INTRODUCTION

Passive solar applications deal with the collection and beneficial use of solar energy without the need for parasitic energy (e.g., pumps, fans,etc.). Normally, passive solar applications deal with a combination of glazing and mass to collect and store energy during the day for use during the cooler night. While not an explicit part of the Code, New Mexico weather offers opportunities for energy conservation through passive solar applications that should not be ignored. A simplified design methodology is presented for use in residences. While the Component Performance Approach allows for trade-offs that could meet the Code exactly (e.g.,excess roof/ceiling insulation to compensate for the extra glass), this may lead to over-design and excess cost. It is suggested that the designer coordinate with the building official if passive approaches are planned.

Also covered in this section is information on Effective U-Values. Again, the use of Effective U-Values is not explicitly covered in the Code, but their use has been shown to lead to energy-conserving designs.

PASSIVE SOLAR DESIGN

It is not the purpose of this Applications Manual to teach the process of passive solar design. However, due to the favorable climate in New Mexico, it is expected that a number of residential designs will incorporate passive features. To provide some guidelines on cost-effective solar designs, the following information is provided. This material is extracted from "Conservation and Solar Guidelines" by J.D. Balcomb published in the proceedings of the 8th Passive Solar Conference held in Santa Fe, New Mexico. A complete description of how to design passive solar residences can be found in Passive Solar Heating Analysis by Los Alamos National Laboratories and available from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

Both conservation and passive solar are proven strategies for reducing energy use in residential buildings in New Mexico. Conservation means added insulation and decreased air infiltration to reduce the gross heating energy required to maintain winter comfort, while passive solar means adding south windows, Trombe walls, or sunspaces to supply some of the gross heating requirements. The net heat required by the building is the gross heat minus the solar savings. Conservation makes the passive solar system's job easier. Good thermal design consists of achieving a proper balance between the two strategies.

Based on the methodology detailed in the referenced reports, guidelines for balancing conservation and passive solar have been developed for New Mexico. The guidelines are shown in Table 3 and give recommended values for insulation, number of glazings, and passive solar collection area (as a percentage of floor area).

TABLE 3: GUIDELINES FOR NEW MEXICO
(plus or minus 20%)

Insulation R-Value

City	Walls	Ceiling	Slab	Basement	# of Glazings	Solar Glazing
Albuquerque	15	26	11	12	2	20%
Clayton	16	28	13	14	2	21%
Farmington	17	30	14	15	3	21%
Los Alamos	18	31	14	16	3	24%
Roswell	14	24	10	11	2	18%
T or C	12	23	9	10	2	17%
Tucumcari	14	25	11	12	2	19%
Zuni	17	30	13	15	2	22%

Solar glazing is the percentage of the building floor area for south-facing glazing assuming one-story construction. For two-story construction, use 88% of the value.

The "Number of Glazings" column is for east, west, and north facing windows; south glazing layers will depend on the passive system chosen. It is assumed that the air infiltration has been reduced to less than 1/2 air change per hour. This level is appropriate for all residences whether or not passive solar systems are used. The numbers in the table are intended to be used for guidance only. These are not R-values for code compliance nor do they guarantee that a solar design will work. They indicate the levels of conservation and solar aperture which appear to be balanced for New Mexico's conditions. The designer should try to stay within 20% of the values in the early design stages. When doing schematic or design development, the techniques in the Passive Solar Heating Analysis manual should be employed. The guidelines are applicable to new residential construction or to small commercial buildings having residential levels of internal heat generation from people, lights, and equipment (roughly 30 to 60 Btu/day-sf).

The recommended total area of solar glazing is the same regardless of the passive system type. However, the performance will vary somewhat among the different system types. If the total solar glazing area is less than that recommended in Table 3, then the performance of the passive system will be reduced accordingly. The building should have adequate mass to prevent overheating. This may be a problem in direct gain systems for frame construction. In this case, the direct gain area should not exceed 5% of the total floor area or 9% if the floor is massive and not carpeted.

Beyond these limits, mass must be added along with glazing area to maintain comfort. The minimum recommended exposed mass area within the direct gain space is six times the glazing area. An effective approach is to limit the direct gain area, based on available mass, and then use an indirect system (Trombe wall or sunspace) to achieve the total passive system collection area. It is usually good practice to mix passive system types.

