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Reduction in the Thermal Resistance (R-Value) of Loose-Fill Insulation and Fiberglass Batts Due to Compression

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Applied Research
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Residential Conservation Service Program

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RELATED REPORTS

1. DOE/CS-0059: The National Program Plan for Building Thermal Envelope Systems and Insulating Materials (January 1979).

2. LBL-8822: A New Measurement Strategy for In-Situ Testing of Wall Thermal Performance (March 1979).

3. LBL-8925: Thermal Performance of Buildings and Building Envelope Systems: An Annotated Bibliography (March 1979).

4. ORNL/SUB-7556/I: Assessment of the Corrosiveness of Cellulosic Insulating Materials (June 1979).

5. ORNL/SUB-7504/3: Recessed Light Fixture Test Facility (July 1979).

6. ORNL/SUB-7559/I: Problems Associated with the Use of Urea-Formaldehyde Foam for Residential Insulation (September 1979).

7. ORNL/Sub-7551/I: Interim Progress Report on an Investigation of Energy Transport in Porous Insulator Systems (October 1979).

8. ORNL/TM-6494: A Technique for Measuring the Apparent Conductivity of Flat Insulations (October 1979).

9. LBL-9821: Measurement of In-Situ Dynamic Thermal Performance of Building Envelopes Using Heat Flow Meter Arrays (December 1979).

10. ORNL/Sub-79/13660/I: Minnesota Retrofit Insulation In Situ Test Program Extension and Review (February 1980).

11. ORNL/TM-7266: An Experimental Study of Thermal Resistance Values (R-Values) of Low-Density Mineral-Fiber Building Insulation Batts Commercially Available in 1977 (April 1980).

12. NBS/BS Series 123: The Effect of Moisture on the Thermal Conductance of Roofing Systems (April 1980).

13. ORNL/Sub-78/97726/I: A Field Study of Moisture Damage in Walls Insulated Without a Vapor Barrier (May 1980).

14. ORNL/CON-46: An Appraisal of the M Factor and the Role of Building Thermal Mass in Energy Conservation (July 1980).

15. ORNL/Sub-7686/I: Smoldering Combustion Hazards of Thermal Insulation Materials (July 1980).

16. NBSIR 80-2097: Precision Measurements on Fibrous Glass Insulation (July 1980).

17. NBSIR 80-2085: Fire Performance of Loose-Fill Cellulosic Insulation in Residential Occupancies (August 1980).

18. ORNL/Sub-7556/2: Corrosion Testing of Urea-Formaldehyde Foam Insulating Materials (September 1980).

19. NBSIR 80-2100: Thermal Resistance Measurements of a Built-Up Roof System (October 1980).

20. NBSIR 80-2129: Modeling for Determination of Temperatures of Electrical Cables Within Thermally Insulated Walls (October 1980).

21. ORNL/CON-61: An Experimental Plan for Investigating Building-Earth Heat Transfer at the Joint Institute for Heavy-Ion Research Building (December 1980).

22. ORNL/Sub-7715/1: Operating Temperatures for a Convectively Cooled Recessed Incandescent Light Fixture (December 1980).

23. ORNL/TM-7481: Analysis of Heat Transfer in Building Thermal Insulations (December 1980).

24. ORNL/tr-4679: Roofing Felt on Polystyrene (December 1980).

25. STP-718: Proceedings of ASTM/DOE Thermal Insulation Conference, Tampa, Florida, October 1978 (December 1980).

26. ORNL/Sub-7559/3: Problems Associated with the Use of Urea-Formaldehyde Foam for Residential Insulation: Part III: Residential Studies in Colorado and Wisconsin (February 1981).

27. ORNL/Sub-7559/4: Problems Associated with the Use of Urea-Formaldehyde Foam for Residential Insulation. Part IV: The Relevance of Materials Standards to Problems Associated with the Use of Urea-Formaldehyde Foam Insulation (February 1981.

Summary

The compression of fiberglass batt, loose-fill fiberglass, loose-fill rock wool, and loose-fill cellulosic insulations due to the installation of one insulation on top of another has been simulated by subjecting specimens to known static loads. Decrease in thickness was measured as a function of loading for freshly blown loose-fill insulations and fiberglass batts shaken to full thickness. The low density materials were affected the most, showing compressions as high as 40% for loads of 12 kg/m^2 (2.5 lb/ft^2). The magnitude of the compression due to loading decreases as the density of the loaded insulation increases. Correlations for compression as a function of loading were obtained and used to calculate R-values for stacked insulations.

The decrease in R-value due to compression can be offset by increasing the amount of insulation added to reach a desired total R-value. Tables have been prepared for the estimation of the amount of loose-fill insulation required to upgrade existing R-11 or R-19 thermal barriers to higher R-values. In most cases an increase in the thickness of the added insulation of 25 mm (1.0 inch) or less will compensate for the compression effect.

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Reduction in the Thermal Resistance (R-Value) of Loose-Fill Insulation and Fiberglass Batts due to Compression

Introduction

The recommended amount of residential thermal insulation has increased as a result of rising energy costs. In many cases homeowners find it economically desirable to install additional insulation in attics on top of insulation already in place. The current practice for determining the amount (thickness) of insulation to be added assumes that the total R-value achieved is the sum of the R-values of the original insulation and the newly installed insulation. The installation of a second layer of insulation in an attic space, however, results in a compressive force and resultant reduction in the thickness of the first layer of compression. Additional insulation, therefore, must be added to bring the total R-value to the desired level. The data reported in this report can be used to determine the thickness reduction of loose-fill insulations and fiberglass batts that result from compressive forces exerted by additional insulation. The thickness reduction is accompanied by an increase in density and a reduction in the R-value of the compressed layer.

The R-value, R, of thermal insulation is defined in terms of thickness, T, and thermal conductivity, k. The thermal conductivity of a specimen of

$$R = T/k \qquad (1)$$

insulation is related to the density, ρ, of the insulation by Equation (2)

$$k = a' + b'\rho + c'/\rho \qquad (2)$$

while the density varies inversely with thickness. Thus, an insulation specimen with an initial density, ρ_0, and initial thickness, T_0, will have density ρ

$$\rho = T_0\rho_0/T \qquad (3)$$

after compression to thickness T. Equations (1), (2), and (3) can be combined to give R as a function of T for an insulation specimen. The thickness of a specimen of insulation can be determined as a function of compressive force loading, and the resultant R-value can then be calculated from relationships between k and ρ.

Measurement of Thickness and Density

Initial specimen thicknesses and thicknesses under loading were measured with a Gaertner Model M-911 cathetometer. Specimens of fiberglass batts 1.219 m (48 inches) in length were shaken to obtain recovery beyond full thickness. The specimens were then affixed to plywood sections slightly larger than the specimen by stapling the paper facing to the plywood. The insulation specimens were marked at five equally spaced points along the top edge using a syringe filled with black ink. Initial thickness was determined by measuring the elevation relative to the cathetometer zero point of the top of the mounting board and the average of the five inked points along the top edge of the batt. Flat loads approximately the same size as the batt specimens were fabricated from cardboard and styrofoam. The loads were constructed to provide increments of about 2.44 kg/m^2 (0.5 lb/ft^2). Load increments were placed on top of the batt specimens and the resultant thicknesses were measured. The first series of measurements were allowed to stand for several hours between load increments to make certain that an equilibrium thickness had been reached. In every case it was observed that equilibrium was attained in less than ten minutes. A period of thirty minutes, therefore, was taken as sufficient for equilibrium. Figure (1) is a photograph of a specimen of fiberglass batt insulation with two increments of compressive load. Densities of the batt specimens were determined from the mass and dimensions of the specimen

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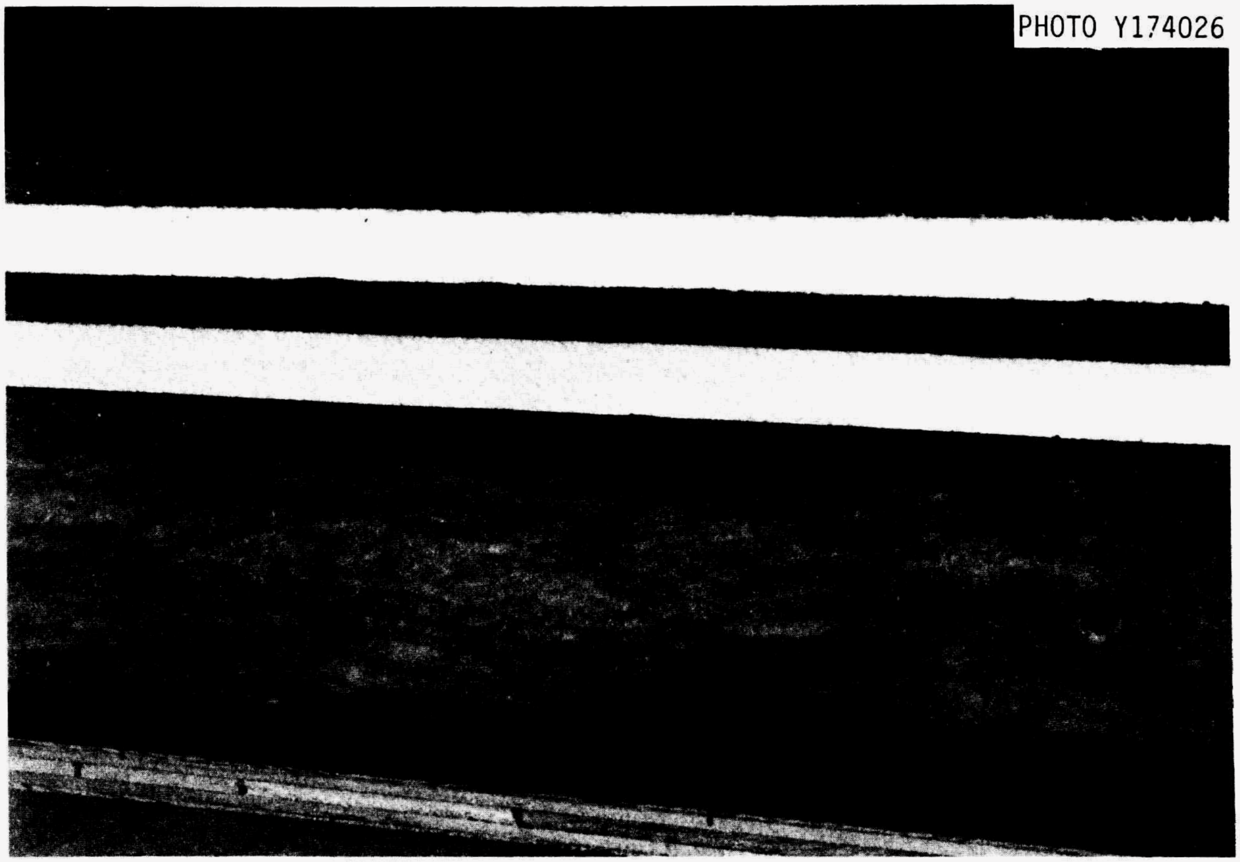

Figure 1. Photograph of Fiberglass Batt with Two Load Increments

at label thickness.

Testing of loose-fill insulations was accomplished using a 305 x 305 x 305 mm (12 x 12 x 12 in) plywood box into which the insulation was blown. A slot was cut in each of the vertical sides of the box to permit sighting of the top of the insulation in the box. The box containing loose-fill insulation was placed on a revolving platform so that four thickness measurements could be made. A photograph of the apparatus is shown in Figure 2. The loose-fill insulations were also loaded with increments of approximately 2.44 kg/m^2 (0.5 lb/ft^2) and the thicknesses measured with a spotlight and the Gaertner cathetometer. Specimen density was determined from a measurement of the mass of the insulation in the box.

Thicknesses were measured in this work to better than $\pm$0.1 cm ($\pm$.04 inches). The values for the load increments were known to better than $\pm$.05 kg/m^2 ($\pm$.01 lb/ft^2). Specimen masses were known to better than $\pm$0.2 grams ($\pm$.0004 lb).

Results for Thickness under Loading

Results for thickness under loading were obtained for loose-fill cellulose insulation (LFC), loose-fill rock wool insulation (LFRW), loose-fill fiberglass insulation (LFFG) and fiberglass batts produced by the three major producers. Appendix A identifies the particular products that were tested.

Appendix B contains the data that were obtained. In most cases thickness measurements were made at loads ranging from 0 kg/m^2 (0 lb/ft^2) to 12.21 kg/m^2 (2.5 lb/ft^2) in steps of 2.44 kg/m^2 (0.5 lb/ft^2). Specimen dimensions and density data are included in Appendix B.

The experimental thickness data were analyzed using Equation (4)

$$-\Delta T/T = a + bw + cw^2 \qquad (4)$$

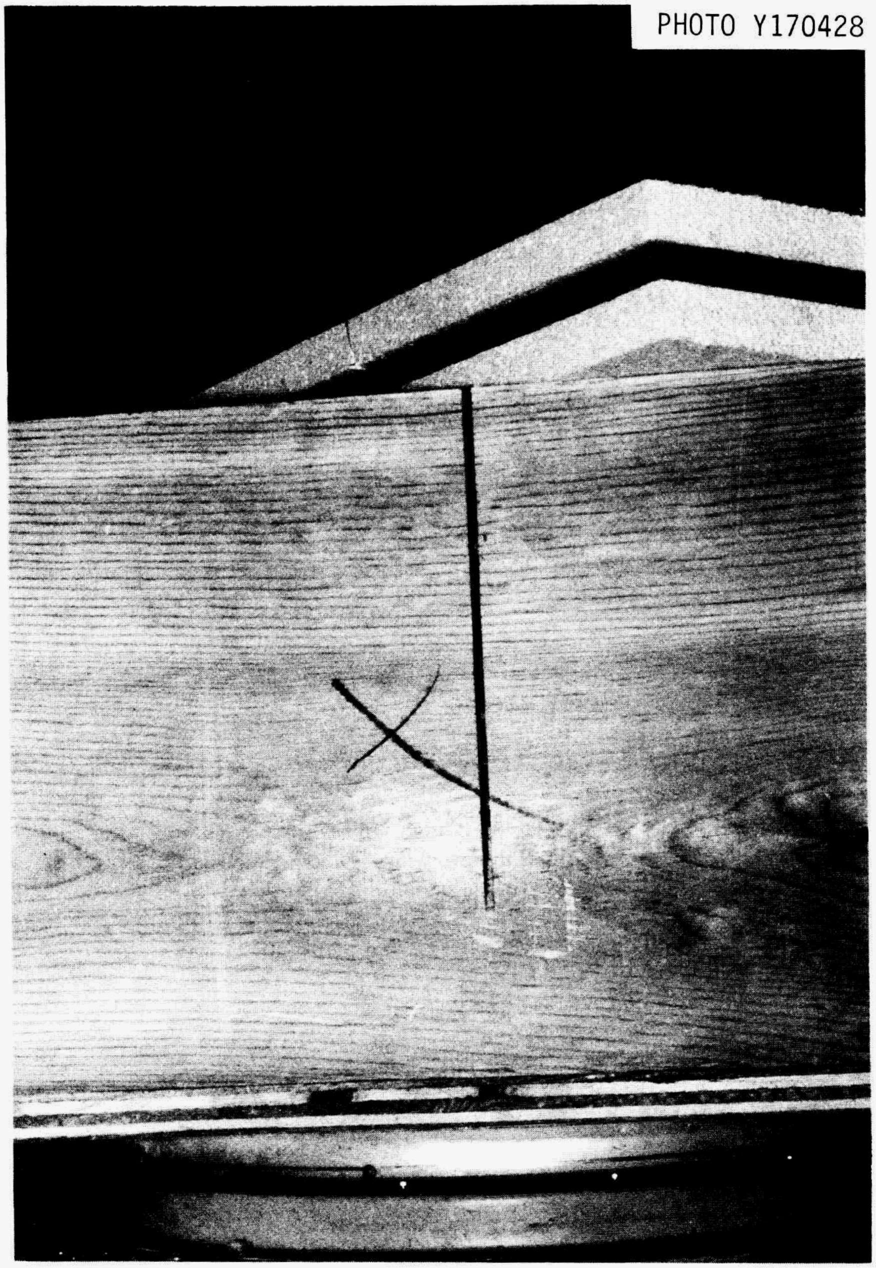

Figure 2. Photograph of Slotted Box Mounted on Revolving Pedestal that was used for Loose-Fill Insulations

where ΔT is the change in thickness resulting from a loading of w lb/ft^2. Values for the parameters a, b, and c in Equation (4) were determined for each of the products tested using the Method of Least Squares. Results for the insulations tested are given in Table 1. Figures 3, 4, and 5 show curves of $-\Delta T/T$ versus loading. The curves were drawn from the results tabulated in Table 1. Figure 6 shows the scatter about Equation (4) of the experimental compression data for R-11(A) fiberglass batts. Experimental results for the other insulations tested are similar to those shown in Figure 6. Figure 7 is a plot of compression at 4.88 kg/m^2 (1.0 lb/ft^2) loading as a function of initial density. All of the products tested are represented in Figure 7.

