Conservation and Heat Loss Calculations

WORKSHOP IN

THE PRACTICAL ASPECTS OF

SOLAR SPACE AND DOMESTIC WATER HEATING SYSTEMS

FOR

RESIDENTIAL BUILDINGS

MODULE 3

ENERGY CONSERVATION AND HEAT LOSS CALCULATIONS

SOLAR ENERGY APPLICATIONS LABORATORY

COLORADO STATE UNIVERSITY

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GLOSSARY

BTU	British Thermal Unit. It is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit
Design Temperature	Low temperature expected in the locality
Degree Days (DD)	The temperature difference between a reference temperature, 65°F, and the average of the high and low temperature during a day (°F-days)

Example:

high temperature = 30°F

low temperature = -10°F

average temperature = [30 + (-10)]/2 = 10°F

Degree Days = 65 - 10 = 55°F-days

Design Temperature Difference	The difference between the indoor design temperature and the outdoor design temperature used to calculate heat losses from buildings
Design Heat Loss Rate	The heat loss rate (Btu/hr) from a building based upon the Design Temperature Difference
Building UA	Thermal property of a building which characterizes the rate of heat loss from the building
Average Heating Load	Average heat loss rate from a building based upon long term average outdoor air temperature

INTRODUCTION

Energy conservation in buildings should be considered for every building regardless of the heating method. However, carried to extremes, it will be found that the energy conservation measure will be more expensive than the value of heat saved. To determine if energy conservation measures are economical, heat loss calculations for the building are necessary. Heat loss determinations will also be found useful in determining the fraction of the heating load that can be supplied by solar energy. For these reasons, details of heat transmission characteristics and a simplified heat loss calculation method are described in this module. By making heat loss calculations, comparative effectiveness of energy conservation measures can be readily determined.

OBJECTIVES

Using the material in this module, participants should be able to:

1. Calculate a design heat load for a building and calculate average monthly and annual heating loads.
2. Calculate the percent reduction in heating load obtained by any conservation modification in a building.
3. Identify the level of insulation and weatherization appropriate for a solar building.

HEAT LOSS MECHANISMS

Heat that is transmitted out of a building is called "heat loss". Heat is lost by conduction, convection, and radiation. The first two are the most important heat loss mechanisms although radiation losses also occur from the outside surface of the building to the surroundings.

CONDUCTION

Conduction is the process whereby heat is transferred through solid materials from a region of high temperature to a region of low temperature. Building materials are rated for their resistance to this type of heat transfer by an "R-Value". (A list of R-Values of common materials is listed in Table 3-1.) The best resistance to this type of heat transfer is represented by a vacuum as utilized in the common "Thermos" or vacuum bottle. The next best material is air which is prevented from circulating. Good insulating materials offer resistance to heat loss by confining air in small pockets or bubbles.

CONVECTION

Convection is the process of heat transfer by movement of fluids from areas of high temperature to areas of low temperature. Convection can be classified as free when it occurs without the aid of fans or pumps (as in baseboard convectors used in the home heating), or as forced when fans or pumps are used to move the fluid (as in hot air heating systems). Convective heat transfer occurs at both inside and outside surfaces of the building enclosure and also by a process called infiltration, when cold outside air leaks into a house forcing warm air out of the house.

Table 3-1. Values of R and U for Some Structural and Finish Materials, Glass, Doors, Insulation, Air Spaces and Surface Air Films*

Materials	R/in	R	U
Wood bevel siding, .5 x 8, lapped		0.81	
Wood siding shingles, 16" x 7.5" exposure		0.87	
Asbestos-cement shingles		0.21	
Stucco	0.20		
Building paper		0.06	
1/2" nail-base insulation board sheathing		1.14	
Insulation board sheathing, regular density	0.63		
Plywood	1.24		
1/4" hardboard		0.18	
Softwood board	1.25		
Concrete blocks, 3 oval cores			
Cinder, 4" thick		1.11	
Aggregate, 12" thick		1.89	
8" thick		1.72	
Sand and gravel aggregate, 8" thick		1.11	
Lighweight aggregate, 8" thick		2.00	
Concrete blocks, 2 rectangular cores			
Sand and gravel aggregate, 8" thick		1.04	
Lightweight aggregate, 8" thick		2.18	
Common brick	0.20		
Face brick	0.11		
Sand-and-gravel concrete	0.08		
Gypsumboard (plasterboard)	0.90		
.5" lightweight-aggregate gypsum plaster		0.32	
25/32" hardwood finish flooring		0.68	
Asphalt, linoleum, cinyl, or rubber floor tile		0.05	
Carpet and fibrous pad		2.08	
Carpet and foam rubber pad		1.23	
Asphalt roof shingles		0.44	
Wood roof shingles		0.94	
3/8" built-up roof		0.33	
Basement floor below grade			0.06
Glass			
Single			1.13
Double, 1/4" air space			0.65
1/2" air space			0.58
Triple, 1/4" air spaces			0.47
1/2" air spaces			0.36
Storm Windows, 1-4" air space			0.56

* From ASHRAE Handbook of Fundamentals

Table 3-1 (continued)

Solid Wood Slab Door U-Values:	No Storm Door	Storm Door Wood	Storm Door Metal
1.00" thick	0.64	0.30	0.39
1.25" thick	0.55	0.28	0.34
1.50" thick	0.49	0.27	0.33
2.20" thick	0.43	0.24	0.29

Materials	R/in	R	U
Insulation			
Fiberglass	3.1		
Styrofoam	5.5		
Urethane	6.0		
Fiberglas, 3½"		11.0	
6"		19.0	
Concrete Slab Floors: Use linear feet of exposed length of slab edge in place of A:h=U (lin. ft) ΔT			
1" x 24" insulation			0.21
1" x 12" insulation			0.46
No insulation			0.81
AIR SPACES, 3-4 inches			
Heat Flow Up, Non-reflective		0.87	
Reflective, 1 surface**		2.23	
Heat Flow Down or Horizontal,			
Non reflective		1.01	
Reflective, 1 surface**		3.50	
SURFACE AIR FILMS			
Heat Flow Up, Non-reflective		0.61	
Reflective		1.32	
Heat Flow Down, Non-Reflective		0.92	
Reflective		4.55	
Heat Flow Horizontal			
Through vertical surface, non-reflective		0.68	
Outside (15 mph wind)		0.17	

** The addition of a second reflective surface facing the first reflective surface increases the thermal resistance values of and air space only 4 to 7 percent.

These air leaks are due to poor construction, inadequate weather-stripping and caulking, non-sealing appliance vents, and opening of doors and windows. Wind is the major driving force for infiltration as cold air enters on the windward side of a house and warm air is forced out on the leeward side. Infiltration is also caused by natural convection, or the so-called chimney effect, due to a temperature difference between the inside and outside of a building which produces a flow of cold air into the lower parts of a house and a corresponding loss of warm air from the upper parts of a house.

RADIATION

Radiation is the heat transfer process which occurs when a high temperature body radiates electromagnetic waves (infra-red or light). It is the kind of heat transfer we observe when near a fireplace and is the mechanism by which solar energy is transmitted through space. It is the only type of heat transfer which can occur through a vacuum. Radiation can be minimized through the use of reflective surfaces. In a well-insulated house it is not a major cause for heat loss and the effect is usually included in the "R-Values" for air spaces and surface air films.

HEAT LOSS CALCULATIONS

CONDUCTION HEAT LOSS

Conduction heat loss occurs through all of the components of the building envelope, i.e., walls, ceilings, floors, windows and doors. The rate of heat loss (in Btu/hr) depends upon the area of a given building component, the materials of which it is constructed (and their thickness), and the temperature differences between the inside and outside air. The heat transfer rate for a given building component (for instance. a wall) is given by:

$$h = UA\ (T_R - T_a), \quad \text{(Btu/hr)} \tag{3-1}$$

where

- h is the rate of heat loss, Btu/hr
- U is the heat transfer coefficient of the wall, Btu/(hr•f²•°F)
- A is the area of the wall, ft²
- T_R is the room temperature, °F
- T_a is the outside area temperature, °F.

The heat transfer coefficient U depends upon the materials in the building component and upon their thicknesses. It can be calculated from the thermal resistances or R-values of the elements in the wall by:

$$U = 1/R_T \quad \text{(Btu/(hr•ft}^2\text{•°F)} \tag{3-2}$$

where R_T is the total thermal resistance in hr•ft²•°F/Btu and is the sum of the thermal resistances of the wall elements (sheathing, insulation, siding etc.):

$$R_T = R_1 + R_2 + R_3 + \text{etc.} \quad \text{(Btu/(hr•ft}^2\text{•°F)} \tag{3-3}$$

Thermal resistances (R-values) of common building materials and heat transfer coefficients (U-values) of common building elements are given in Table 3-1. Several features of this table are worth noting. The thermal resistances of common insulating materials are much larger than other building materials and the thermal resistances of well insulated walls and ceilings are therefore primarily due to the insulation. Air layers and surface air films have thermal resistances and R-values depend upon the direction of heat flow and whether or not adjoining surfaces are reflective. Surface air films are thin layers of air which are made immobile by the adjoining solid surface. These surface films exist on the inside and outside of all surfaces exposed to air. Because their thickness depends upon the speed of air movement, film resistances are different for inside and outside surfaces. It should also be noted that from Table 3-1, building materials which are available in various thicknesses are specified by the R-value per inch of thickness.

INFILTRATION HEAT LOSS

Infiltration heat loss occurs when cold outside air leaks into a house displacing warm, heated air. It can be minimized (often inexpensively) by the use of caulking and weather-stripping, sealing of appliance vents, and use of air locks (vestibules) on outside doors. It is the most difficult heat loss to account for accurately. A simplified technique involves an estimate of the number of times each hour that the total volume of inside air is exchanged with outside air. The rate of heat loss by infiltration is given by:

$$h = 0.018\ NV\ (T_R - T_a), \quad \text{(Btu/hr)} \qquad (3\text{-}4)$$

where

0.018 is the volumetric heat capacity of air, Btu/($ft^3 \cdot °F$)

N is the number of air changes per hour

V is the volume of the heated space, ft^3.

In an older poorly sealed house without storm windows or doors, N may be as high as three air changes per hour. For a modern, well-constructed house, N should be about one air change per hour and with extra careful construction and the use of air locks (vestibules) N may be as low as one-half air changes per hour. Life-style of building occupants has a large influence on N due to opening of doors and windows.

FLOOR HEAT LOSS

Building floors are often exposed to ground temperature rather than ambient air temperature and therefore require different calculation techniques depending upon type of building foundation.

Floors Over Unheated Basements or Crawl Spaces

The U-value of the floor is calculated by summing the R-values of the floor materials and using Equation (3-1). The design temperature difference to be used in the quotation is the inside temperature minus the design ambient air temperature. If the floor is over an unheated basement use one-third of design temperature difference in the heat loss calculations. If the floor is over an unvented crawlspace with insulated walls use one-half of the design temperature difference. If the crawlspace is vented or otherwise open to the outside use the design temperature difference.

Concrete Slabs on Grade

The heat loss rate from a concrete slab on grade is calculated on the basis of exposed edge length rather than on floor area. The heat loss rate is:

$$h = U \text{ (linear feet of exposed slab area) } \Delta T \qquad (3\text{-}5)$$

where ΔT is the difference between indoor and average outdoor temperature in degrees Fahrenheit. The U-values for use in Equation (3-5) are listed in Table 3-1.