Summer cooling should also be a major concern to the designer, especially in the hotter areas of the State. Avoid solar gains in the summer through effective window shading and placement. Deciduous trees are particularly effective to the east and west of the house but should not be used within 45 degrees of south. With proper care, no additional cooling should be needed in the milder New Mexico climates, and evaporative cooling should be adequate in the warmer areas.

The passive system types considered in these guidelines are:

Direct Gain: The mass-surface-area-to-glass-area ratio is 6 to 1. The mass is thick masonry (4 to 6 inches thick) and the diurnal heat capacity is 72 Btu/deg. F per square foot of direct gain window area.

Trombe Wall: Unvented (venting improves performance by about 4%), 12 inch thick, dense masonry (140 to 150 lbs/cubic foot). Adobe Trombe wall is 10 inch thick (110 lbs/cubic foot).

Sunspaces: See schematics in <u>Passive Solar Heating Analysis.</u>

All systems are double glazed and should be oriented within 15 degrees of south for best performance. Tilted glazing in New Mexico usually creates more of a cooling problem than the advantage gained in improved heating performance. Night insulation will greatly improve the performance of any passive system in any climate. However, the cost effectiveness and the necessity of night insulation increases in the colder climates (climate zones 1, 2, 3, 4, and 5). In addition to improving the system performance, night insulation improves comfort by shielding the individual from an otherwise cold window surface at night.

As a general rule, the performance sensitivity of passive solar buildings to variations in design parameters increases as the solar savings increase or as the building load decreases. There is a wide range for choice when the system is providing a small part of the gross heat load, but at higher values, the designer should study the sensitivities carefully and design as close to the optimum as possible.

Remember, these are just guidelines to start on the design of a passive solar heating system for residences. The insulation levels in Table 3 may seem high, but any reduction in gross building heating load will improve the performance of a passive system. Thus, the guidelines represent a reasonable balance between conservation levels to reduce the gross building load and passive solar to provide some of the heating as required.

Radiant Heating and Cooling Equivalents

Indoor surrounding air design temperatures for buildings with radiant heating (e.g., from passive solar designs) or cooling may be modified to create the same comfort level as would be achieved with a different system using the tabulated design temperatures. Depending upon the designed mean radiant temperatures of the room surfaces, surrounding air temperatures with radiant heating systems may be lower for winter than given, and these temperatures may be higher than given for summer with a radiant cooling system.

A room's mean radiant temperature means that the radiant temperature is roughly the average temperature of the floor, walls, and ceiling. The chart below shows combined pairs of temperatures which all give the same relative feeling of comfort (i.e., 70 deg. F).

Equivalent Air and Radiant Temperatures (deg. F)

Air Temperature	49	56	63	70	77	84	91
Mean Radiant Temperature	85	80	75	70	65	60	55

For example, if the air temperature (AT) is 70 deg. and the mean radiant temperature (MRT) is 70 deg., we feel like it is 70 deg., but if AT is 84 deg. and the walls, floor, and ceilings are so cold that MRT is 60 deg., we still feel like both are 70 deg., but we may not be as comfortable. (This is a common situation in poorly insulated homes with forced air heating.) On the other hand, if MKT is 75 deg., we can let AT drop to 63 deg. and still feel like everything is 70 degrees. (This can occur in a passive solar home with warm walls or a warm floor.) Verifying calculations should be submitted to the building code official if radiant systems are used.

EFFECTIVE U-VALUES

Effective U-Values represent an average response of building materials to an average winter week with average temperature and solar radiation. Effective U-Values are indicative of the interaction between solar radiation and thermal insulation. They are intended to be used to estimate actual energy use for complying with prescriptive building code requirements.

Effective U-Values should not be used when sizing heating equipment as they represent average performance and do not account for peak effects.

Effective U-Values are a result of research carried out in the late 1970's sponsored by the State of New Mexico Energy and Minerals Department and the New Mexico Energy Institute. Copies of the reports on Effective U-Values for wall sections and windows or roofs/ceilings may be obtained from the New Mexico Research and Development Institute.