The numerical results in Table 1 can be used to obtain the thickness to which an insulation will be reduced due to a compressive load. Thickness under compression is obtained by subtracting the thickness decrease, $(\Delta T/T)T_o$, from the initial thickness, T_o. The value for the thickness under compression can then be used to calculate the density, using Equation (3), and the thermal conductivity. Values for thickness and density can then be used to calculate R-value using Equations (1) and (2).

R-Value Calculation for a Compressed Insulation

Thermal resistances were calculated by substituting the thicknesses and thermal conductivities of the compressed specimens into Equation (1). Values for thickness under compression were determined from the information summarized in Table 1. Label thicknesses were assumed as the starting point for unloaded fiberglass batts. The change in k resulting from compression of the batts from ρ_o to ρ_f was obtained using Equation (5) with b' and c' values

$$\Delta k = \int_{\rho_o}^{\rho_f} (\frac{\partial k}{\partial \rho} d\rho = b'(\rho_f - \rho_o) + c'(1/\rho_f - 1/\rho_o) \qquad (5)$$

obtained from a published report dealing with insulating batts.[1] The changes in k with ρ for loose-fill mineral fiber insulations were taken to be the same as the corresponding batt insulations. Correlations for loose-fill cellulose published by Shirtliffe and Bomberg[2] were used. The numerical data used are listed in Appendix C.

Figures 8, 9, and 10 show results obtained for the percent decrease in R-value resulting from compression. The percentage decrease in R-value is less than the percentage decrease in thickness since k for the products tested decreases with density in the density interval tested. The results shown in Figures 8, 9, and 10 are given in Tables 2, 3, and 4. The computter codes used to obtain these results are reproduced in Appendix C.

Thermal Resistance of Two Layers of Insulation

The numerical data in the preceding section can be used to determine the total thermal resistance of two layers of insulation. The effective thermal resistance of the bottom layer is reduced due to compression. Equation (6) gives the total R-value in terms of the R-value per inch of added insulation, $\bar{R}_2$, the thickness of added insulation, T_2, density of the added insulation, D_2, and the R-value for the bottom layer of insulation, R_1.

$$\text{R-Total} = \bar{R}_2 T_2 + R_1(1 - \Delta R/R) \qquad (6)$$

$$\Delta R/R = C_1 + C_2 w + C_3 w^2$$

$$w = D_2 T_2 / 12.0$$

The reduction term, $\Delta R/R$, is represented in the above equation as a function of the loading, w. The coefficients C_1, C_2, and C_3 were obtained by the Method of Least Squares and are listed in Appendix C.

The amount, T_2, of added insulation required to upgrade a given installed insulation to a specified R-TOTAL can be determined from Equation (6). A

Table 1

Values for the Constants a, b, and c in Equation (4)

Product		a	b	c	Number of Specimens	Number of Points	Average Deviation %[1]	Std. Deviation[2]
Fiberglass Batts		- - - - - -	- - - - -	- - - - - -	- - - - -	- - - - -	- - - - - -	- - - - - - - - -
R-11	(A)[3]	-1.5100E-2	2.4658E-1	-2.7728E-2	5	40	11.0	4.80E-2
R-11	(B)	7.2433E-2	3.0427E-1	-3.8971E-2	3	24	7.6	3.97E-2
R-11	(C)	2.3352E-2	2.6026E-1	-3.0797E-2	3	24	6.3	2.64E-2
R-13	(A)	-1.8906E-2	1.6497E-1	-1.4553E-2	5	27	14.6	3.50E-2
R-19	(A)	-3.6435E-2	2.3789E-1	-2.6452E-2	3	24	5.1	1.56E-2
R-19	(B)	5.1182E-1	3.1385E-1	-4.0332E-2	3	24	17.6	7.94E-2
R-19	(C)	9.5779E-2	2.4159E-1	-2.9926E-2	3	24	2.9	1.39E-2
Loose-Fill		- - - - - -	- - - - -	- - - - - -	- - - - -	- - - - -	- - - - - -	- - - - - - - - -
Cellulose	(D)	2.3744E-2	1.0503E-1	-1.1340E-2	10	50	11.4	2.02E-2
Fiberglass	(F)	2.5511E-2	2.5155E-1	-3.8825E-2	12	60	11.5	3.76E-2
Rock Wool	(E)	-2.8012E-2	1.2973E-1	-1.0507E-2	9	44	32.4	4.36E-2

(1) Average deviation computed using: $\left| \frac{(-\Delta T/T)_{calc} - (-\Delta T/T)_{exp}}{(-\Delta T/T)_{exp}} \right| \times 100$

(2) $\left(\sum_{i=1}^{N} \left((-\Delta T/T)_{i\ calc} - (-\Delta T/T)_{i\ exp} \right)^2 / N \right)^{0.5}$

(3) Refers to producer, see Appendix A

ORNL-DWG 7305

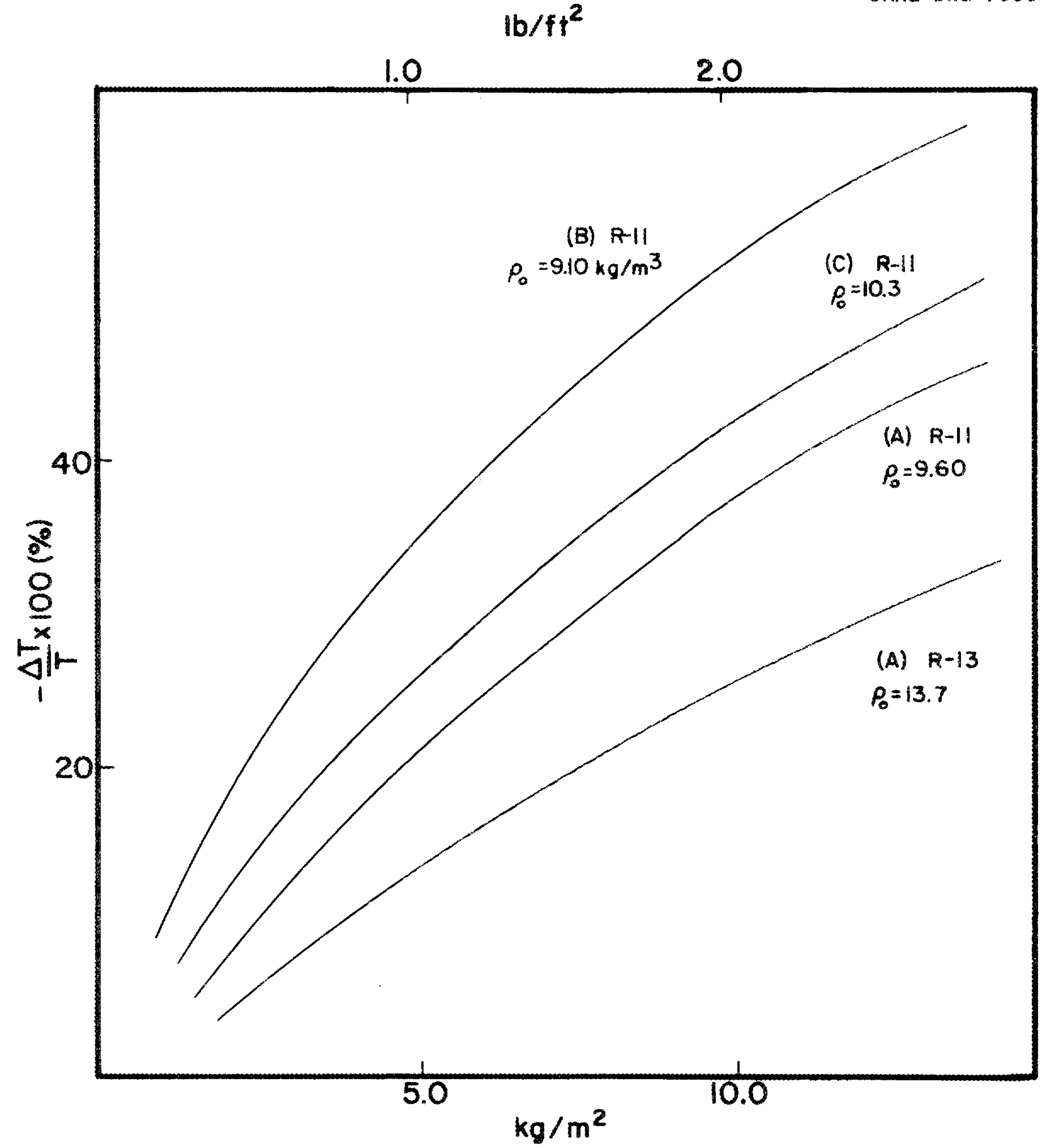

Figure 3. Compression of R-11 and R-13 Fiberglass Batts for Loads up to 13.4 kg/m^2 (2.75 lb/ft^2).

ORNL-DWG 7306

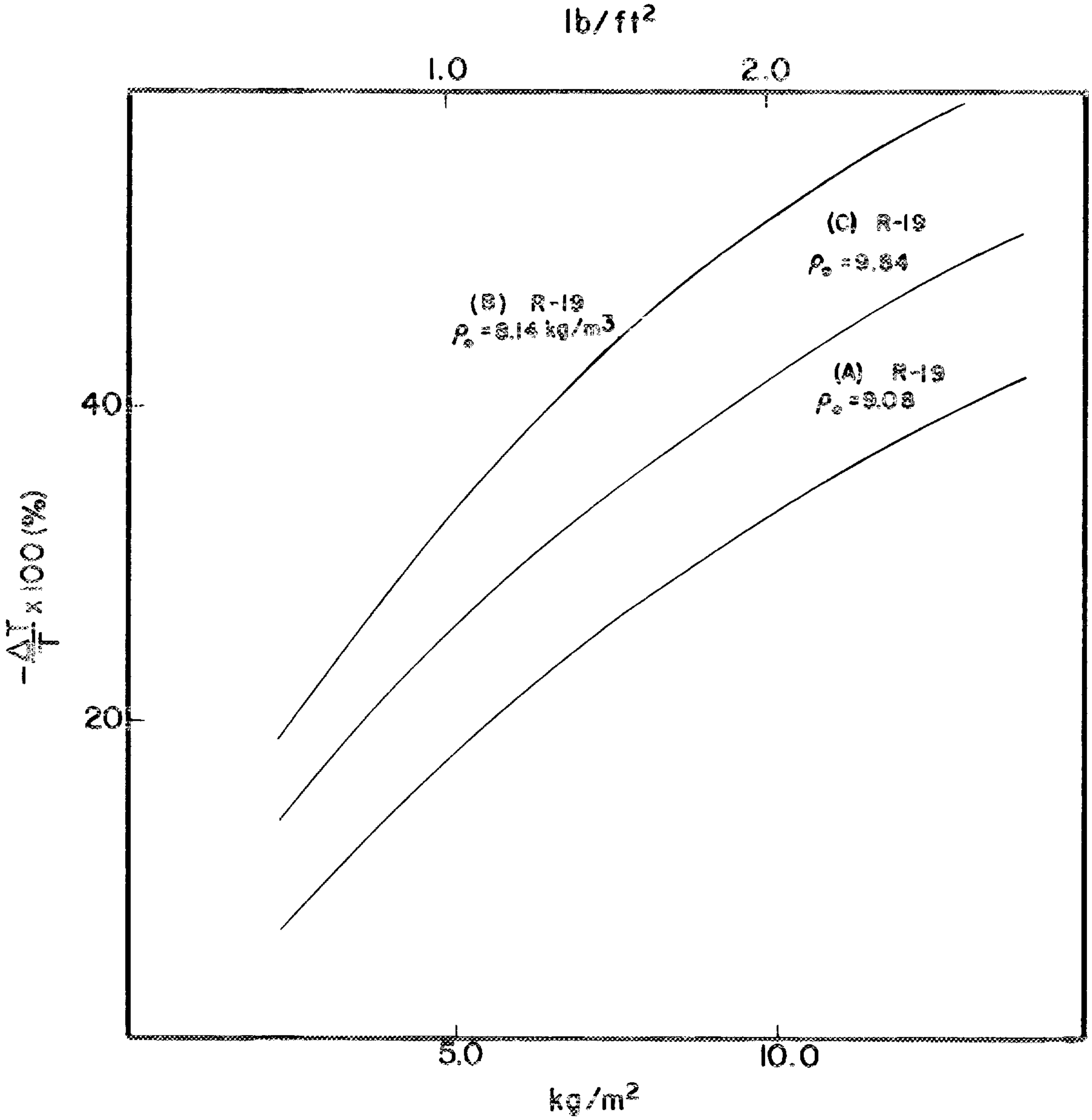

Figure 4. Compression of R-19 Fiberglass Batts for Loads up to 12.2 kg/m^2 (2.5 lb/ft^2).

