NEW MEXICO ENERGY INSTITUTE
THE UNIVERSITY OF NEW MEXICO
117 RICHMOND DRIVE NE
ALBUQUERQUE, NEW MEXICO 87106

EFFECTIVE U VALUES*

Wybe J. van der Meer**
L. W. Bickle, Ph.D.***

NMEI REPORT NO. 76-161B

FEBRUARY 1978

---------------(SECOND REVISION)---------------

New Mexico, as one of the first states to adopt Chapter 53 of the Uniform Building Code (UBC), has become heavily involved in understanding the performance of building components under local climatic conditions. The analysis of potential problems of implementing the energy conservation code for New Mexico revealed that a key problem results from a failure to distinguish between the steady-state U values of materials, as published in the ASHRAE Handbook of Fundamentals, and their dynamic performance when diurnal temperature variation, insolation, variable wind speed, radiation to the night sky, etc., are properly considered. The strategy developed to overcome this problem is to replace the steady-state U values with effective U values which characterize the average dynamic performance of various wall types. Preliminary findings and conclusions have been so surprising and contradictory that they must be shared with others. This condensed report presents the definition of an effective U value, describes the computer simulation program that has been developed to compute effective U values, and offers some preliminary results and conclusions.

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*A Method for Calculating the Average Thermal Performance of Building Components

**Associate Professor, Architecture, The University of New Mexico

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RESEARCH SUMMARY

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This research project was funded by the New Mexico Energy Resources Board through the New Mexico Energy Institute at The University of New Mexico.

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Effective U Values

In order to work within the basically sound framework of Chapter 53, UBC, and to take advantage of all material available, the concept of an effective U value that takes into account solar input and time-dependent boundary conditions has been developed. In essence, the effective U values are designed to measure average heat transfer rather than peak steady-state heat transfer. If effective U values are measures of for steady-state U values in the thermal efficiency analysis, the result is a building code that controls average rather than peak energy consumption.

Any U value may be calculated from the following equation:

$$U = \frac{(q/A)}{\Delta T}$$

where q(BTU/hr) is the rate of heat transferred through the wall, A(sq.ft.) is the area, and ΔT (^{o}F) is the temperature difference.

One problem is to determine which heat transfer rate to use in defining the U value. Also, heat transfer rates are not necessarily in phase with the temperature fluctuations; thus, when a heat transfer is selected relative to a specific temperature difference is as important as where in the wall the rate is measured. When the temperature across the wall or the boundary conditions are changing with time, the heat entering the inside surface is not equal to the heat leaving the outside surface (the difference is the energy being stored in or removed from the wall). The conclusion is that the steady-state U value is not applicable to dynamic situations.

An effective U value for walls can be defined in a number of ways. One definition that has proven useful in computing average energy losses through walls for heating is as follows:

$$U_e = \frac{\overline{(q/A)}}{\overline{\Delta T}}$$

where U_e is the effective U value, $\overline{(q/A)}$ is the average heat transfer per unit area at the inside surface of the wall over an extended time period, and $\overline{\Delta T}$ is the average temperature difference over the same time interval. If the selected time interval is "typical" for the winter heating season, and if all boundary conditions including insolation are considered, the effective U value will be a measure of the average energy loss for the heating season. If the effective U values are used in lieu of the steady-state U values, the prescriptive standards can be used "as is," but they will control average fuel consumption rather than peak consumption.

In order to use the above definition of effective U values, it is necessary to compute the heat transfer at the inside surface of the wall, or a "typical" time sequence of boundary variables -- including temperature, insolation, wind speed, etc. The complexities of this type of calculation dictate the use of a sophisticated computerized heat transfer model.

Calculation of Energy Flow Through Walls

Consider the composite or layered wall shown in Figure 1. If there is a temperature difference across the wall, and between the wall and its surroundings, energy (heat) will flow from the higher temperature region to the lower temperature region. The rate at which heat flows through a given area of wall depends on the temperature difference, the material properties of the wall, and the "boundary" conditions. If the inside and outside temperatures are fixed for long periods of time, and if the temperatures of all the inside and outside surroundings are held constant, then the wall will eventually reach a steady-state condition. That is, the rate at which energy is entering the inside surface of the wall is exactly equal to the

