  OF
C     WIND SPEED AND TEMPERATURE DIFFERENTIAL
 60   CONTINUE
      WRITE (6,1510)
      IF (IDETAL.EQ.0) GO TO 70
      WRITE (6,1550)
      WRITE (6,1560) ROOMNO,HT,AG,NOFLR,QCU,ZROOM(9),ZROOM(10)
      WRITE (6,1740)
 70   CONTINUE
      S(1)=LAT
      S(2)=LONG
      S(3)=TZN
      IF (IDETAL.EQ.0) GO TO 80
      WRITE (6,1570)
      WRITE (6,1560) LAT,LONG,TZN.ZNORM
      WRITE (6,1740)
      WRITE (6,1580)
      RHIN=RHS
      WRITE (6,1560) QLITY,QEQPX,CFMV,DBIN,TGW,TV,RHIN
      WRITE (6,1740)
      WRITE (6,1600) NEXP,ITK,ITHST
 80   CONTINUE
      WRITE (6,1510)
      IF (IROT.NE.0) GO TO 90
      WRITE (6,1470)
      READ (5,1460) UENDW,UCELNG,AENDW,ATCHT,AIRCHG,AIRNT
      WRITE (6,1480)
      READ (5,1460) IEXTSD,IEXMS,IEXME,NTVNT,NVENT
      READ(5,605)JTITLE @ NBSLD-XO MODIFICATION
      CFMNT=NTVNT*AG*HT/60.
 90   CONTINUE
      IF (IDETAL.EQ.0) GO TO 100
      WRITE (6,1740)
      WRITE (6,1590)
      WRITE (6,1560) UENDW,UCELNG,AENDW,ATCHT
 100  CONTINUE
      IF (IROT.NE.0) GO TO 210
      SUM=0.
      DO 200 I=1,NEXP
      K=IRF(I)
      IF (Y(K,1).GT.1..OR.DR(K).LT.0.01) IRF(I)=10
      NR(I)=MR(K)
      IF(IRF(I).EQ.10)NR(I)=1
      UT(I)=VT(K)
      CR(I)=DR(K)
      IF (NR(I).EQ.0) NR(I)=1
      IF (NR(I).GT.48) NR(I)=48
      IF (ITYPE(I).EQ.3) ABSP(I)=0.
      IF (ITYPE(I).EQ.5) ABSP(I)=0.
      IF (ITYPE(I).GE.6) ABSP(I)=0.
```

```
      IHT(I)=1
      IF (ITYPE(I).EQ.3) IHT(I)=-1
      H(I)=6.0
      HI(I)=1.46-HR
      IF (ITYPE(I).GE.5) H(I)=0.
      IF (ITYPE(I).EQ.1) HI(I)=1.630-HR
      IF (ITYPE(I).EQ.5) HI(I)=1.080-HR
      IF (ITYPE(I).EQ.7) U(I)=500.
      IF (ITYPE(I).EQ.8) H(I)=1.46
      IF (IRF(I).NE.10) U(I)=0.
      IF (U(I)) 110,110,120
110   RU=1./UT(I)+1./(HI(I)+HR)
      IF (ITYPE(I).LT.5.OR.ITYPE(I).EQ.8) RU=RU+1./H(I)
      U(I)=1./RU
120   CONTINUE
      IF (X(K,2)) 170,130,170
130   IF (H(I)) 140,150,140
140   R=1./U(I)-1./H(I)
      GO TO 160
150   R=1./U(I)
160   UT(I)=1./(R-1./(HI(I)+HR))
      IF (UT(I).LE.0.) UT(I)=28.0
      IF (ITYPE(I).EQ.7) UT(I)=500.
170   CONTINUE
      IF (UCELNG) 190,190,180
180   IF (ITYPE(I).NE.1) GO TO 190
      RTA=1./UCELNG-1./(HI(I)+HR)
      UXM=UT(I)
      UT(I)=1./RTA
190   CONTINUE
      UW(I)=U(I)
      IF (ITYPE(I).GT.4) GO TO 200
      SUM=SUM+A(I)*U(I)
200   CONTINUE
      IF(ZLF.EQ.0.)ZLF=1.
      ZK=SUM/ZLF
      FC=1.-0.02*ZK
210   IF (IROT.EQ.0) GO TO 240
      WROT=IROT
      DO 220 I=1,NEXP
      AZW(I)=AZW(I)+WROT
      IF (AZW(I).LT.-180.) AZW(I)=AZW(I)+360.
220   IF (AZW(I).GT.180.) AZW(I)=AZW(I)-360.
      DO 230 I=1,NEXP
      DO 230 J=1,NEXP
230   G(I,J)=G(I,J)/HR
240   CONTINUE
      WRITE (6,1680)
      DO 250 I=1,NEXP
      WRITE (6,1650) I,ITYPE(I),IHT(I),IRF(I),ABSP(I),U(I),H(I),A(I),AZW
     2(I),SHADE(I),UT(I),HI(I)
      UE(I)=U(I)     @ NBSLD-XO MODIFICATION
250   CONTINUE
      IF (IDETAL.EQ.0) GO TO 280
      WRITE (6,1690)
      DO 260 I=1,NEXP
260   WRITE (6,1560) (SHAW(I,J),J=1,15)
      IF (ASHRAE.EQ.1) GO TO 300
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      WRITE (6,1700)
      WRITE (6,1710)
      DO 270 I=1,NEXP
      WRITE(6,1720) I,(G(I,J),J=1,NEXP)
  270 CONTINUE
  280 DO 290 I=1,NEXP
      DO 290 J=1,NEXP
  290 G(I,J)=HR*G(I,J)
  300 TIM=75.
      QLITO=QLITY*AG*3.413*NOFLR
      QEQPO=QEQPX*AG*3.413*NOFLR
      DO 310 I=1,NEXP
      QO(I)=0.
      QI(I)=0.
  310 CONTINUE
      QRFO=0.
      QRFI=0.
C     DBM=TIM= REFERENCE TEMPERATURE
      TA=TIM
      MOT=0
      TCLLD=0.
      THTLD=0.
      IF (IJKLMN.GT.1) GO TO 320
  320 CONTINUE
      NEND=DAYSKP+NDAY
      IF (RUNTYP.NE.2) GO TO 340
      NEND=7
      DO 330 J=1,24
      DB(J)=ZBLDG(4)-ZBLDG(5)*DBPF(J)
      DPT(J)=DPMAX
      WST(J)=0.
      PBT(J)=29.921
      TC(J)=0.