Heated Basements

Basement floors below grade have a heat loss rate of about 1 Btu/hr for each square foot of floor area. In Table 3-1, for basement walls below grade, $U = 0.06$ Btu/(hr·ft^2·°F). The temperature difference is the indoor temperature minus the ground temperature, and the ground temperature for Colorado can be assumed to be about 45°F in winter. For heated basement walls above grade the heat loss is calculated using the same procedure as any exposed wall.

DESIGN HEAT LOSS RATE AND ANNUAL HEAT LOSS CALCULATIONS

To calculate the design heat loss rate for a building it is necessary to determine the heat transmission rate through all parts of the building envelope and add the infiltration heat loss rate.

The design heat loss rate h_D, is the total building heat loss when the inside temperature (T_R) is at 70°F and the outside temperature is at the design temperature (T_o) for the region in question. These design temperatures have been calculated by the American Society of Heating

Refrigeration and Air Conditioning Engineers (ASHRAE) and are given in Table 3-2.

Also of interest is the heating load per degree day (h_{DD}). This can be calculated from:

$$h_{DD} = \frac{\text{Design heat loss rate x 24}}{(70-T_o)} \ \frac{\text{Btu}}{\text{DD}} \qquad (3\text{-}6)$$

If this heating load per degree day is divided by the heated floor area of the house, a useful measure of the thermal effectiveness of the building envelope is obtained:

$$\text{Envelope Thermal Effectiveness} = \frac{\text{Heating load per DD}}{\text{Heated floor area}} \ \frac{\text{Btu}}{\text{DD ft}^2} \qquad (3\text{-}7)$$

The monthly heating load is calculated by multiplying the heat loss rate per degree day by the number of degree days for the month. It is usually expressed in millions of BTU's (MMBTU):

$$\text{Monthly Heating Load} = \frac{\text{Heating load per DD x Monthly DD}}{1{,}000{,}000} \ \text{MMBtu} \qquad (3\text{-}8)$$

The average monthly degree days are listed for various cities in Table 3-2, and are shown in degree-day maps in Figure 3-1 through Figure 3-12.

The annual heating load, is calculated in similar manner to the monthly heating load except that the annual average degree days is used instead of the monthly degree days.

$$\text{Annual Heating Load} = \frac{\text{Heating load per DD x Annual DD}}{1{,}000{,}000} \ \text{MMBtu.} \qquad (3\text{-}9)$$

Average annual degree days for various cities in the United States are also listed in Table 3-2.

(Test continues on page 3-32)

Table 3-2. Data Values for Heating Load Computations*

STATE AND STATION	NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)													Design T_o °F	
	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.†	SUMM.Π
ALA: Birmingham	0	0	6	93	363	555	592	462	363	108	9	0	2551	19	97
Huntsville	0	0	12	127	426	663	694	557	434	138	19	0	3070	13	97
Mobile	0	0	0	22	213	357	415	300	211	42	0	0	1560	26	95
Montgomery	0	0	0	68	330	527	543	417	316	90	0	0	2291	22	98
ALASKA: Anchorage	245	291	516	930	1284	1572	1631	1316	1293	879	592	315	10864	-25	73
Annette	242	208	327	567	738	899	949	837	843	648	490	321	7069		
Barrow	803	840	1035	1500	1971	2362	2517	2332	2468	1944	1445	957	20174	-45	58
Barter Is.	735	775	987	1482	1944	2337	2536	2369	2477	1923	1373	924	19862		
Bethel	319	394	612	1042	1434	1866	1903	1590	1655	1173	806	402	13196		
Cold Bay	474	425	525	772	918	1122	1153	1036	1122	951	791	591	9880		
Cordova	366	391	522	781	1017	1221	1299	1086	1113	864	660	444	9764		
Fairbanks	171	332	642	1203	1833	2254	2359	1901	1739	1068	555	222	14279	-53	82
Juneau	301	338	483	725	921	1135	1237	1070	1073	810	601	381	9075	- 7	75
King Salmon	313	322	513	908	1290	1606	1600	1333	1411	966	673	408	11343		
Kotzebue	381	446	723	1249	1728	2127	2192	1932	2080	1554	1057	636	16105		
McGrath	208	338	633	1184	1791	2232	2294	1817	1758	1122	648	258	14283		
Nome	481	496	693	1094	1455	1820	1879	1666	1770	1314	930	573	14171	-32	66
Saint Paul	605	539	612	862	963	1197	1228	1168	1265	1098	936	726	11199		
Shemya	577	475	501	784	876	1042	1045	958	1011	885	837	696	9687		
Yakutat	338	347	474	716	936	1144	1169	1019	1042	840	632	435	9092		
ARIZ: Flagstaff	46	68	201	558	867	1073	1169	991	911	651	437	180	7152	0	84
Phoenix	0	0	0	22	234	415	474	328	217	75	0	0	1765	31	108
Prescott	0	0	27	245	579	797	865	711	605	360	158	15	4362	15	96
Tucson	0	0	0	25	231	406	471	344	242	75	6	0	1800	29	105
Winslow	0	0	6	245	711	1008	1054	770	601	291	96	0	4732	9	97
Yuma	0	0	0	0	148	319	363	228	130	29	0	0	1217	37	111
ARK: Fort Smith	0	0	12	127	450	704	781	596	456	144	22	0	3292	15	101
Little Rock	0	0	9	127	465	716	756	577	434	126	9	0	3219	19	99
Texarkana	0	0	0	78	345	561	626	468	350	105	0	0	2533	22	99
CALIF: Bakersfield	0	0	0	37	282	502	546	364	267	105	19	0	2122	31	103
Bishop	0	0	42	248	576	797	874	666	539	306	143	36	4227		
Blue Canyon	34	50	120	347	579	766	865	781	791	582	397	195	5507		
Burbank	0	0	6	43	177	301	366	277	239	138	81	18	1646	36	97

*From Climatic Atlas of the United States, U.S. Department of Commerce, Env. Sci. Serv. Adm. June 1968
†From Table 1, Chapter 33, ASHRAE Handbook of Fundamentals 1972 (99% of time warmer than this temperature)
ΠFrom Table 1, Chapter 33, ASHRAE Handbook of Fundamentals 1972 (1% of time dry bulb temperature is greater)

STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	Design T_o °F WIN.	SUMM.
NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)															
CALIF: Eureka	270	257	258	329	414	499	546	470	505	438	372	285	4643	32	67
Fresno	0	0	0	78	339	558	586	406	319	150	56	0	2492	28	101
Long Beach	0	0	12	40	156	288	375	297	267	168	90	18	1711	36	87
Los Angeles	28	22	42	78	180	291	372	302	288	219	158	81	2061	42	94
Mt. Shasta	25	34	123	406	696	902	983	784	738	525	347	159	5722		
Oakland	53	50	45	127	309	481	527	400	353	255	180	90	2870	35	85
Point Arguello	202	186	162	205	291	400	474	392	403	339	298	243	3595		
Red Bluff	0	0	0	53	318	555	605	428	341	168	47	0	2515		
Sacramento	0	0	12	81	363	577	614	442	360	216	102	6	2773	30	100
Sandberg	0	0	30	202	480	691	778	661	620	426	264	57	4209		
San Diego	6	0	15	37	123	251	313	249	202	123	84	36	1439	42	86
San Francisco	81	78	60	143	306	462	508	395	363	279	214	126	3015	42	80
Santa Catalina	16	0	9	50	165	279	353	308	326	249	192	105	2052		
Santa Maria	99	93	96	146	270	391	459	370	363	282	233	165	2967	32	85
COLO: Alamosa	65	99	279	639	1065	1420	1476	1162	1020	696	440	168	8529	-17	84
Colorado Springs	9	25	132	456	825	1032	1128	938	893	582	319	84	6423	- 1	90
Denver	6	9	117	428	819	1035	1132	938	887	558	288	66	6283	- 2	92
Grand Junction	0	0	30	313	786	1113	1209	907	729	387	146	21	5641	8	96
Pueblo	0	0	54	326	750	986	1085	871	772	429	174	15	5462	- 5	96
CONN: Bridgeport	0	0	66	307	615	986	1079	966	853	510	208	27	5617	4	90
Hartford	0	6	99	372	711	1119	1209	1061	899	495	177	24	6172	1	90
New Haven	0	12	87	347	648	1011	1097	991	871	543	245	45	5897	5	88
DEL: Wilmington	0	0	51	270	588	927	980	874	735	387	112	6	4930	12	93
FLA: Apalachicola	0	0	0	16	153	319	347	260	180	33	0	0	1308		
Daytona Beach	0	0	0	0	75	211	248	190	140	15	0	0	879	32	94
Fort Myers	0	0	0	0	24	109	146	101	62	0	0	0	442	38	94
Jacksonville	0	0	0	12	144	310	332	246	174	21	0	0	1239	29	96
Key West	0	0	0	0	0	28	40	31	9	0	0	0	108	55	90
Lakeland	0	0	0	0	57	164	195	146	99	0	0	0	661	35	95
Miami Beach	0	0	0	0	0	40	56	36	9	0	0	0	141	45	91
Orlando	0	0	0	0	72	198	220	165	105	6	0	0	766	33	96
Pensacola	0	0	0	19	195	353	400	277	183	36	0	0	1463	29	92
Tallahassee	0	0	0	28	198	360	375	286	202	36	0	0	1485	25	96

NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														Design T_o °F	
STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
FLA: Tampa	0	0	0	0	60	171	202	148	102	0	0	0	683	36	92
West Palm Beach	0	0	0	0	6	65	87	64	31	0	0	0	253	40	92
GA: Athens	0	0	12	115	405	632	642	529	431	141	22	0	2929	17	96
Atlanta	0	0	18	127	414	626	639	529	437	168	25	0	2983	18	95
Augusta	0	0	0	78	333	552	549	445	350	90	0	0	2397	20	98
Columbus	0	0	0	87	333	543	552	434	338	96	0	0	2383	23	98
Macon	0	0	0	71	297	502	505	403	295	63	0	0	2136	23	98
Rome	0	0	24	161	474	701	710	577	468	177	34	0	3326	16	97
Savannah	0	0	0	47	246	437	437	353	254	45	0	0	1819	24	96
Thomasville	0	0	0	25	198	366	394	305	208	33	0	0	1529		
IDAHO: Boise	0	0	132	415	792	1017	1113	854	722	438	245	81	5809	4	96
Idaho Falls 46W	16	34	270	623	1056	1370	1538	1249	1085	651	391	192	8475		
Idaho Falls 42NW	16	40	282	648	1107	1432	1600	1291	1107	657	388	192	8760		
Lewiston	0	0	123	403	756	933	1063	815	694	426	239	90	5542	6	98
Pocatello	0	0	172	493	900	1166	1324	1058	905	555	319	141	7033	- 8	94
ILL: Cairo	0	0	36	164	513	791	856	680	539	195	47	0	3821		
Chicago	0	0	81	326	753	1113	1209	1044	890	480	211	48	6155	- 3	94
Moline	0	9	99	335	774	1181	1314	1100	918	450	189	39	6408	- 7	94
Peoria	0	6	87	326	759	1113	1218	1025	849	426	183	33	6025	- 2	94
Rockford	6	9	114	400	837	1221	1333	1137	961	516	236	60	6830	- 7	92
Springfield	0	0	72	291	696	1023	1135	935	769	354	136	18	5429	- 1	95
IND: Evansville	0	0	66	220	606	896	955	767	620	237	68	0	4435	6	96
Fort Wayne	0	9	105	378	783	1135	1178	1028	890	471	189	39	6205	0	93
Indianapolis	0	0	90	316	723	1051	1113	949	809	432	177	39	5699	0	93
South Bend	0	6	111	372	777	1125	1221	1070	933	525	239	60	6439	- 2	92
IOWA: Burlington	0	0	93	322	768	1135	1259	1042	859	426	177	33	6114	- 4	95
Des Moines	0	9	99	363	837	1231	1398	1163	967	489	211	39	6808	- 7	95
Dubuque	12	31	156	450	906	1287	1420	1204	1026	546	260	78	7376	-11	92
Sioux City	0	9	108	369	867	1240	1435	1198	989	483	214	39	6951	-10	96
Waterloo	12	19	138	428	909	1296	1460	1221	1023	531	229	54	7320	-12	91

STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
NORMAL TOTAL HEATING DEGREE DAYS (Base 65^{o})														Design T_o ^{o}F	
KANSAS: Concordia	0	0	57	276	705	1023	1163	935	781	372	149	18	5479		
Dodge City	0	0	33	251	666	939	1051	840	719	354	124	9	4986	3	99
Goodland	0	6	81	381	810	1073	1166	955	884	507	236	42	6141	- 2	99
Topeka	0	0	57	270	672	980	1122	893	722	330	124	12	5182	3	99
Wichita	0	0	33	229	618	905	1023	804	645	270	87	6	4620	5	102
KY: Covington	0	0	75	291	669	983	1035	893	756	390	149	24	5265	3	93
Lexington	0	0	54	239	609	902	946	818	685	325	105	0	4683	6	94
Louisville	0	0	54	248	609	890	930	818	682	315	105	9	4660	8	96
LA: Alexandria	0	0	0	56	273	431	471	361	260	69	0	0	1921	25	97
Baton Rouge	0	0	0	31	216	369	409	294	208	33	0	0	1560	25	96
Burrwood	0	0	0	0	96	214	298	218	171	27	0	0	1024		
Lake Charles	0	0	0	19	210	341	381	274	195	39	0	0	1459	29	95
New Orleans	0	0	0	19	192	322	363	258	192	39	0	0	1385	32	93
Shreveport	0	0	0	47	297	477	552	426	304	81	0	0	2184	22	99
MAINE: Caribou	78	115	336	682	1044	1535	1690	1470	1308	858	468	183	9767	-18	85
Portland	12	53	195	508	807	1215	1339	1182	1042	675	372	111	7511	- 5	88
MD: Baltimore	0	0	48	264	585	905	936	820	679	327	90	0	4654	16	94
Frederick	0	0	66	307	624	955	995	876	741	384	127	12	5087	7	94
MASS: Blue Hill Obsy	0	22	108	381	690	1085	1178	1053	936	579	267	69	6368		
Boston	0	9	60	316	603	983	1088	972	846	513	208	36	5634	6	91
Nantucket	12	22	93	332	573	896	992	941	896	621	384	129	5891		
Pittsfield	25	59	219	524	831	1231	1339	1196	1063	660	326	105	7578	- 1	86
Worcester	6	34	147	450	774	1172	1271	1123	998	612	304	78	6969	1	89
MICH: Alpena	68	105	273	580	912	1268	1404	1299	1218	777	446	156	8506	- 5	87
Detroit (City)	0	0	87	360	738	1088	1181	1058	936	522	220	42	6232	4	92
Escanaba	59	87	243	539	924	1293	1445	1296	1203	777	456	159	8481	- 7	82
Flint	16	40	159	465	843	1212	1330	1198	1066	639	319	90	7377	- 1	89
Grand Rapids	9	28	135	434	804	1147	1259	1134	1011	549	279	75	6894	2	91
Lansing	6	22	138	431	813	1163	1262	1142	1011	579	273	69	6909	2	89
Marquette	59	81	240	527	936	1268	1411	1268	1187	771	468	177	8393	- 8	88
Muskegon	12	28	120	400	762	1088	1209	1100	995	594	310	78	6696	4	87
Sault Ste. Marie	96	105	279	580	951	1367	1525	1380	1277	810	477	201	9048	-12	83

NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														Design T_o °F	
STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
MINN: Duluth	71	109	330	632	1131	1581	1745	1518	1355	840	490	198	10000	-19	85
Internat'l Falls	71	112	363	701	1236	1724	1919	1621	1414	828	443	174	10606	-29	86
Minneapolis	22	31	189	505	1014	1454	1631	1380	1166	621	288	81	8382	-14	92
Rochester	25	34	186	474	1005	1438	1593	1366	1150	630	301	93	8295	-17	90
Saint Cloud	28	47	225	549	1065	1500	1702	1445	1221	666	326	105	8879	-20	90
MISS: Jackson	0	0	0	65	315	502	546	414	310	87	0	0	2239	21	98
Meridian	0	0	0	81	339	518	543	417	310	81	0	0	2289	20	97
Vicksburg	0	0	0	53	279	462	512	384	282	69	0	0	2041	23	97
MO: Columbia	0	0	54	251	651	967	1076	874	716	324	121	12	5046	2	97
Kansas	0	0	39	220	612	905	1032	818	682	294	109	0	4711	4	100
St. Joseph	0	6	60	285	708	1039	1172	949	769	348	133	15	5484	- 1	97
St. Louis	0	0	60	251	627	936	1026	848	704	312	121	15	4900	7	96
Springfield	0	0	45	223	600	877	973	781	660	291	105	6	4561	5	97
MONT: Billings	6	15	186	487	897	1135	1296	1100	970	570	285	102	7049	-10	94
Glasgow	31	47	270	608	1104	1466	1711	1439	1187	648	335	150	8996	-25	96
Great Falls	28	53	258	543	921	1169	1349	1154	1063	642	384	186	7750	-20	91
Havre	28	53	306	595	1065	1367	1584	1364	1181	657	338	162	8700	-22	91
Helena	31	59	294	601	1002	1265	1438	1170	1042	651	381	195	8129	-17	90
Kalispell	50	99	321	654	1020	1240	1401	1134	1029	639	397	207	8191	- 7	88
Miles City	6	6	174	502	972	1296	1504	1252	1057	579	276	99	7723	-19	97
Missoula	34	74	303	651	1035	1287	1420	1120	970	621	391	219	8125	- 7	92
NEBR: Grand Island	0	6	108	381	834	1172	1314	1089	908	462	211	45	6530	- 6	98
Lincoln	0	6	75	301	726	1066	1237	1016	834	402	171	30	5864	- 4	100
Norfolk	9	0	111	397	873	1234	1414	1179	983	498	233	48	6979	-11	97
North Platte	0	6	123	440	885	1166	1271	1039	930	519	248	57	6684	- 6	97
Omaha	0	12	105	357	828	1175	1355	1126	939	465	208	42	6612	- 5	97
Scottsbluff	0	0	138	459	876	1128	1231	1008	921	552	285	75	6673	- 8	96
Valentine	9	12	165	493	942	1237	1395	1176	1045	579	288	84	7425		
NEV: Elko	9	34	225	561	924	1197	1314	1036	911	621	409	192	7433	-13	94
Ely	28	43	234	592	939	1184	1308	1075	977	672	456	225	7733	- 6	90
Las Vegas	0	0	0	78	387	617	688	487	335	111	6	0	2709	23	103
Reno	43	87	204	490	801	1026	1073	823	729	510	357	189	6332	12	94
Winnemucca	0	34	210	536	876	1091	1172	916	837	573	363	153	6761	1	97

NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														Design T_o °F	
STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
NH: Concord	6	50	177	505	822	1240	1358	1184	1032	636	298	75	7383	-11	91
Mt. Wash. Obsy.	493	536	720	1057	1341	1742	1820	1663	1652	1260	930	603	13817		
NJ: Atlantic City	0	0	39	251	549	880	936	848	741	420	133	15	4812	14	91
Newark	0	0	30	248	573	921	983	876	729	381	118	0	4859	11	94
Trenton	0	0	57	264	576	924	989	885	753	399	121	12	4980	12	92
NM: Albuquerque	0	0	12	229	642	868	930	703	595	288	81	0	4348	14	96
Clayton	0	6	66	310	699	899	986	812	747	429	183	21	5158		
Raton	9	28	126	431	825	1048	1116	904	834	543	301	63	6228	- 2	92
Roswell	0	0	18	202	573	806	840	641	481	201	31	0	3793	16	101
Silver City	0	0	6	183	525	729	791	605	581	261	87	0	3705	14	95
NY: Albany	0	19	138	440	777	1194	1311	1156	992	564	239	45	6875	1	91
Binghamton (AP)	22	65	201	471	810	1184	1277	1154	1045	645	313	99	7286	- 2	91
Binghamton (PO)	0	28	141	406	732	1107	1190	1081	949	543	229	45	6451		
Buffalo	19	37	141	440	777	1156	1256	1145	1039	645	329	78	7062	- 5	90
Central Park	0	0	30	233	540	902	986	885	760	408	118	9	4871	11	94
JF Kennedy Intl.	0	0	36	248	564	933	1029	935	815	480	167	12	5219	17	91
LaGuardia	0	0	27	223	528	887	973	879	750	414	124	6	4811	12	93
Rochester	9	31	126	415	747	1125	1234	1123	1014	597	279	48	6748	2	91
Schenectady	0	22	123	422	756	1159	1283	1131	970	543	211	30	6650	- 5	90
Syracuse	6	28	132	415	744	1153	1271	1140	1004	570	248	45	6756	- 2	90
NC: Asheville	0	0	48	245	555	775	784	683	592	273	87	0	4042	13	91
Cape Hatteras	0	0	0	78	273	521	580	518	440	177	25	0	2612		
Charlotte	0	0	6	124	438	691	691	582	481	156	22	0	3191	18	96
Greensboro	0	0	33	192	513	778	784	672	552	234	47	0	3805	14	94
Raleigh	0	0	21	164	450	716	725	616	487	180	34	0	3393	16	95
Wilmington	0	0	0	74	291	521	546	462	357	96	0	0	2347	23	94
Winston Salem	0	0	21	171	483	747	753	652	524	207	37	0	3595	14	94
N. DAK: Bismarck	34	28	222	577	1083	1463	1708	1442	1203	645	329	117	8851	-24	95
Devils Lake	40	53	273	642	1191	1634	1872	1579	1345	753	381	138	9901	-23	93
Fargo	28	37	219	574	1107	1569	1789	1520	1262	690	332	99	9226	-22	92
Williston	31	43	261	601	1122	1513	1758	1473	1262	681	357	141	9243	-21	94

NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														Design T_o °F	
STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
OHIO: Akron	0	9	96	381	726	1070	1138	1016	871	489	202	39	6037	1	89
Cincinnati	0	0	54	248	612	921	970	837	701	336	118	9	4806	8	94
Cleveland	9	25	105	384	738	1088	1159	1047	918	552	260	66	6351	2	91
Columbus	0	6	84	347	714	1039	1088	949	809	426	171	27	5660	2	92
Dayton	0	6	78	310	696	1045	1097	955	809	429	167	30	5622	0	92
Mansfield	9	22	114	397	768	1110	1169	1042	924	543	245	60	6403	1	91
Sandusky	0	6	66	313	684	1032	1107	991	868	495	198	36	5796	4	92
Toledo	0	16	117	406	792	1138	1200	1056	924	543	242	60	6494	1	92
Youngstown	6	19	120	412	771	1104	1169	1047	921	540	248	60	6417	1	89
OKLA: Oklahoma City	0	0	15	164	498	766	868	664	527	189	34	0	3725	11	100
Tulsa	0	0	18	158	522	787	893	683	539	213	47	0	3860	12	102
OREG: Astoria	146	130	210	375	561	679	753	622	636	480	363	231	5186	27	79
Burns	12	37	210	515	867	1113	1246	988	856	570	366	177	6957		
Eugene	34	34	129	366	585	719	803	627	589	426	279	135	4726	22	91
Meacham	84	124	288	580	918	1091	1209	1005	983	726	527	339	7874		
Medford	0	0	78	372	678	871	918	697	642	432	242	78	5008	21	98
Pendleton	0	0	111	350	711	884	1017	773	617	396	205	63	5127	3	97
Portland	25	28	114	335	597	735	825	644	586	396	245	105	4635	26	91
Roseburg	22	16	105	329	567	713	766	608	570	405	267	123	4491	25	93
Salem	37	31	111	338	594	729	822	647	611	417	273	144	4754	21	92
Sexton Summit	81	81	171	443	666	874	958	809	818	609	465	279	6524		
PA: Allentown	0	0	90	353	693	1045	1116	1002	849	471	167	24	5810	3	92
Erie	0	25	102	391	714	1063	1169	1081	973	585	288	60	6451	7	88
Harrisburg	0	0	63	298	648	992	1045	907	766	396	124	12	5251	9	92
Philadelphia	0	0	60	291	621	964	1014	890	744	390	115	12	5101	11	93
Pittsburgh	0	9	105	375	726	1063	1119	1002	874	480	195	39	5987	7	90
Reading	0	0	54	257	597	939	1001	885	735	372	105	0	4945	6	92
Scranton	0	19	132	434	762	1104	1156	1028	893	498	195	33	6254	2	89
Williamsport	0	9	111	375	717	1073	1122	1002	856	468	177	24	5934	1	91
RI: Block Island	0	16	78	307	594	902	1020	955	877	612	344	99	5804		
Providence	0	16	96	372	660	1023	1110	988	868	534	236	51	5954	6	89

STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	Design T_o °F WIN.	SUMM.
	NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														
SC: Charleston	0	0	0	59	282	471	487	389	291	54	0	0	2033	26	95
Columbia	0	0	0	84	345	577	570	470	357	81	0	0	2484	20	98
Florence	0	0	0	78	315	552	552	459	347	84	0	0	2387	21	96
Greenville	0	0	0	112	387	636	648	535	434	120	12	0	2884	19	95
Spartanburg	0	0	15	130	417	667	663	560	453	144	25	0	3074	18	95
S. DAK: Huron	9	12	165	508	1014	1432	1628	1355	1125	600	288	87	8223	-16	97
Rapid City	22	12	165	481	897	1172	1333	1145	1051	615	326	126	7345	- 9	96
Sioux Falls	19	25	168	462	972	1361	1544	1285	1082	573	270	78	7839	-14	95
TENN: Bristol	0	0	51	236	573	828	828	700	598	261	68	0	4143	11	92
Chattanooga	0	0	18	143	468	698	722	577	453	150	25	0	3254	15	97
Knoxville	0	0	30	171	489	725	732	613	493	198	43	0	3494	13	95
Memphis	0	0	18	130	447	698	729	585	456	147	22	0	3232	17	98
Nashville	0	0	30	158	495	732	778	644	512	189	40	0	3578	12	97
Oak Ridge (CO)	0	0	39	192	531	772	778	669	552	228	56	0	3817		
TEXAS: Abilene	0	0	0	99	366	586	642	470	347	114	0	0	2624	17	101
Amarillo	0	0	18	205	570	797	877	664	546	252	56	0	3985	8	98
Austin	0	0	0	31	225	388	468	325	223	51	0	0	1711	25	101
Brownsville	0	0	0	0	66	149	205	106	74	0	0	0	600	36	94
Corpus Christi	0	0	0	0	120	220	291	174	109	0	0	0	914	32	95
Dallas	0	0	0	62	321	524	601	440	319	90	6	0	2363	19	101
El Paso	0	0	0	84	414	648	685	445	319	105	0	0	2700	21	100
Fort Worth	0	0	0	65	324	536	614	448	319	99	0	0	2405	20	102
Galveston	0	0	0	0	138	270	350	258	189	30	0	0	1235	32	91
Houston	0	0	0	6	183	307	384	288	192	36	0	0	1396	29	96
Laredo	0	0	0	0	105	217	267	134	74	0	0	0	797	32	103
Lubbock	0	0	18	174	513	744	800	613	484	201	31	0	3578	11	99
Midland	0	0	0	87	381	592	651	468	322	90	0	0	2591	19	100
Port Arthur	0	0	0	22	207	329	384	274	192	39	0	0	1447	29	94
San Angelo	0	0	0	68	318	536	567	412	288	66	0	0	2255	20	101
San Antonio	0	0	0	31	207	363	428	286	195	39	0	0	1549	25	99
Victoria	0	0	0	6	150	270	344	230	152	21	0	0	1173	28	98
Waco	0	0	0	43	270	456	536	389	270	66	0	0	2030	21	101
Wichita Falls	0	0	0	99	381	632	698	518	378	120	6	0	2832	15	103

NORMAL TOTAL HEATING DEGREE DAYS (Base 65°)														Design T_o °F	
STATE AND STATION	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANNUAL	WIN.	SUMM.
UTAH: Milford	0	0	99	443	867	1141	1252	988	822	519	279	87	6497		
Salt Lake City	0	0	81	419	849	1082	1172	910	763	459	233	84	6052	5	97
Wendover	0	0	48	372	822	1091	1178	902	729	408	177	51	4778		
VT: Burlington	28	65	207	539	891	1349	1513	1333	1187	714	353	90	8269	-12	88
VA: Cape Henry	0	0	0	112	360	645	694	633	536	246	53	0	3279		
Lynchburg	0	0	51	223	540	822	849	731	605	267	78	0	4166	15	94
Norfolk	0	0	0	136	408	698	738	655	533	216	37	0	3421	20	94
Richmond	0	0	36	214	495	784	815	703	546	219	53	0	3865	14	96
Roanoke	0	0	51	229	549	825	834	722	614	261	65	0	4150	15	94
Wash. Nat'l AP	0	0	33	217	519	834	871	762	626	288	74	0	4224		
WASH: Olympia	68	71	198	422	636	753	834	675	645	450	307	177	5236	21	85
Seattle	50	47	129	329	543	657	738	599	577	396	242	177	4424	23	82
Seattle Boeing	34	40	147	384	624	763	831	655	608	411	242	99	4838		
Seattle Tacoma	56	62	162	391	633	750	828	678	657	474	295	159	5145	20	85
Spokane	9	25	168	493	879	1082	1231	980	834	531	288	135	6655	- 2	93
Stampede Pass	273	291	393	701	1008	1178	1287	1075	1085	855	654	483	9283		
Tatoosh Island	295	279	306	406	534	639	713	613	645	525	431	333	5719		
Walla Walla	0	0	87	310	681	843	986	745	589	342	177	45	4805	12	98
Yakima	0	12	144	450	828	1039	1163	868	713	435	220	69	5941	6	94
W. VA: Charleston	0	0	63	254	591	865	880	770	648	330	96	9	4476	9	92
Elkins	9	25	135	400	729	992	1008	896	791	444	198	48	5675	1	87
Huntington	0	0	63	257	585	856	880	764	636	294	99	12	4446	10	95
Parkersburg	0	0	60	264	606	905	942	826	691	339	115	6	4754	8	93
WIS: Green Bay	28	50	174	484	924	1333	1494	1313	1141	654	335	99	8029	-12	88
La Crosse	12	19	153	437	924	1339	1504	1277	1070	540	245	69	7589	-12	90
Madison	25	40	174	474	930	1330	1473	1274	1113	618	310	102	7863	- 9	92
Milwaukee	43	47	174	471	876	1252	1376	1193	1054	642	372	135	7635	- 6	90
WYO: Casper	6	16	192	524	942	1169	1290	1084	1020	657	381	129	7410	-11	92
Cheyenne	19	31	210	543	924	1101	1228	1056	1011	672	381	102	7278	- 6	89
Lander	6	19	204	555	1020	1299	1417	1145	1017	654	381	153	7870	-16	92
Sheridan	25	31	219	538	948	1200	1355	1154	1054	642	366	150	7683	-12	95