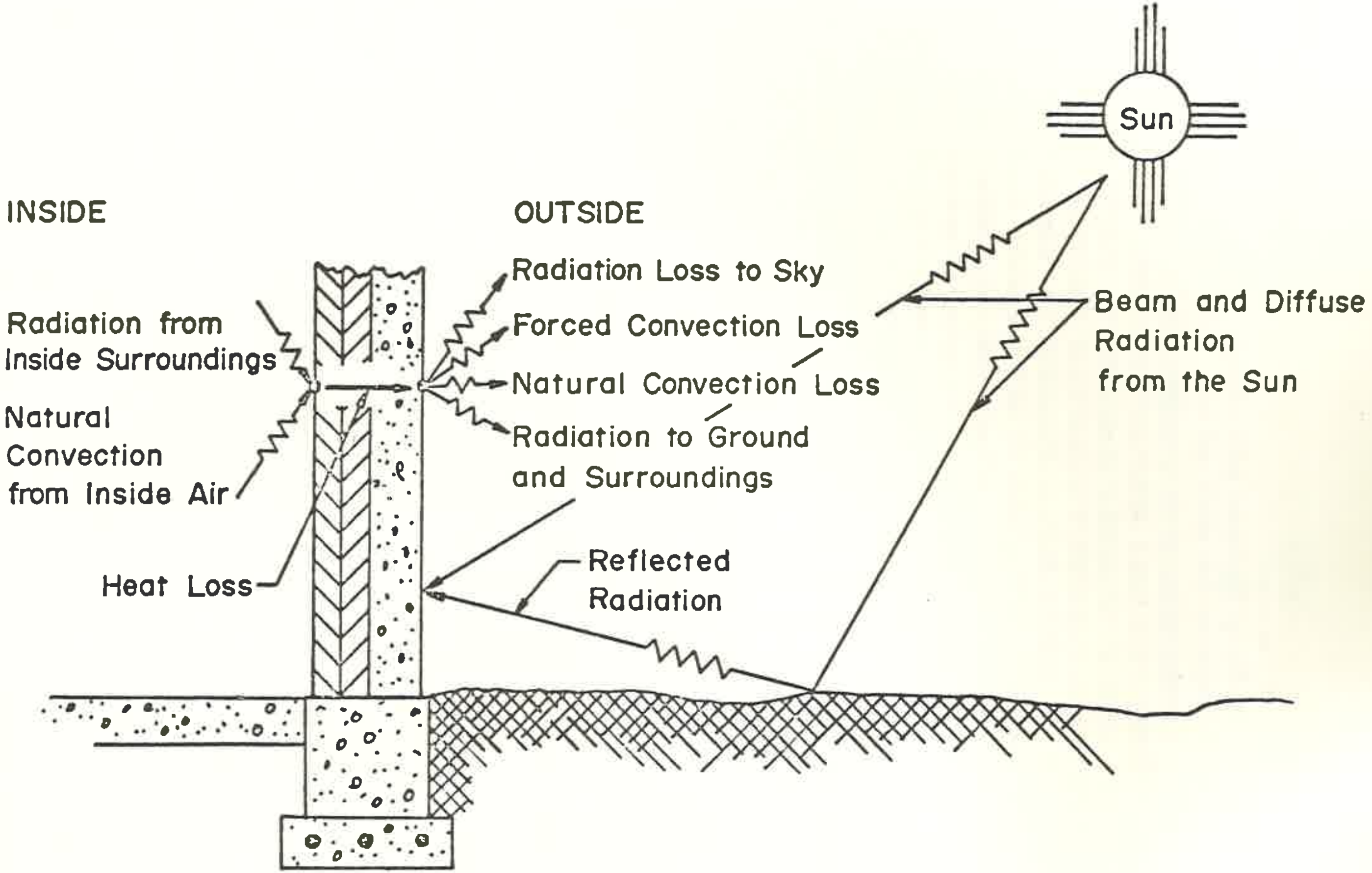

INSIDE
OUTSIDE
Sun
Radiation from Inside Surroundings
Natural Convection from Inside Air
Heat Loss
Radiation Loss to Sky
Forced Convection Loss
Natural Convection Loss
Radiation to Ground and Surroundings
Reflected Radiation
Beam and Diffuse Radiation from the Sun

Figure 1

rate at which heat is being removed from the outside surface, and the temperature at any specific point in the wall is constant with time. An important consequence of this steady-state condition is that the energy stored in the wall is not changing with time.

A U value is composed of two parts, as follows:

U = properties of the wall, thickness and thermal conductivity + characteristics of the boundary conditions (heat transfer between surfaces and surroundings)

The first part of the U value distinguishes between different types of walls. A thick wall with low thermal conductivity has a lower U value than a thinner wall of the same material and/or a wall with higher thermal conductivity. Since the thermal storage characteristics of the wall do not enter into the steady-state calculations, the mass and heat capacity of the wall material are <u>not</u> a part of the U value.

The second part of the U value, the boundary conditions, is very complex. At the inside surface of the wall, heat transfer takes place by natural convection and radiation. The natural convection is controlled by the temperature difference between the wall and the inside air. The heat transferred to the inside surface of the wall by radiation depends on the temperature of the materials and surfaces in the room. In some cases, the radiation heat transfer can account for 50% to 60% of all energy reaching the inside surface. The absorption and reflection characteristics of the surface are also important.

The outside boundary is even more complex. In addition to natural convection, winds result in forced convection. The radiation transfer is also important because radiation to the night sky can have effective radiation temperatures of as low as -100°F. During the day, both direct and diffuse radiation from the sun must be considered.

Because of these complexities in describing boundary conditions, the typical approach used for steady-state calculations is to assign "average" values for temperature differences, wind speeds, radiation temperatures, etc., and to lump all of the heat transfer processes into a single "surface" or "film-factor."

It must be remembered that steady-state U values were developed as an aid in estimating peak loads for selecting heating equipment. These peak loads are calculated by assuming that there is no solar energy input, that the lowest probable outside temperature has been constantly maintained for a period of several days, and that average wind speeds prevail. If the furnace or heating system can maintain adequate inside temperatures for these conditions, then the system has adequate peak capacity.

The steady-state calculation techniques are well understood, experimentally verified, and simple to use. Adding insulation lowers the U value and thus reduces peak loads. Because of this, many of the prescriptive type building codes are based on adding insulation to reduce U values. There is little doubt that this approach will lower peak heating loads, and that in itself is worthwhile.

However, reducing steady-state U values by adding insulation does not necessarily reduce average fuel consumption!

The key to understanding this paradox is recognition of two facts:

1. With day-to-day and hour-to-hour fluctuations in outside temperature and boundary conditions (e.g., wind speed), walls are seldom, if ever, in a steady-state condition. The average temperature, and the temperature at any specific point in the wall, varies with time. It follows from this that the correlation between boundary variables is important (e.g., how often does high wind speed

occur simultaneously with low outside temperature and clear skies that have low effective radiation temperatures?).

2. Solar input, which is ignored in steady-state heat loss calculations (presumably because peak loads tend to occur at night), is critically important in determining average fuel consumption over extended time periods. This point can be readily illustrated by considering a south-facing single-pane window. A steady-state calculation without solar input would indicate that the window has a poor (i.e., large) U value of about 1.13 BTU/sf-hr-^{o}F compared to even a modestly insulated wall with a U value of 0.10 BTU/sf-hr-^{o}F. An energy conservation code that takes the approach of minimizing steady-state U values would clearly indicate that the window should be eliminated or reduced to the minimal acceptable size for emergency egress. Nevertheless, in areas with high insolation, our calculations show that a single-glazed, south-facing window is a net energy gainer for the heating season even in areas that experience harsh winters (e.g., 7500 heating degree days). In fact, passive solar houses that are designed for areas with harsh winters typically use large amounts of south-facing windows to actually reduce average fuel consumption.

Development of A Computer Program For Computing Effective U Values

Two computer programs have been developed by L.W. Bickle and Associates for computing the effective U values of opaque walls and windows. The program for opaque walls used the lumped-node network model. Briefly, the program includes the following operations:

1. Read a weather tape of actual hour-by-hour weather data including date, time, total global insolation on a horizontal surface, temperature, and wind speed. (See Figure 2, New Mexico Design Conditions; and Figure 3, New Mexico Climatic Regions Map.)