      NTOC(J)=0
  330 CONTINUE
  340 DO 1250 ND=1,NEND
      NSKP=ND-DAYSKP
      N=NSKP
      IF (RUNTYP.EQ.2) GO TO 380
      READ (7) DB,DPT,WBT,WST,PBT,TC,TOC,PR,PS,YEAR,MONTH,LDAY,ICITY
      DO 350 IZ1=1,24
      NTOC(IZ1)=TOC(IZ1)
  350 CONTINUE
      IF (N.LT.1) GO TO 1250
      INDAY=DAYSKP+N
      IF (IDETAL.EQ.0) GO TO 360
      WRITE (6,1620) N,INDAY,YEAR,MONTH,LDAY
      WRITE (6,1610) NAMERM
  360 CONTINUE
      KDAY=WKDAY(YEAR,MONTH,LDAY)
      CALL HOLDAY (YEAR,MONTH,LDAY,KDAY,IHOL)
      CALL DST (YEAR,MONTH,LDAY,DSTX,DSTY)
      IDST=1
      IF (MONTH.LT.4) IDST=0
      IF (MONTH.GT.10) IDST=0
      IF (MONTH.NE.4.OR.MONTH.NE.10) GO TO 370
      IF (MONTH.EQ.4.AND.LDAY.LT.DSTX) IDST=0
      IF (MONTH.EQ.10.AND.LDAY.GT.DSTY) IDST=0
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  370 DSX=IDST
      JJ=1
C     IF (KDAY.EQ.7.OR.KDAY.EQ.1) JJ=2
      IF (IHOL.EQ.1) JJ=3
  380 IF (RUNTYP.EQ.2) JJ=1
      DO 390 J=1,24
      QLITE(J)=QLITO*QLITX(J,JJ)
      QEQUP(J)=QEQPO*QEQUX(J,JJ)
  390 CONTINUE
      IF (MONTH.EQ.MOT) GO TO 550
      TG=TGW
      IF (MONTH.GT.5.AND.MONTH.LT.10) TG=TGS
      MOT=MONTH
      S(4)=IEDAY(MONTH)
      IF (RUNTYP.EQ.2) S(4)=ZBLDG(3)
      S(6)=IDST
      IF (RUNTYP.EQ.2) S(6)=0.
      S(7)=0.2
      S(8)=1.0
      S(38)=1.
      IF (IDETAL.EQ.0) GO TO 400
      WRITE (6,1730)
  400 CONTINUE
      DO 530 I=1,NEXP
      IF (ITYPE(I).LT.5) GO TO 420
      DO 410 J=1,24
      QSUN(I,J)=0.
      QGLAS(I,J)=0.
  410 QSKY(I,J)=0.
      GO TO 520
  420 WAZ=AZW(I)
      S(9)=WAZ
      S(10)=90.
      IF (ITYPE(I).EQ.1) S(10)=0.
      SHDX(1)=SHAW(I,1)
      SHDX(2)=SHAW(I,2)
      SHDX(3)=SHAW(I,3)
      SHDX(4)=SHAW(I,4)
      SHDX(5)=SHAW(I,5)
      SHDX(6)=SHAW(I,6)
      SHDX(7)=SHAW(I,7)
      SHDX(8)=SHAW(I,8)
      SHDX(9)=SHAW(I,9)
      SHDX(10)=SHAW(I,10)
      SHDX(11)=SHAW(I,11)
      SHDX(12)=SHAW(I,12)
      SHDX(13)=SHAW(I,13)
      SHDX(14)=SHAW(I,14)
      SHDX(15)=SHAW(I,15)
  430 CONTINUE
      DO 510 J=1,24
      QSKY(I,J)=0.
      TIME=J
      S(5)=TIME
      CALL SUN
      SALT(J)=S(20)
      IF (S(25).GT.0.) GO TO 440
      QSUN(I,J)=0.
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      QGLAS(I,J)=0.
      GO TO 510
440   QSUN(I,J)=S(25)*ABSP(I)
      HSUN(J)=QSUN(I,J)
      QGLAS(I,J)=0.
      PHI=S(21)*PI/180.
      XQ=S(20)*PI/180.
      COSZ=SIN(XQ)
      IF (SHD(I)) 460,460,450
450   SHDF(I,J)=0.
      GO TO 480
460   SHDF(I,J)=1.
      IF (SHDX(1)) 480,480.470
470   SHDX(16)=S(9)*PI/180.
      CALL SHADOW (SHDX,PHI,COSZ,SHDF(I,J))
480   CONTINUE
      IF (ITYPE(I).NE.3) GO TO 500
      WSHADE=1.0
      IF(MONTH.GT.4.AND.MONTH.LT.10)WSHADE=0.5
      IF (IEXTSD.EQ.0) GO TO 490
      IF (MONTH.GE.IEXTS.AND.MONTH.LE.IEXTE) SHDF(I,J)=0.
490   CONTINUE
      CALL GLASS (SHDF(I,J),SHADE(I),1.,1.,QGLAS(I,J))
500   CONTINUE
      S34=S(25)-S(26)-S(27)
      QSUN(I,J)=(S34*SHDF(I,J)+S(26)+S(27))*ABSP(I)
510   CONTINUE
520   IF (IDETAL.NE.0) WRITE (6,1660) I
      IF (IDETAL.NE.0) WRITE (6,1670) (QSUN(I,J),J=1,24)
      IF (IDETAL.NE.0) WRITE (6,1670) (QGLAS(I,J),J=1,24)
530   CONTINUE
      DO 540 I=1,NEXP
      DO 540 J=1,24
      PGLAS(I,J)=QGLAS(I.J)
540   PSUN(I,J)=QSUN(I,J)
550   CONTINUE
      IF (N.NE.1) GO TO 640
      DO 560 J=1,24
      DO 560 I=1.NEXP
560   TOS(I,J)=DB(24-J+1)-TIM
      DO 570 J=25,48
      DO 570 I=1,NEXP
570   TOS(I,J)=TOS(I,J-24)
      DO 580 I=1,NEXP
      DO 580 J=1,48
580   TIS(I,J)=0.
      TA=TIM
      DO 590 J=1,48
      TNEW(J)=0.
590   TATTIC(J)=0.
      IF (ASHRAE) 640,640,600
600   DO 620 I=1,NEXP
      DO 610 J=1,24
610   TIS(I,J)=RHDBS(24-J+1)-TIM
      DO 620 J=25,48
620   TIS(I,J)=TIS(I,J-24)
      DO 630 II=1,2
      HEATC(II)=0.
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      HEATX(II)=0.
      HEATIS(II)=0.
      HLCG(II)=0
      HLCX(II)=0.
  630 HLCIS(II)=0.
  640 CONTINUE
C     END OF INITIALIZATION
C     TIME CALCULATION BEGINS HERE
      DO 1150 NK=1,24
      LL1=NK.GE.ISTART.AND.NK.LE.ILEAVE
      LL2=NK.LT.ISTART.OR.NK.GT.ILEAVE
      LL3=NVENT.NE.0.AND.DB(NK).LT.TV.AND.QL.LT.10.
      IF (ITK.NE.0) GO TO 650
      IF (ITHST.NE.1) GO TO 650
      CALL TEMPSH (MONTH,JJ,NK,RMDBS,RMDBW,RMDBWO,RMDBSO,TA)
  650 CONTINUE
      IF (RUNTYP.NE.2) GO TO 660
      FOT=4.
      ACHG=ZROOM(9)
      CM=1.
      WST(NK)=7.5
      GO TO 670
  660 WSTX=WST(NK)
      CALL FC (WSTX,3,FOC,FOT,0)
C     AIR CHANGE AS A FUNCTION OF WIND SPEED
C     COBLENZ AND ACHENBACH  1963 ASHRAE TRANSACTION
      WSTZ=WST(NK)*1.151
      ACH=0.15+0.013*WSTZ+0.005*ABS(DB(NK)-TA)
      ACHG=ACH*CONST
      CM=CCM(SALT(NK),NTOC(NK),TC(NK))
  670 CFML=A(1)*ACHG*HT/60.+CFMIN
      CCZ(NK)=CM
      CFMLX=CFML
      IF (LL1) GO TO 680
      CFMV=0.