At the time Effective U-Values were developed, the State was represented climatically by 11 Climatic Regions. Figure 2 shows the 11 regions, and Table 4 lists the major population areas by each region. (Note that Figure 2 should only be used with Effective U-Values. In all other applications in the New Mexico Energy Code, Figure 1 should be used to identify climate zones.) This is followed by Table 5 which lists 26 wall sections analyzed for Effective U-Values. Illustrations and Effective U-values of the 26 wall sections are located in Appendix D. Also included in Appendix D are single and double glazing sections. Finally, the Appendix has a Table of Roof/Ceiling Effective U-Values.

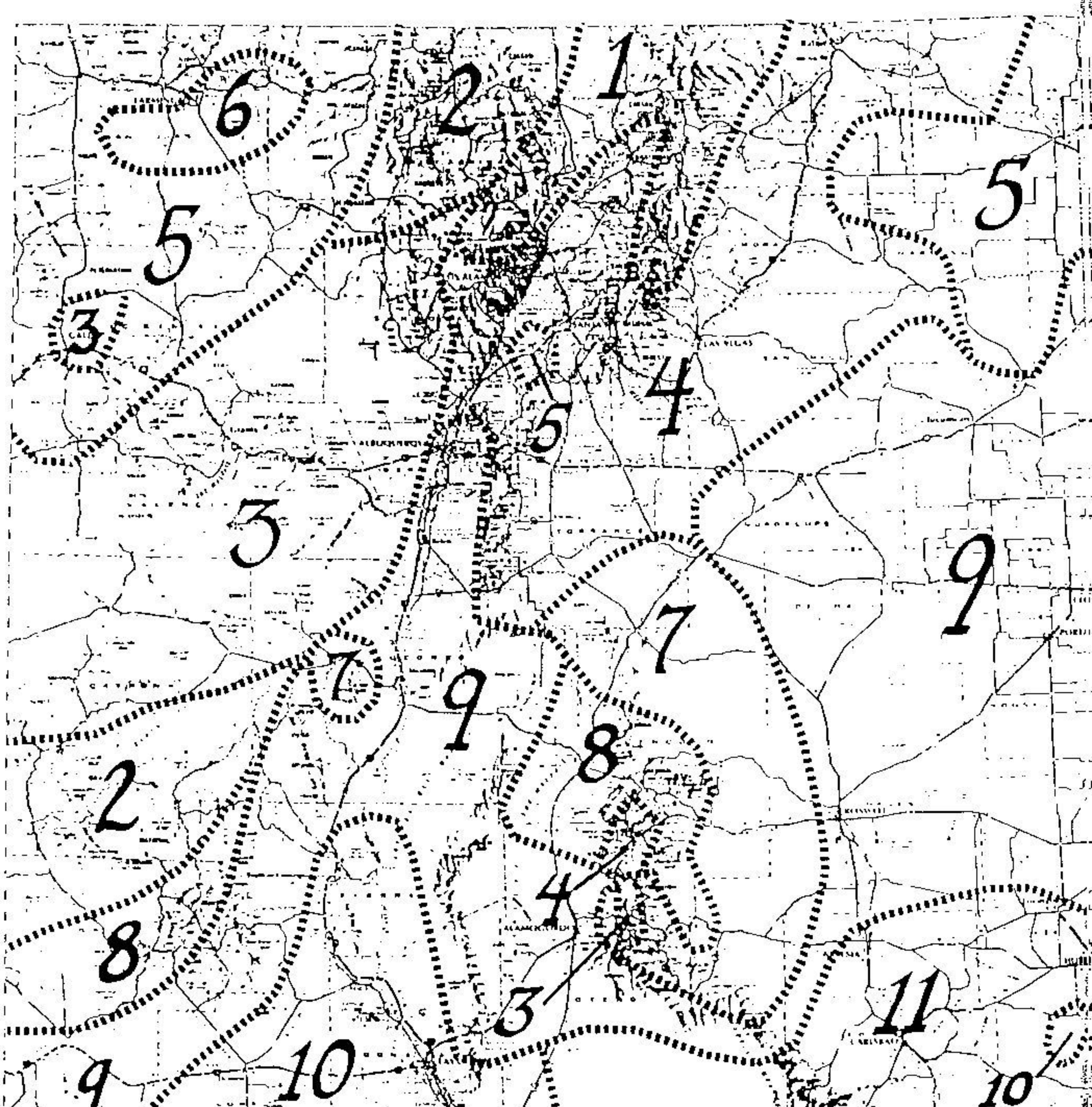


FIGURE 2: NEW MEXICO CLIMATE REGIONS FOR EFFECTIVE U-VALUES

TABLE 4: POPULATION AREAS BY CLIMATIC REGION FOR EFFECTIVE U-VALUES

Climatic Region 1:
- Eagle Nest
- Questa
- Red River

Climatic Region 2:
- Chama
- Cuba
- Tierra Amarilla

Climatic Region 3:
- Cloudcroft
- Gallup
- Grants
- Luna Range

Climatic Region 4:
- Cimarron
- Las Vegas
- Los Alamos
- Mountainair
- Raton
- Ruidoso
- Sandia Ranger Station
- Santa Fe
- Springer
- Taos
- Las Cruces

Climatic Region 5:
- Aztec Ruins
- Chaco Canyon
- Clayton
- Farmington
- Shiprock

Climatic Region 6:
- Bloomfield

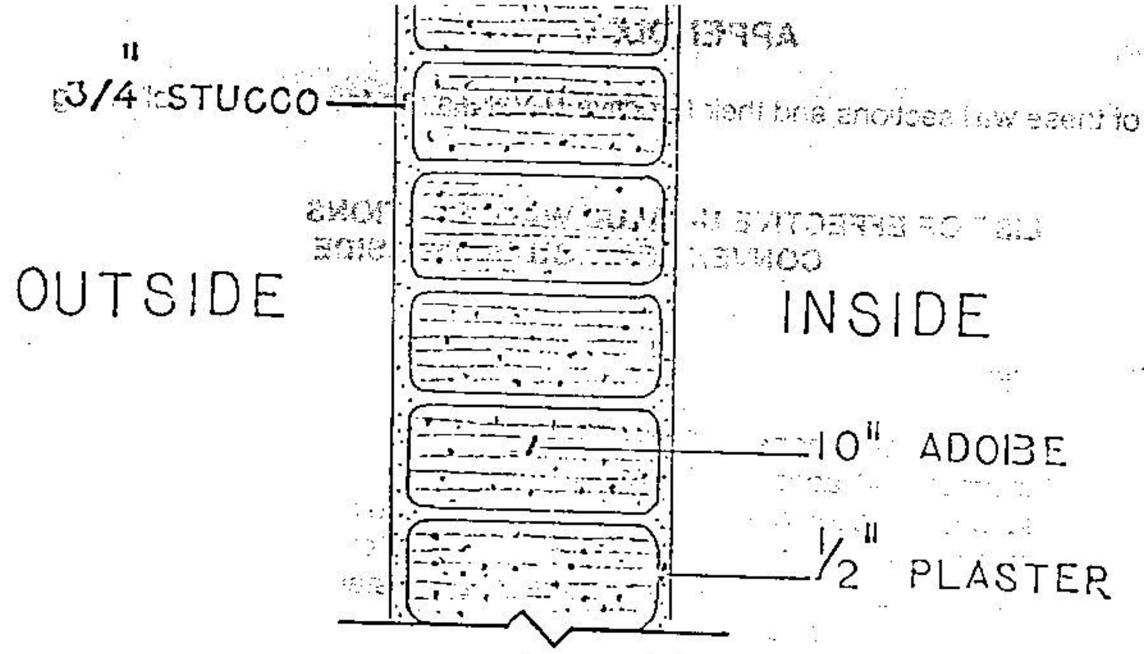
Climatic Region 7:
- Magdelena
- Corona
- Mayhill

Climatic Region 8:
- Carrizozo
- Silver City

Climatic Region 9:
- Alamogordo
- Albuquerque
- Clovis
- Lordsburg
- Roswell
- Socorro
- Tatum
- Tucumcari
- Vaughn
- White Sands

Climatic Region 10:
- Deming
- Truth or Consequences

Climatic Region 11:
- Artesia
- Carlsbad
- Hobbs
- Orogrande



WALL TYPE 1 : ASHRAE STEADY STATE U-VALUE 0.263

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	.212	.159
2	.237	.219	.200	.231	.205	.179	.225	.199	.155	.233	.208	.194
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	.183
8	.233	.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