NEW MEXICO DESIGN CONDITIONS

CLIMATIC REGION	WINTER	SUMMER		DEGREE DAY HEATING	DEGREE DAY COOLING
		DRY BULB	WET BULB		
1	- 8°F	82°F	60°F	9316	7
2	- 4°F	86°F	63°F	7681	113
3	- 3°F	86°F	62°F	7082	230
4	+ 9°F	86°F	63°F	6018	386
5	+ 9°F	93°F	65°F	5720	537
6	+10°F	94°F	67°F	5321	830
7	+12°F	90°F	65°F	4919	544
8	+14°F	88°F	63°F	4418	701
9	+17°F	97°F	66°F	3911	1443
10	+23°F	97°F	69°F	3203	1582
11	+19°F	99°F	71°F	2803	1911

Figure 2. New Mexico Design Conditions

2. Compute the position of the sun and partition the insolation into a beam component and a diffuse component. Use the orientation of the wall to compute the incident solar radiation.

3. Use the absorptivity of the wall at solar wavelengths to calculate the solar gains.

4. Use the emmisivity of the wall at long wavelengths to calculate the re-radiation losses to the sky and surroundings. Note that the solar absorptivity and long wavelength emmisivity are independent input variables and are generally different.

5. Use the wind speed and an empirical correlation to compute convection losses at the outside surface.

6. Assign inside air temperature (this can follow a schedule such as night setback) and separately compute radiation and natural convection at the inside surface.

7. Use the outside temperature and the boundary gains and losses from steps 3, 4, 5, & 6 as the forcing function to drive the network model.

8. Solve the network model using an implicit differencing technique that treats solids as pure, linear conductances and air spaces as nonlinear radiation and convection cavities.

9. As separate calculations, compute the average heat transfer per unit area at the inside surface of the wall and the average difference between inside and outside temperatures.

10. Take the ratio to determine the effective U value.

Experience has shown that it is not necessary to use hour-by-hour weather data for the entire winter. One to two weeks of "typical" hour-by-hour data is sufficient for the effective U value to stabilize at an average value.

The computer program that computes the effective U value of glazings is a modification of the program for opaque walls. All steps are similar to those for the opaque wall (the word "wall" should now be replaced by "glazing" in steps 1-6) program except 3, 7, 8, & 9 as follows:

3. Calculate the insolation reflected, absorbed, and transmitted by the glazing.

7. Select a treatment on the inside surface of the glazing.

8. Use the outside temperature and the boundary gains and losses from steps 4, 5 and 6 as the forcing functions to drive the thermal network.

9. Solve the network model using an implicit differencing technique which treats the glazing as a pure, linear conductance and air spaces as nonlinear radiation and convection cavities.

10. As a separate calculation compute the average heat loss from the room to the glazing, the average solar gain through the window, and the average inside-outside temperature difference. The effective U value is the ratio of average loss minus average solar gain to the average temperature difference.

Preliminary Results

The opaque wall program has been applied to 26 wall sections, and the glazing program has been applied to 2 window sections.

In all cases, the walls were assumed to have a long wavelength emmissivity of 0.9. The solar absorptivity was varied from 0.2 to 0.5 to 0.8 to simulate light, medium and dark colored walls, respectively. Also, calculations were performed for north-, east-, south- and west-facing walls and windows, since the influence of insolation is significantly different for each of these orientations. Examples of effective U values are shown in Figures 4 through 12.

Conclusions

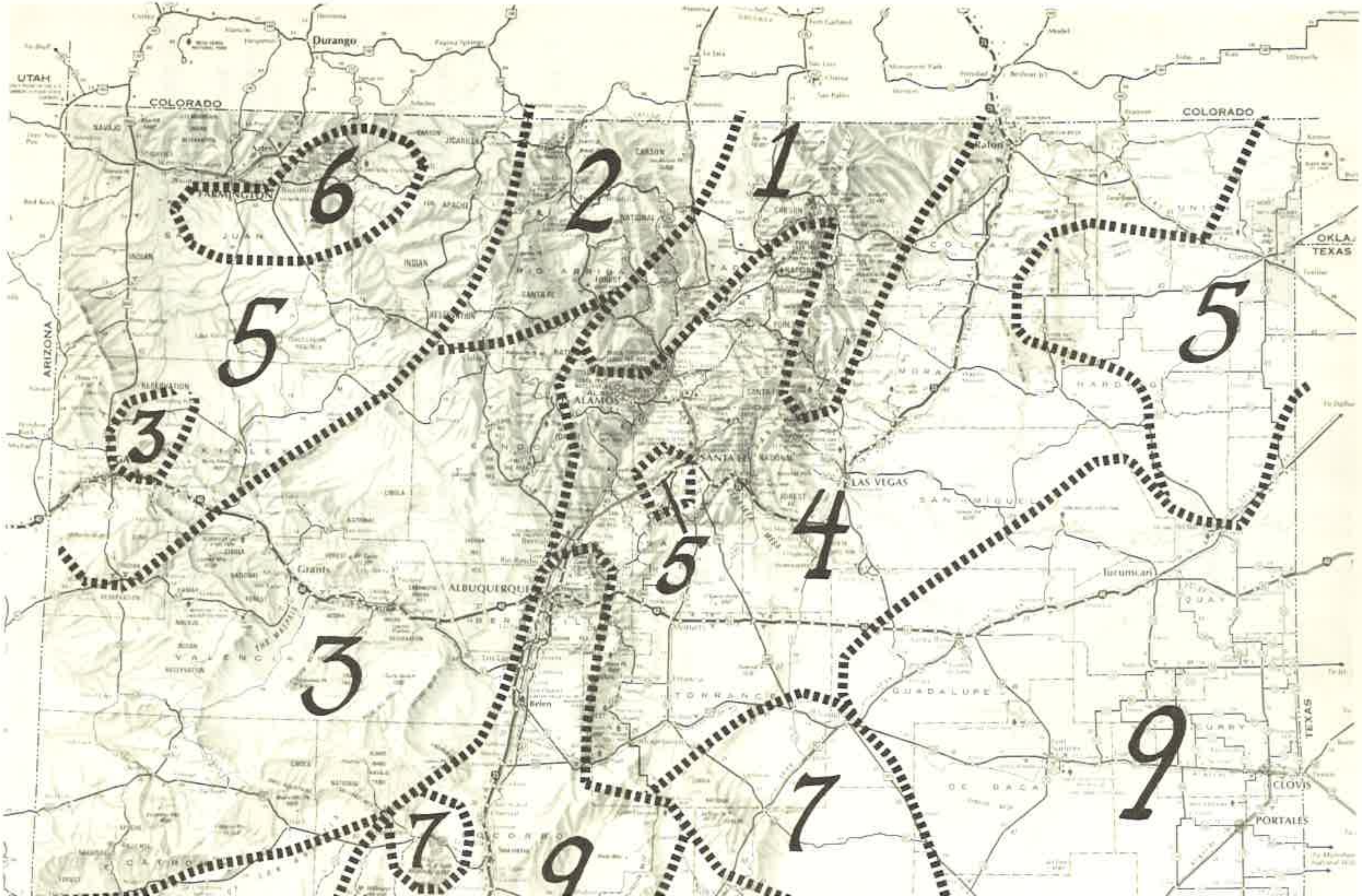
The sheer bulk of data will take months of study to assimilate all of the trends and subtle implications. However, a few preliminary conclusions follow:

1. Effective U values are significantly different from steady-state U values. Thus, inclusion of thermal storage and solar effects is important.

2. The effective U values for east, west and south walls is a strong function of color. (In some instances it may be more cost-effective to paint than to insulate.)

3. The economic optimum insulation is different for different orientation walls and different from what would be predicted using steady-state U values. Generally speaking, less insulation will be required if effective U values are used for economic optimization. (A separate study of actual use of energy for heating of buildings, constructed to new and old FHA insulation standards, indicated that houses constructed to the older insulation standards, which required less insulation than the present standards, were actually on an average more energy conservative than houses built to the newer standards.)

4. Some wall combinations have negative effective U values. This indicates that the wall is acting as a solar collector and is a net energy gainer. Further research is needed on how to optimize and


UTAH
COLORADO
Durango
COLORADO
OKLA.
TEXAS
ARIZONA
TEXAS
FARMINGTON
Raton
LOS ALAMOS
SANTA FE
LAS VEGAS
Tucumcari
Grants
ALBUQUERQUE
Belen
CLOVIS
PORTALES
SAN JUAN
RIO ARRIBA
COLFAX
MORA
HARDING
SAN MIGUEL
QUAY
GUADALUPE
TORRANCE
DE BACA
CURRY
VALENCIA
SOCORRO
CATRON
McKINLEY
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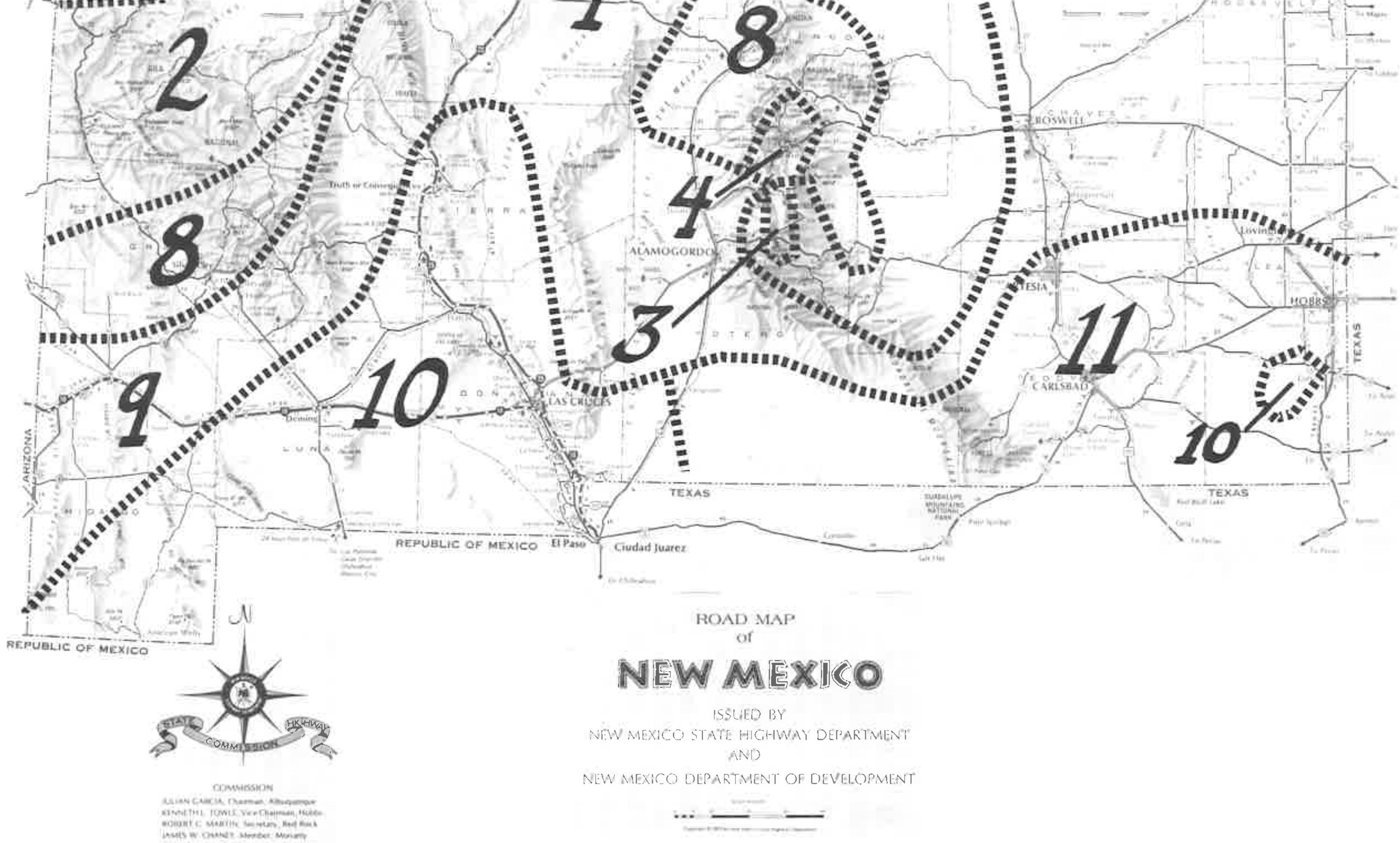

Figure 3. New Mexico Climate Regions

enhance this effect.