      GO TO 690
  680 IF (JJ.GT.1) CFMV=0.
  690 CONTINUE
      DO 720 I=1,NEXP
      NRR=NR(I)
      QSUN(I,NK)=PSUN(I,NK)*CM
      QGLAS(I,NK)=PGLAS(I,NK)*CM*WSHADE
      QSKY(I,NK)=0.
      IF (ITYPE(I).EQ.1) QSKY(I,NK)=2.*(10.-TC(NK))
      IF (NRR.LT.2) GO TO 720
      DO 700 NTT=2,NRR
  700 TOY(NTT)=TOS(I,NTT-1)
      DO 710 NTT=2,NRR
  710 TOS(I,NTT)=TOY(NTT)
  720 CONTINUE
      DO 800 I=1,NEXP
      NRR=NR(I)
      IF (ASHRAE.GT.0) TIS(I,1)=TA-TIM
      K=IRF(I)
      DO 730 J=1,NRR
      XDUM(J)=X(K,J)
      YDUM(J)=Y(K,J)
      ZDUM(J)=Z(K,J)
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      TDUM(J)=TOS(I,J)
      IF (ITYPE(I).EQ.6.OR.ITYPE(I).EQ.7) TDUM(J)=TIS(I,J)
      IF (ITYPE(I).EQ.5) TDUM(J)=TG-TIM
      TI(J)=TIS(I,J)
  730 CONTINUE
      UX=U(I)
      IF (H(I)) 750,750,740
  740 H(I)=FOT
      RX=1./UT(I)+1./(HI(I)+HR)
      RXX=RX+1./H(I)
      U(I)=1./RXX
      UX=1./RX
  750 CONTINUE
      IF (ITYPE(I).EQ.1.AND.UENDW.NE.0.) GO TO 760
      GO TO 780
  760 ATCACG=AIRCHG*AIRNT
      IF (LL1) ATCACG=AIRCHG
      CALL ATTIC(XDUM,YDUM,ZDUM,CR(I),NRR,UXX,H(I),DB(NK),QSUN(I,NK),QSK
     2Y(I,NK),TDUM,TATTIC,TNEWO,TA,TIM,QRFO,QRFI,QO(I),QI(I),UENDW,UCELN
     3G,AENDW,A(I),ATCHT,ATCACG)
      TEMPSO(1,NK)=TATTIC(1)
      DO 770 J=1,NRR
      TNEW(J)=TDUM(J)
  770 TOS(1,J)=TATTIC(J)
      GO TO 800
  780 CONTINUE
      IF (RUNTYP.EQ.2) ITEMP=0
      CALL OUTSID (XDUM,YDUM,ZDUM,CR(I),UX,H(I),DB(NK),TIM,QO(I),QI(I),Q
     2SUN(I,NK),QSKY(I,NK),TDUM,TI,TNEWO,TA,NRR)
      DO 790 J=1,NRR
  790 TOS(I,J)=TDUM(J)
  800 CONTINUE
      QOCPS(NK)=QOCUP(NK,JJ)*10.*(100.-TA)*QCU
      QOCPL=10.*(TA-60.)*QOCUP(NK,JJ)*QCU
      IF (TA-100.) 820,810,810
  810 QOCPS(NK)=0.
      QOCPL=400.*QOCUP(NK,JJ)*QCU
      GO TO 840
  820 IF (TA-65.) 830,840,840
  830 QOCPS(NK)=350.*QOCUP(NK,JJ)*QCU
      QOCPL=50.*QOCUP(NK,JJ)*QCU
  840 DO 870 I=1,NEXP
      NRR=NR(I)
      IF (NRR.LT.2) GO TO 870
      DO 850 NTT=2,NRR
  850 TOY(NTT)=TIS(I,NTT-1)
      DO 860 NTT=2,NRR
  860 TIS(I,NTT)=TOY(NTT)
  870 CONTINUE
      IF (ASHRAE) 900,900,880
  880 QSUMG=0.
      QSUMX=0.
      DO 890 I=1,NEXP
      IF (ITYPE(I).LE.3.OR.ITYPE(I).EQ.8) QSUMX=QSUMX-QI(I)*A(I)
      IF (ITYPE(I).EQ.3) QSUMG=QSUMG+QGLAS(I,NK)*A(I)
  890 CONTINUE
      HEATG(1)=HEATG(2)
      HEATG(2)=QSUMG
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            HEATX(1)=HEATX(2)
            HEATX(2)=QSUMX+QOCPS(NK)+QEQUP(NK)
            HEATIS(1)=HEATIS(2)
            NKK=NK-1
            IF (NKK.EQ.0) NKK=24
            HEATIS(2)=QLITE(NKK)
            HLCG(1)=HLCG(2)
            HLCX(1)=HLCX(2)
            HLCIS(1)=HLCIS(2)
            ISC=1
            CALL RMRT (HEATG,HLCG,HEATX,HLCX,HEATIS,HLCIS,IW,IL,FC,ISC)
            QL=HLCG(2)+HLCX(2)+HLCIS(2)+1.08*CFML*(DB(NK)-TA)
            QGAIN=HEATG(2)+HEATX(2)+HEATIS(2)
            QL=-QL
            GO TO  965
      900   CONTINUE
            DO 960 I=1,NEXP
            HI(I)=0.542
            HTEST=TIS(I,1)
            IF (I.NE.1) GO TO 930
            IF (HTEST) 910,910,920
      910   HI(1)=0.712
            GO TO 960
      920   HI(1)=0.162
            GO TO 960
      930   IF (I.NE.NEXP) GO TO 960
            IF (HTEST) 940,940,950
      940   HI(NEXP)=0.162
            GO TO 960
      950   HI(NEXP)=0.712
      960   H24(I,NK)=HI(I)     @ NBSLD-XO MODIFICATION
      965   CONTINUE
            IF (NTVNT.EQ.0) GO TO 1010
            IF (DB(NK).LT.DBVMIN.OR.DB(NK).GT.DBVMAX ) GO TO 1010
      970   IF (TA-DB(NK)) 1010,1010,980
      980   IF (JJ.GT.1) GO TO 990
            IF (LL1) GO TO 1010
      990   IF (QL+10) 1000,1010,1010
     1000   CFML=CFMLX+CFMNT
     1010   CONTINUE
            V(3)=0.
            V(2)=CFML
            V(1)=DB(NK)
            IF(LL2 .OR..NOT.LL3.OR.JJ.GT.1)GO TO 1011
            V(3)=CFMV
     1011   CONTINUE
            CFMLNC=CFML+V(3)
            IF(ASHRAE.GT.0.)GO TO 1040
            V(4)=FRAS
            V(5)=FLCG
            V(6)=TIM
            V(7)=QCMAX
            V(8)=QHMAX
            IF (JJ.GT.1) GO TO 1020
            IF (LL2) GO TO 1020
            V(9)=TUL
            V(10)=TLL
            GO TO 1030
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 1020 V(9)=RMDBSO
      V(10)=RMDBWO
 1030 CONTINUE
      V(11)=TA
      V(12)=FRAS
      V(13)=HR
      V(14)=METHOD
      CALL RMTMK (V,TIF,QL,TA,NEXP,NK,ITK)
      DO 1031 I=1,NEXP
 1031 QIGAIN(I,NK)=QI(I)     @ NBSLD-XO MODIFICATION
      IF(LL1 .AND.LL3 .AND.QL.GT.0..AND.DB(NK).GT.60.)QL=0.