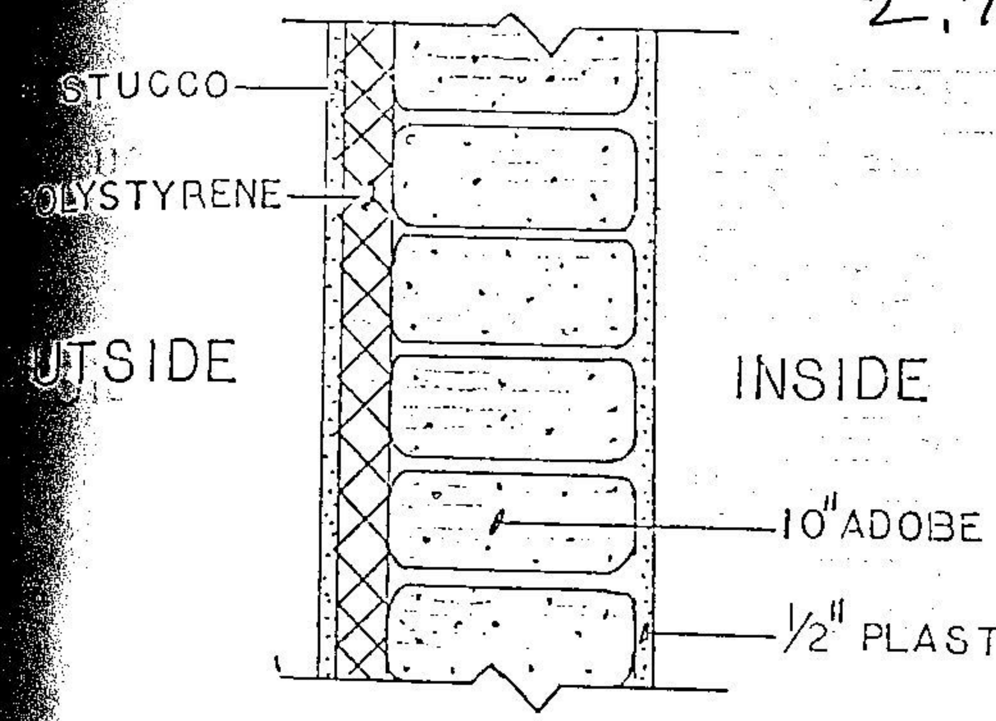
Roswell Clovis

*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

Close to Dallas

ADOBE Poly
2.76 + 11 = 13.76



$R = \frac{1}{U}$

$R = \frac{1}{.07} = 14.2$

N = 16.4
E = 17.5
S 18.86
W 17.24

WALL TYPE 6 : ASHRAE STEADY STATE U-VALUE 0.070 Btu/hr SF °F

EFFECTIVE "U"-VALUE (U_E): HEATING

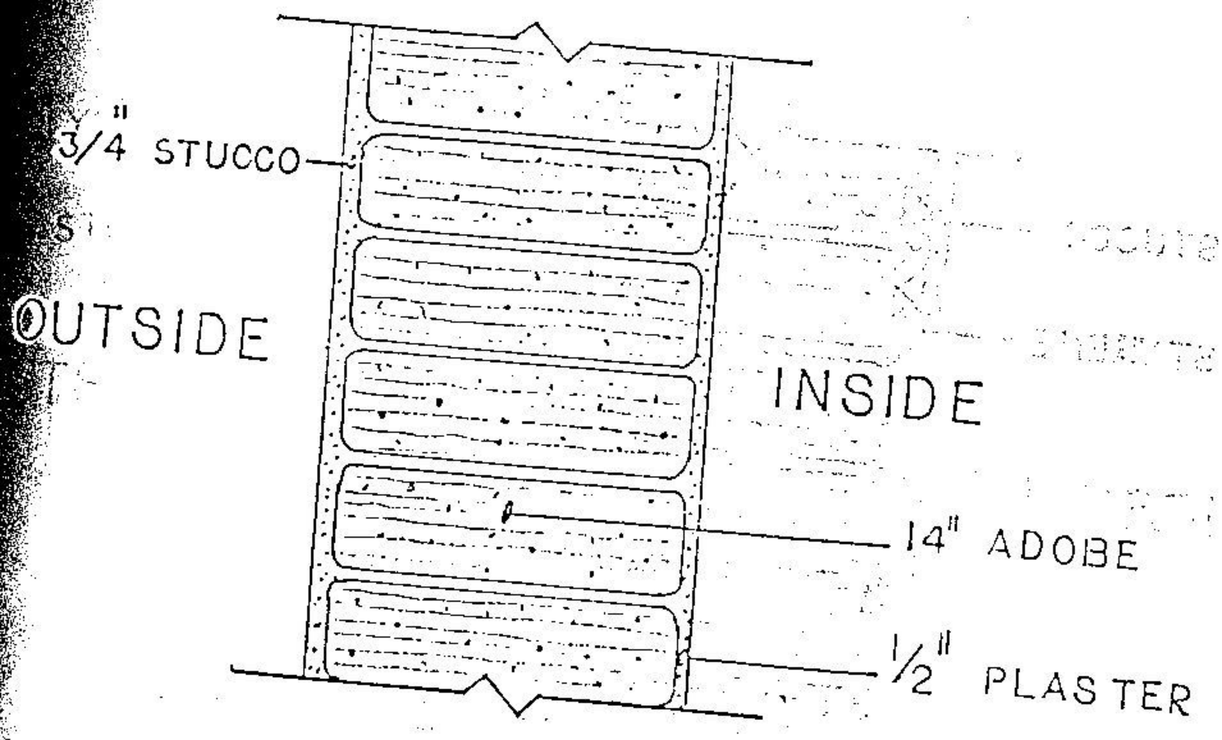
N.M. CLIMATIC REGION	WALL ORIENTATION											
	NORTH			EAST			SOUTH			WEST		
	*L	M	D	L	M	D	L	M	D	L	M	D
1	.075	.067	.059	.073	.062	.051	.072	.052	.045	.074	.064	.054
2	.066	.062	.057	.064	.058	.052	.063	.054	.046	.065	.059	.054
3	.064	.061	.057	.063	.057	.052	.061	.053	.046	.063	.058	.054