5. Properly oriented and treated windows can be large energy gainers. Prescriptive building codes that stress steady-state U values erroneously indicate that window areas should be minimized, thus eliminating passive solar systems.

6. Effective U values can be easily substituted in a descriptive building code. The result is a performance code that allows a broader range of construction and focuses on average rather than peak energy use.

Summary

At this point, the results are preliminary and a great deal of work remains to be done. The influence on summer cooling loads, roofs, windows and other portions of the building envelope must be considered. Also, the results are applicable only to New Mexico.

The effective U values contained herein represent an average response to an average winter week selected for its conformance to average winter temperature and insolation conditions. Because of variability of temperature and solar radiation, and some nonlinear response with respect to these variables (most noticeable for glazing and dark south facing walls), it is recognized that the effective U values may not be true averages for the entire heating season. However, the effective U values are indicative of the interaction of solar radiation and thermal insulation and represent reasonable approximations at this time.

There is probably some upper limit of glass area to floor area for which the effective U values for glass are valid, since all of the energy entering through the glass is assumed to be usable. However, since a good correlation was achieved with houses having as much as 16.3% of the floor area as glazing, the limit must be something greater. At this time it is suggested that a limit of 20% glass to floor area seems reasonable until further studies can be made.

A final caution is that the effective U values should not be used for sizing heating equipment at this time. It is intended that they be used for compliance with prescriptive building codes and to estimate average annual energy use.

It is believed that the concept of an effective U value and the results presented in this report represent a reasonable first step toward implementing a performance-type building code that minimizes average energy use rather than minimizing peak energy consumption.

Information Dissemination

To compliment the normal extensive reporting of research project results, the New Mexico Energy Institute has briefed the New Mexico public on this research breakthrough at public hearings recently conducted by the New Mexico Energy Resources Board. In addition, special briefings for key Federal Energy Administration, Energy Research and Development Administration, and several State officials were held in Washington, D.C. during the month of May, 1977. The results of the research on effective U values were also introduced and discussed at the June 26-28 Public Meeting for 16 western states, conducted by the Energy Research and Development Administration in Phoenix, Arizona. Key members of the National Conference of States on Building Codes and Standards (NCBCS), ICBO, and local members of VA, FHA, HUD, and FEA, have also been briefed on the use of the concept of effective U values.

Readers of this research summary are encouraged to submit comments on the methodology contained herein. Contact the New Mexico Energy Institute in writing or by phone (505/277-3661). Your questions and/or comments will be most welcome.

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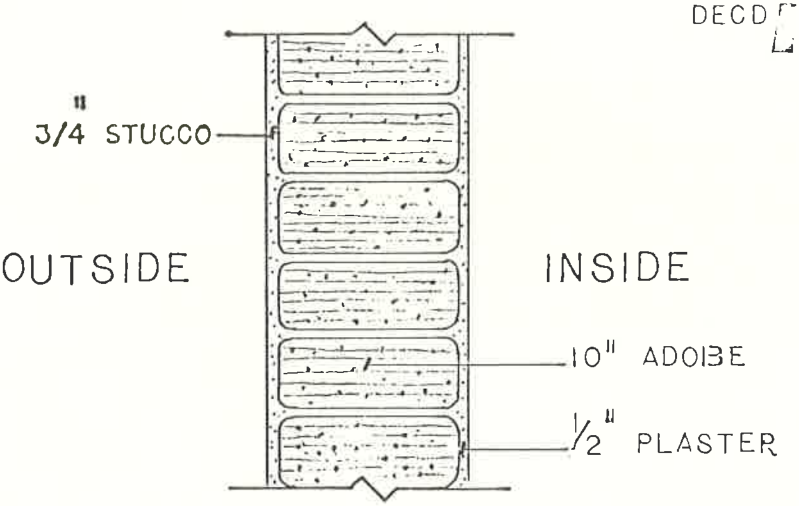

WALL TYPE 1: ASHRAE STEADY STATE U-VALUE 0.263 BTU/SF-HR-°F

EFFECTIVE "U"-VALUE (U_E): HEATING

N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.260	.225	.191	.252	.205	.160	.244	.188	.138	.254	.210	.158
2	.237	.219	.200	.231	.205	.179	.225	.189	.155	.233	.208	.184
3	.232	.218	.203	.227	.204	.182	.220	.187	.156	.228	.209	.187
4	.230	.218	.207	.224	.203	.183	.215	.181	.149	.225	.206	.188
5	.230	.219	.207	.223	.202	.182	.214	.179	.145	.225	.206	.187
6	.231	.220	.208	.224	.202	.179	.214	.176	.139	.226	.206	.186
7	.234	.221	.209	.225	.201	.176	.214	.172	.131	.227	.205	.123
8	.238	.224	.209	.228	.199	.171	.215	.166	.119	.231	.205	.179
9	.244	.227	.209	.232	.198	.164	.217	.160	.105	.235	.204	.174
10	.255	.232	.209	.240	.195	.152	.221	.150	.082	.243	.204	.165
11	.262	.235	.208	.245	.194	.144	.224	.143	.067	.249	.203	.159

*WALL COLORS: L=LIGHT
M=MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THIS TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 4

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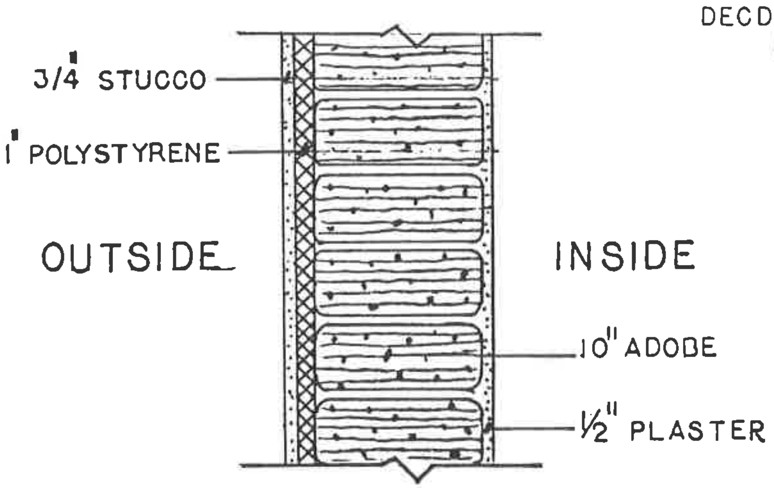