 1040 CALL PSY2 (DB(NK),DPT(NK),PBT(NK),WBT(NK),PVO,WA,HA,VA,RHA)
      IF(ABS(QL).LT.10.)QL=0.
      PLAT(NK)=-QOCPL*ZNORM
      WV=WA
      QOCPL=QOCPL/1060.
 1080 WIN=(4.5*CFMLNC*WA+QOCPL)/4.5/CFMLNC
      PVI=PB*WIN/(0.622+WIN)
      RHIN=100.*PVI/PVSF(TA)
      IF(RHIN.GT.100)RHIN=100.
      IF(QL.EQ.0.)GO TO 1086
      IF(QL.GT.0.)GO TO 1085
      IF(RHIN.GT.RES)RHIN=RES
 1085 IF(QL.LT.0.)GO TO 1086
      IF(RHIN.LT.RHW)RHIN=RHW
 1086 CONTINUE
      CALDB(NK)=TA
      CALRH(NK)=RHIN
      CALL DBRH (TA,RHIN,WIN)
      AIRLAT(NK)=4.5*CFMLNC*(WIN-WA)*1060.*ZNORM
      RALD(NK)=QLITE(NK)*FLCG*ZNORM
      BASEL(NK)=(QLITE(NK)+QEQUP(NK))*ZNORM
      AIRLK(NK)=1.08*CFMLNC*(TA-DB(NK))*ZNORM
      QSOL(NK)=PSUN(1,NK)
      QLATNT=(4.5*CFMLNC*(WIN-WA)-QOCPL)*1060.
      QPEOPL(NK)=-QOCPL*1060
      IF((QL.GT.0..AND.RHIN.GT.RHW).OR.(QL.LT.0..AND.RHIN.LT.RES))
     1QLATNT=0.
      IF (RUNTYP.EQ.2) GO TO 1100
      IF (ASHRAE.EQ.0) GO TO 1100
      CALL ADJUST (QL,QLATNT,MONTH,NK,JJ)
 1100 CONTINUE
C
      QLS(NK)=QL*ZNORM
      QLL(NK)=QLATNT*ZNORM
      IF (ABS(QLS(NK))-1.) 1110,1110,1120
 1110 QLL(NK)=0.
 1120 CONTINUE
      IF (UENDW) 1141,1141,1130
 1130 NRR=NR(1)
      DO 1140 J=1,NRR
 1140 TOS(1,J)=TNEW(J)
 1141 DO 1142 J=1,NEXP  @ NBSLD-XO MODIFICATION
      TEMPSI(J,NK)=TIS(J,1)  @ NBSLD-XO MODIFICATION
      IF(J.EQ.1)GO TO 1142  @ NBSLD-XO MODIFICATION
      TEMPSO(J,NK)=TOS(J,1)  @ NBSLD-XO MODIFICATION
 1142 CONTINUE  @ NBSLD-XO MODIFICATION
 1150 CONTINUE
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      IF ((RUNTYP.EQ.2.OR.IDDAY.EQ.1).AND.ND.LT.7) GO TO 1250  @ NBSLD-XO MODIFICATION
      QLMAX=ABS(QLS(1))
      NMAX=1
      TSUM=0.
      QLDSUM=0.
      CLDAY=0.
      HLDAY=0.
      DO 1200 NK=1,24
      INFL6=AIRLK(NK)*(-12.0)  @ NBSLD-XO MODIFICATION
      IF(QLS(NK).LT.0.0.AND.INFL6.LT.QLS(NK))GO TO 556 @ NBSLD-XO MODIFICATION
      GO TO 555  @ NBSLD-XO MODIFICATION
556   QLS(NK)=0.0  @ NBSLD-XO MODIFICATION
      QLL(NK)=0.0  @ NBSLD-XO MODIFICATION
555   CONTINUE  @ NBSLD-XO MODIFICATION
      IF (QLMAX-ABS(QLS(NK))) 1160,1170,1170
1160  QLMAX=ABS(QLS(NK))
      NMAX=NK
      GO TO 1170
1170  CONTINUE
      TSUM=TSUM+DB(NK)
      QLDSUM=QLDSUM+QLS(NK)+QLL(NK)
      QLDS=QLS(NK)+QLL(NK)
      IF (QLDS) 1180,1180,1190
1180  CLDAY=CLDAY+QLDS
      GO TO 1200
1190  HLDAY=HLDAY+QLDS
1200  CONTINUE
      TCLLD=TCLLD+CLDAY
      THTLD=THTLD+HLDAY
      DBA=TSUM/24.
      QLMAX=QLS(NMAX)+QLL(NMAX)
      IF (RUNTYP.EQ.2) N=1
      IF (N.GT.1) GO TO 1210
      WRITE (6,1520) NAMERM,MONTH
1210  CONTINUE
      WRITE (6,1530) MONTH,LDAY,NMAX,QLMAX,CLDAY,HLDAY,DBA
      IF(MOD(YEAR,4).EQ.0)MDAYS(2)=29
      TMTHH=TMTHH+HLDAY
      TMTHC=TMTHC+CLDAY
      IF(QLMAX.LT.YMAXH)GO TO 1207
      YMAXH=QLMAX
      NMAXH=NMAX
      LDAYH=LDAY
      LMH=MONTH
1207  IF(QLMAX.GT.YMAXC)GO TO 1208
      YMAXC=QLMAX
      NMAXC=NMAX
      LDAYC=LDAY
      LMC=MONTH
1208  IF(LDAY.NE.MDAYS(MONTH))GO TO 1209
      WRITE(6,1271)TMTHC,TMTHH
      TMTHC=0.
      TMTHH=0.