Figure 3-1

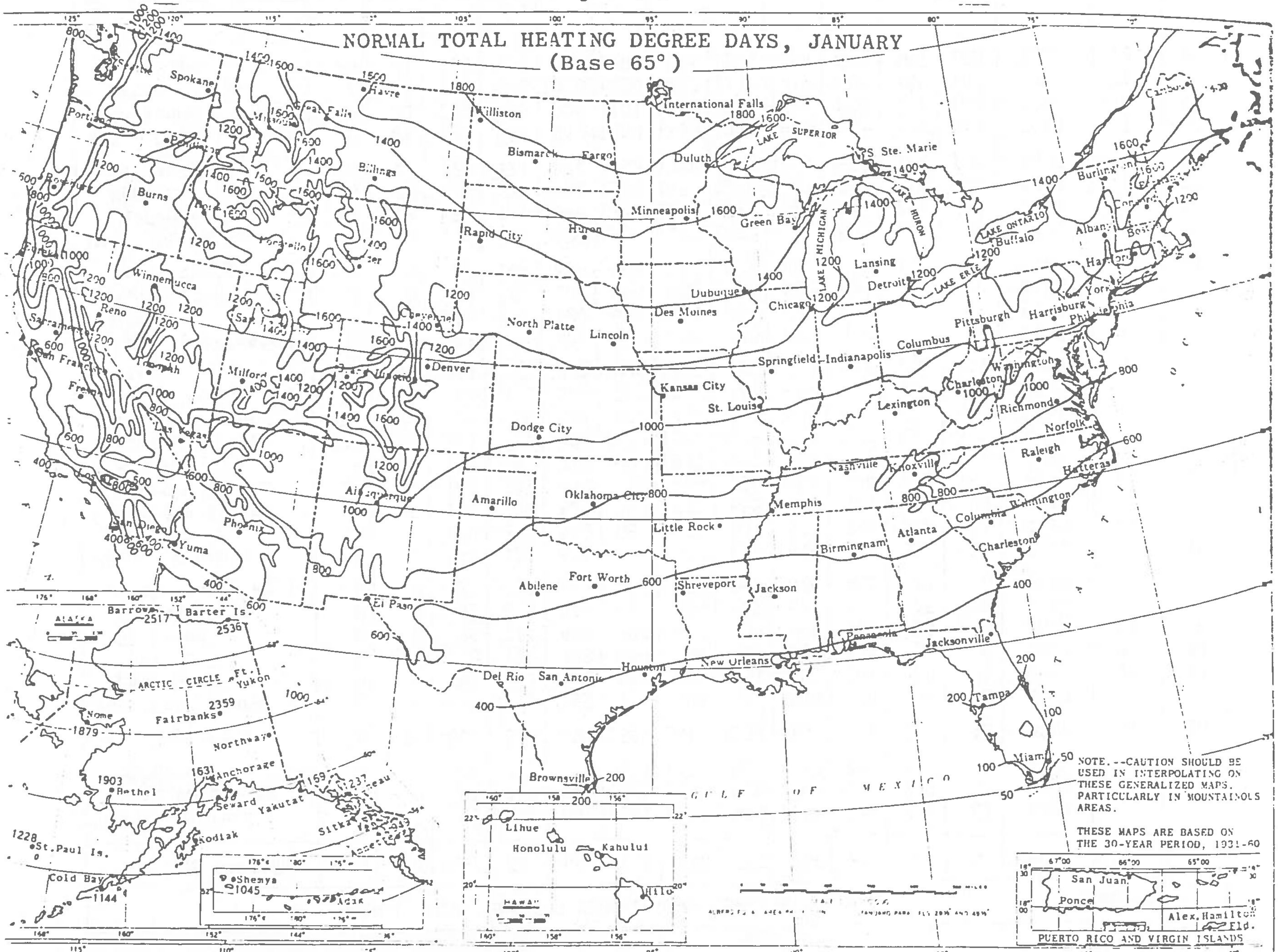
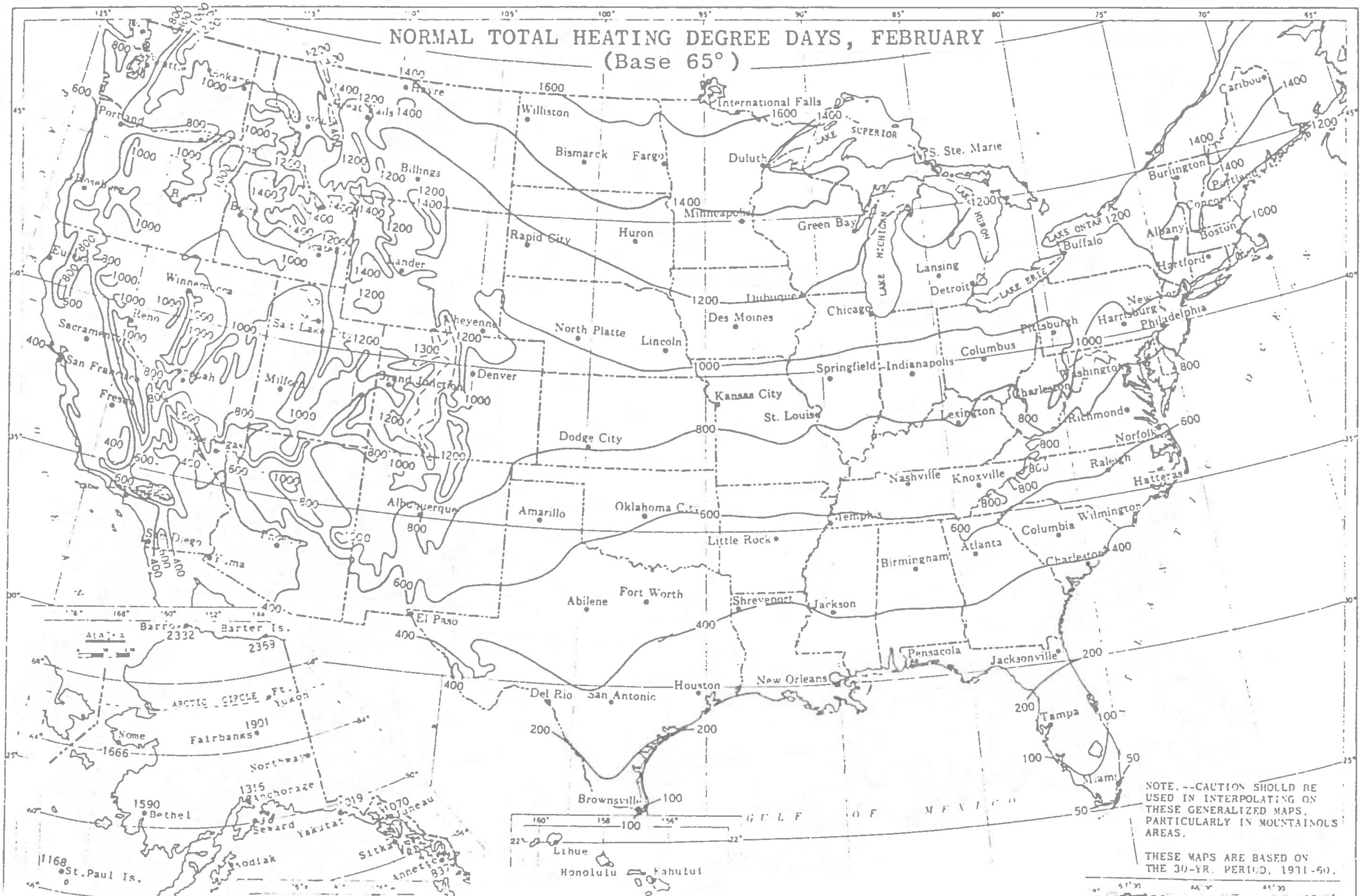

NORMAL TOTAL HEATING DEGREE DAYS, JANUARY
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YEAR PERIOD, 1931-60
Spokane
Portland
Burns
Winnemucca
Reno
Sacramento
Fresno
Las Vegas
San Diego
Yuma
Phoenix
Havre
Billings
Williston
Bismarck
Fargo
Rapid City
Huron
International Falls
Duluth
Minneapolis
Green Bay
Lansing
Detroit
Buffalo
Albany
Boston
Burlington
Caribou
Cheyenne
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
New York
Philadelphia
Washington
Charleston
Richmond
Norfolk
Kansas City
St. Louis
Lexington
Dodge City
Amarillo
Oklahoma City
Nashville
Knoxville
Raleigh
Hatteras
Wilmington
Memphis
Little Rock
Albuquerque
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Atlanta
Columbia
Charleston
Jacksonville
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
Miami
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Barrow
2517
Barter Is.
2536
ARCTIC CIRCLE
Ft. Yukon
Fairbanks
2359
Nome
1879
Northway
Anchorage
1631
Bethel
1903
Seward
Yakutat
Kodiak
Sitka
St. Paul Is.
1228
Cold Bay
1144
Shemya
1045
Adak
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

Figure 3-2



NORMAL TOTAL HEATING DEGREE DAYS, FEBRUARY
(Base 65°)
Havre
Williston
International Falls
Bismarck
Fargo
Duluth
S. Ste. Marie
Billings
Minneapolis
Green Bay
Rapid City
Huron
Lander
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Salt Lake City
Milford
Grand Junction
Denver
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Buffalo
Burlington
Caribou
Portland
Concord
Albany
Boston
Hartford
New York
Harrisburg
Philadelphia
Pittsburgh
Columbus
Springfield
Indianapolis
Kansas City
St. Louis
Lexington
Charleston
Washington
Richmond
Norfolk
Dodge City
Amarillo
Oklahoma City
Nashville
Knoxville
Raleigh
Hatteras
Albuquerque
Memphis
Little Rock
Birmingham
Atlanta
Columbia
Wilmington
Charleston
San Diego
Yuma
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
Barrow 2332
Barter Is. 2359
ARCTIC CIRCLE
Ft. Yukon
Nome 1666
Fairbanks 1901
Northway
Anchorage 1315
Bethel 1590
Seward
Yakutat
Juneau 1070
Sitka
Annette 837
Kodiak
St. Paul Is. 1168
Lihue
Honolulu
Kahului
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.

Figure 3-3


NORMAL TOTAL HEATING DEGREE DAYS, MARCH
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.
International Falls
Williston
Bismarck
Duluth
Minneapolis
Green Bay
Rapid City
Huron
Dubuque
Chicago
Des Moines
Lansing
Detroit
Buffalo
Burlington
Concord
Albany
Boston
Hartford
New York
Harrisburg
Philadelphia
Pittsburgh
Columbus
North Platte
Lincoln
Cheyenne
Denver
Kansas City
St. Louis
Springfield
Indianapolis
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Dodge City
Nashville
Knoxville
Amarillo
Oklahoma City
Memphis
Little Rock
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Houston
New Orleans
Del Rio
San Antonio
Tampa
Miami
Brownsville
Portland
Burns
Winnemucca
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
Grand Junction
Great Falls
Havre
Spokane
Caribou
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
ALASKA
Barrow 2468
Barter Is. 2477
ARCTIC CIRCLE
Ft. Yukon
Nome 1770
Fairbanks 1739
Northway
Bethel 1655
Anchorage 1233
Seward
Yakutat 1042
Juneau 1073
Sitka
Annette 843
Kodiak
St. Paul Is. 1265
Cold Bay 1132
Shemya 995
Adak
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

Figure 3-4

NORMAL TOTAL HEATING DEGREE DAYS, APRIL
(Base 65°)
Spokane
Portland
Eureka
Reno
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Havre
Great Falls
Billings
Salt Lake
Milford
Lander
Cheyenne
Denver
Grand Junction
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Dubuque
Kansas City
St. Louis
Little Rock
Shreveport
Jackson
Memphis
New Orleans
Green Bay
Chicago
Springfield
Indianapolis
Lansing
Detroit
Columbus
Lexington
Nashville
Knoxville
Birmingham
Atlanta
Pensacola
Jacksonville
Miami
Sault Ste. Marie
Pittsburgh
Harrisburg
Philadelphia
New York
Washington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Buffalo
Albany
Hartford
Boston
Concord
Burlington
Portland
Caribou
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
ALASKA
Barrow
1944
Barter Is.
1923
ARCTIC CIRCLE
Ft. Yukon
Nome
1314
Fairbanks
1068
Northway
879
Anchorage
1173
Bethel
Seward
Yakutat
Juneau
1098
St. Paul Is.
Kodiak
Sitka
Annette
663
Cold Bay
351
Shemya
885
Adak
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.

Figure 3-5

NORMAL TOTAL HEATING DEGREE DAYS, MAY
(Base 65°)
Spokane
Havre
Great Falls
Williston
Bismarck
Fargo
International Falls
Duluth
LAKE SUPERIOR
S. Ste. Marie
Billings
Minneapolis
Green Bay
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Caribou
Burlington
Portland
Concord
Albany
Boston
Hartford
Buffalo
Lansing
Detroit
Rapid City
Huron
Pocatello
Lander
Eureka
Reno
Salt Lake
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Pittsburgh
Harrisburg
New York
Philadelphia
Sacramento
San Francisco
Fresno
Tonopah
Milford
Grand Junction
Denver
Springfield
Indianapolis
Columbus
Washington
Charleston
Kansas City
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Raleigh
Nashville
Knoxville
Hatteras
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
Columbia
Little Rock
Atlanta
Birmingham
Charleston
Phoenix
Yuma
San Diego
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
ALASKA
Barrow 1445
Barter Is.
1373
ARCTIC CIRCLE
Ft. Yukon
Fairbanks 555
Nome
930
Northway
Anchorage 592
Bethel 806
Seward
Yakutat 632
Juneau 601
Kodiak
Sitka
Annette 505
St. Paul Is. 936
Cold Bay 791
Adak
Lihue
Honolulu
Kahului
Hilo
HAWAII
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE THE 30-YR. PERIOD, 1931-60.