ORNL-DWG 7307

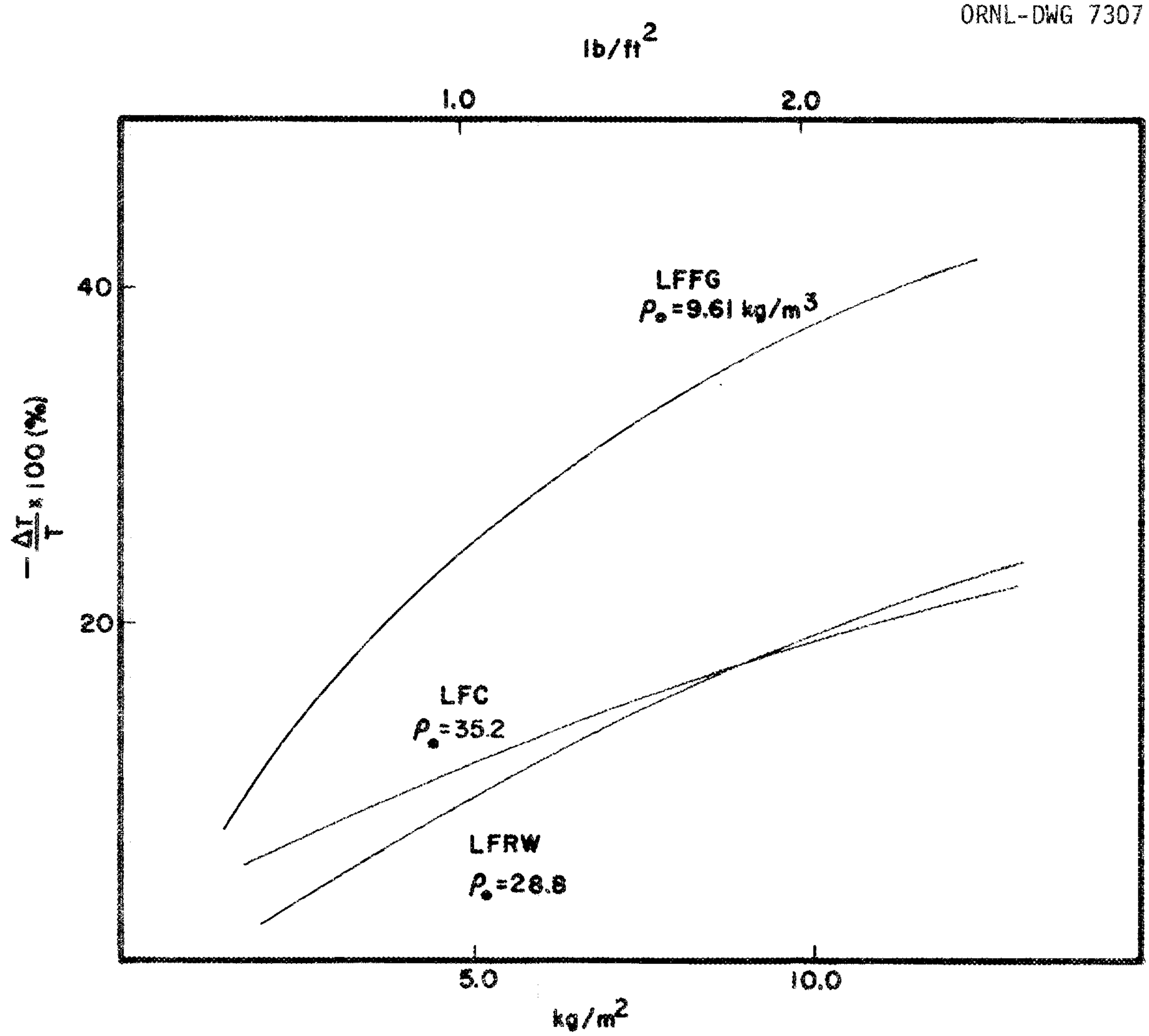

Figure 5. Compression of Loose-Fill Insulations for Loads up to 12.2 kg/m^2 (2.5 lb/ft^2).

ORNL-DWG 7304

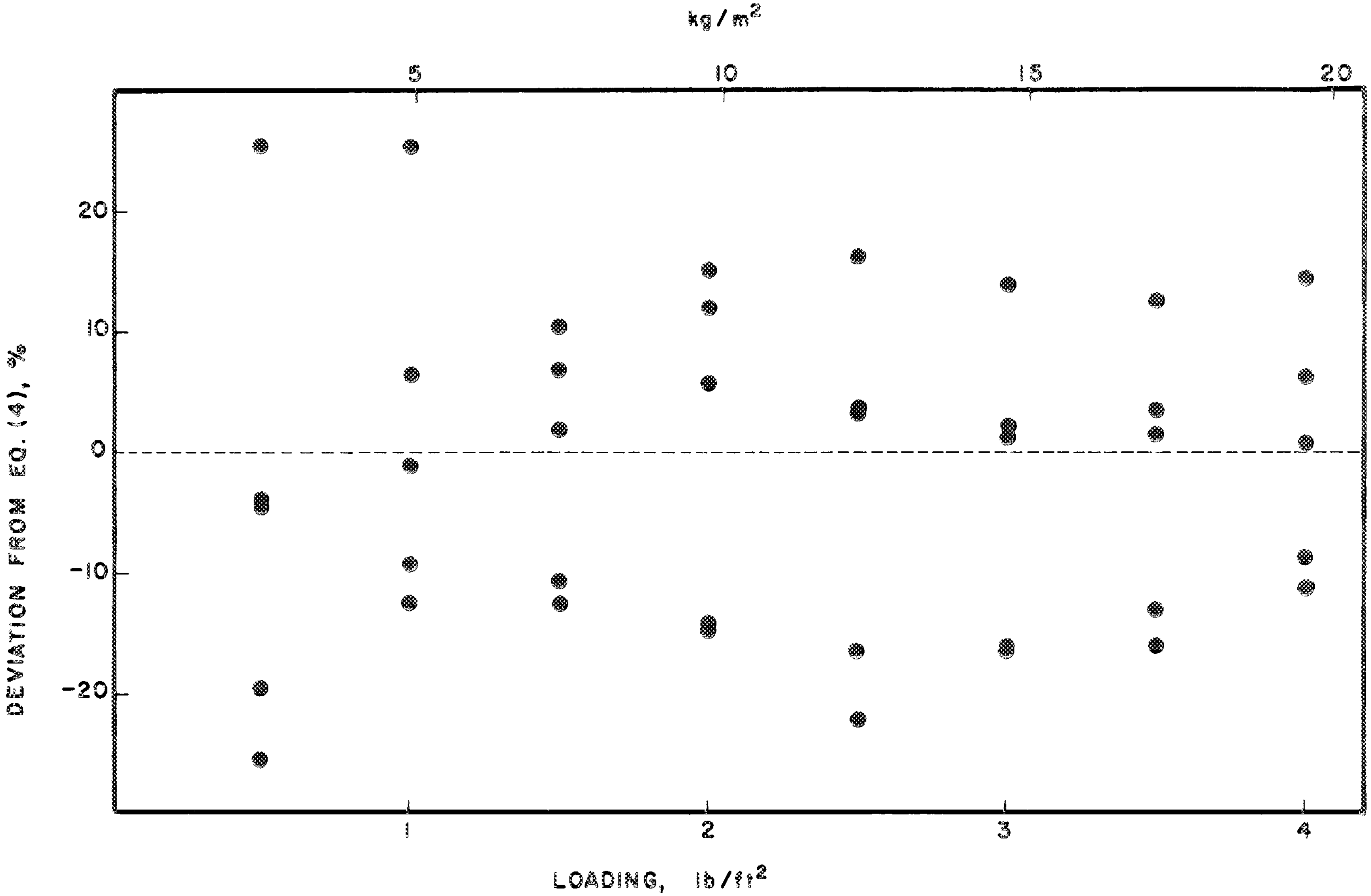

Figure 6. Deviation of Experimental Data for Compression of Product R-11 (A) from Equation (4).

ORNL-DWG 7302

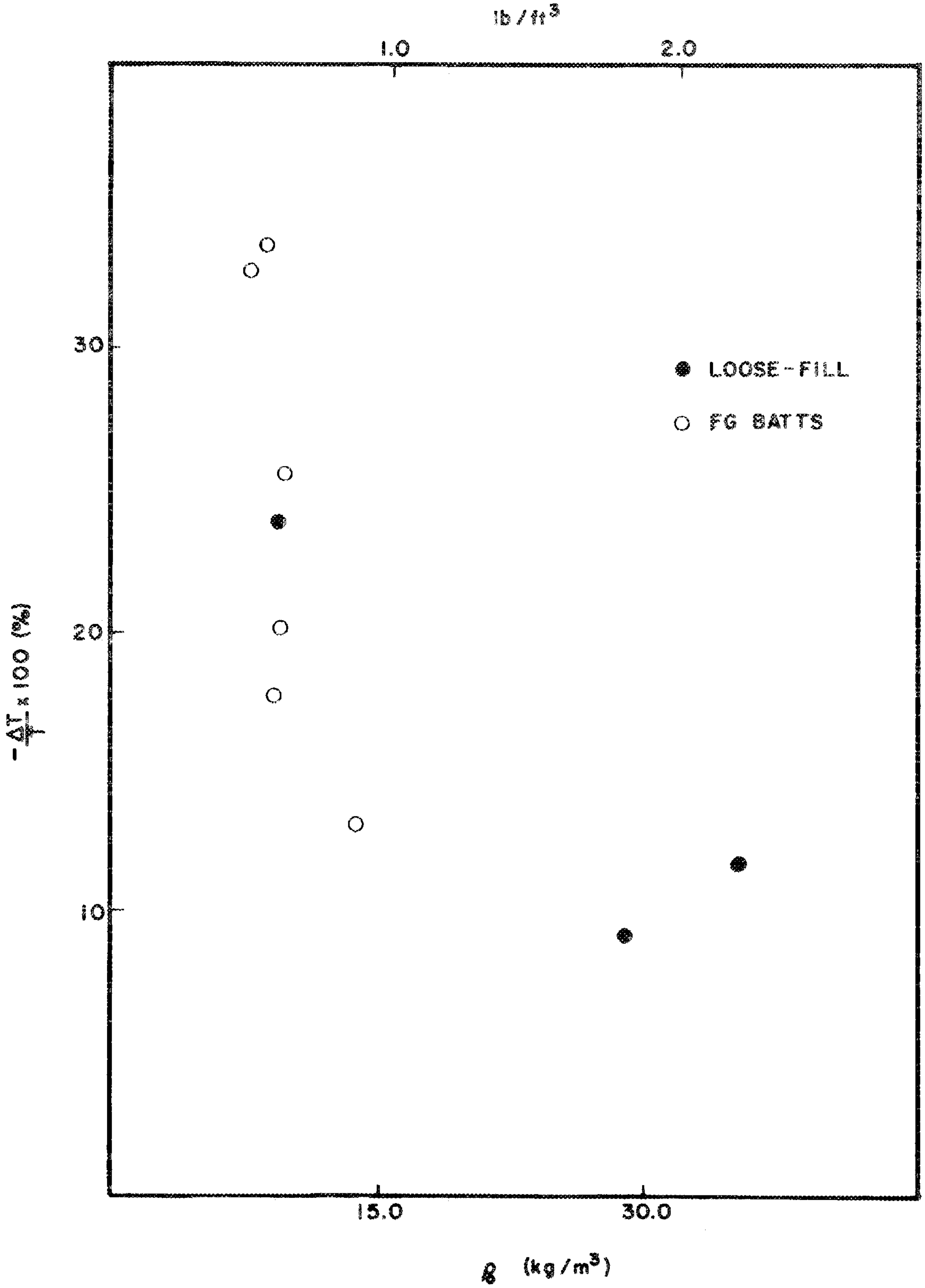

Figure 7. Compression at 4.88 kg/m^2 (1.0 lb/ft^2).

Fortran program and numerical output for R-TOTAL for several combinations of insulation are given in Appendix D.

Table 5 contains computed T_2 results for nine combinations of stacked loose-fill insulations. The table gives the thickness of insulation required to upgrade an R-11 insulation to R-30. Compression is included in the calculation of numbers labeled T_2(corr) while no compression is included in the calculation of numbers labeled T_2(uncorr). The results in Table 5 were obtained from the tables included in Appendix D.

ORNL-DWG 7303

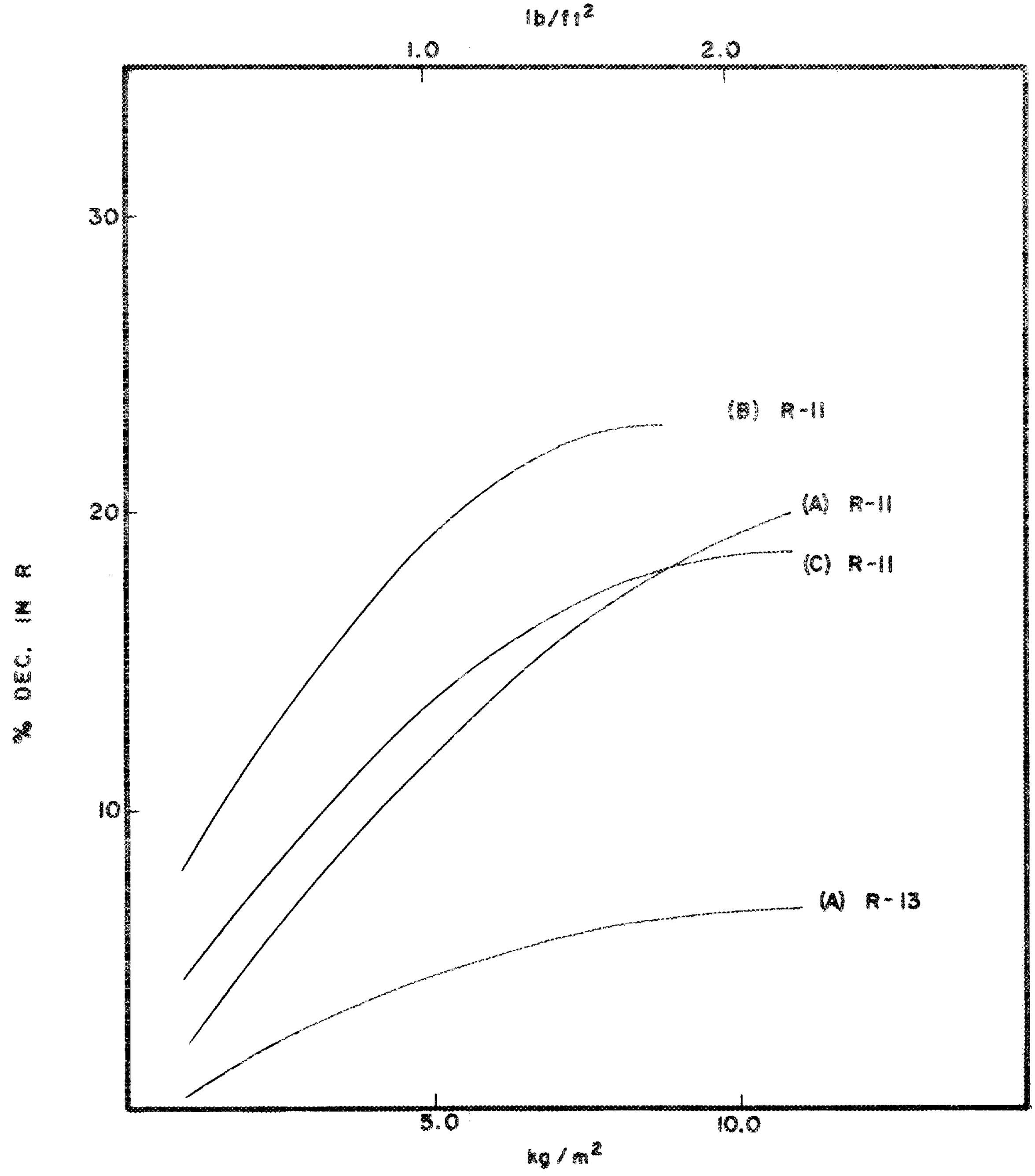

Figure 8. Percentage Decrease in R-Value of R-11 and R-13 Fiberglass Batts due to Compression.