      IF(ND.EQ.NEND)GO TO 1209
      WRITE(6,1272)
1209  CONTINUE
      IF (ND.EQ.NEND) WRITE (6,1510)
      IF (RUNTYP.NE.2.AND.IDDAY.EQ.0) GO TO 1230  @ NBSLD-XO MODIFICATION
```

```
      IF (ND.NE.NEND) WRITE (6,1510)
      WRITE (6,1540) YEAR,MONTH,LDAY
      WRITE(47,1830)  @ NBSLD-XO MODIFICATION
      WRITE(47,606)JTITLE,IDATE  @ NBSLD-MODIFICATION
      IF (RUNTYP.EQ.2) CALL WINTER (A,UW,ITYPE,NEXP,CFMWT,DBIN,DBWT,UG,T
     2GW.RHW,RHOW,UENDW,UCELNG,AENDW,ATCHT,AIRCHG)
  606 FORMAT(1X,21A6)
      WRITE (6,1490)
      WRITE (47,1491)  @ NBSLD-XO MODIFICATION
      DO 1220 J=1,24
      WRITE (6,1500) J,DB(J),WBT(J),CALDB(J),CALRH(J),QLS(J),QLL(J)
 1220 WRITE(47,1501) J,WST(J),CCZ(J),ESUN(J),DB(J),WBT(J),CALDB(J),CALRH  @ NBSLD-XO MODIF
     *(J),QLS(J),QLL(J)  @ NBSLD-XO MODIFICATION
      WRITE (6,1510)
      WRITE (47,1510)  @ NBSLD-XO MODIFICATION
 1230 CONTINUE
      IF (IDETAL.EQ.0) GO TO 1240
      WRITE (6,1750) DBA,QLDSUM
      WRITE (6,1760) CLDAY,HLDAY
      WRITE (47,1760) CLDAY,HLDAY  @ NBSLD-XO MODIFICATION
      WRITE (6,1770) N,TCLLD,N,THTLD
 1240 CONTINUE
      IF (TAPE2.EQ.0) GO TO 1250
      WRITE (TAPE2) NAMERM,MONTH,LDAY,DB,DPT,WBT,WST,PBT,TC,NTOC,CALDB,C
     2ALRH,QLS,QLL,DBA,CLDAY,HLDAY,TCLLD,THTLD,QLITE,QEQUP,QSOL,QOCPS,AI
     3RLK
C     WRITE (10) QLS,PLAT,AIRLAT,DB,DPT,CALDB,RALD,BASEL
 1250 CONTINUE
      CLDSUM=CLDSUM+TCLLD
      HLDSUM=HLDSUM+THTLD
      WRITE(6.1273)YMAXC,LMC,LDAYC,NMAXC,YMAXH,LMH,LDAYH,NMAXH
      WRITE(47,1273)YMAXC,LMC,LDAYC,NMAXC,YMAXH,LMH,LDAYH,NMAXH  @ NBSLD-XO MODIFICATION
      WRITE (47,1760) CLDAY,HLDAY  @ NBSLD-XO MODIFICATION
      WRITE (6,1780) IJKLMN,CLDSUM,IJKLMN,HLDSUM
      WRITE (47,1780) IJKLMN,CLDSUM,IJKLMN,HLDSUM  @ NBSLD-XO MODIFICATION
      IF(RUNTYP.EQ.2.OR.IDDAY.EQ.1)  @ NBSLD-XO MODIFICATION
     *CALL PRTOUT(ITYPE,AZW,UE,A,QLITE,QEQUP,QOCPS,QPEOPL,AIRLK,  @ NBSLD-XO MODIFICATION
     *AIRLAT,QIGAIN,QGLAS,UCELNG,NEXP,TEMPSI,TEMPSO,H24,DB,JTITLE,CALDB)  @ NBSLD-XO MODI
 1259 REWIND 7
 1260 CONTINUE
      END FILE TAPE2
      END FILE 10
      STOP
C
C
 1271 FORMAT(//' MONTHLY COOLING LOAD=',E15.8,' BTU',//' MONTHLY HEATING
     * LOAD=',E15.8,' BTU')
 1272 FORMAT(1H1,'MONTH  DAY',7X,'MHR   QLMAX',5X,'CLDAY',5X,'HLDAY',7X,
     *'DBA')
 1273 FORMAT(' MAX COOLING LOAD =',F10.0,' MONTH =',I3,' DAY =',I3,' HOU
     *R =',I3,/' MAX HEATING LOAD =',F10.0,' MONTH ='.I3,' DAY =',I3,' H
     *OUR =',I3)
 1270 FORMAT (//34H RUNID,RUNTYP,ASHRAE,IDETAL,METHOD/41H RUNID.........
     2IDENTIFICATION OF THE RUN /42H                  1 NEED RESPONSE FACTO
     3R DATA/42H              2 SKIP RESPONSE FACTOR DATA/26H RUNTYP...
     4.....TYPE OF RUN/56H            1 ENERGY CALCULATION ..NEEDS WE
     5ATHER TAPE/40H              2 DESIGN LOAD CALCULATION/52H
     6       3 DESIGN AND ENERGY LOAD CALCULATIONS/28H ASHRAE........0
```

```
      7 USE RMTMP/47H                    1   USE ASHRAE WEIGHTING FACTORS/37H
      8IDETAL........0   NO DETAILED OUTPUT/34H                    1   DETAILE
      9D OUTPUT/49H METHOD........0   REGULAR TREATMENT FOR THE ROOM/43H.
      *..............1   SPECIAL TREATMENT OF THE ROOM)
 1280 FORMAT (31H LIGHTING SCHEDULE FOR WEEKDAYS)
 1290 FORMAT (30H LIGHTING SCHEDULE FOR WEEKEND)
 1300 FORMAT (42H LIGHTING SCHEDULE FOR THE VACATION PERIOD)
 1310 FORMAT (38H EQUIPMENT USAGE SCHEDULE FOR WEEKDAYS)
 1320 FORMAT (32H EQUIPMENT SCHEDULE FOR WEEKENDS)
 1330 FORMAT (49H EQUIPMENT USAGE SCHEDULE FOR THE VACATION PERIOD)
 1340 FORMAT (32H OCCUPANCY SCHEDULE FOR WEEKDAYS)
 1350 FORMAT (31H OCCUPANCY SCHEDULE FOR WEEKEND)
 1360 FORMAT (43H OCCUPANCY SCHEDULE FOR THE VACATION PERIOD)
 1370 FORMAT (42H THERMOSTAT SETTING FOR THE COOLING SEASON)
 1380 FORMAT (42H THERMOSTAT SETTING FOR THE HEATING SEASON)
 1390 FORMAT (22H RMDBWO,RMDBSO,RHW,RHS)
 1400 FORMAT (33H DATA SHEET NO 1:NDAY,NSKIP,TAPE2)
 1410 FORMAT (96H DATA SHEET NO 2 +3 :MONTH,DAY,ELAPS,DBMAX,RANGE,WBMAX,
     2    DBMWT,TCS,TGW,UG,LONG,LAT,TZN,ZLF,REOW)
 1420 FORMAT (34H DATA SHEET NO 4: NAME OF THE ROOM)
 1430 FORMAT (35H DATA SHEET NO 5:IROT,ISKIP,INCLUDE)
 1440 FORMAT (85H DATA SHEET NO 8: ROOMNO,QLITY,QEQPY,QCU,FLCG,FRAS,TS,C
     2FMV,ARCHGS,ARCHGW,ARCHGM,ZNORM)
 1450 FORMAT (58H DATA SHEET NO.9: IW,IL,TUL,TLL,QCMAX,QHMAX,ITHST,ITK)
 1460 FORMAT ()
 1470 FORMAT (56H DATA SHEET NO 10: UENDW,UCELNG,AENDW,ATCHT,AIRCHG,AIRN
     2T)
 1480 FORMAT (49H DATA SHEET NO 14: IEXTSD,IEXMS,IEXME,NTVNT,NVENT//)
 1490 FORMAT (//69H       TIME      DBOUT      WBOUT       DBIN       RHIN
     2    QLS         QLL)
 1491 FORMAT (  //'       TIME         WIND      CLOUD      ESOLAR     DBOUT   @ NBSLD-XO MODIF
     2  WBOUT       DBIN        RHIN        QLS          QLL')  @ NBSLD-XO MODIFICATION
 1500 FORMAT (I10,4F10.1,2F10.0)
 1501 FORMAT (I10,F10.1,2F10.0,4F10.1,2F10.0)
 1510 FORMAT (///)
 1520 FORMAT (///14H   ROOM NAME= 9A4,9H  MONTH= I6/56H        DAY
     2HR QLMAX     CLDAY     HLDAY        DBA)
 1530 FORMAT (I4,I6,I10,3F10.0,F10.1)
 1540 FORMAT (18H ***** YEAR =,I5,14H ***** MONTH =,I3,12H ***** DAY =,I
     23/)
 1550 FORMAT (8H  ROOMNO,6X2HHT,6X2HAG,3X5HNOFLR,5X3HQCU,2X6HARCHGS,2X6H
     2ARCHGW)
 1560 FORMAT (15F8.1)
 1570 FORMAT (5X3HLAT,4X4HLONG,5X3HTZN,3X5HZNORM)
 1580 FORMAT (3X5HQLITY,3X5HQEQPX,4X4HCFMV,4X4HDBIN,6X2HTG,6X2HTV,4X4HRH
     2IN)
 1590 FORMAT (/31H  UENDW  UCELNG   AENDW   ATCHT)
 1600 FORMAT (6X,4HNEXP,7X,3HITK,5X,5HITHST/3(8X,I2))
 1610 FORMAT (1H ,6A6)
 1620 FORMAT (24H  CLIMATIC DATA FOR DAY=,I5/27H  DAYS ELAPSED SINCE JAN