Figure 3-6

3-25

Figure 3-7

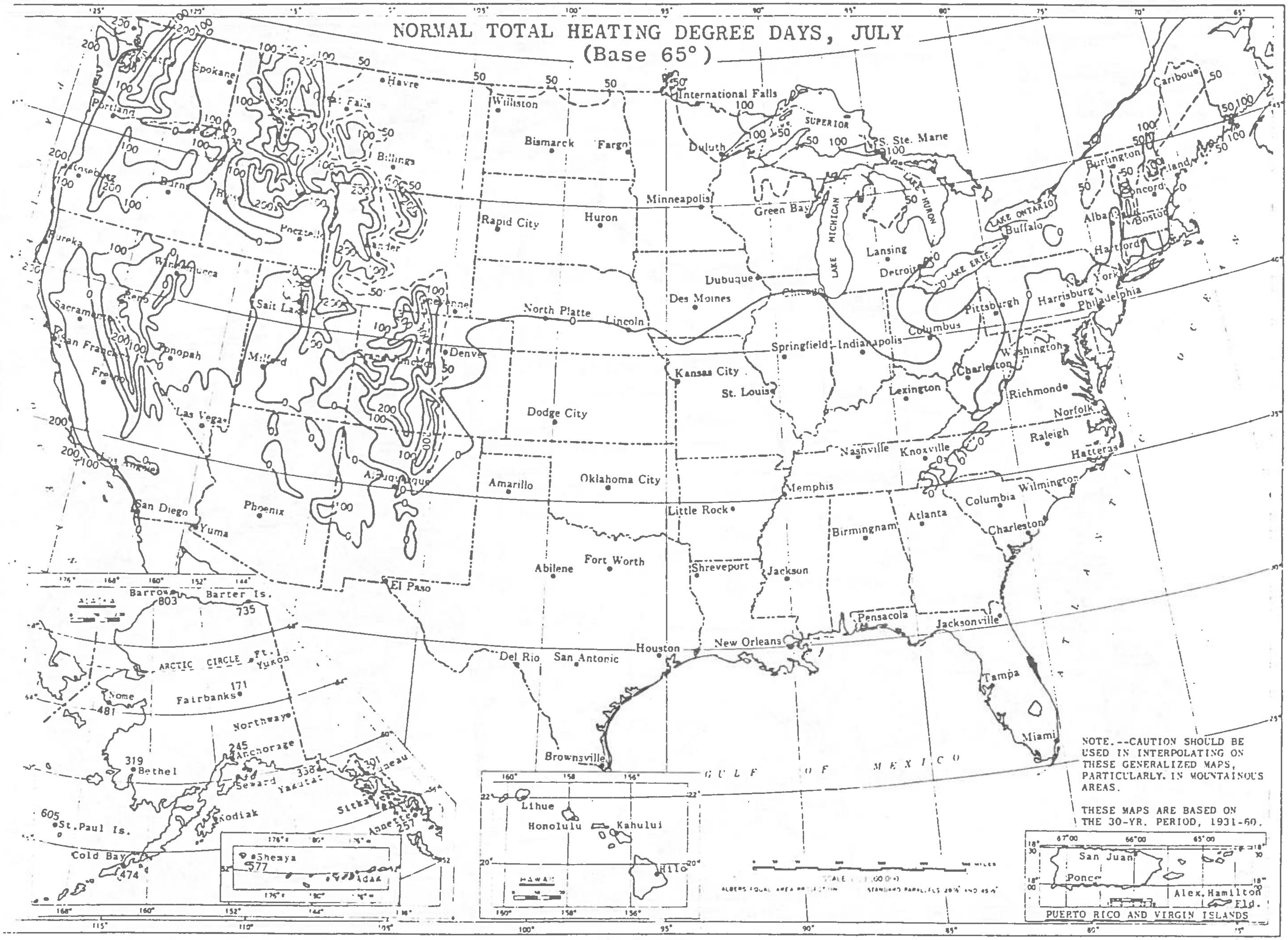

NORMAL TOTAL HEATING DEGREE DAYS, JULY
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.
GULF OF MEXICO
PUERTO RICO AND VIRGIN ISLANDS
Barrow 803
Barter Is. 735
Fairbanks 171
Nome 481
Bethel 319
Anchorage 245
St. Paul Is. 605
Cold Bay 474
Shemya 577
Annette 257
Yakutat 338
Juneau 301
International Falls
Minneapolis
Kansas City
St. Louis
New Orleans
Houston
Miami
Havre
Williston
Bismarck
Fargo
Duluth
Spokane
Portland
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Detroit
Lansing
Buffalo
Albany
Boston
Concord
Hartford
Philadelphia
Harrisburg
Pittsburgh
Columbus
Indianapolis
Springfield
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Charleston
Columbia
Atlanta
Birmingham
Jackson
Memphis
Nashville
Knoxville
Lexington
Little Rock
Shreveport
Oklahoma City
Dodge City
Amarillo
Abilene
Fort Worth
El Paso
Del Rio
San Antonio
Brownsville
Pensacola
Jacksonville
Tampa
Phoenix
Yuma
San Diego
Las Vegas
Fresno
Sacramento
Reno
Tonopah
Milford
Salt Lake
Cheyenne
Rapid City
Huron
Green Bay
Caribou
Burlington
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.

Figure 3-8

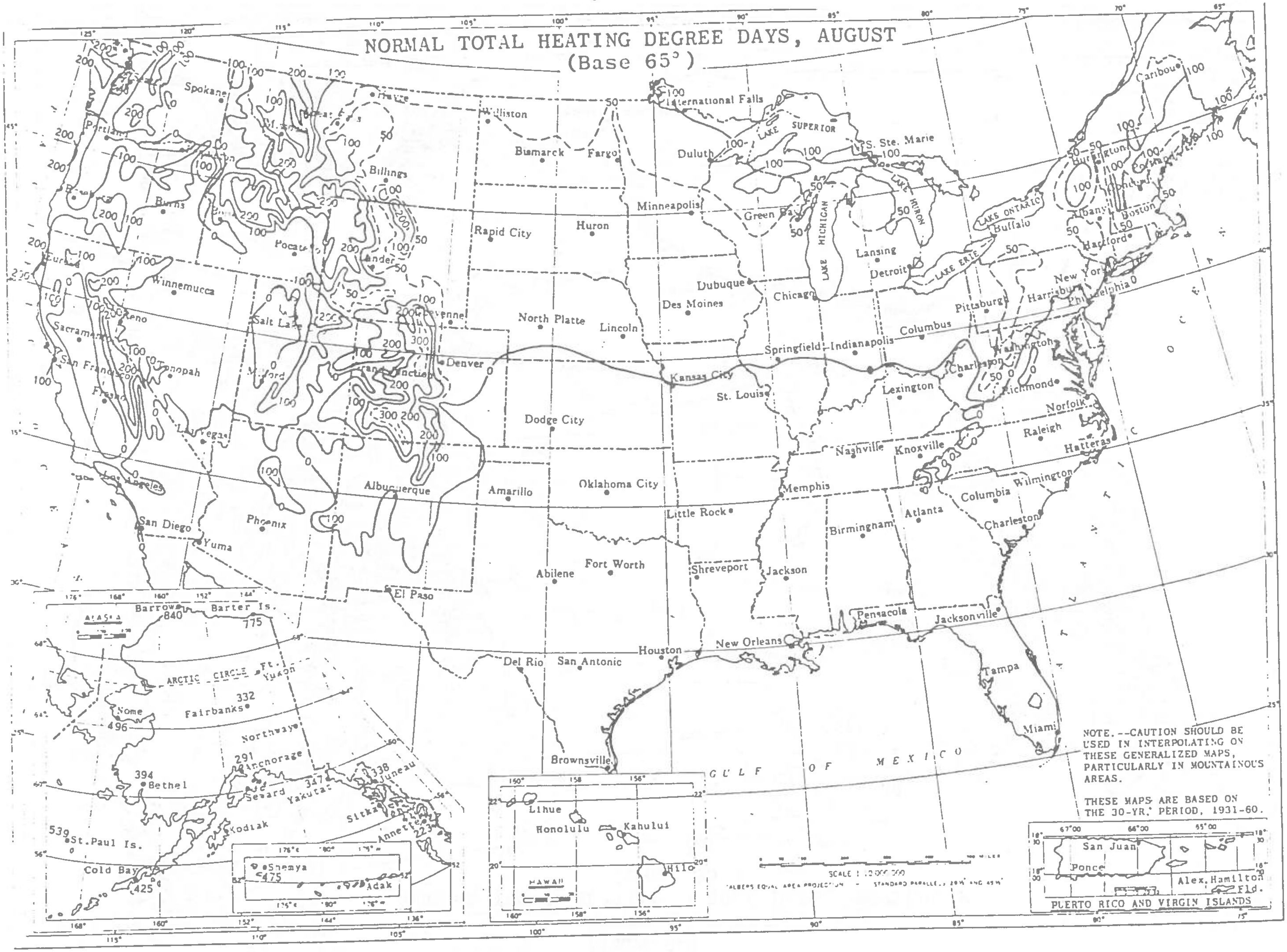
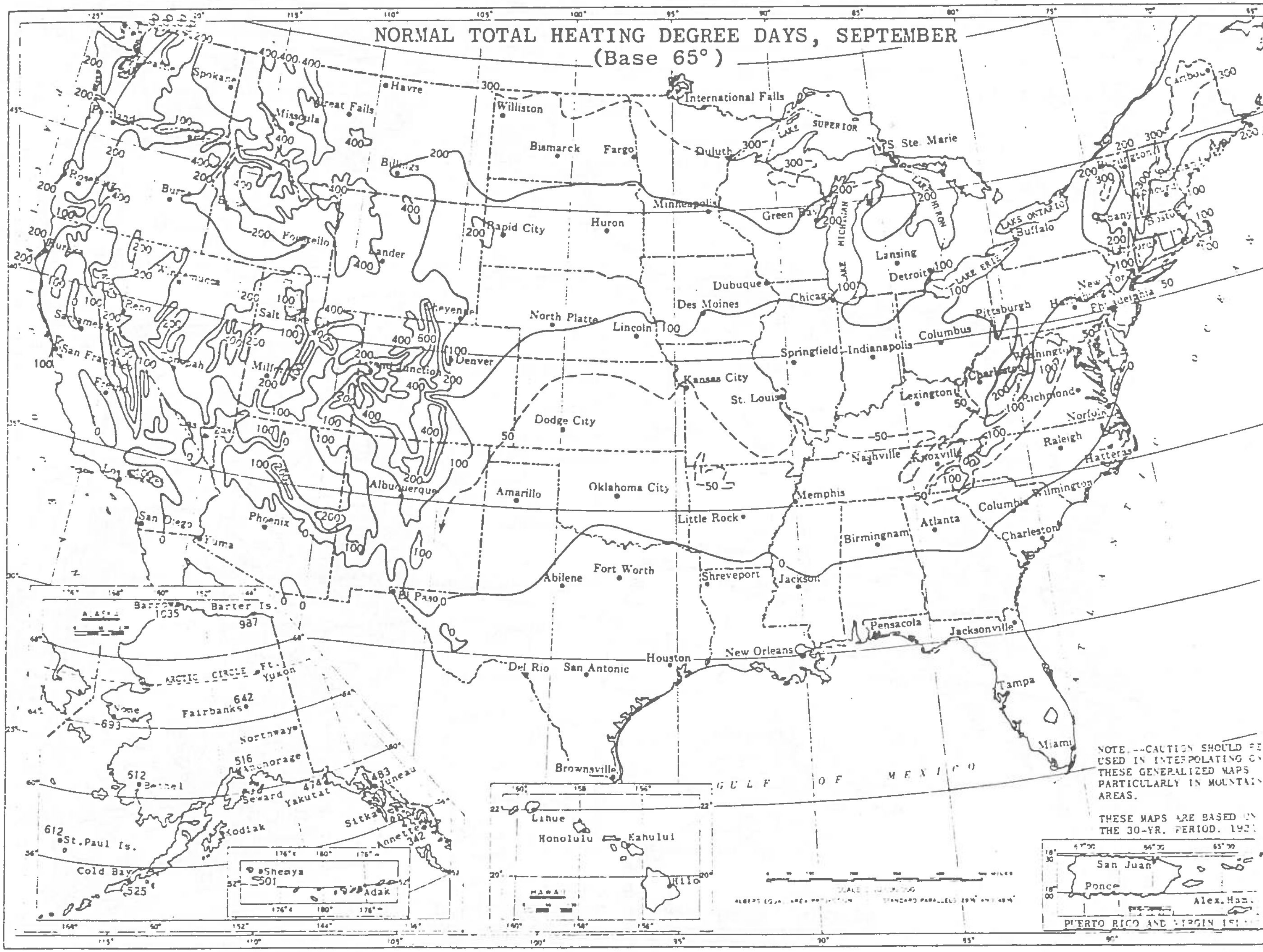