ORNL-DWG 7308

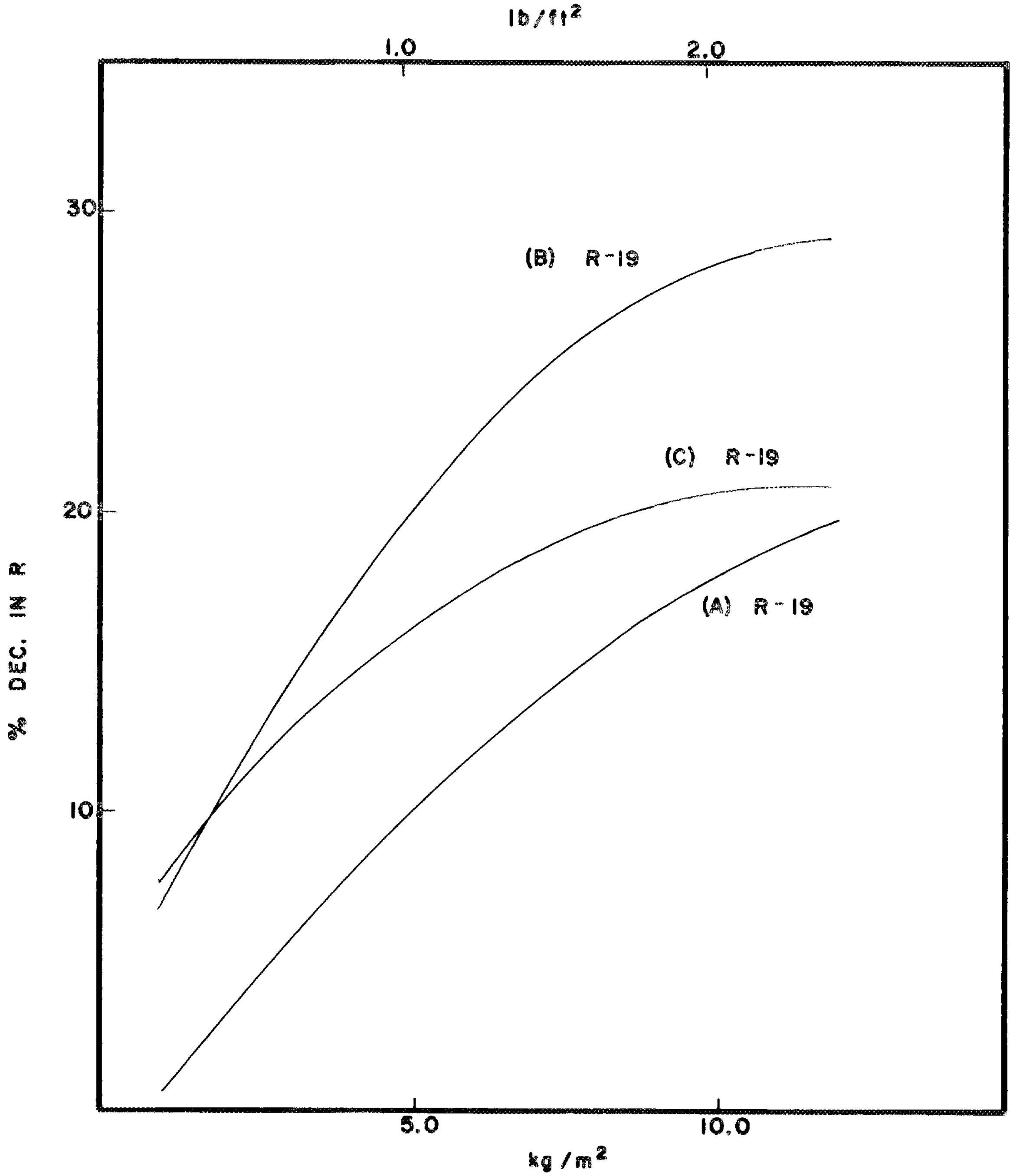

Figure 9. Percentage Decrease in R-Value of R-19 Fiberglass Batts due to Compression.

ORNL-DWG 7309

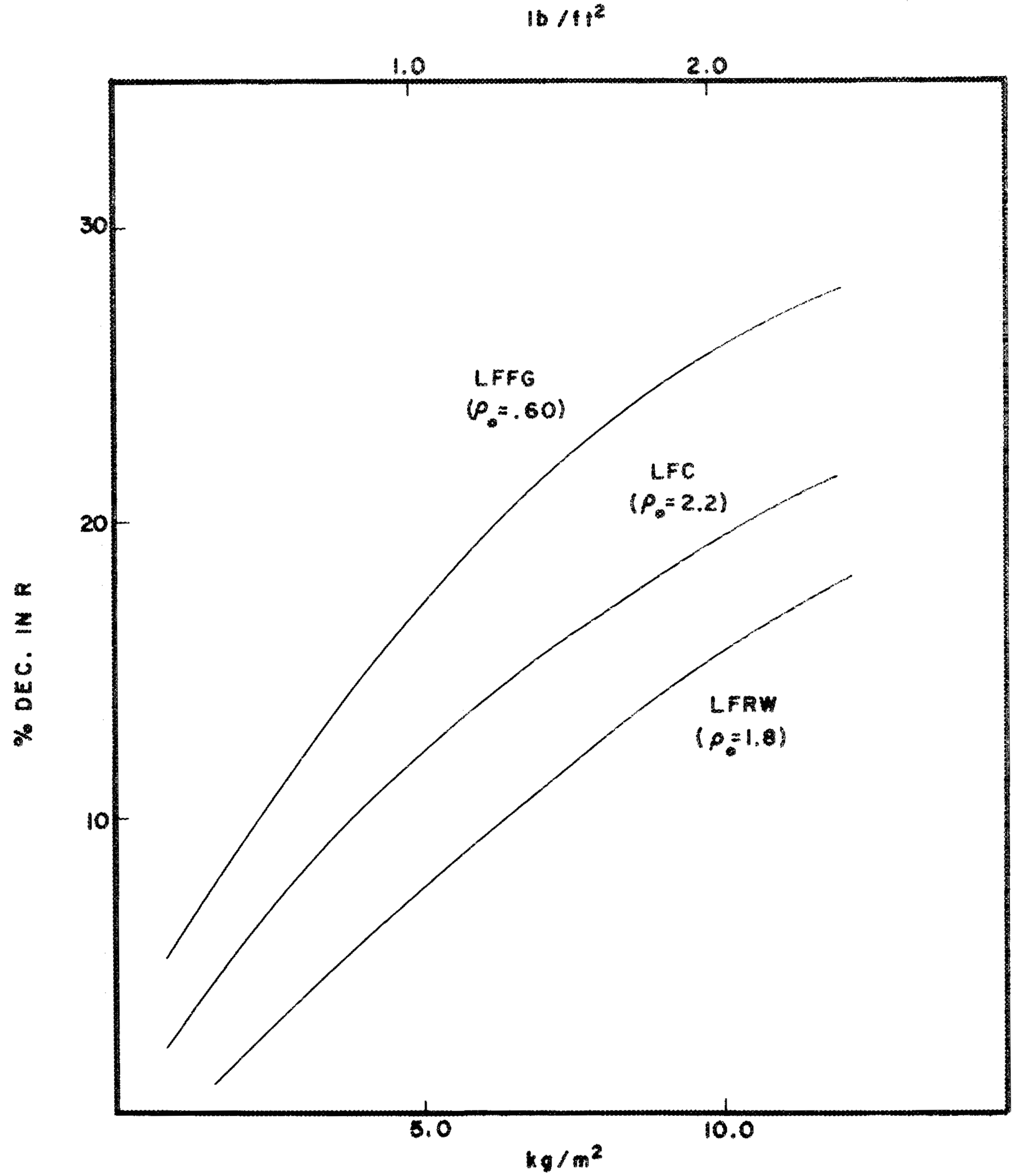

Figure 10. Percentage Decrease in R-Value of Loose-Fill Insulations due to Compression.

Table 2

Percentage Decrease in Thermal Resistance of R-11 and R-13 Fiberglass Batts Resulting from Compression

Load kg/m^2	lb/ft^2	Percentage Decrease in R[1] R-11 (A)[2]	R-11 (B)	R-11 (C)	R-13 (A)
0.000	0.000	0.00	0.00	0.00	0.00
0.977	0.200	2.01	8.06	4.28	0.54
1.953	0.400	4.76	11.32	6.96	1.73
2.929	0.600	7.32	14.25	9.39	2.80
3.906	0.800	9.67	16.81	11.58	3.75
4.882	1.000	11.81	18.99	13.49	4.57
5.859	1.200	13.74	20.75	15.13	5.25
6.835	1.400	15.45	22.04	16.48	5.81
7.812	1.600	16.94	23.01[3]	17.52	6.23
8.788	1.800	18.20		18.24	6.50
9.765	2.000	19.24		18.64	6.64

(1) $(-\Delta R/R_o) \times 100$, R_o is label R-Value at label thickness

(2) Refers to producer code in Appendix A

(3) Extrapolation of k versus ρ becomes questionable beyond this point.

Table 3

Percentage Decrease in Thermal Resistance of R-19 Fiberglass Batts Resulting from Compression

Load		Percentage Decrease in R[1]		
kg/m^2	lb/ft^2	R-19 (A)[2]	R-19 (B)	R-19 (C)
0.000	0.000	0.00	0.00	0.00
0.977	0.200	0.58	6.93	7.85
1.953	0.400	3.11	10.48	10.19
2.929	0.600	5.51	13.78	12.33
3.906	0.800	7.75	16.82	14.25
4.882	1.000	9.84	19.58	15.93
5.859	1.200	11.77	22.03	17.37
6.835	1.400	13.53	24.16	18.55
7.812	1.600	15.13	25.94	19.47
8.788	1.800	16.56	27.35	20.12
9.765	2.000	17.82	28.36	20.50

(1) $(-\Delta R/R_o) \times 100$, R_o is label R-Value at label thickness

(2) Refers to producer code in Appendix A.

Table 4

Percentage Decrease in Thermal Resistance of Loose-Fill Insulations

Load kg/m^2	lb/ft^2	Percentage Decrease in R[1] Cellulose	Rock Wool	Fiberglass
0.000	0.000	0.00	0.00	0.00
0.977	0.200	4.49	-0.20[2]	5.38
1.953	0.400	6.48	1.80	8.65
2.929	0.600	8.38	3.74	11.67
3.906	0.800	10.19	5.59	14.43
4.882	1.000	11.90	7.38	16.94
5.859	1.200	13.53	9.10	19.19
6.835	1.400	15.06	10.74	21.20
7.812	1.600	16.51	12.31	22.96
8.788	1.800	17.86	13.81	24.48
9.765	2.000	19.12	15.24	25.77

(1) $(-\Delta R/R) \times 100$: Average ρ_o values: 2.2 lb/ft^3 for cellulose, 1.8 lb/ft^3 for rock wool, 0.6 lb/ft^3 for fiberglass. Corresponding nominal R-values per inch: 3.55 for cellulose, 2.9 for rock wool, 2.2 for fiberglass.

(2) Apparent anomaly caused by scatter in compression data at low density.

Table 5

Amount of Loose-Fill Insulation Required
to Upgrade R-11 to R-30

	Top Layer								
	LFC[1]			LFRW			LFFG		
Bottom Layer	T_2(uncorr)[2]	T_2(corr)	Diff.[3]	T_2(uncorr)	T_2(corr)	Diff.	T_2(uncorr)	T_2(corr)	Diff.
LFC	5.35	5.74	7.3%	6.55	7.03	7.3%	8.64	8.96	3.7%
LFRW	5.35	5.58	4.3%	6.55	6.83	4.3%	8.64	8.77	1.5%
LFFG	5.35	5.95	11.2%	6.55	7.28	11.1%	8.64	9.10	5.3%

1 LFC = Loose-Fill Cellulose, LFRW = Loose-Fill Rock Wool, LFFG = Loose-Fill Fiberglass

2 Entries are in inches

3 Diff. = (T_2(corr) - T_2(uncorr)) x 100/(T_2(uncorr))

Discussion of Results

The extent of compression which results from the installation of insulation on top of existing insulation is shown in Figures 3, 4, and 5. The data show compressions well above 40% for the fiberglass batts tested. It was also observed that the thickness of fiberglass batts continued to decrease for compressive loads as high as 12.2 kg/m^2 (2.5 lb/ft^2). It is unlikely at present that loads due to added insulation will exceed that value.

The experimental compression data tend to be scattered for the first increment of loading. This is due at least in part from different starting densities for the specimens tested. As-blown loose-fill specimens or as-recovered batt specimens exhibited variation in density that has not been taken into account in the numerical calculations. An example of the variation of compression with a given load is shown in Figure 7. The average compressions in Figure 7 show quite clearly that starting density is an important factor for the fiberglass products.

Calculated values for the decrease in thermal resistance due to compression are substantially less than the corresponding compression factors. The increase in value per inch with density partly compensates for the decrease in insulation thickness. Figures 8, 9, and 10 show R-value decreases above 25% for the lowest density materials tested. The effect of loading on R-value decreases as the density of the loaded material increases. Thus, rock wool and cellulose are less affected by stacking than fiberglass.

The overall effect of stacking of insulations is that material must be added to the second layer to compensate for the compression of the bottom layer. Table 5 contains examples of the amount of added insulation needed to upgrade an R-11 insulation to R-30. As expected, the most significant results occur when a high density insulation is installed on top of a low density material. The compression caused by the installation of rock wool above fiberglass can be compensated with approximately 0.75 inches of rock wool. Tables have been prepared and included in Appendix D for the estimation of the amount of added insulation required to upgrade from R-11 or R-19 to a higher R-value. The amount of extra added insulation is generally less than one inch for the lowest density insulations and is around one-half inch for the higher density insulations.

The sample size for the present study is admittedly small. The sample did, however, include specimens of the commonly available fiberglass batt insulations and a number of specimens for each of the major loose-fill insulations.

Conclusions and Recommendations

Experimental data have been obtained which show that loose-fill insulations and fiberglass batts will be compressed by the addition of a second layer of insulation. Compressions were greatest from the low density insulations where thickness decreases as much as 40% were measured.

Calculations have been completed which show that the R-value of the bottom layer of insulation in a stacked configuration will be reduced. The reduction is greatest for the fiberglass insulations. Adjustment in the amount of insulation added must be made if the desired R-TOTAL is to be obtained. Tables which can be used to estimate the amount of insulation needed to reach a specified R-value have been prepared using the compression data obtained in this study. The loss of R-value due to compression can be offset by installing additional material in the top layer. As much as 15% additional insulation is needed to compensate for compression when high density material is installed on top of low density insulation.

The compression factors should be included in the calculation of the amount of insulation required to upgrade existing insulations. The result of including the compression factor will be the installation of additional insulation.

Results have not been obtained for currently produced rock wool batts. The rock wool products should be tested. There are also a number of products that presently have a small percentage of the insulation market that should be tested.

All of the insulation material tested in this project was fresh. In practice, however, the loaded insulation will have been in place for some time. The effect of aging on the compression of insulation under static loads should be investigated.

References

(1) Tye, R. P., A. O. Dejarlais, D. W. Yarbrough and D. L. McElroy, "An Experimental Study of Thermal Resistance Values (R-Values) of Low Density Mineral Fiber Building Insulation Batts Commercially Available in 1977", ORNL/TM-7266, 1980, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

(2) Shirtliffe, C. J. and M. Bomberg, "Blown Cellulose Fiber Thermal Insulations - Part 2 - Thermal Resistance", NRCC 17139, 1978, National Research Council of Canada, Ottawa, Canada.