     2 1=,I5,7H  YEAR=,I5,8H  MONTH=,I3,6H  DAY=,I5)
 1630 FORMAT (1X,9A4)
 1640 FORMAT (9A4)
 1650 FORMAT (I3,3I10,8F10.2)
 1660 FORMAT (I10,F10.0)
 1670 FORMAT (24F5.0)
 1680 FORMAT (58H SURFACE NO ITYPE   IHT      IRF      ABSP      U
     2  H,9X,1HA9X,3HWAZ5X,5HSHADE8X,2HUT8X,2HHI)
```

```
 1690 FORMAT (//21H  SHADOW CASTING DATA/121H       HT        FL        FP
     2   AW       BWL       BWR        D       FP1       A1        B1        C1
     3 FP2       A2        B2        C2)
 1700 FORMAT (///33H    RADIATION INTERCHANGE FACTORS)
 1710 FORMAT (108H  SURFACE            1           2           3           4
     2   5           6           7           8           9          10)
 1720 FORMAT (I10,10F10.3)
 1730 FORMAT (27H   SOLAR DATA (QSUN/QGLASS))
 1740 FORMAT (4H    /5H     )
 1750 FORMAT (6H DBA =,F6.2/9H QLDSUM =,F10.0//)
 1760 FORMAT (36H TOTAL COOLING CONSUMPTION PER DAY =,F10.0,4H BTU/36H T
     2OTAL HEATING CONSUMPTION PER DAY =,F10.0,4H BTU)
 1770 FORMAT (49H TOTAL COOLING CONSUMPTION FOR THE ROOM OVER THE ,I3,14
     2H  DAY PERIOD =,E11.5,4H BTU/49H TOTAL HEATING CONSUMPTION FOR THE
     3 ROOM OVER THE ,I3,13H DAY PERIOD =,E11.5,4H BTU)
 1780 FORMAT (31H TOTAL COOLING CONSUMPTION FOR ,I2,8H ROOMS =,E11.5,4H
     2BTU/31H TOTAL HEATING CONSUMPTION FOR ,I2,8H ROOMS =,E11.5,4H BTU)
 1790 FORMAT (///39H CONGRATULATIONS## NOW YOU ARE ON NBSLD)
 1800 FORMAT (/46H  WE ASSUME YOU HAVE ALREADY PREPARED THE DATA)
 1810 FORMAT (52H  ON NBS DATA FORMS..IF YOU HAD NOT .PLEASE TURN OFF)
 1820 FORMAT (57H  THE TERMINAL AND HAVE YOUR DATA READY ON THE DATA FOR
     2MS)
 1830 FORMAT(1H1)
 605  FORMAT(13A6)  @ NBSLD-XO MODIFICATION
C
      END
```

APPENDIX D. LISTING OF DATA FOR NBSLD ANALYSIS OF MODEL HOUSE

Tables D-1 and D-2 contain a listing of the input data for NBSLD as used in the analysis of the "low" insulation and "high" insulation model houses. These tables correspond exactly to the NBSLD input format.

The thermo-physical properties and response factors computed for the roof, walls, and slab floor are shown in tables D-3 through D-6. These latter tables correspond exactly to the standard NBSLD output format. The IRF is an identification code assigned in the main NBSLD program to identify the envelope element type. The data required to describe each layer (I) of a particular envelope element includes its thickness (L(I), in feet), thermal conductivity (K(I), in Btu per (hour) (square foot) (Fahrenheit degree temperature difference) per foot of thickness), density (P(I), in pounds per cubic feet), specific heat (C(I), in Btu per (lb) (°F)), and thermal resistance value (R(I), in (hr) (square foot) (°F) per Btu). (Note that this last parameter is specified only if the layer has no significant heat storage characteristics; in such a case the first four parameters do not need to be specified.) The remainder of the parameters shown in tables D-3 through D-6 are explained in the NBSLD program manual.

Table D-1. Input Data[a] for Low Insulation Model House

```
LOW INSULATION CASE
-------------------

1       1,2,0,0,0,0
2        RANCH-STYLE HOME ON SLAB
3       0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
4       .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
5       .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
6       .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
7       1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
8       .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
9       0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
10      .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
11      .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
12      .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
13      1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
14      .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
15      0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
16      .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
17      .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
18      .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
19      1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
20      .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
21      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
22      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
23      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
24      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
25      68.,78.,20.,60.
26      365,0,0
27      1.,21.,20.,40.,22.,33.,18.,68.,56.,0.1,76.5,38.,5.,160.,20.
28      1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CYC
29      LE,WASH D.C.,RUN AS 1 SPACE
30        ONE SPACE,NOT ZONED
31      0,0,1
32      3
33      0.,0.,0.,0.,0.6
34      0.0417,0.07,34.,0.29,0.,0.63
35      0.,0.,0.,0.,0.5
36      INSIDE SURF. RES.
37      1/2 IN. PLYWOOD
38       BUILD. PAP.+ASPH. SHIG.
39      4
40      0.0417,0.0938,50.,0.2,0.,0.45
41      0.275,0.025,2.0,0.2,0.,11.
42      0.0417,0.0317,20.,.31,0.,1.32
43      0.03125,0.0497,37.,.29,0.,0.59
44      1/2 IN. GYPBOARD
45      3 1/2 IN. INSULATION
46      1/2 IN. SHEATHING
47      3/8 IN. WOOD SIDING
48      4
49      0.0417,0.0938,50.,0.2,0.,0.45
50      0.302,0.07,32.,.33,0.
51      0.0417,0.0317,20.,.31,0.,1.32
52      0.03125,0.0497,37.,.29,0.,0.59
```

[a] Lines 28 and 29 contain titling data not used in the regular NBSLD program but needed in the expanded output (PRTOUT) subroutine.