NORMAL TOTAL HEATING DEGREE DAYS, AUGUST
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.
Spokane
Portland
Burns
Eureka
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Los Angeles
San Diego
Yuma
Phoenix
Salt Lake
Milford
Grand Junction
Denver
Cheyenne
Billings
Pocatello
Lander
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Dubuque
Kansas City
St. Louis
Little Rock
Shreveport
Jackson
Memphis
Nashville
Green Bay
Chicago
Springfield
Indianapolis
Lansing
Detroit
Columbus
Lexington
S. Ste. Marie
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
Buffalo
Pittsburgh
Harrisburg
Philadelphia
New York
Hartford
Boston
Albany
Burlington
Concord
Portland
Caribou
Washington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Knoxville
Atlanta
Birmingham
Pensacola
Jacksonville
New Orleans
Tampa
Miami
GULF OF MEXICO
ALASKA
Barrow 840
Barter Is. 775
ARCTIC CIRCLE
Ft. Yukon
Nome 496
Fairbanks 332
Northway
291 Anchorage
394 Bethel
Seward
347 Yakutat
338 Juneau
Sitka
Annette 223
Kodiak
539 St.Paul Is.
Cold Bay 425
Shemya 475
Adak
Lihue
Honolulu
Kahului
Hilo
HAWAII
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION

Figure 3-9



NORMAL TOTAL HEATING DEGREE DAYS, SEPTEMBER
(Base 65°)
Spokane
Havre
Great Falls
Missoula
Williston
International Falls
Bismarck
Fargo
Duluth
LAKE SUPERIOR
S. Ste. Marie
Billings
Minneapolis
Green Bay
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
Buffalo
Rapid City
Huron
Pocatello
Lander
Lansing
Detroit
LAKE ERIE
Winnemucca
Dubuque
Des Moines
Chicago
Reno
Salt Lake
Cheyenne
North Platte
Lincoln
Pittsburgh
Philadelphia
Sacramento
San Francisco
Tonopah
Milford
Denver
Springfield
Indianapolis
Columbus
Kansas City
St. Louis
Lexington
Charleston
Richmond
Norfolk
Dodge City
Raleigh
Nashville
Knoxville
Hatteras
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
Columbia
San Diego
Phoenix
Yuma
Little Rock
Atlanta
Birmingham
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
Barrow
1035
Barter Is.
987
ARCTIC CIRCLE
Ft. Yukon
Nome
693
Fairbanks
642
Northway
516
Anchorage
512
Bethel
Seward
474
Yakutat
483
Juneau
Kodiak
Sitka
Annette
342
612
St. Paul Is.
Cold Bay
525
Shemya
501
Adak
Lihue
Honolulu
Kahului
Hilo
HAWAII
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS PARTICULARLY IN MOUNTAIN AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 192
San Juan
Ponce
Alex.Ham.
PUERTO RICO AND VIRGIN ISL

Figure 3-10

NORMAL TOTAL HEATING DEGREE DAYS, OCTOBER
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.
International Falls
Williston
Bismarck
Fargo
Duluth
Minneapolis
Rapid City
Huron
Green Bay
Sault Ste. Marie
Lansing
Detroit
Chicago
Dubuque
Des Moines
North Platte
Lincoln
Cheyenne
Denver
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
Philadelphia
New York
Albany
Burlington
Concord
Portland
Boston
Caribou
Buffalo
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Knoxville
Nashville
Memphis
Little Rock
Dodge City
Amarillo
Oklahoma City
Albuquerque
Phoenix
Yuma
San Diego
Tonopah
Milford
Salt Lake
Grand Junction
Pocatello
Billings
Spokane
Pendleton
Roseburg
Eureka
Sacramento
San Francisco
Winnemucca
Reno
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Jacksonville
Pensacola
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
Miami
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
ALASKA
Barrow 1500
Barter Is. 1482
ARCTIC CIRCLE
Ft. Yukon
Fairbanks 1203
Nome 1094
Northway
Anchorage 930
Bethel 1042
Seward
Yakutat 716
Juneau 725
Sitka
Annette 567
Kodiak
St. Paul Is. 856
Cold Bay 772
Shemya 784
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

Figure 3-11


NORMAL TOTAL HEATING DEGREE DAYS, NOVEMBER
(Base 65°)
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
THESE MAPS ARE BASED ON THE 30-YR. PERIOD, 1931-60.
Spokane
Havre
Williston
International Falls
Bismarck
Fargo
Duluth
S. Ste. Marie
Caribou
Billings
Minneapolis
Green Bay
Burlington
Concord
Albany
Boston
Huron
Rapid City
Lander
Buffalo
Lansing
Detroit
Hartford
Winnemucca
Dubuque
Des Moines
New York
Harrisburg
Philadelphia
Pittsburgh
Cheyenne
North Platte
Lincoln
Columbus
Sacramento
San Francisco
Denver
Springfield
Indianapolis
Washington
Kansas City
St. Louis
Charleston
Richmond
Lexington
Norfolk
Dodge City
Raleigh
Nashville
Knoxville
Hatteras
Oklahoma City
Amarillo
Albuquerque
Memphis
Wilmington
Columbia
Phoenix
Little Rock
Atlanta
Yuma
Birmingham
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Barter Is.
ARCTIC CIRCLE
Nome
Fairbanks
Northway
Bethel
Anchorage
Yakutat
Juneau
Sitka
Kodiak
St. Paul Is.
Cold Bay
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

Figure 3-12

NORMAL TOTAL HEATING DEGREE DAYS, DECEMBER (Base 65°)

SAMPLE HEAT LOSS CALCULATIONS

Heat loss calculations and the effects of conservation measures for a sample house with three levels of weatherization are illustrated in this section. A sample floor plan of a one story house located in Denver is shown in Figure 3-13. Three levels of weatherization will be used as a basis for comparing the effects of weatherization modifications on heat losses and heating costs. The three levels of weatherization are identified below and might correspond respectively to an older poorly constructed home, a standard (pre-energy concern) home, and a modern well insulated and weatherized home.

Level 1

Insulation - 2 inches above ceiling, none elsewhere

Windows - single glazed, no weatherstrip

Doors - no storm doors, no weatherstrip

Infiltration - 2 air changes per hour

Floors - Hardwood over subfloor

Level 2

Insulation - 3½ inches in walls, 6 inches above ceiling, none under floor

Windows - Double glazed, 1/4 air space, weatherstripped

Doors - Storm doors, weatherstripped

Infiltration - one air change per hour

Floors - carpeted

Level 3

Insulation - 6 inches in walls, 12 inches above ceiling, 9 inches under floor

Windows - Triple glazed, 1/2 inch air space, weatherstripped

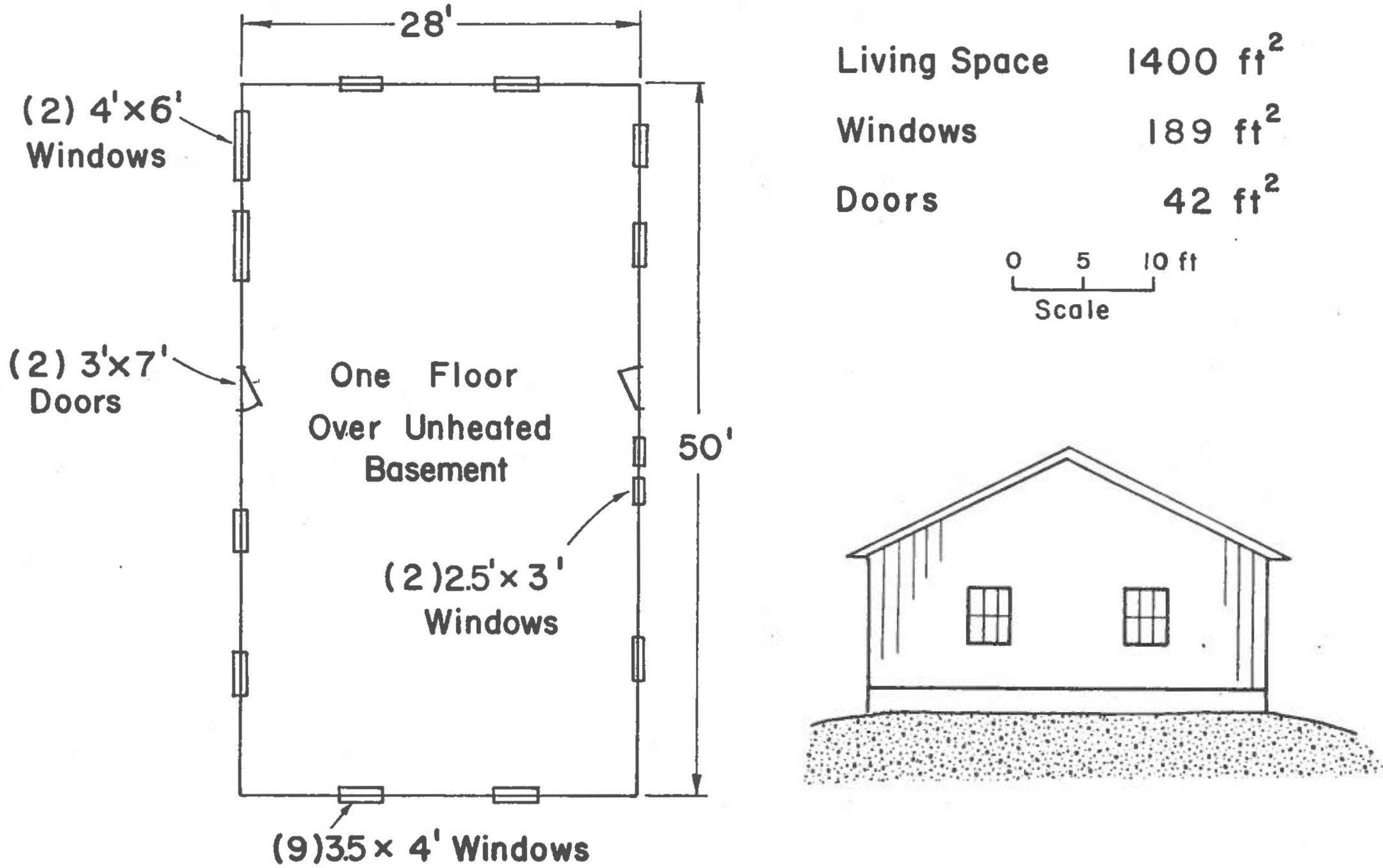


Figure 3-13. Sample Building

Doors - Storm doors, weatherstripped, vestibule installed

Infiltration - One-half air change per hour

Floors - carpeted

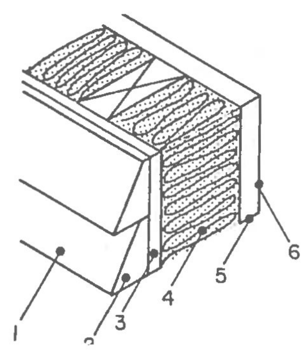
A complete heat loss calculation is carried out for level 3 weatherization of the building on worksheets (HL-1). (Extra worksheets are provided at the end of this module.) The calculations of heat transmission coefficients (U-factors) are given below.

Heat Transmission Coefficients

Calculations of U-factors for walls, ceiling and floor for the level 3 building are shown below. U-factors for windows and doors can be found directly from Table 3-1.