Appendix A

Identification of Insulation Products Tested

Identification	Manufacturer
Fiberglass Batts	
A	Owens-Corning Fiberglas
B	Johns-Manville
C	Certainteed
Loose-Fill	
D	Tennessee Cellulose Insulation
E	Delta Maid Rock Wool
F	Owens-Corning Fiberglas

Appendix B

Experimental Values for Thickness as a Function of Loading

SPECIMEN NUMBER : 11

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.208 WIDTH (inches) 15.5

TOTAL MASS (grams) 466 PAPER (grams) 75.8

INSULATION MASS (grams) 390.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.568

(kg/m^3) 9.10

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.76
0.5000	8.43
1.0026	7.08
1.5149	6.54
2.0056	5.52
2.5078	4.75
3.0003	4.37
3.4897	4.09
3.9915	3.73

SPECIMEN NUMBER : 12

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.508 WIDTH (inches) 15.5

TOTAL MASS (grams) 500 PAPER (grams) 74.7

INSULATION MASS (grams) 425.3

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.629

(kg/m^3) 10.07

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	8.72
0.5026	8.12
1.0149	6.94
1.4977	6.13
1.9986	5.08
2.5004	4.84
2.9898	4.49
3.4898	4.13
3.9920	3.81

SPECIMEN NUMBER : 13

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 46.815 WIDTH (inches) 15.5

TOTAL MASS (grams) 485 PAPER (grams) 73.7

INSULATION MASS (grams) 411.3

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.616

(kg/m^3) 9.87

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.41
0.5018	8.61
1.0027	7.36
1.5027	6.45
2.0049	5.74
2.4956	5.25
3.0159	4.86
3.4987	4.55
3.9881	4.41

SPECIMEN NUMBER : 15

BATT : ✓ LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2 hr °F/Btu$) 11

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.166 WIDTH (inches) 15.5

TOTAL MASS (grams) 484 PAPER (grams) 757

INSULATION MASS (grams) 408.3

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.595

(kg/m^3) 9.53

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.43
0.4907	8.53
1.0110	7.65
1.5145	6.92
2.0145	6.39
2.5154	6.11
3.0079	5.57
3.5101	5.19
3.9995	4.86

SPECIMEN NUMBER : 16

BATT : ✓ LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2 hr °F/Btu$) 11

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.625 WIDTH (inches) 15.5

TOTAL MASS (grams) 473 PAPER (grams) 74.9

INSULATION MASS (grams) 398.1

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.587

(kg/m^3) 9.40

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.43
0.5035	8.66
1.0035	7.72
1.5044	6.98
1.9969	6.41
2.4991	5.96
2.9885	5.58
3.4713	5.31
3.9532	4.96

SPECIMEN NUMBER : 17

BATT : B LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2 hr °F/Btu$) 11

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.083 WIDTH (inches) 15.5

TOTAL MASS (grams) 505 PAPER (grams) 61.9

INSULATION MASS (grams) 432.1

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.639

(kg/m^3) 10.23

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	11.06
0.5009	9.12
0.9934	7.50
1.4956	6.33
1.9850	5.56
2.4678	4.86
2.9497	4.37
3.4620	3.94
3.9638	3.65

SPECIMEN NUMBER : 18

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 46.75 WIDTH (inches) 15.5

TOTAL MASS (grams) 419 PAPER (grams) 66.1

INSULATION MASS (grams) 352.9

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.530

(kg/m^3) 8.49

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.82
0.5018	8.08
1.0141	6.59
1.4960	5.63
1.9788	4.95
2.4682	4.44
2.9718	4.03
3.4740	3.75
3.9568	3.51

SPECIMEN NUMBER : 19

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.01 WIDTH (inches) 15.5

TOTAL MASS (grams) 433 PAPER (grams) 67.8

INSULATION MASS (grams) 365.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.534

(kg/m^3) 8.56

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	11.70
0.5018	8.83
1.0141	6.48
1.4960	5.75
1.9788	4.97
2.4824	4.35
2.9718	3.92
3.4546	3.53
3.9568	3.28

SPECIMEN NUMBER : 27

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 49.208 WIDTH (inches) 15.5

TOTAL MASS (grams) 552 PAPER (grams) 101.6

INSULATION MASS (grams) 450.4

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.643

(kg/m^3) 10.30

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.86
0.5018	9.12
1.0141	7.62
1.4960	6.71
1.9788	6.03
2.4824	5.44
2.9718	5.06
3.4546	4.60
3.9568	4.30

SPECIMEN NUMBER : 28

BATT : ✓ LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.333 WIDTH (inches) 15.5

TOTAL MASS (grams) 551 PAPER (grams) 99.8

INSULATION MASS (grams) 451.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.655

(kg/m^3) 10.50

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.38
0.5018	9.22
1.0141	7.77
1.4960	6.93
1.9788	6.17
2.4824	5.42
2.9718	4.87
3.4546	4.52
3.9568	4.22

SPECIMEN NUMBER : 29

BATT : ✓ LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3½

R-VALUE ($ft^2hr°F/Btu$) 11

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.833 WIDTH (inches) 15.5

TOTAL MASS (grams) 564 PAPER (grams) 100.8

INSULATION MASS (grams) 463.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.66

(kg/m^3) 10.57

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	8.91
0.5018	7.78
1.0141	6.58
1.4960	5.87
1.9788	5.33
2.4824	4.95
2.9718	4.57
3.4546	4.36
3.9568	4.10

SPECIMEN NUMBER : 3

BATT : ✓ LOOSE-FILL : __

LABEL INFORMATION : THICKNESS (inches) 3⅝

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.00 WIDTH (inches) 15½

TOTAL MASS (grams) 648 PAPER (grams) 82.8

INSULATION MASS (grams) 565.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.798

(kg/m^3) 12.79

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.29
0.50	9.67
1.00	8.93
1.50	8.23

SPECIMEN NUMBER : 4

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.350 WIDTH (inches) 15.5

TOTAL MASS (grams) 678 PAPER (grams) 81.7

INSULATION MASS (grams) 596.3

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.854

(kg/m^3) 13.68

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.15
0.50	9.47
1.00	8.91
1.50	8.07
2.00	7.61
2.50	7.05
3.00	6.55

SPECIMEN NUMBER : 5

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.50 WIDTH (inches) 15.5

TOTAL MASS (grams) 678 PAPER (grams) 81.9

INSULATION MASS (grams) 596.1

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.851

(kg/m^3) 13.63

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.71
0.50	9.74
1.00	8.84
1.50	7.95
2.00	7.49
2.50	6.79
3.00	6.40

SPECIMEN NUMBER : 6

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.00 WIDTH (inches) 15.5

TOTAL MASS (grams) 714 PAPER (grams) 82.8

INSULATION MASS (grams) 631.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.891

(kg/m^3) 14.28

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	8.97
0.50	8.67
1.00	8.11
1.50	7.61
2.00	7.16
2.50	6.76
3.00	6.32

SPECIMEN NUMBER : 7

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.5 WIDTH (inches) 15.5

TOTAL MASS (grams) 696 PAPER (grams) 81.9

INSULATION MASS (grams) 614.1

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.876

(kg/m^3) 14.04

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	9.40
0.50	8.94
1.00	8.24
1.50	7.63
2.00	7.12
2.50	6.67
3.00	6.29

SPECIMEN NUMBER : 9

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.58 WIDTH (inches) 15.5

TOTAL MASS (grams) 668 PAPER (grams) 83.1

INSULATION MASS (grams) 585.9

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.835

(kg/m^3) 13.37

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	10.23
1.0031	7.89
1.9991	4.23

SPECIMEN NUMBER : 14

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 3 5/8

R-VALUE ($ft^2hr°F/Btu$) 13

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.125 WIDTH (inches) 15.5

TOTAL MASS (grams) 707 PAPER (grams) 83

INSULATION MASS (grams) 624

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.879

(kg/m^3) 14.08

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	11.37
1.0110	8.44
2.064	6.96

SPECIMEN NUMBER : 23

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.792 WIDTH (inches) 15.5

TOTAL MASS (grams) 747 PAPER (grams) 55.5

INSULATION MASS (grams) 691.5

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.592

(kg/m^3) 9.49

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	15.86
0.5018	14.58
1.0141	13.02
1.4960	11.64
1.9788	10.59
2.4824	9.92
2.9718	9.13
3.4546	8.51
3.9568	8.02

SPECIMEN NUMBER : 24

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.25 WIDTH (inches)

TOTAL MASS (grams) 695 PAPER (grams) 54.8

INSULATION MASS (grams) 640.2

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.555

(kg/m^3) 8.89

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	17.13
0.5018	15.98
1.0141	14.28
1.4960	12.83
1.9788	11.61
2.4824	10.67
2.9718	10.22
3.4546	9.21
3.9568	8.73

SPECIMEN NUMBER : 25

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) 46.833 WIDTH (inches)

TOTAL MASS (grams) 688 PAPER (grams) 54.4

INSULATION MASS (grams) 633.6

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.554

(kg/m^3) 8.88

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	15.82
0.5018	14.84
1.0141	12.70
1.4960	11.33
1.9788	10.14
2.4824	9.34
2.9718	8.73
3.4546	8.24
3.9568	7.80

SPECIMEN NUMBER : 20

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 6½

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.000 WIDTH (inches) 15.5

TOTAL MASS (grams) 702 PAPER (grams) 71.4

INSULATION MASS (grams) 630.6

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.496

(kg/m^3) 7.95

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	17.88
0.5018	13.39
1.0141	10.33
1.4960	8.44
1.9788	7.38
2.4824	6.39
2.9718	5.76
3.4546	5.23
3.9568	4.85

SPECIMEN NUMBER : 21

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 6½

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.333 WIDTH (inches) 15.5

TOTAL MASS (grams) 731 PAPER (grams) 71.9

INSULATION MASS (grams) 659.1

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.516

(kg/m^3) 8.26

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	15.59
0.5018	12.62
1.0141	9.70
1.4960	8.23
1.9788	6.79
2.4824	6.03
2.9718	5.45
3.4546	4.99
3.9568	4.67

SPECIMEN NUMBER : 22

BATT : ✓ LOOSE-FILL : ___

LABEL INFORMATION : THICKNESS (inches) 6.5

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER B

SPECIMEN DIMENSIONS :

LENGTH (inches) 47.792 WIDTH (inches) 15.5

TOTAL MASS (grams) 719 PAPER (grams) 71.1

INSULATION MASS (grams) 647.9

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.513

(kg/m^3) 8.21

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	16.89
0.5018	15.02
1.0141	13.02
1.4960	11.51
1.9788	10.10
2.4824	8.94
2.9718	8.09
3.4546	7.52
3.9568	6.96

SPECIMEN NUMBER : 30

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.042 WIDTH (inches)

TOTAL MASS (grams) 702 PAPER (grams)

INSULATION MASS (grams) 702

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.598

(kg/m^3) 9.58

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	16.75
0.5018	13.53
1.0141	11.26
1.4960	10.00
1.9788	9.04
2.4824	8.20
2.9718	7.61
3.4546	7.15
3.9568	6.72

SPECIMEN NUMBER : 31

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.458 WIDTH (inches)

TOTAL MASS (grams) 730 PAPER (grams)

INSULATION MASS (grams) 730

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.617

(kg/m^3) 9.88

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	16.07
0.5018	12.95
1.0141	10.96
1.4960	9.88
1.9788	8.86
2.4824	8.17
2.9718	7.64
3.4546	7.21
3.9568	6.88

SPECIMEN NUMBER : 32

BATT : ✓ LOOSE-FILL :

LABEL INFORMATION : THICKNESS (inches) 6

R-VALUE ($ft^2hr°F/Btu$) 19

MANUFACTURER C

SPECIMEN DIMENSIONS :

LENGTH (inches) 48.833 WIDTH (inches)

TOTAL MASS (grams) 751 PAPER (grams)

INSULATION MASS (grams) 751

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.630

(kg/m^3) 10.09

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (cm)
0.0	17.36
0.5018	13.82
1.0141	11.66
1.4960	10.38
1.9788	9.33
2.4824	8.37
2.9718	7.76
3.4546	7.19
3.9568	6.92

SPECIMEN NUMBER : LFC1

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1842

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.104

(or as blown) (kg/m^3) 33.70

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.782
0.5028	11.964
1.0082	11.207
1.5110	10.663
2.0151	10.202
2.5167	9.824

SPECIMEN NUMBER : LFC2

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1699

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.122

(or as blown) (kg/m^3) 33.99

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.708
0.5028	10.981
1.0082	10.296
1.5110	9.764
2.0151	9.474
2.5167	9.144

SPECIMEN NUMBER : LFC3

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1555

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.028

(or as blown) (kg/m^3) 32.49

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.095
0.5028	10.000
1.0082	9.439
1.5110	8.986
2.0151	8.575
2.5167	8.280

SPECIMEN NUMBER : LFC4

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1732

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.267

(or as blown) (kg/m^3) 36.31

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.053
0.5028	10.358
1.0082	9.817
1.5110	9.400
2.0151	9.062
2.5167	8.671

SPECIMEN NUMBER : LFC5

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1840

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.333

(or as blown) (kg/m^3) 37.37

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.531
0.5028	10.840
1.0082	10.469
1.5110	10.089
2.0151	9.853
2.5167	9.475

SPECIMEN NUMBER : LFC6

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1643

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.059

(or as blown) (kg/m^3) 32.98

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.000
0.5028	10.878
1.0082	10.318
1.5110	9.941
2.0151	9.529
2.5167	8.990

SPECIMEN NUMBER : LFC7

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2 hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 2046

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.390

(or as blown) (kg/m^3) 38.28

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.495
0.5028	11.771
1.0082	11.253
1.5110	10.827
2.051	10.498
2.5167	10.099

SPECIMEN NUMBER : LFC8

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2 hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1863

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.346

(or as blown) (kg/m^3) 37.63

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.613
0.5028	10.840
1.0082	10.288
1.5110	9.873
2.0151	9.704
2.5167	9.257

SPECIMEN NUMBER : LFC9

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2 hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1666

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.179

(or as blown) (kg/m^3) 34.92

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.063
0.5028	10.075
1.0082	9.554
1.5110	9.173
2.0151	8.859
2.5167	8.564

SPECIMEN NUMBER : LFC10

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER D

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1693

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.199
(or as blown) (kg/m^3) 35.22

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.254
0.5028	10.416
1.0082	10.005
1.5110	9.500
2.0151	9.208
2.5167	8.908

SPECIMEN NUMBER : LFF1

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 409

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.529
(or as blown) (kg/m^3) 8.47

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.178
0.5028	9.287
1.0044	7.730
1.5098	6.993
2.0139	6.363
2.5167	5.941

SPECIMEN NUMBER : LFF2

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 457

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.528
(or as blown) (kg/m^3) 8.46

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.628
0.5028	10.963
1.0044	9.582
1.5098	8.946
2.0126	7.950
2.5167	7.456

SPECIMEN NUMBER : LFF3

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 438

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.557

(or as blown) (kg/m^3) 8.92

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.504
0.5028	10.153
1.0082	8.886
1.5110	7.873
2.0151	7.180
2.5167	6.735

SPECIMEN NUMBER : LFF4

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 517

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.588

(or as blown) (kg/m^3) 9.42

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.839
0.5028	10.774
1.0082	9.371
1.5110	8.527
2.0151	7.784
2.5167	7.274