4	.063	.060	.057	.061	.056	.052	.059	.051	.044	.062	.058	.053
5	.063	.060	.058	.061	.056	.051	.059	.051	.043	.062	.058	.053
6	.063	.061	.058	.062	.056	.051	.059	.050	.042	.062	.058	.053
7	.064	.061	.059	.062	.056	.051	.060	.050	.040	.063	.058	.053
8	.066	.063	.059	.064	.057	.050	.061	.049	.033	.064	.059	.053
9	.068	.064	.060	.066	.057	.049	.062	.049	.036	.066	.060	.053
10	.073	.067	.062	.069	.058	.048	.065	.048	.032	.070	.061	.052
11	.076	.069	.063	.072	.059	.047	.067	.048	.029	.073	.062	.052

Espumela

*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

+ R =>



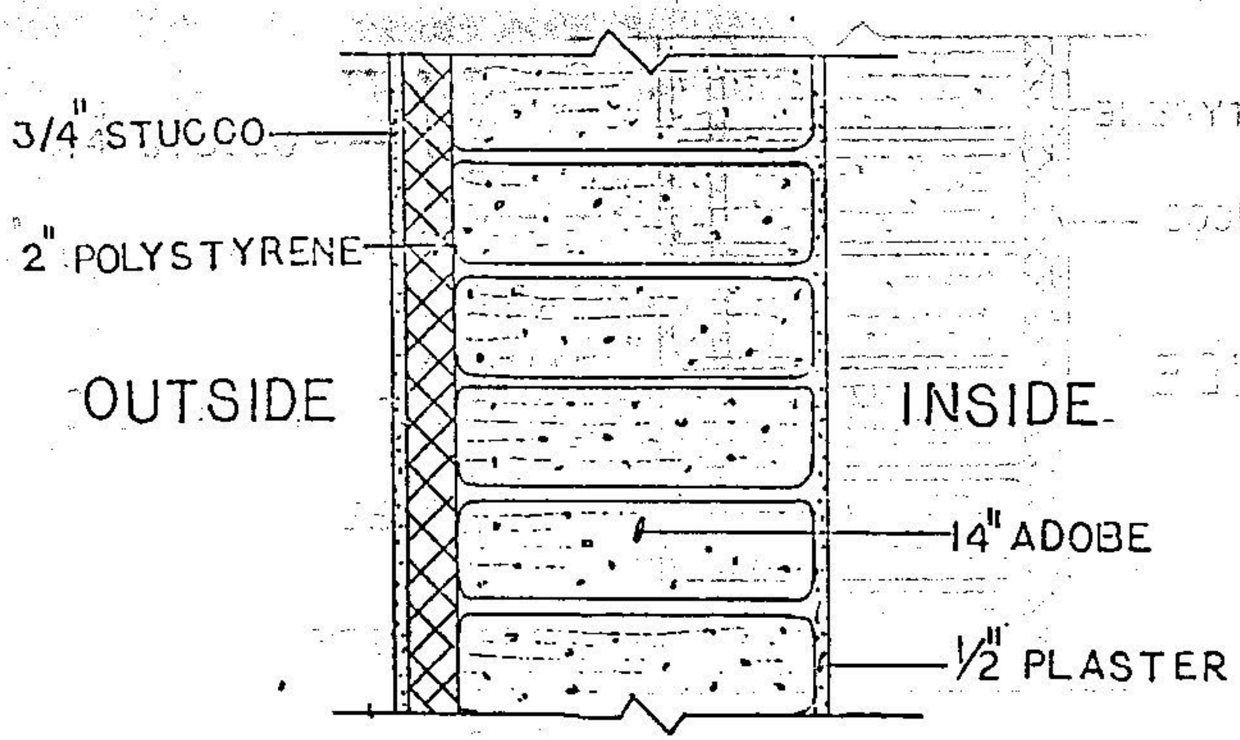
WALL TYPE 2: ASHRAE STEADY STATE U-VALUE 0.203 Btu / hr SF °F