WALL TYPE 3 : ASHRAE STEADY STATE U-VALUE 0.110 $\frac{BTU}{SF\text{-}HR\text{-}^{\circ}F}$

EFFECTIVE "U"-VALUE (U_E): HEATING

N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.118	.104	.091	.114	.096	.078	.112	.089	.069	.116	.099	.083
2	.104	.097	.090	.102	.091	.081	.099	.085	.072	.102	.093	.084
3	.101	.095	.090	.099	.090	.081	.096	.083	.071	.100	.092	.084
4	.099	.095	.090	.097	.089	.081	.093	.081	.068	.098	.091	.084
5	.100	.095	.091	.097	.089	.081	.093	.080	.067	.098	.091	.084
6	.100	.096	.091	.097	.089	.080	.093	.079	.065	.098	.091	.083
7	.102	.097	.092	.098	.089	.079	.094	.078	.062	.099	.091	.083
8	.104	.099	.093	.100	.089	.078	.095	.076	.058	.101	.092	.082
9	.108	.101	.094	.103	.090	.076	.097	.075	.054	.104	.093	.082
10	.114	.105	.096	.108	.091	.074	.101	.073	.047	.110	.095	.080
11	.119	.108	.098	.112	.092	.072	.104	.072	.042	.114	.096	.080

*WALL COLORS: L=LIGHT
M-MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THIS TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 5

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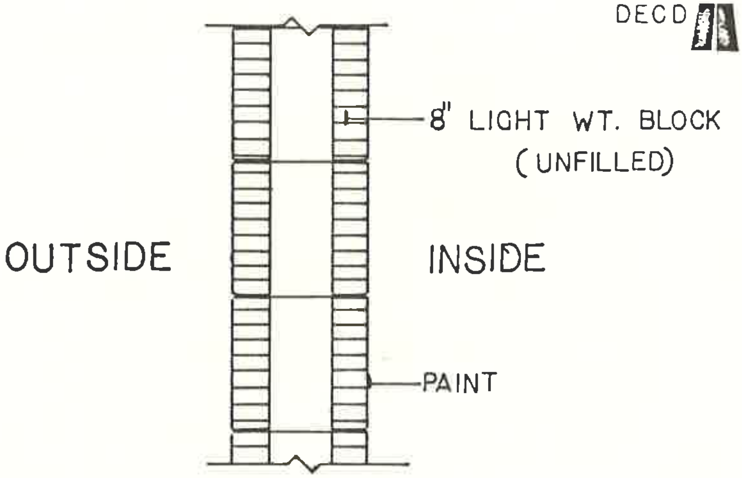


WALL TYPE 9: ASHRAE STEADY STATE U-VALUE 0.314 $\frac{\text{BTU}}{\text{SF-HR-}^{\circ}\text{F}}$

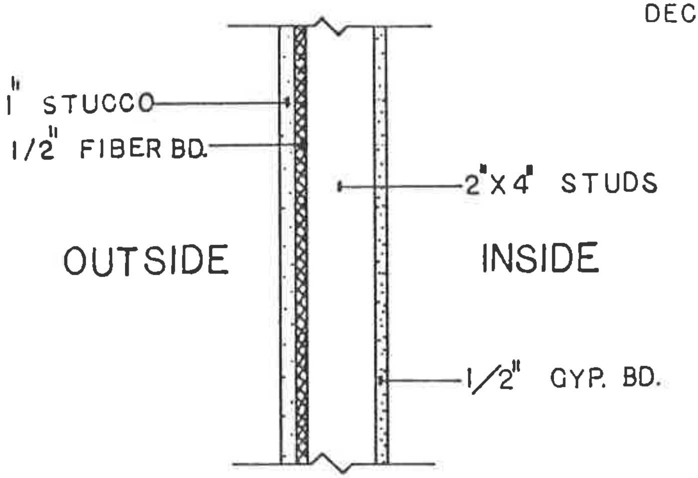
EFFECTIVE "U"-VALUE (U_E): HEATING

N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.290	.234	.175	.277	.202	.119	.264	.158	.052	.279	.201	.124
2	.275	.245	.214	.266	.223	.179	.255	.194	.133	.268	.226	.185
3	.272	.247	.223	.263	.226	.190	.252	.198	.145	.265	.231	.197
4	.270	.250	.232	.260	.226	.195	.246	.195	.143	.262	.233	.204
5	.270	.251	.232	.259	.225	.193	.245	.191	.137	.262	.232	.203
6	.270	.251	.232	.258	.222	.188	.243	.185	.125	.262	.230	.199
7	.272	.251	.231	.258	.219	.181	.241	.176	.109	.262	.228	.193
8	.274	.250	.227	.258	.212	.168	.238	.162	.083	.263	.222	.181
9	.278	.249	.221	.259	.204	.150	.236	.145	.049	.264	.215	.165
10	.284	.247	.210	.260	.190	.119	.232	.115	-008	.267	.203	.136
11	.284	.245	.201	.262	.181	.097	.231	.096	-047	.269	.194	.117

*WALL COLORS: L=LIGHT
M-MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THE TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 6