SPECIMEN NUMBER : LFF5

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 499

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.593

(or as blown) (kg/m^3) 9.50

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.296
0.5028	10.235
1.0082	8.938
1.5110	8.134
2.0151	7.471
2.5167	7.058

SPECIMEN NUMBER : LFF6

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2 hr °F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 464

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.568

(or as blown) (kg/m^3) 9.10

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.808
0.5028	9.231
1.0082	8.057
1.5110	7.245
2.0151	6.635
2.5167	6.105

SPECIMEN NUMBER : LFF7

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2 hr °F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 545

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.627

(or as blown) (kg/m^3) 10.04

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.678
0.5028	10.939
1.0082	9.849
1.5110	9.029
2.0151	8.416
2.5167	7.758

SPECIMEN NUMBER : LFF8

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2 hr °F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 520

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.667

(or as blown) (kg/m^3) 10.68

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.396
0.5028	10.289
1.0082	9.286
1.5110	8.407
2.0151	7.863
2.5167	7.253

SPECIMEN NUMBER : LFF9

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 514

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.670

(or as blown) (kg/m^3) 10.73

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.105
0.5028	9.788
1.0082	8.478
1.5110	7.756
2.0151	7.144
2.5167	6.748

SPECIMEN NUMBER : LFF10

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 525

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.602

(or as blown) (kg/m^3) 9.64

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.739
0.5028	11.060
1.0082	10.144
1.5110	9.173
2.0151	8.333
2.5167	7.613

SPECIMEN NUMBER : LFF11

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 571

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.663

(or as blown) (kg/m^3) 10.62

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.580
0.5028	11.332
1.0082	10.325
1.5110	8.830
2.0151	8.437
2.5167	7.948

SPECIMEN NUMBER : LFF12

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER A

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 488

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 0.599

(or as blown) (kg/m^3) 9.60

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.918
0.5028	10.276
1.0082	8.917
1.5110	8.069
2.0151	7.305
2.5167	6.920

SPECIMEN NUMBER : LFR2

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1546

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.920

(or as blown) (kg/m^3) 30.76

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.65
0.5028	11.40
1.0082	10.89
1.5110	10.39
2.0151	9.73
2.5167	9.29

SPECIMEN NUMBER : LFR3

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1477

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.783

(or as blown) (kg/m^3) 28.56

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.12
0.5028	11.64
1.0082	11.04
1.5110	10.34
2.0151	9.60
2.5167	9.29

SPECIMEN NUMBER : LFR4

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1470

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.90

(or as blown) (kg/m^3) 30.44

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.20
0.5028	11.10
1.0082	10.16
1.5110	9.59
2.0151	9.06
2.5167	8.65

SPECIMEN NUMBER : LFR5

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1526

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.79

(or as blown) (kg/m^3) 28.67

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.46
0.5028	12.16
1.0082	11.69
1.5110	11.22
2.0151	10.59
2.5167	10.18

SPECIMEN NUMBER : LFR6

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ___

R-VALUE ($ft^2hr°F/Btu$) ___

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ___ WIDTH (inches) ___

TOTAL MASS (grams) ___ PAPER (grams) ___

INSULATION MASS (grams) 1669

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 2.15

(or as blown) (kg/m^3) 34.44

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.26
0.5028	11.04
1.0082	10.69
1.5110	10.12
2.0151	9.65
2.5167	9.23

SPECIMEN NUMBER : LER7

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1571

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.94
(or as blown) (kg/m^3) 31.08

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	11.84
0.5028	11.90
1.0082	11.43
1.5110	10.99
2.0151	10.03
2.5167	9.61

SPECIMEN NUMBER : LER8

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1456

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.67
(or as blown) (kg/m^3) 26.75

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.74
0.5028	12.38
1.0082	11.29
1.5110	10.46
2.0151	9.95
2.5167	9.56

SPECIMEN NUMBER : LER9

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ______

R-VALUE ($ft^2hr°F/Btu$) ______

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ______ WIDTH (inches) ______

TOTAL MASS (grams) ______ PAPER (grams) ______

INSULATION MASS (grams) 1345

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.61
(or as blown) (kg/m^3) 25.79

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	12.20
0.5028	11.35
1.0082	10.57
1.5110	9.74
2.0151	9.16
2.5167	8.64

SPECIMEN NUMBER : LFR10

BATT : ___ LOOSE-FILL : ✓

LABEL INFORMATION : THICKNESS (inches) ________

R-VALUE ($ft^2 hr °F/Btu$) ________

MANUFACTURER E

SPECIMEN DIMENSIONS :

LENGTH (inches) ________ WIDTH (inches) ________

TOTAL MASS (grams) ________ PAPER (grams) ________

INSULATION MASS (grams) 1322

DENSITY AT NOMINAL THICKNESS (lb/ft^3) 1.48
(or as blown) (kg/m^3) 2371

THICKNESS AS A FUNCTION OF LOADING:

TOTAL LOAD (lb/ft^2)	TOTAL THICKNESS (in.)
0.0	13.04
0.5028	12.00
1.0082	10.88
1.5110	10.11
2.0151	9.29
2.5167	9.00

Appendix C

Calculation of $\Delta R/R$ from Compression Data

This appendix contains Fortran programs and output for $\Delta R/R$ as a function of loading for the products tested. The programs use the compression parameters a, b, and c listed in Table 1 and values for b' and c' in Equation (5) published by Tye et al.[1] for fiberglass and rock wool and Shirtliffe and Bomberg[2] for cellulose. Table C-1 is a listing of the numerical data that were used. The variation of thermal conductivity, k, with density for the loose-fill mineral fiber insulations were taken to be the same as the composite values for R-11 batt insulations[1].

Table C-1

Numerical Data for the Calculation of ΔR/R as a Function of Loading

Product	Initial Thickness (inches)	Initial R (BTU/ft^2 hr ^{o}F)	Initial Density (lb/ft^3)	Compression Constants a	b	c	k variation b'	c'
Fiberglass Batts								
R-11 (A)	3.5	11.0	0.599	-1.5100E-2	2.4658E-1	-2.7728E-2	-.184631	.7683E-2
R-11 (B)	3.5	11.0	0.568	7.2433E-2	3.0427E-1	-3.8971E-2	-.184631	.7683E-2
R-11 (C)	3.5	11.0	0.646	2.3352E-2	2.6026E-1	-3.0797E-2	-.184631	.7683E-2
R-13 (A)	3.625	13.0	0.855	-1.8906E-2	1.6497E-1	-1.4553E-2	-.184631	.7683E-2
R-19 (A)	6.0	19.0	0.567	-3.6435E-2	2.3789E-1	-2.6452E-2	-.156311	2.6055E-2
R-19 (B)	6.5	19.0	0.508	5.1182E-2	3.1385E-1	-4.0332E-2	-.156311	2.6055E-2
R-19 (C)	6.0	19.0	0.614	9.5779E-2	2.4159E-1	-2.9926E-2	-.156311	2.6055E-2
Loose-Fill								
Rock Wool	12.0	34.8	1.80	-2.8012E-2	1.2973E-1	-1.0507E-2	-.035837	.0
Cellulose	12.0	42.6	2.20	2.3744E-2	1.0503E-1	-1.1340E-2	.0(1)	.0
Fiberglass	12.0	26.4	0.600	2.5511E-2	2.5155E-1	-3.8825E-2	-.184631	.7683E-2

(1) Constants for loose-fill cellulose are included in the program.

Figure C-1

Fortran Program for the Calculation of ΔR/R
as a Function of Loading for Mineral Fiber Insulations

```
C     CALC OF R AFTER COMPRESSION
1        READ(5,100,END=999)ST,SR,SD,A,B,C,C2,C3
100      FORMAT(8F9.1)
         WRITE(6,150)ST,SD,SR
         WRITE(6,150)A,B,C
         WRITE(6,150)C2,C3
150      FORMAT(2X,3(F12.4,2X))
         WRITE(6,151)
151      FORMAT(2X,'LOAD (LB/FT2)    (KG/M2)   THICKNESS (IN)   (CM)
       & R (ENG)      (SI)       DEC IN R   %',/)
         DO 2 J=1,14
         W=J*0.2
         FT=ST*(1.-(A+B*W+C*W**2))
         FD=ST*SD/FT
         DK=C2*(FD-SD)+C3*(1./FD-1./SD)
         FK=(ST/SR)+DK
         FR=FT/FK
         FTS=FT*2.54
         WS=W*4.8826
         FRS=FR/5.674
         RD=(1.-FR/SR)*100.0
         WRITE(6,200)W,WS,FT,FTS,FR,FRS,RD
200      FORMAT(2X,7(F10.4,2X))
2          CONTINUE
         GO TO 1
999      CONTINUE
        CALL EXIT
         END
```

Nomenclature

ST	Starting thickness, inches
SR	Starting R-value, ft^2hr^oF/BTU
SD	Starting density, lb/ft^3
A,B,C	Compression constants from Table C-1
C2, C3	k variation constants from Table C-1

Figure C-2

Fortran Program for the Calculation of ΔR/R as a Function of Loading for Loose-Fill Cellulosic Insulation

```
C     CALC OF R AFTER COMPRESSION
1          READ(5,100,END=999)ST,SR,SD,A,B,C,C2,C3
100        FORMAT(8F3.1)
           WRITE(6,150)ST,SD,SR
           WRITE(6,150)A,B,C
           WRITE(6,150)C2,C3
150        FORMAT(2X,3(F12.4,2X))
           WRITE(6,151)
151        FORMAT(2X,'LOAD (LB/FT2)    (KG/M2)   THICKNESS (IN)   (CM)
         & R (ENG)    (SI)      DEC IN R   %',/)
           DO 2 J=1,14
           W=J*0.2
           FT=ST*(1.-(A+B*W+C*W**2))
           FD=ST*SD/FT
           DK=C2*(FD-SD)+C3*(1./FD-1./SD)
           FK=(ST/SR)+DK
           FR=1.165+3.56*FT-FD*(.183+.0331*FT)
           FTS=FT*2.54
           WS=W*4.8824
           FRS=FR/5.674
           RD=(1.-FR/SR)*100.0
           WRITE(6,200)W,WS,FT,FTS,FR,FRS,RD
200        FORMAT(2X,7(F10.4,2X))
2            CONTINUE
           GO TO 1
999        CONTINUE
         CALL EXIT
           END
```

Table C-2

Decrease in R-Value of R-11 (A) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R
0.2000	0.9765	3.3841	8.5957	10.7785	1.8996	2.0139
0.4000	1.9530	3.2232	8.1868	10.4761	1.8463	4.7632
0.6000	2.9294	3.0700	7.7977	10.1953	1.7968	7.3156
0.8000	3.9059	2.9245	7.4283	9.9368	1.7513	9.6657
1.0000	4.8824	2.7869	7.0786	9.7011	1.7097	11.8080
1.2000	5.8589	2.6570	6.7487	9.4889	1.6724	13.7371
1.4000	6.8354	2.5348	6.4384	9.3007	1.6392	15.4481
1.6000	7.8118	2.4204	6.1479	9.1370	1.6103	16.9366
1.8000	8.7883	2.3138	5.8771	8.9980	1.5858	18.1997
2.0000	9.7648	2.2150	5.6261	8.8840	1.5657	19.2361
2.2000	10.7413	2.1239	5.3947	8.7948	1.5500	20.0473
2.4000	11.7178	2.0406	5.1831	8.7298	1.5386	20.6384
2.6000	12.6942	1.9650	4.9911	8.6879	1.5312	21.0192
2.8000	13.6707	1.8972	4.8189	8.6674	1.5276	21.2058

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^2 {}^oK/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-3

Decrease in R-Value of R-11 (B) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	3.0390	7.7189	10.1133	1.7824	8.0607
0.4000	1.9530	2.8423	7.2195	9.7549	1.7192	11.3191
0.6000	2.9294	2.6566	6.7478	9.4330	1.6625	14.2453
0.8000	3.9059	2.4818	6.3038	9.1505	1.6127	16.8139
1.0000	4.8824	2.3179	5.8876	8.9106	1.5704	18.9948
1.2000	5.8589	2.1650	5.4990	8.7173	1.5364	20.7521
1.4000	6.8354	2.0229	5.1382	8.5753	1.5113	22.0426
1.6000	7.8118	1.8918	4.8051	8.4903	1.4964	22.8151
1.8000	8.7883	1.7715	4.4996	8.4689	1.4926	23.0099

(1) R(ENG) R-Value with units $ft^2 hr {}^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}K/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-4

Decrease in R-Value of R-11 (C) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	3.2404	8.2306	10.5295	1.8557	4.2772
0.4000	1.9530	3.0712	7.8007	10.2348	1.8038	6.9565
0.6000	2.9294	2.9105	7.3927	9.9668	1.7566	9.3928
0.8000	3.9059	2.7585	7.0067	9.7267	1.7143	11.5753
1.0000	4.8824	2.6151	6.6425	9.5159	1.6771	13.4918
1.2000	5.8589	2.4804	6.3002	9.3357	1.6454	15.1298
1.4000	6.8354	2.3543	5.9798	9.1876	1.6192	16.4763
1.6000	7.8118	2.2368	5.6814	9.0730	1.5990	17.5182
1.8000	8.7883	2.1279	5.4048	8.9932	1.5850	18.2435
2.0000	9.7648	2.0276	5.1501	8.9493	1.5772	18.6430
2.2000	10.7413	1.9360	4.9174	8.9417	1.5759	18.7117

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}K/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-5

Decrease in R-Value of R-13 Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	3.5760	9.0831	12.9303	2.2789	0.5364
0.4000	1.9530	3.4628	8.7954	12.7755	2.2516	1.7272
0.6000	2.9294	3.3537	8.5184	12.6363	2.2270	2.7981
0.8000	3.9059	3.2489	8.2522	12.5131	2.2053	3.7454
1.0000	4.8824	3.1483	7.9966	12.4065	2.1865	4.5656
1.2000	5.8589	3.0519	7.7518	12.3169	2.1708	5.2549
1.4000	6.8354	2.9597	7.5177	12.2447	2.1580	5.8098
1.6000	7.8118	2.8718	7.2943	12.1905	2.1485	6.2269
1.8000	8.7883	2.7880	7.0816	12.1545	2.1421	6.5035
2.0000	9.7648	2.7085	6.8796	12.1371	2.1391	6.6373

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}k$/watt

(3) LOADS in lb/ft^2 or kg/m^2

Table C-6

Decrease in R-Value of R-19 (A) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	5.9395	15.0863	18.8901	3.3292	0.5783
0.4000	1.9530	5.6731	14.4096	18.4084	3.2443	3.1136
0.6000	2.9294	5.4193	13.7651	17.9540	3.1643	5.5054
0.8000	3.9059	5.1783	13.1529	17.5279	3.0892	7.7480
1.0000	4.8824	4.9500	12.5730	17.1311	3.0192	9.8364
1.2000	5.8589	4.7343	12.0252	16.7645	2.9546	11.7657
1.4000	6.8354	4.5314	11.5098	16.4290	2.8955	13.5317
1.6000	7.8118	4.3412	11.0266	16.1251	2.8419	15.1312
1.8000	8.7883	4.1636	10.5756	15.8532	2.7940	16.5619
2.0000	9.7648	3.9988	10.1569	15.6136	2.7518	17.8229
2.2000	10.7413	3.8466	9.7704	15.4061	2.7152	18.9154
2.4000	11.7178	3.7072	9.4162	15.2299	2.6842	19.8426
2.6000	12.6942	3.5804	9.0943	15.0840	2.6584	20.6105
2.8000	13.6707	3.4664	8.8046	14.9667	2.6378	21.2278