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	.210	.185	.161	.204	.170	.138	.198	.157	.120	.205	.175	.144
2	.187	.174	.161	.183	.164	.146	.178	.152	.128	.184	.157	.150
3	.182	.172	.162	.179	.162	.147	.173	.150	.127	.180	.165	.152
4	.180	.171	.163	.175	.161	.146	.169	.145	.122	.176	.163	.150
5	.180	.172	.164	.175	.160	.145	.168	.144	.119	.175	.163	.150
6	.181	.173	.165	.176	.160	.144	.168	.141	.115	.177	.163	.149
7	.184	.175	.166	.178	.160	.142	.169	.139	.110	.179	.163	.148
8	.188	.177	.167	.181	.160	.140	.171	.136	.103	.182	.164	.146
9	.193	.181	.169	.185	.160	.136	.174	.133	.094	.187	.165	.144
10	.204	.187	.171	.193	.161	.130	.130	.129	.080	.196	.169	.141
11	.211	.192	.173	.199	.162	.126	.134	.126	.071	.202	.170	.138

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

NOTE: ALL ENTRIES IN THIS TABLE ARE PRECEDED BY "0", THAT IS



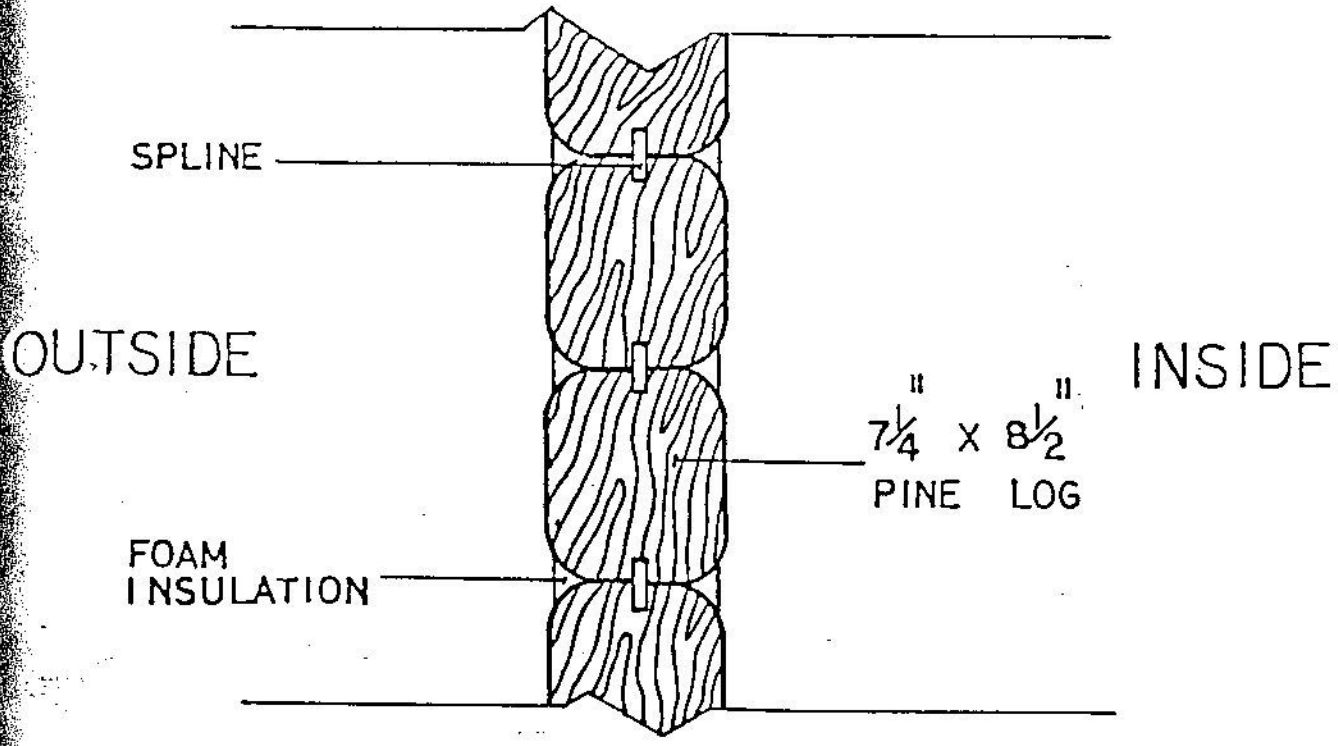
WALL TYPE 5 : ASHRAE STEADY STATE U-VALUE 0.065 [illegible]

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	.070	.064	.058	.068	.060	.052	.067	.057	.047	.069	.061	.054
2	.059	.056	.053	.058	.054	.049	.057	.051	.045	.059	.055	.051
3	.057	.055	.052	.056	.052	.048	.055	.049	.044	.057	.053	.050
4	.056	.054	.052	.055	.051	.048	.053	.048	.042	.055	.052	.049
5	.056	.054	.052	.055	.051	.048	.053	.047	.042	.055	.052	.049
6	.057	.055	.053	.055	.051	.047	.054	.047	.041	.056	.053	.049
7	.058	.055	.053	.056	.052	.047	.054	.047	.040	.057	.053	[illegible]
8	.059	.057	.054	.058	.053	.048	.055	.047	.039	.058	.054	[illegible]
9	.062	.059	.056	.060	.054	.048	.057	.047	.038	.060	.055	[illegible]