Insulated Frame Wall (2 x 6 studs)

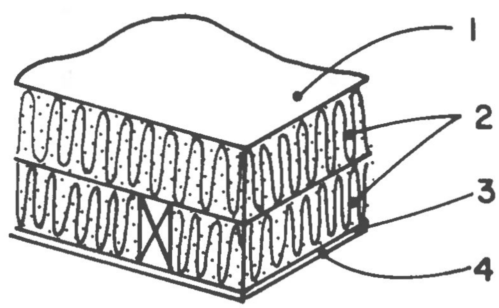
	ITEM	R
1.	Outside film (15 mph wind, winter)	0.17
2.	Siding, wood (1/2 x 8 lapped)	0.81
3.	Sheathing (1/2 inch regular)	1.32
4.	Insulation batt (5-1/2 inch)	19.00
5.	Gypsum wall board (1/2 inch)	0.45
6.	Inside surface (winter)	0.68
	Total Resistance, R_T	22.43
	$U = 1/R_T$	0.045



The calculated U-factor for the wall applies to the area between studs. Because the resistance to heat flow through the 2 x 6 stud is different from the insulation, a correction is sometimes applied. However, the effective corrections to R_T is small and usually are within the range of accuracy of the R values. Corrections are therefore considered unnecessary.

Insulated Ceiling, 12 inches

	ITEM	R
1.	Inside surface	0.68
2.	Insulation batts (2, 6 inch)	38.00
3.	Gypsum board (1/2 inch)	0.45
4.	Inside surface	0.68
	Total Resistance, R_T	39.81
	$U = 1/R_T$	0.025



Insulated Floor (Over Unheated Basement)

	ITEM	R
1.	Surface (heat flow down)	0.91
2.	Carpet and fibrous pad	2.08
3.	Plywood (3/4 inch)	0.93
4.	Insulation (9 inch)	24.00
5.	Surface (still air)	0.61
	Total Resistance, R_T	28.53
	$U = 1/R_T$	0.035

COMPARISONS OF THE THREE LEVELS OF WEATHERIZATION

Comparisons of heat losses through all components of the building enclosure are shown in Table 3-3 for the three levels of weatherization. The percent reduction in heat loss rate with level 2 weatherization compared to level one is shown in the table. Similarly for level 3, the percent reductions compared to level 2 are given. Annual fuel costs for heating are shown at the bottom of the table and assumes electricity cost at 4¢ per kWh and natural gas cost at 11¢/100 ft^3. There are several important aspects about the level 3 weatherization. The U-factors, or R-values, for the various building components may be achieved by a combination of different building materials. For instance, an R-22 wall can be obtained with 2 x 6 studs (24" on center) filled with 5½ inches of fiberglas insulation as in this example, or with 2 x 4 studs (16 inches on center) with 3½ inches of fiberglas insulation and 1½ inches of styrofoam sheets over the outside sheating. For the same R-value the heat loss will be the same, regardless of wall design. The cost effectiveness of all building heat conservation measures requires careful attention. Experience indicates that the cost of insulated walls with 2 x 6 studs on 24-inch centers is about the same as the cost for insulated walls with 2 x 4 studs on 16-inch centers. Because an R-value of about 22 can be achieved with the 2 x 6-stud walls compared to R-14 for 2 x 4 stud walls for about the same cost, the wall with thicker insulation is recommended. However, triple glazed windows may or may not be cost effective in this area depending upon the glazing technique and incremental cost of the third glazing. Other design features such as minimizing the total area of windows in the north wall and maximizing south window area to take advantage of solar gains are helpful. In this example, a major savings is obtained by insulating the floor over an unheated basement. Precautions should be taken to see that any plumbing in the basement area is protected from freezing.

Table 3-3. Comparisons of Levels of Weatherization
(Annual Degree Days 6283)

Building Component	Levels of Weatherization							
	Level 1		Level 2			Level 3		
	U	Heat Loss Rate Btu/hr	U	Heat Loss Rate Btu/hr	% Reduction Compared to Level 1	U	Heat Loss Rate Btu/hr	% Reduction Compared to Level 2
Walls	0.23	16,842	0.069	5,052	70	0.045	3,295	35
Ceiling	0.114	11,491	0.048	4,820	58	0.025	2,520	48
Floor	0.32	10,752	0.22	7,392	31	0.035	1,176	86
Windows	1.13	15,378	0.65	8,845	42	0.36	4,899	45
Doors	0.64	1,935	0.24	726	62	0.24	726	0
Infiltration	N=2	29,032	N=1	14,516	50	N=0.5	7,258	50
Design Heating Load Btu/hr		85,430		41,351	52		19,874	52
Effective Building UA (Btu/DD)		28,477		13,784	52		6,624	52
Annual Heating Load MMBtu		178.92		86.60	52		41.62	52
Annual Fuel Cost (Elect. @4¢/kWh Resist. Heating)		$2,097		$1,015			$488	
Annual Fuel Cost (Natural Gas @$1.10/MCF and furnace efficiency, 0.5)		$463		$224			$108	

Worksheet HL-1
Sheet 1 of 2

Building Heat Load Calculations

Job Sample House, Level 3 Number of Occupants 4
Computed by ______ Date January 10, 1978
Location Denver, Colorado Latitude 39.5°

Indoor temperature, T_R 70 °F
Design winter outdoor temperature, T_o -2 °F
Design temperature difference 72 °F
Design degree-day, 65 - T_o, 67 °F

Building Dimensions:

Above Grade: Length 50 ft Width 28 ft Ceiling Ht. 8 ft
Below Grade: Length 50 ft Width 28 ft Depth 7.5 ft

Concrete Floor Slab: Exposed perimeter ____ ft

Exterior Wall Area: 8 x (50+28) x 2 = 1248 ft²

Window Area: 3.5 x 4 x 9 + 4 x 5 x 2 + 2 x 3 x 2 = 189 ft²

Door Area: 2 x 3 x 7 = 42 ft²

Net Exterior Wall Area: 1248 - 189 - 42 = 1017 ft²

Ceiling Area: 50 x 28 = 1400 ft²

Floor Area: 50 x 28 = 1400 ft²

Basement Wall Area: Not Needed (Unheated)

Heating Degree-Days*: January 1132 °F-days
Annual 6283 °F-days

* From Table 3-2

Workshett HL-1
Sheet 2 of 2

		U Btu/(hr)(ft²)(°F)	A	ΔT °F (T_R- T_o)	h = UAΔT Btu/hr
Exterior Walls (net)		0.045	1017	72	3295
Basement Walls	Above grade				
	Below grade	unheated		*	
Windows and Sliding Patio Doors	Single				
	Double				
	Triple	0.36	189	72	4899
	Storm				
Exterior Slab Doors		0.24	42	72	726
Floors	Over Crawlspace				
	Concrete Slab on Grade				
	Basement	0.035	1400	24	1176
Ceiling		0.025	1400	72	2520
Infiltration: (0.018) x 1400x8 ft³ x 72 °F 0.5 Air changes/hour					7258
Design Heating Load: Btu/hr					19,874
Design Heating Load: Btu/DD Design Heating Load (Btu/hr) x (24 hr/Design TD)					6624
January Heating Load: MMBtu (Btu/DD) x (January DD)					7.50
Annual Heating Load: MMBtu (Btu/DD) x (Annual DD)					41.62

*$\Delta T = T_R - 45°$

DOMESTIC HOT WATER LOAD

Number of occupants x 16,680 Btu/day	66,720
January Load (MMBtu) (Btu/day) x 31 x 10^{-6}	2.07
Annual Load (MMBtu) (January load x 12)	24.8

Building Heat Load Calculations

Job ________________________________ Number of Occupants ________

Computed by _________________________ Date _____________________

Location ____________________________ Latitude __________________

Indoor temperature, T_R _________________°F

Design winter outdoor temperature, T_O _____°F

Design temperature difference _____________°F

Design degree-day, 65 - T_O, _____________°F

Building Dimensions:

Above Grade: Length _____ft Width _____ft Ceiling Ht. _____ft

Below Grade: Length _____ft Width _____ft Depth _____ft

Concrete Floor Slab: Exposed perimeter _____ft

Exterior Wall Area: ____

____

Window Area: ____

____

Door Area: ____

____

Net Exterior Wall Area: ____

____

Ceiling Area: ____

____

Floor Area: ____

____

Basement Wall Area: ____

____

Heating Degree-Days*: January __________°F days

Annual __________°F-days

* From Table 3-2

		U Btu/(hr)(ft²)(°F)	A	ΔT °F (T_R-T_o)	h = UAΔT Btu/hr
Exterior Walls (net)					
Basement Walls	Above grade				
	Below grade			*	
Windows and Sliding Patio Doors	Single				
	Double				
	Triple				
	Storm				
Exterior Slab Doors					
Floors	Over Crawlspace				
	Concrete Slab on Grade				
	Basement				
Ceiling					
Infiltration: (0.018) x _____ ft³ x _____ °F _____ Air changes/hour					
Design Heating Load: Btu/hr					
Design Heating Load: Btu/DD Design Heating Load (Btu/hr) x (24 hr/Design TD)					
January Heating Load: MMBtu (Btu/DD) x (January DD)					
Annual Heating Load: MMBtu (Btu/DD) x (Annual DD)					

*$\Delta T = T_R - 45°$

DOMESTIC HOT WATER LOAD

Number of occupants x 16,680 Btu/day	
January Load (MMBtu) (Btu/day) x 31 x 10^{-6}	
Annual Load (MMBtu) (January load x 12)	

Building Heat Load Calculations

Job ______________________ Number of Occupants ________

Computed by ______________________ Date ______________________

Location ______________________ Latitude ______________________

Indoor temperature, T_R ______________ °F

Design winter outdoor temperature, T_o _____ °F

Design temperature difference __________ °F

Design degree-day, 65 - T_o, ____________ °F

Building Dimensions:

Above Grade: Length _____ ft Width _____ ft Ceiling Ht. _____ ft

Below Grade: Length _____ ft Width _____ ft Depth _____ ft

Concrete Floor Slab: Exposed perimeter _____ ft

Exterior Wall Area: ______________________________

____

Window Area: ______________________________

____

Door Area: ______________________________

____

Net Exterior Wall Area: ______________________________

____

Ceiling Area: ______________________________

____

Floor Area: ______________________________

____

Basement Wall Area: ______________________________

____

Heating Degree-Days*: January _________ °F-days

Annual _________ °F-days

* From Table 3-2

		U Btu/(hr)(ft²)(°F)	A	ΔT °F (T_R- T_o)	h = UAΔT Btu/hr
Exterior Walls (net)					
Basement Walls	Above grade				
	Below grade			*	
Windows and Sliding Patio Doors	Single				
	Double				
	Triple				
	Storm				
Exterior Slab Doors					
Floors	Over Crawlspace				
	Concrete Slab on Grade				
	Basement				
Ceiling					
Infiltration: (0.018) x _____ft³ x _____°F _____ Air changes/hour					
Design Heating Load: Btu/hr					
Design Heating Load: Btu/DD Design Heating Load (Btu/hr) x (24 hr/Design TD)					
January Heating Load: MMBtu (Btu/DD) x (January DD)					
Annual Heating Load: MMBtu (Btu/DD) x (Annual DD)					

$*\Delta T = T_R - 45°$

DOMESTIC HOT WATER LOAD

Number of occupants x 16,680 Btu/day	
January Load (MMBtu) (Btu/day) x 31 x 10^{-6}	
Annual Load (MMBtu) (January load x 12)	