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}k/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-7

Decrease in R-Value of R-19 (B) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	5.7698	14.6553	17.6828	3.1165	6.9326
0.4000	1.9530	5.3933	13.6989	17.0093	2.9978	10.4776
0.6000	2.9294	5.0377	12.7957	16.3818	2.8872	13.7800
0.8000	3.9059	4.7031	11.9458	15.8040	2.7853	16.8209
1.0000	4.8824	4.3895	11.1492	15.2798	2.6930	19.5800
1.2000	5.8589	4.0968	10.4059	14.8133	2.6107	22.0354
1.4000	6.8354	3.8251	9.7158	14.4088	2.5394	24.1641
1.6000	7.8118	3.5744	9.0790	14.0709	2.4799	25.9425
1.8000	8.7883	3.3447	8.4954	13.8040	2.4329	27.3473
2.0000	9.7648	3.1359	7.9652	13.6121	2.3990	28.3574
2.2000	10.7413	2.9481	7.4882	13.4981	2.3789	28.9576
2.4000	11.7178	2.7813	7.0645	13.4627	2.3727	29.1438

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}K/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-8

Decrease in R-Value of R-19 (C) Fiberglass Batts Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	5.1426	13.0622	17.5083	3.0857	7.8512
0.4000	1.9530	4.8742	12.3806	17.0630	3.0072	10.1947
0.6000	2.9294	4.6202	11.7354	16.6573	2.9357	12.3298
0.8000	3.9059	4.3806	11.1267	16.2935	2.8716	14.2450
1.0000	4.8824	4.1553	10.5546	15.9736	2.8152	15.9282
1.2000	5.8589	3.9444	10.0189	15.7001	2.7670	17.3678
1.4000	6.8354	3.7479	9.5197	15.4750	2.7274	18.5526
1.6000	7.8118	3.5657	9.0569	15.3001	2.6965	19.4731
1.8000	8.7883	3.3979	8.6307	15.1767	2.6748	20.1225
2.0000	9.7648	3.2445	8.2410	15.1053	2.6622	20.4982
2.2000	10.7413	3.1054	7.8877	15.0852	2.6587	20.6042

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}K/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-9

Decrease in R-Value of Loose-Fill Cellulosic Insulation Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	11.4684	29.1298	40.6976	7.1726	4.4882
0.4000	1.9530	11.2327	28.5311	39.6495	7.0232	6.4786
0.6000	2.9294	11.0078	27.9599	39.0402	6.8805	8.3778
0.8000	3.9059	10.7939	27.4164	38.2698	6.7446	10.1859
1.0000	4.8824	10.5908	26.9006	37.5382	6.6158	11.9028
1.2000	5.8589	10.3986	26.4124	36.8456	6.4938	13.5284
1.4000	6.8354	10.2173	25.9519	36.1918	6.3785	15.0625
1.6000	7.8118	10.0469	25.5190	35.5771	6.2702	16.5052
1.8000	8.7883	9.8873	25.1138	35.0014	6.1687	17.8564
2.0000	9.7648	9.7387	24.7362	34.4647	6.0742	19.1158
2.2000	10.7413	9.6009	24.3863	33.9672	5.9865	20.2835
2.4000	11.7178	9.4740	24.0640	33.5088	5.9057	21.3594
2.6000	12.6942	9.3580	23.7694	33.0895	5.8318	22.3433
2.8000	13.6707	9.2529	23.5024	32.7095	5.7648	23.2352

(1) R(ENG) — R-Value with units $ft^2 hr\,^oF/BTU$

(2) R(SI) — R-Value with units $m^2\,^oK/watt$

(3) LOADS in — lb/ft^2 or kg/m^2

Table C-10

Decrease in R-Value of Loose-Fill Rock Wool Insulation Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	12.0298	30.5558	34.8703	6.1456	-0.2021
0.4000	1.9530	11.7336	29.8034	34.1726	6.0227	1.8028
0.6000	2.9294	11.4475	29.0766	33.5002	5.9042	3.7352
0.8000	3.9059	11.1714	28.3754	32.8530	5.7901	5.5949
1.0000	4.8824	10.9055	27.6999	32.2310	5.6805	7.3822
1.2000	5.8589	10.6496	27.0500	31.6342	5.5753	9.0971
1.4000	6.8354	10.4038	26.4257	31.0626	5.4745	10.7398
1.6000	7.8118	10.1681	25.8270	30.5160	5.3782	12.3104
1.8000	8.7883	9.9425	25.2539	29.9944	5.2863	13.8093
2.0000	9.7648	9.7270	24.7065	29.4977	5.1987	15.2366
2.2000	10.7413	9.5215	24.1847	29.0258	5.1156	16.5925
2.4000	11.7178	9.3262	23.6885	28.5786	5.0368	17.8775
2.6000	12.6942	9.1409	23.2179	28.1561	4.9623	19.0918
2.8000	13.6707	8.9657	22.7729	27.7579	4.8921	20.2358

(1) R(ENG) R-Value with units $ft^2 hr ^oF/BTU$

(2) R(SI) R-Value with units $m^{2} {}^oK/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Table C-11

Decrease in R-Value of Loose-Fill Fiberglass Insulation Due to Loading

LOAD (LB/FT2)	(KG/M2)	THICKNESS (IN)	(CM)	R (ENG)	(SI)	DEC IN R %
0.2000	0.9765	11.1088	28.2163	24.9800	4.4025	5.3788
0.4000	1.9530	10.5610	26.8249	24.1165	4.2503	8.6497
0.6000	2.9294	10.0504	25.5281	23.3201	4.1100	11.6661
0.8000	3.9059	9.5772	24.3260	22.5911	3.9815	14.4276
1.0000	4.8824	9.1412	23.2186	21.9292	3.8649	16.9350
1.2000	5.8589	8.7424	22.2058	21.3339	3.7599	19.1899
1.4000	6.8354	8.3810	21.2877	20.8043	3.6666	21.1957
1.6000	7.8118	8.0568	20.4643	20.3393	3.5847	22.9571
1.8000	8.7883	7.7699	19.7356	19.9371	3.5138	24.4808
2.0000	9.7648	7.5203	19.1015	19.5955	3.4536	25.7747
2.2000	10.7413	7.3079	18.5621	19.3120	3.4036	26.8484
2.4000	11.7178	7.1328	18.1173	19.0839	3.3634	27.7124
2.6000	12.6942	6.9950	17.7673	18.9084	3.3325	28.3773
2.8000	13.6707	6.8944	17.5119	18.7828	3.3103	28.8532

(1) R(ENG) R-Value with units $ft^2 hr^oF/BTU$

(2) R(SI) R-Value with units $m^{2o}K/watt$

(3) LOADS in lb/ft^2 or kg/m^2

Appendix D

CALCULATED R-VALUES FOR STACKED INSULATION

The Fortran program included in this appendix can be used to compute R-TOTAL for two layers of insulation. The program is designed to use a quadratic expression for the fractional decrease in R-value due to compression. Table D-1 contains values for the coefficients C_1, C_2, and C_3 in Equation (6) obtained using the Method of Least Squares. Tables D-2 to D-13 are output from the computer program. Tables have been generated for each of the products tested. Values have been computed for R-TOTAL resulting from the addition of T_2 inches of loose-fill insulation. Entries are shown for R-TOTAL uncorrected for compression (R UNCORR) and R-TOTAL which includes a correction for compress (R CORR). A listing has been included for each product loaded with loose-fill cellulose, loose-fill rock wool, and loose-fill fiberglass.

Figure D-1

Fortran Program for the Calculation of
R-TOTAL for Stacked Insulations

```
C PROGRAM TO COMPUTE R TOTAL RESULTING FROM TWO LAYERS
C OF INSULATION
      DIMENSION XX(3),YY(3)
      DIMENSION XR1(12),XC1(12),XC2(12),XC3(12)
      DATA XX/2.2,1.3,.6/
      DATA YY/3.55,2.9,2.2/
      DATA XR1/11.,11.,11.,13.,19.,19.,19.,11.,19.,11.,19.,
     &11./
      DATA XC1/-.42098,.50091,1.461,-.34217,-.93748,1.2001,
     62.162,1.011,1.011,-.95483,-.95483,.78993/
      DATA XC2/14.403,17.195,26.242,6.1403,11.525,23.845,
     &19.556,13.286,13.286,8.05,8.05,20.237/
      DATA XC3/-2.2509,-4.0871,-8.1943,-1.296,-.99126,-5.199
     &,-5.3467,-2.1914,-2.1914,.094988,.094988,-3.0365/
      DO 4 I=1,12
      R1=XR1(I)
      C1=XC1(I)
      C2=XC2(I)
      C3=XC3(I)
      DO 3 K=1,3
      D2=XX(K)
      R2I=YY(K)
      WRITE(6,110)R1,C1,C2,C3
      WRITE(6,111)D2,R2I
      WRITE(6,112)
      DO 2 J=1,10
      T2=2+J
      XM=T2*D2/12.
       DR=(C1+C2*XM+C3*XM**2)/100.0
       R1C=R1*(1.-DR)
       R2=R2I*T2
       RT=R1C+R2
       RU=R1+R2
       WRITE(6,113)T2,R1C,R2,RT,RU
 2     CONTINUE
 3     CONTINUE
 4    CONTINUE
 110    FORMAT(2X,///,2X,'R 0 ',F6.2,4X,'DR CONS.',3(E13.5,1X))
 111   FORMAT(2X,'DEN OF + INS',F6.2,2X,'R/IN.+',F6.2,//)
 112   FORMAT(8X,'ADDED(IN)  R1 CORR   R2          R TOTAL    R\
    \ UNCORR')
 113    FORMAT(2X,5(F10.2,1X))
 99    CONTINUE
       CALL EXIT
       END
```

Table D-1

Definition of Variables in Program for the Calculation of R-TOTAL for Stacked Insulations

DR	$\Delta R/R$ expressed as a fraction
R1C	R-Value for the bottom layer under compression, ft^2hr^oF/BTU
R2	R-Value of added insulation, ft^2hr^oF/BTU
RT	R-Total, corrected for compression, ft^2hr^oF/BTU
RU	R-Total, uncorrected for compression, ft^2hr^oF/BTU
T2	Thickness of added insulation, inches
XC1	C_1 value for Equation (6)
XC2	C_2 value for Equation (6)
XC3	C_3 value for Equation (6)
XM	Loading due to added layer, lb/ft^2
XX, D2	Density of added insulation, lb/ft^3
YY, R2I	R per inch of added insulation, ft^2hr^oF/BTU in

Table D-2

R-Total for R-11 (A) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.25	10.65	20.90	21.65
4.00	10.02	14.20	24.22	25.20
5.00	9.80	17.75	27.55	28.75
6.00	9.60	21.30	30.90	32.30
7.00	9.42	24.85	34.27	35.85
8.00	9.26	28.40	37.66	39.40
9.00	9.11	31.95	41.06	42.95
10.00	8.97	35.50	44.47	46.50
11.00	8.86	39.05	47.91	50.05
12.00	8.76	42.60	51.36	53.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.38	8.70	19.08	19.70
4.00	10.18	11.60	21.78	22.60
5.00	10.00	14.50	24.50	25.50
6.00	9.82	17.40	27.22	28.40
7.00	9.66	20.30	29.96	31.30
8.00	9.50	23.20	32.70	34.20
9.00	9.36	26.10	35.46	37.10
10.00	9.23	29.00	38.23	40.00
11.00	9.11	31.90	41.01	42.90
12.00	9.00	34.80	43.80	45.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.81	6.60	17.41	17.60
4.00	10.74	8.80	19.54	19.80
5.00	10.67	11.00	21.67	22.00
6.00	10.59	13.20	23.79	24.20
7.00	10.52	15.40	25.92	26.40
8.00	10.45	17.60	28.05	28.60
9.00	10.38	19.80	30.18	30.80
10.00	10.32	22.00	32.32	33.00
11.00	10.25	24.20	34.45	35.20
12.00	10.18	26.40	36.58	37.40

Table D-3

R-Total for R-11 (B) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	9.52	10.65	20.17	21.65
4.00	9.21	14.20	23.41	25.20
5.00	8.95	17.75	26.70	28.75
6.00	8.75	21.30	30.05	32.30
7.00	8.62	24.85	33.47	35.85
8.00	8.54	28.40	36.94	39.40
9.00	8.53	31.95	40.48	42.95
10.00	8.58	35.50	44.08	46.50
11.00	8.68	39.05	47.73	50.05
12.00	8.85	42.60	51.45	53.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	9.72	8.70	18.42	19.70
4.00	9.43	11.60	21.03	22.60
5.00	9.18	14.50	23.68	25.50
6.00	8.97	17.40	26.37	28.40
7.00	8.80	20.30	29.10	31.30
8.00	8.67	23.20	31.87	34.20
9.00	8.59	26.10	34.69	37.10
10.00	8.54	29.00	37.54	40.00
11.00	8.53	31.90	40.43	42.90
12.00	8.56	34.80	43.36	45.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.43	6.60	17.03	17.60
4.00	10.30	8.80	19.10	19.80
5.00	10.17	11.00	21.17	22.00
6.00	10.05	13.20	23.25	24.20
7.00	9.94	15.40	25.34	26.40
8.00	9.83	17.60	27.43	28.60
9.00	9.72	19.80	29.52	30.80
10.00	9.62	22.00	31.62	33.00
11.00	9.52	24.20	33.72	35.20
12.00	9.43	26.40	35.83	37.40

Table D-4

R-Total for R-11 (C) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.ØØ	1Ø.Ø4	1Ø.65	2Ø.69	21.65
4.ØØ	9.8Ø	14.2Ø	24.ØØ	25.2Ø
5.ØØ	9.59	17.75	27.34	28.75
6.ØØ	9.41	21.3Ø	3Ø.71	32.3Ø
7.ØØ	9.26	24.85	34.11	35.85
8.ØØ	9.14	28.4Ø	37.54	39.4Ø
9.ØØ	9.Ø5	31.95	41.ØØ	42.95
1Ø.ØØ	8.99	35.5Ø	44.49	46.5Ø
11.ØØ	8.96	39.Ø5	48.Ø1	5Ø.Ø5
12.ØØ	8.96	42.6Ø	51.56	53.6Ø

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.ØØ	1Ø.18	8.7Ø	18.88	19.7Ø
4.ØØ	9.97	11.6Ø	21.57	22.6Ø
5.ØØ	9.78	14.5Ø	24.28	25.5Ø
6.ØØ	9.61	17.4Ø	27.Ø1	28.4Ø
7.ØØ	9.45	2Ø.3Ø	29.75	31.3Ø
8.ØØ	9.32	23.2Ø	32.52	34.2Ø
9.ØØ	9.21	26.1Ø	35.31	37.1Ø
1Ø.ØØ	9.12	29.ØØ	38.12	4Ø.ØØ
11.ØØ	9.Ø5	31.9Ø	4Ø.95	42.9Ø
12.ØØ	9.ØØ	34.8Ø	43.8Ø	45.8Ø

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.ØØ	1Ø.67	6.6Ø	17.27	17.6Ø
4.ØØ	1Ø.58	8.8Ø	19.38	19.8Ø
5.ØØ	1Ø.5Ø	11.ØØ	21.5Ø	22.ØØ
6.ØØ	1Ø.42	13.2Ø	23.62	24.2Ø
7.ØØ	1Ø.34	15.4Ø	25.74	26.4Ø
8.ØØ	1Ø.26	17.6Ø	27.86	28.6Ø
9.ØØ	1Ø.18	19.8Ø	29.98	3Ø.8Ø
1Ø.ØØ	1Ø.11	22.ØØ	32.11	33.ØØ
11.ØØ	1Ø.Ø4	24.2Ø	34.24	35.2Ø
12.ØØ	9.97	26.4Ø	36.37	37.4Ø