```
1/2 IN. GYPBOARD
2X4 STUD
1/2 IN. SHEATHING
3/8 IN. WOOD SIDING
3
0.,0.,0.,0.,1.5
0.333,1.0,140.,0.2,0.
0.333,0.75,140.,0.2,0.
CARPET&PADDING
4 IN. CONCRETE SLAB
4 IN. GRAVEL
0
1.,.55,.97,3.,0.,0.5,75.,640.,0.5,0.5,.1,1.
3,4,1,24
78.,68.,50000.,50000.,65.,45.
1,1
3,3,3,3
40.,40.,8.
1,1,1600.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,0.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,90.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,180.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,180.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,180.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,-90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,-90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,-90.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
5,4,1600.,0.,0.,0.,0.0,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
0.4,0.117,120.,1.8,2.,1.
0,0,0,0,0
```

Table D-2. Input Data[a] for High Insulation Model House

```
HIGH INSULATION CASE
--------------------
1       1,2,0,1,0,0
2        BASIC RANCH-STYLE HOME
3       0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
4       .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
5       .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
6       .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
7       1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
8       .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
9       0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
10      .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
11      .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
12      .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
13      1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
14      .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
15      0.,0.,0.,0.,0.,0.,.31,1.,.42,.16,.36,.13
16      .09,0.,0.,.18,.18,.13,.22,.31,.53,.71,.36,0.
17      .25,.25,.25,.25,.25,.25,.33,.46,.63,.88,.35,.58
18      .42,.25,.25,.58,.58,1.,.92,.68,.68,.68,.51,.25
19      1.,1.,1.,1.,1.,1.,1.,.67,.5,.5,.5,.5
20      .5,0.,0.,.5,.5,1.,1.,.67,.67,1.,1.,1.
21      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
22      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
23      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
24      68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.,68.
25      68.,78.,20.,60.
26      365,0,0
27      1.,21.,20.,40.,22.,33.,18.,56.,56.,0.1,76.5,38.,5.,160.,20.
28      1600 SQ. FT. SQUARE FRAME HOUSE ON SLAB WITH ATTIC,HEATING MODE,DIURNAL TEMP CYC
29      LE,WASH D.C.,RUN AS 1 SP.,HIGH INSUL.
30        ONE SPACE,NOT ZONED
31      0,0,1
32      3
33      0.,0.,0.,0.,0.6
34      0.0417,0.07,34.,0.29,0.,0.63
35      0.,0.,0.,0.,0.5
36      INSIDE SURF. RES.
37      1/2 IN. PLYWOOD
38       BUILD. PAP.+ASPH. SHIG.
39      4
40      0.0417,0.0938,50.,0.2,0.,0.45
41      0.475,0.025,2.0,0.2,0.,19.
42      0.0417,0.0317,20.,.31,0.,1.32
43      0.03125,0.0497,37.,.29,0.,0.59
44      1/2 IN. GYPBOARD
45      5.7 IN. INSULATION
46      1/2 IN. SHEATHING
47      3/8 IN. WOOD SIDING
48      4
49      0.0417,0.0938,50.,0.2,0.,0.45
50      0.458,0.07,32.,.33,0.
51      0.0417,0.0317,20.,.31,0.,1.32
52      0.03125,0.0497,37.,.29,0.,0.59
```

[a] Lines 28 and 29 contain titling data not used in the regular NBSLD program but needed in the expanded output (PRTOUT) subroutine.

```
1/2 IN. GYPBOARD
2X6 STUD
1/2 IN. SHEATHING
3/8 IN. WOOD SIDING
4
0.,0.,0.,0.,1.5
0.333,1.0,140.,0.2,0.
0.,0.,0.,0.,10.
0.333,0.75,140.,0.2,0.
CARPET&PADDING
4 IN. CONCRETE SLAB
R10 FOAM INSUL
4 IN. GRAVEL
0
1.,.55,.97,3.,0.,0.5,75.,640.,0.5,0.5,.1,1.
3,4,1,24
78.,68.,50000.,50000.,65.,45.
1,1
3,3,3,3
40.,40.,8.
1,1,1600.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,0.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,0.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,90.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,180.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,180.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,180.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,2,224.,-90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
2,3,48.,-90.,0.,0.,0.9,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
3,10,48.,-90.,1.13,1.0,0.,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
5,4,1600.,0.,0.,0.,0.0,0.
0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
0.4,0.034,120.,1.8,2.,1.
0,0,0,0,0
```

Table D-3. Thermo-Physical Properties and Response Factors for the Roof of the Model House

IRF = 1

ROOF COMPOSITION

LAYER NO.	L(I)	K(I)	P(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.000	.000	.00	.000	.60	INSIDE SURF. RES.
2	.042	.070	34.00	.290	.00	1/2 IN. PLYWOOD
3	.000	.000	.00	.000	.50	BUILD. PAP.+ASPH. SHIG.

TIME INCREMENT DT=1.

THERMAL CONDUCTANCE U = .590

RESPONSE FACTORS

J	X	Y	Z
0	.6849	.4916	.7092
1	-.0952	.0981	-.1194
2	-.0001	.0001	-.0001
3	-.0000	.0000	-.0000
4	-.0000	.0000	-.0000

COMMON RATIO CR = .00056

I. R-11 Insulation

DATA SHEET NO 7: DESCRIPTION OF EACH LAYER

IRF= 2

WALL COMPOSITION

LAYER NO	L(I)	K(I)	(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.042	.094	50.00	.200	.00	1/2 IN. GYPBOARD
2	.275	.025	2.00	.200	.00	3 1/2 IN. INSULATION
3	.042	.032	20.00	.310	.00	1/2 IN. SHEATHING
4	.031	.050	37.00	.290	.00	3/8 IN. WOOD SIDING

TIME INCREMENT DT = 1.

THERMAL CONDUCTANCE U = .075

RESPONSE FACTORS

J	X	Y	Z
0	.5194	.0231	.6108
1	-.4431	.0459	-.5145
2	-.0015	.0053	-.0203
3	-.0001	.0003	-.0013
4	-.0000	.0000	-.0001
5	-.0000	.0000	-.0000
6	-.0000	.0000	-.0000

COMMON RATIO CR = .06412

II. R-19 Insulation

IRF = 2

WALL COMPOSITION

LAYER NO	L(I)	K(I)	P(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.042	.094	50.00	.200	.00	1/2 IN. GYPBOARD
2	.475	.025	2.00	.200	.00	5 1/2 IN. INSULATION
3	.042	.032	20.00	.310	.00	1/2 IN. SHEATHING
4	.031	.050	37.00	.290	.00	3/8 IN. WOOD SIDING

TIME INCREMENT DT = 1.