WALL TYPE 19: ASHRAE STEADY STATE U-VALUE 0.269 BTU/SF-HR-°F

EFFECTIVE "U"-VALUE (U_E): HEATING

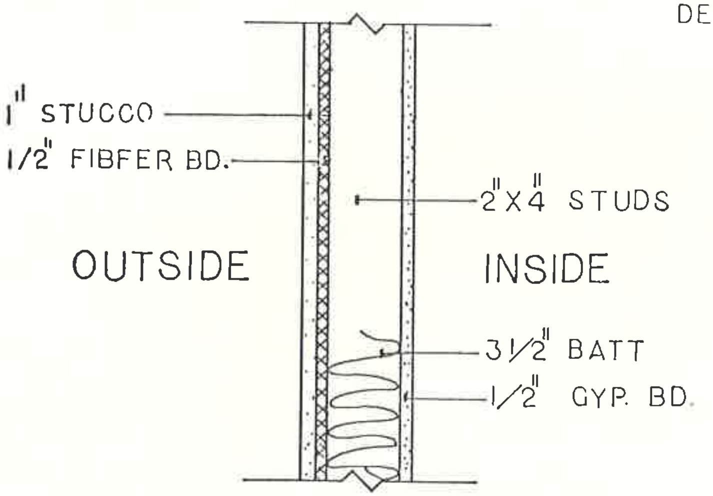
N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.272	.231	.188	.262	.209	.146	.255	.172	.097	.265	.205	.148
2	.255	.232	.210	.248	.217	.183	.241	.193	.150	.250	.218	.188
3	.251	.233	.215	.245	.217	.190	.237	.196	.158	.246	.221	.196
4	.249	.234	.220	.241	.216	.192	.231	.193	.155	.243	.222	.201
5	.249	.235	.221	.241	.215	.191	.230	.191	.151	.243	.221	.200
6	.250	.235	.221	.240	.213	.183	.229	.186	.143	.243	.220	.198
7	.251	.235	.220	.241	.211	.183	.227	.180	.131	.244	.219	.193
8	.254	.236	.219	.242	.207	.174	.227	.171	.113	.245	.216	.186
9	.257	.236	.216	.243	.202	.163	.226	.160	.090	.248	.212	.176
10	.265	.237	.210	.246	.194	.142	.226	.141	.051	.252	.205	.157
11	.269	.237	.205	.249	.189	.128	.227	.128	.024	.256	.201	.144

*WALL COLORS: L=LIGHT
M=MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THIS TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 7

DECD UNM



WALL TYPE 21 : ASHRAE STEADY STATE U-VALUE 0.080 $\frac{\text{BTU}}{\text{SF-HR-}}$

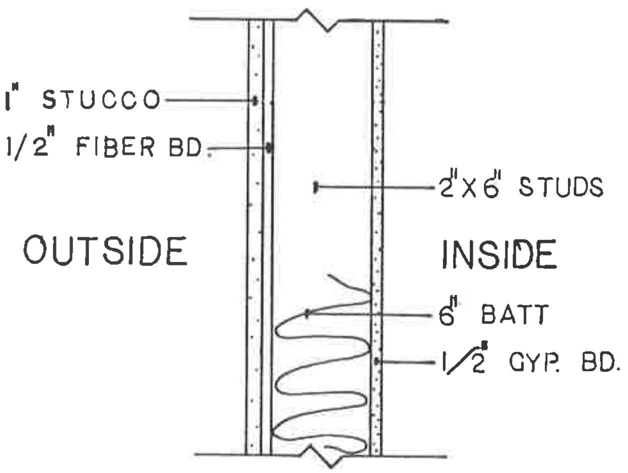
EFFECTIVE "U"-VALUE (U_E): HEATING												
N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.089	.075	.061	.086	.067	.048	.083	.059	.035	.037	.069	.051
2	.084	.076	.069	.081	.071	.060	.079	.064	.050	.082	.072	.063
3	.082	.077	.071	.080	.071	.062	.078	.065	.052	.081	.073	.065
4	.082	.077	.073	.079	.071	.063	.076	.063	.051	.080	.073	.066
5	.082	.077	.073	.079	.071	.063	.076	.063	.050	.030	.073	.066
6	.082	.078	.073	.080	.071	.062	.076	.061	.047	.080	.073	.065
7	.083	.078	.073	.080	.070	.060	.075	.059	.044	.081	.072	.064
8	.084	.079	.073	.080	.069	.058	.075	.057	.038	.082	.072	.062
9	.086	.079	.072	.081	.068	.054	.076	.053	.032	.083	.071	.059
10	.089	.080	.070	.083	.065	.048	.076	.048	.020	.085	.069	.054
11	.091	.080	.069	.084	.064	.043	.076	.044	.012	.086	.068	.050

*WALL COLORS: L=LIGHT
M=MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THE TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122

Figure 8

DECD UNM



WALL TYPE 22 : ASHRAE STEADY STATE U-VALUE 0.054 BTU / SF-HR-°

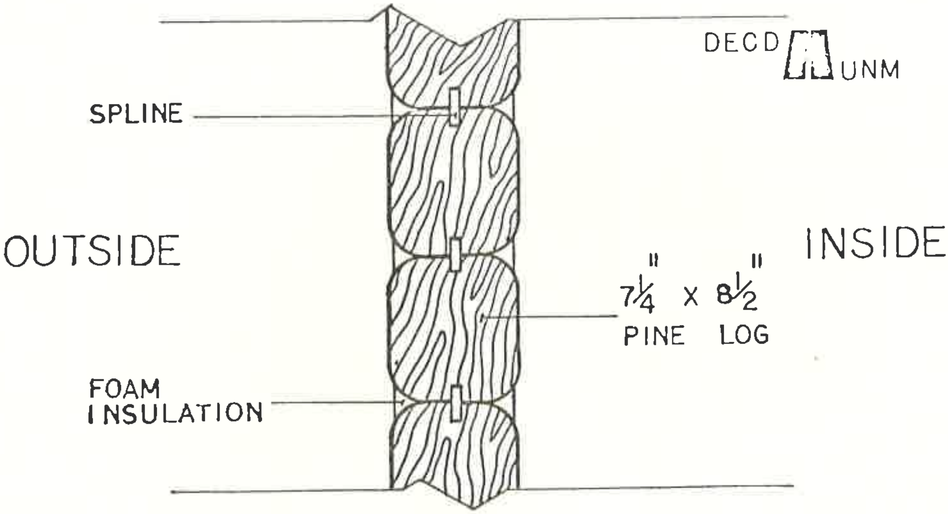
EFFECTIVE "U"-VALUE (U_E): HEATING

N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.062	.052	.043	.060	.047	.034	.058	.041	.025	.060	.048	.036
2	.058	.053	.048	.056	.049	.042	.054	.044	.035	.057	.050	.043
3	.057	.053	.049	.055	.049	.043	.054	.045	.036	.056	.050	.045
4	.056	.053	.050	.055	.049	.044	.053	.044	.035	.055	.050	.046
5	.057	.053	.050	.055	.049	.044	.052	.043	.034	.055	.050	.045
6	.057	.054	.051	.055	.049	.043	.052	.042	.033	.055	.050	.045
7	.057	.054	.051	.055	.048	.042	.052	.041	.030	.056	.050	.044
8	.058	.054	.050	.056	.048	.040	.052	.039	.027	.056	.050	.043
9	.060	.055	.050	.056	.047	.038	.052	.037	.022	.057	.049	.041
10	.062	.055	.049	.058	.045	.033	.053	.033	.014	.059	.048	.038
11	.063	.056	.048	.059	.044	.030	.053	.031	.009	.060	.048	.035