Table D-5

R-Total for R-19 (A) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.03	10.65	28.68	29.65
4.00	17.67	14.20	31.87	33.20
5.00	17.33	17.75	35.08	36.75
6.00	17.00	21.30	38.30	40.30
7.00	16.68	24.85	41.53	43.85
8.00	16.37	28.40	44.77	47.40
9.00	16.08	31.95	48.03	50.95
10.00	15.80	35.50	51.30	54.50
11.00	15.53	39.05	54.58	58.05
12.00	15.27	42.60	57.87	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.23	8.70	26.93	27.70
4.00	17.93	11.60	29.53	30.60
5.00	17.64	14.50	32.14	33.50
6.00	17.36	17.40	34.76	36.40
7.00	17.09	20.30	37.39	39.30
8.00	16.82	23.20	40.02	42.20
9.00	16.57	26.10	42.67	45.10
10.00	16.32	29.00	45.32	48.00
11.00	16.08	31.90	47.98	50.90
12.00	15.85	34.80	50.65	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.85	6.60	25.45	25.60
4.00	18.75	8.80	27.55	27.80
5.00	18.64	11.00	29.64	30.00
6.00	18.54	13.20	31.74	32.20
7.00	18.43	15.40	33.83	34.40
8.00	18.33	17.60	35.93	36.60
9.00	18.23	19.80	38.03	38.80
10.00	18.13	22.00	40.13	41.00
11.00	18.03	24.20	42.23	43.20
12.00	17.93	26.40	44.33	45.40

Table D-6

R-Total for R-19 (B) Fiberglass Batts with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	16.58	10.65	27.23	29.65
4.00	15.98	14.20	30.18	33.20
5.00	15.45	17.75	33.20	36.75
6.00	14.98	21.30	36.28	40.30
7.00	14.58	24.85	39.43	43.85
8.00	14.25	28.40	42.65	47.40
9.00	13.99	31.95	45.94	50.95
10.00	13.79	35.50	49.29	54.50
11.00	13.65	39.05	52.70	58.05
12.00	13.59	42.60	56.19	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	16.93	8.70	25.63	27.70
4.00	16.41	11.60	28.01	30.60
5.00	15.93	14.50	30.43	33.50
6.00	15.49	17.40	32.89	36.40
7.00	15.10	20.30	35.40	39.30
8.00	14.76	23.20	37.96	42.20
9.00	14.46	26.10	40.56	45.10
10.00	14.20	29.00	43.20	48.00
11.00	13.99	31.90	45.89	50.90
12.00	13.82	34.80	48.62	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.11	6.60	24.71	25.60
4.00	17.91	8.80	26.71	27.80
5.00	17.70	11.00	28.70	30.00
6.00	17.50	13.20	30.70	32.20
7.00	17.31	15.40	32.71	34.40
8.00	17.12	17.60	34.72	36.60
9.00	16.93	19.80	36.73	38.80
10.00	16.75	22.00	38.75	41.00
11.00	16.58	24.20	40.78	43.20
12.00	16.41	26.40	42.81	45.40

Table D-7

R-Total for R-19 (C) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	16.85	10.65	27.50	29.65
4.00	16.41	14.20	30.61	33.20
5.00	16.04	17.75	33.79	36.75
6.00	15.73	21.30	37.03	40.30
7.00	15.49	24.85	40.34	43.85
8.00	15.32	28.40	43.72	47.40
9.00	15.22	31.95	47.17	50.95
10.00	15.19	35.50	50.69	54.50
11.00	15.23	39.05	54.28	58.05
12.00	15.33	42.60	57.93	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	17.12	8.70	25.82	27.70
4.00	16.73	11.60	28.33	30.60
5.00	16.37	14.50	30.87	33.50
6.00	16.07	17.40	33.47	36.40
7.00	15.81	20.30	36.11	39.30
8.00	15.59	23.20	38.79	42.20
9.00	15.42	26.10	41.52	45.10
10.00	15.30	29.00	44.30	48.00
11.00	15.22	31.90	47.12	50.90
12.00	15.19	34.80	49.99	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.05	6.60	24.65	25.60
4.00	17.89	8.80	26.69	27.80
5.00	17.72	11.00	28.72	30.00
6.00	17.57	13.20	30.77	32.20
7.00	17.41	15.40	32.81	34.40
8.00	17.27	17.60	34.87	36.60
9.00	17.12	19.80	36.92	38.80
10.00	16.99	22.00	38.99	41.00
11.00	16.85	24.20	41.05	43.20
12.00	16.73	26.40	43.13	45.40

Table D-8

R-Total for R-11 LFC with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.16	10.65	20.81	21.65
4.00	9.95	14.20	24.15	25.20
5.00	9.75	17.75	27.50	28.75
6.00	9.57	21.30	30.87	32.30
7.00	9.41	24.85	34.26	35.85
8.00	9.26	28.40	37.66	39.40
9.00	9.13	31.95	41.08	42.95
10.00	9.02	35.50	44.52	46.50
11.00	8.92	39.05	47.97	50.05
12.00	8.84	42.60	51.44	53.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.28	8.70	18.98	19.70
4.00	10.10	11.60	21.70	22.60
5.00	9.93	14.50	24.43	25.50
6.00	9.77	17.40	27.17	28.40
7.00	9.62	20.30	29.92	31.30
8.00	9.48	23.20	32.68	34.20
9.00	9.36	26.10	35.46	37.10
10.00	9.24	29.00	38.24	40.00
11.00	9.13	31.90	41.03	42.90
12.00	9.04	34.80	43.84	45.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.67	6.60	17.27	17.60
4.00	10.61	8.80	19.41	19.80
5.00	10.54	11.00	21.54	22.00
6.00	10.47	13.20	23.67	24.20
7.00	10.41	15.40	25.81	26.40
8.00	10.34	17.60	27.94	28.60
9.00	10.28	19.80	30.08	30.80
10.00	10.22	22.00	32.22	33.00
11.00	10.16	24.20	34.36	35.20
12.00	10.10	26.40	36.50	37.40

Table D-9

R-Total for R-19 LFC with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	17.55	10.65	28.20	29.65
4.00	17.18	14.20	31.38	33.20
5.00	16.84	17.75	34.59	36.75
6.00	16.53	21.30	37.83	40.30
7.00	16.25	24.85	41.10	43.85
8.00	16.00	28.40	44.40	47.40
9.00	15.78	31.95	47.73	50.95
10.00	15.58	35.50	51.08	54.50
11.00	15.41	39.05	54.46	58.05
12.00	15.27	42.60	57.87	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	17.76	8.70	26.46	27.70
4.00	17.44	11.60	29.04	30.60
5.00	17.15	14.50	31.65	33.50
6.00	16.87	17.40	34.27	36.40
7.00	16.62	20.30	36.92	39.30
8.00	16.38	23.20	39.58	42.20
9.00	16.16	26.10	42.26	45.10
10.00	15.96	29.00	44.96	48.00
11.00	15.78	31.90	47.68	50.90
12.00	15.61	34.80	50.41	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.44	6.60	25.04	25.60
4.00	18.32	8.80	27.12	27.80
5.00	18.20	11.00	29.20	30.00
6.00	18.09	13.20	31.29	32.20
7.00	17.98	15.40	33.38	34.40
8.00	17.86	17.60	35.46	36.60
9.00	17.76	19.80	37.56	38.80
10.00	17.65	22.00	39.65	41.00
11.00	17.55	24.20	41.75	43.20
12.00	17.44	26.40	43.84	45.40

Table D-10

R-Total for R-11 LFRW with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.61	10.65	21.26	21.65
4.00	10.45	14.20	24.65	25.20
5.00	10.28	17.75	28.03	28.75
6.00	10.12	21.30	31.42	32.30
7.00	9.95	24.85	34.80	35.85
8.00	9.78	28.40	38.18	39.40
9.00	9.62	31.95	41.57	42.95
10.00	9.45	35.50	44.95	46.50
11.00	9.28	39.05	48.33	50.05
12.00	9.11	42.60	51.71	53.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.70	8.70	19.40	19.70
4.00	10.57	11.60	22.17	22.60
5.00	10.44	14.50	24.94	25.50
6.00	10.30	17.40	27.70	28.40
7.00	10.16	20.30	30.46	31.30
8.00	10.03	23.20	33.23	34.20
9.00	9.89	26.10	35.99	37.10
10.00	9.75	29.00	38.75	40.00
11.00	9.62	31.90	41.52	42.90
12.00	9.48	34.80	44.28	45.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.97	6.60	17.57	17.60
4.00	10.93	8.80	19.73	19.80
5.00	10.88	11.00	21.88	22.00
6.00	10.84	13.20	24.04	24.20
7.00	10.79	15.40	26.19	26.40
8.00	10.75	17.60	28.35	28.60
9.00	10.70	19.80	30.50	30.80
10.00	10.66	22.00	32.66	33.00
11.00	10.61	24.20	34.81	35.20
12.00	10.57	26.40	36.97	37.40

Table D-11

R-Total for R-19 LFRW with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.33	10.65	28.98	29.65
4.00	18.05	14.20	32.25	33.20
5.00	17.76	17.75	35.51	36.75
6.00	17.48	21.30	38.78	40.30
7.00	17.19	24.85	42.04	43.85
8.00	16.90	28.40	45.30	47.40
9.00	16.61	31.95	48.56	50.95
10.00	16.32	35.50	51.82	54.50
11.00	16.02	39.05	55.07	58.05
12.00	15.73	42.60	58.33	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.49	8.70	27.19	27.70
4.00	18.26	11.60	29.86	30.60
5.00	18.02	14.50	32.52	33.50
6.00	17.79	17.40	35.19	36.40
7.00	17.56	20.30	37.86	39.30
8.00	17.32	23.20	40.52	42.20
9.00	17.08	26.10	43.18	45.10
10.00	16.85	29.00	45.85	48.00
11.00	16.61	31.90	48.51	50.90
12.00	16.37	34.80	51.17	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.95	6.60	25.55	25.60
4.00	18.87	8.80	27.67	27.80
5.00	18.80	11.00	29.80	30.00
6.00	18.72	13.20	31.92	32.20
7.00	18.64	15.40	34.04	34.40
8.00	18.57	17.60	36.17	36.60
9.00	18.49	19.80	38.29	38.80
10.00	18.41	22.00	40.41	41.00
11.00	18.33	24.20	42.53	43.20
12.00	18.26	26.40	44.66	45.40

Table D-12

R-Total for R-11 LFFG with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	9.79	10.65	20.44	21.65
4.00	9.46	14.20	23.66	25.20
5.00	9.15	17.75	26.90	28.75
6.00	8.87	21.30	30.17	32.30
7.00	8.61	24.85	33.46	35.85
8.00	8.37	28.40	36.77	39.40
9.00	8.15	31.95	40.10	42.95
10.00	7.95	35.50	43.45	46.50
11.00	7.78	39.05	46.83	50.05
12.00	7.63	42.60	50.23	53.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	9.98	8.70	18.68	19.70
4.00	9.70	11.60	21.30	22.60
5.00	9.43	14.50	23.93	25.50
6.00	9.18	17.40	26.58	28.40
7.00	8.94	20.30	29.24	31.30
8.00	8.72	23.20	31.92	34.20
9.00	8.52	26.10	34.62	37.10
10.00	8.33	29.00	37.33	40.00
11.00	8.15	31.90	40.05	42.90
12.00	7.99	34.80	42.79	45.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	10.59	6.60	17.19	17.60
4.00	10.48	8.80	19.28	19.80
5.00	10.38	11.00	21.38	22.00
6.00	10.28	13.20	23.48	24.20
7.00	10.17	15.40	25.57	26.40
8.00	10.08	17.60	27.68	28.60
9.00	9.98	19.80	29.78	30.80
10.00	9.88	22.00	31.88	33.00
11.00	9.79	24.20	33.99	35.20
12.00	9.70	26.40	36.10	37.40

Table D-13

R-Total for R-19 LFFG with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	16.96	10.65	27.61	29.65
4.00	16.43	14.20	30.63	33.20
5.00	15.95	17.75	33.70	36.75
6.00	15.52	21.30	36.82	40.30
7.00	15.14	24.85	39.99	43.85
8.00	14.81	28.40	43.21	47.40
9.00	14.53	31.95	46.48	50.95
10.00	14.30	35.50	49.80	54.50
11.00	14.12	39.05	53.17	58.05
12.00	14.00	42.60	56.60	61.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	17.27	8.70	25.97	27.70
4.00	16.81	11.60	28.41	30.60
5.00	16.38	14.50	30.88	33.50
6.00	15.99	17.40	33.39	36.40
7.00	15.63	20.30	35.93	39.30
8.00	15.30	23.20	38.50	42.20
9.00	15.01	26.10	41.11	45.10
10.00	14.75	29.00	43.75	48.00
11.00	14.53	31.90	46.43	50.90
12.00	14.34	34.80	49.14	53.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	18.29	6.60	24.89	25.60
4.00	18.11	8.80	26.91	27.80
5.00	17.93	11.00	28.93	30.00
6.00	17.76	13.20	30.96	32.20
7.00	17.59	15.40	32.99	34.40
8.00	17.43	17.60	35.03	36.60
9.00	17.27	19.80	37.07	38.80
10.00	17.11	22.00	39.11	41.00
11.00	16.96	24.20	41.16	43.20
12.00	16.81	26.40	43.21	45.40

Table D-14

R-TOTAL for R-13(A) Fiberglass Batts
with Added Loose-Fill Insulation

Cellulose Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	12.66	10.65	23.31	23.65
4.00	12.55	14.20	26.75	27.20
5.00	12.45	17.75	30.20	30.75
6.00	12.37	21.30	33.67	34.30
7.00	12.30	24.85	37.15	37.85
8.00	12.24	28.40	40.64	41.40
9.00	12.19	31.95	44.14	44.95
10.00	12.15	35.50	47.65	48.50
11.00	12.12	39.05	51.17	52.05
12.00	12.10	42.60	54.70	55.60

Rock Wool Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	12.72	8.70	21.42	21.70
4.00	12.63	11.60	24.23	24.60
5.00	12.54	14.50	27.04	27.50
6.00	12.46	17.40	29.86	30.40
7.00	12.39	20.30	32.69	33.30
8.00	12.33	23.20	35.53	36.20
9.00	12.27	26.10	38.37	39.10
10.00	12.23	29.00	41.23	42.00
11.00	12.19	31.90	44.09	44.90
12.00	12.15	34.80	46.95	47.80

Fiberglass Added

ADDED(IN)	R1 CORR	R2	R TOTAL	R UNCORR
3.00	12.93	6.60	19.53	19.60
4.00	12.89	8.80	21.69	21.80
5.00	12.86	11.00	23.86	24.00
6.00	12.82	13.20	26.02	26.20
7.00	12.79	15.40	28.19	28.40
8.00	12.75	17.60	30.35	30.60
9.00	12.72	19.80	32.52	32.80
10.00	12.69	22.00	34.69	35.00
11.00	12.66	24.20	36.86	37.20
12.00	12.63	26.40	39.03	39.40

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