10	.066	.062	.059	.064	.056	.048	.061	.048	.037	.065	.058	[illegible]
11	.069	.065	.060	.066	.057	.049	.063	.049	.036	.067	.060	[illegible]

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

NOTE: ALL ENTRIES IN THIS TABLE [illegible] PRECEDED BY "0". THAT IS [illegible] .122 = 0.122; -122 = -0.1[illegible]



WALL TYPE 26 : ASHRAE STEADY STATE U-VALUE 0.099 Btu / hr SF °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

Fill out this data for your house. You will need this information to complete the "Application Worksheet."

DESIGN DATA

Building Location = ______________________, New Mexico

Floor Area = __________ sq. ft.

Flat Ceiling Area = __________ sq. ft.

Gross Wall Area = __________ sq. ft.

Window Area = __________ sq. ft.

Door Area = __________ sq. ft.

Concrete Slab Perimeter = __________ linear ft.

Roof Insulation Used = R = _____

Perimeter Slab Insulation R = _____, Depth ________ ft.

Insulation values for the following components may be obtained from suppliers or publications shown on A-2.

Window Type Used = ______________________________

Doors Used = ______________________________

Wall Assembly = ______________________________

____

TABLE A-1 DATA (Min. R_o Values Allowed by Code)

Fill out this section using the data from Table A-1. You may need to use the data from a nearby town.

Data from this town ______________

Heating Degree Days = ______

Roof/Clg R_o = ______

Walls R_o = ______

Floor Slab Perimeter Insulation R_o = ______

Perimeter Insulation Depth = ______ ft.