THERMAL CONDUCTANCE U = .047

RESPONSE FACTORS

J	X	Y	Z
0	.5144	.0051	.6102
1	-.4603	.0279	-.5259
2	-.0063	.0114	-.0319
3	-.0009	.0021	-.0047
4	-.0002	.0003	-.0008
5	-.0000	.0001	-.0001
6	-.0000	.0000	-.0000
7	-.0000	.0000	-.0000
8	-.0000	.0000	-.0000

COMMON RATIO CR = .16328

Table D-5. Thermo-Physical Properties and Response Factors for the Walls (Stud Area) of the Model House

I. 2 x 4 in. Stud Wall

IRF = 3

WALL COMPOSITION

LAYER No	L(I)	K(I)	(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.042	.094	50.00	.200	.00	1/2 IN. GYPBOARD
2	.302	.070	32.00	.330	.00	2 x 4 STUD
3	.042	.032	20.00	.310	.00	1/2 IN. SHEATHING
4	.031	.050	37.00	.290	.00	3/8 IN. WOOD SIDING

TIME INCREMENT DT = 1.

THERMAL CONDUCTANCE U = .149

RESPONSE FACTORS

J	X	Y	Z
0	1.0397	.0001	.7132
1	-.0324	.0086	-.4130
2	-.0967	.0265	-.0512
3	-.0501	.0285	-.0297
4	-.0321	.0230	-.0199
5	-.0223	.0172	-.0141
6	-.0159	.0125	-.0101
7	-.0114	.0091	-.0073
8	-.0082	.0066	-.0052
9	-.0059	.0047	-.0038
10	-.0043	.0034	-.0027
11	-.0031	.0025	-.0020
12	-.0022	.0018	-.0014
13	-.0016	.0013	-.0010

COMMON RATIO CR = .72330

Table D-5. (continued)

B. 2 x 6 in. Stud Wall

IRF = 3
WALL COMPOSITION

LAYER No		K(I)	(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.042	.094	50.00	.200	.00	1/2 IN. GYPBOARD
2	.458	.070	32.00	.330	.00	2 x 6 STUD
3	???	.032	20.00	.310	.00	1/2 IN. SHEATHING
4	.031	.050	37.00	.290	.00	3/8 IN. WOOD SIDING

TIME INCREMENT DT = 1.
THERMAL CONDUCTANCE U = .112
RESPONSE FACTORS

J	X	Y	Z
0	1.0397	.0000	.7132
1	-.6324	.0003	-.4130
2	-.0965	.0033	-.0512
3	-.0494	.0084	-.0299
4	-.0314	.0114	-.0206
5	-.0223	.0119	-.0154
6	-.0169	.0112	-.0121
7	-.0134	.0100	-.0098
8	-.0108	.0086	-.0080
9	-.0089	.0074	-.0067
10	-.0074	.0063	-.0056
11	-.0062	.0053	-.0047
12	-.0052	.0045	-.0039
13	-.0043	.0037	-.0033
14	-.0036	.0031	-.0027
15	-.0030	.0026	-.0023
16	-.0026	.0022	-.0019
17	-.0021	.0019	-.0016
18	-.0018	.0016	-.0014
19	-.0015	.0013	-.0011
20	-.0013	.0011	-.0010
21	-.0011	.0009	-.0008
22	-.0009	.0008	-.0007

COMMON RATIO CR = .83989

Table D-6. Thermo-Physical Properties and Response Factors for the Slab Floor of the Model House

I. Uninsulated Slab

DATA SHEET NO 7: DESCRIPTION OF EACH LAYER
IRF = 8
FLOOR COMPOSITION

LAYER NO	L(I)	K(I)	(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.000	.000	.00	.000	1.50	CARPET & PADDING
2	.333	1.000	140.00	.200	.00	4 IN. CONCRETE SLAB
3	.333	.750	140.00	.200	.00	4 IN. GRAVEL

TIME INCREMENT DT = 1.
THERMAL CONDUCTANCE U = .439
RESPONSE FACTORS

J	X	Y	Z
0	.6084	.0015	5.1720
1	-.0434	.0325	-3.0014
2	-.0260	.0651	-.4822
3	-.0197	.0636	-.2688
4	-.0157	.0534	-.1945
5	-.0126	.0434	-.1523
6	-.0101	.0350	-.1218
7	-.0081	.0282	-.0979
8	-.0065	.0227	-.0788
9	-.0053	.0183	-.0634
10	-.0042	.0147	-.0510
11	-.0034	.0118	-.0411
12	-.0027	.0095	-.0331

COMMON RATIO CR = .80495

Table D-6. (continued)

II. R-10 Insulated Slab

IRF = 8
FLOOR COMPOSITION

LAYER NO	L(I)	K(I)	(I)	C(I)	RES(I)	DESCRIPTION OF LAYERS
1	.000	.000	.00	.000	1.50	CARPET & PADDING
2	.333	1.000	140.00	.200	.00	4 IN. CONCRETE SLAB
3	.000	.000	.00	.000	10.00	R10 FOAM INSUL
4	.333	.750	140.00	.200	.00	4 IN. GRAVEL

TIME INCREMENT DT = 1.
THERMAL CONDUCTANCE U = .081
RESPONSE FACTORS

J	X	Y	Z
0	.6083	.0000	5.1560
1	-.0471	.0009	-3.2744
2	-.0360	.0028	-.8420
3	-.0330	.0040	-.4434
4	-.0306	.0045	-.2395
5	-.0283	.0046	-.1296
6	-.0262	.0045	-.0703
7	-.0242	.0043	-.0382
8	-.0224	.0041	-.0209
9	-.0208	.0038	-.0116
10	-.0192	.0035	-.0065
11	-.0178	.0033	-.0038
12	-.0165	.0030	-.0023
13	-.0152	.0028	-.0014
14	-.0141	.0026	-.0010
15	-.0131	.0024	-.0007
16	-.0121	.0022	-.0006
17	-.0112	.0021	-.0005
18	-.0104	.0019	-.0004
19	-.0096	.0018	-.0004
20	-.0089	.0016	-.0003
21	-.0082	.0015	-.0003
22	-.0076	.0014	-.0003
23	-.0070	.0013	-.0002
24	-.0065	.0011	-.0002
25	-.0060	.0011	-.0002
26	-.0056	.0010	-.0002
27	-.0052	.0010	-.0002
28	-.0048	.0009	-.0002
29	-.0044	.0008	-.0002
30	-.0041	.0008	-.0001
31	-.0038	.0007	-.0001
32	-.0035	.0007	-.0001
33	-.0032	.0006	-.0001
34	-.0030	.0006	-.0001

COMMON RATIO CR = .92555

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The NBS Load Determination Program (NBSLD) for the calculation of space heating and cooling loads in buildings is a potentially useful tool for the improved thermal design of building envelopes. However, its usefulness is limited because only the net heating and cooling loads are determined. In order to design building envelopes which are to be, from inception, more energy efficient than existing buildings, the thermal performance of the individual envelope elements (e.g., walls, windows, ceilings and floors) must be known and the interrelationships among these components understood. NBSLD-XO is an expanded output version of NBSLD which provides this data on an hourly, daily, monthly and/or annual basis. This report outlines the NBSLD-XO program, format, and output and provides several examples of its use based on a prototypical single-family residential building. A considerable amount of information about the thermal performance of the various envelope elements and their interrelationships is provided as exemplary of the use of the NBSLD-XO computer program.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Building design; thermal performance; HVAC loads; energy conservation; computer analysis; thermal insulation.

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