*WALL COLORS: L=LIGHT
M-MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THE TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 9



WALL TYPE 27 : ASHRAE STEADY STATE U-VALUE 0.099 BTU/SF-HR-°F

EFFECTIVE "U"-VALUE (U_E): HEATING												
N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.089	.071	.052	.087	.066	.044	.085	.059	.035	.088	.067	.045
2	.091	.074	.058	.086	.063	.040	.080	.047	.015	.087	.065	.043
3	.091	.075	.060	.086	.062	.038	.078	.042	.008	.087	.064	.042
4	.092	.078	.063	.085	.060	.036	.074	.034	-005	.086	.063	.041
5	.093	.078	.064	.085	.059	.034	.073	.031	-010	.086	.062	.040
6	.093	.078	.064	.084	.057	.031	.071	.026	-019	.086	.061	.036
7	.093	.077	.062	.083	.053	.024	.069	.018	-032	.085	.058	.031
8	.094	.076	.057	.082	.047	.013	.065	.006	-053	.084	.052	.020
9	.095	.073	.051	.081	.038	-003	.061	-009	-079	.083	.045	.006
10	.096	.066	.037	.078	.023	-031	.055	-035	-126	.081	.031	-019
11	.097	.062	.028	.076	.013	-051	.050	-053	-157	.080	.022	-037

*WALL COLORS: L=LIGHT
M-MEDIUM
D=DARK

NOTE: ALL ENTRIES IN THIS TABLE ARE PRECEDED BY "0". THAT IS: .122 = 0.122; -122 = -0.122

Figure 10

DEGD UNM

\# 1-NO INSIDE ATTENTION.
\# 2-DRAPE, DRAWN AT NIGHT.
\# 3-NIGHT INSULATION, R-5.

EFFECTIVE 'U'-FACTORS FOR SINGLE GLAZING

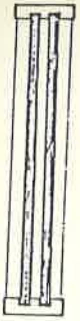
N.M.C.R.	GLASS ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	# 1	# 2	# 3	# 1	# 2	# 3	# 1	# 2	# 3	# 1	# 2	# 3
1	0.581	0.303	0.062	0.563	0.285	0.044	0.523	0.246	0.004	0.564	0.286	0.045
2	0.616	0.328	0.087	0.446	0.158	-0.083	0.144	-0.144	-0.385	0.472	0.184	-0.056
3	0.629	0.337	0.097	0.402	0.111	-0.130	0.005	-0.287	-0.527	0.439	0.147	-0.093
4	0.652	0.353	0.113	0.326	0.027	-0.213	-0.242	-0.540	-0.780	0.379	0.081	-0.159
5	0.655	0.354	0.114	0.301	0.000	-0.240	-0.314	-0.614	-0.854	0.359	0.058	-0.182
6	0.648	0.344	0.103	0.255	-0.049	-0.290	-0.420	-0.724	-0.965	0.320	0.015	-0.225
7	0.629	0.319	0.077	0.196	-0.114	-0.355	-0.537	-0.847	-1.089	0.267	-0.043	-0.284
8	0.587	0.268	0.025	0.103	-0.216	-0.459	-0.699	-1.018	-1.261	0.182	-0.136	-0.380
9	0.524	0.195	-0.051	-0.014	-0.343	-0.589	-0.881	-1.210	-1.456	0.075	-0.255	-0.501
10	0.403	0.055	-0.196	-0.212	-0.560	-0.812	-1.163	-1.511	-1.762	-0.112	-0.459	-0.711
11	0.317	-0.043	-0.298	-0.344	-0.703	-0.959	-1.338	-1.698	-1.953	-0.236	-0.596	-0.851

N.M.C.R._NEW MEXICO CLIMATIC REGION.

<u>NOTE.</u> THESE EFFECTIVE 'U'-FACTORS ASSUME THAT <u>100-PER-CENT</u> OF THE ENERGY ENTERING THROUGH THE GLASS IS USABLE.

Figure 11

DECD UN



#. 1-NO INSIDE ATTENTION.
2-DRAPE, DRAWN AT NIGHT.
3-NIGHT INSULATION, R-5.

EFFECTIVE 'U'-FACTORS FOR DOUBLE GLAZING

N.M.C.R.	GLASS ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	# 1	# 2	# 3	# 1	# 2	# 3	# 1	# 2	# 3	# 1	# 2	# 3
1	0.124	0.002	-0.136	0.111	-0.010	-0.148	0.081	-0.041	-0.179	0.112	-0.010	-0.14
2	0.152	0.026	-0.112	0.012	-0.114	-0.252	-0.244	-0.370	-0.508	0.035	-0.091	-0.22
3	0.162	0.035	-0.103	-0.025	-0.152	-0.289	-0.363	-0.490	-0.628	0.006	-0.121	-0.25
4	0.180	0.051	-0.087	-0.089	-0.219	-0.356	-0.575	-0.704	-0.842	-0.044	-0.174	-0.31
5	0.182	0.052	-0.086	-0.111	-0.241	-0.379	-0.637	-0.767	-0.905	-0.061	-0.192	-0.32
6	0.175	0.042	-0.095	-0.151	-0.283	-0.420	-0.728	-0.860	-0.998	-0.096	-0.228	-0.36
7	0.155	0.021	-0.118	-0.203	-0.338	-0.476	-0.830	-0.964	-1.103	-0.143	-0.277	-0.41
8	0.113	-0.024	-0.164	-0.287	-0.425	-0.564	-0.971	-1.109	-1.248	-0.220	-0.357	-0.497
9	0.052	-0.090	-0.231	-0.392	-0.534	-0.675	-1.130	-1.271	-1.413	-0.317	-0.459	-0.600
10	-0.065	-0.214	-0.358	-0.573	-0.723	-0.867	-1.377	-1.527	-1.671	-0.488	-0.637	-0.781
11	-0.148	-0.302	-0.448	-0.693	-0.848	-0.994	-1.531	-1.685	-1.832	-0.602	-0.756	-0.902

N.M.C.R. – NEW MEXICO CLIMATIC REGION.

NOTE. THESE EFFECTIVE 'U'-FACTORS ASSUME THAT 100-PER-CENT OF THE ENERGY ENTERING THROUGH THE GLASS IS USABLE.

Figure 12