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THE CALIFORNIA RESIDENTIAL ENERGY STANDARDS

Problems and Recommendations Relating to Implementation, Enforcement, and Design

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STATE OF CALIFORNIA
DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

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I. EXECUTIVE SUMMARY

A. HISTORY

In November 1972, before the energy crisis was apparent, the California State Legislature passed Senate Bill 277, requiring California communities to incorporate into their building codes minimum energy insulation standards for all new residential buildings which are heated and/or mechanically cooled.

Regulations incorporating these standards were developed by the Department of Housing and Community Development with assistance of a public advisory committee. The Commission of Housing and Community Development adopted the standards in February 1974, with an operative date of February 22, 1975.

The adopted standards establish maximum heat transmission coefficients (U factors) for each element of the building envelope, along with piping and weatherstripping requirements. The standards also limit the glazing area and require insulating glass in colder climates of the State.

In addition, the standards provide for alternative designs, including designs utilizing nondepleting energy systems such as solar or wind, provided the proposed design does not use more depletable energy than would be used if the specific requirements of the standards were met.

Overall, the standards are prescriptive, but allow design flexibility when equivalency of depletable energy consumption can be established.

B. OBJECTIVE

The objective of this study by the State of California, Department of Housing and Community Development was to evaluate problems of implementation, enforcement, and the design aspects of the California energy insulation standards for new residential buildings.

C. METHODOLOGY

To accomplish the objective of the study, the following tasks were performed:

1. Review of Public Documents and Materials. Documents relevant to the development and implementation of the California energy insulation standards for new residential buildings were evaluated to provide a comprehensive account of the entire process. Elements included legislation, notification and results of public meetings, development of the standards and the design manual, enforcement and implementation, training and plan checking.

2. Survey. A survey was conducted to determine problems encountered in the implementation, enforcement, and design aspects of the standards. Data was collected by surveying those involved in the building process, namely, enforcement officials, builders and developers, architects and engineers, manufacturers and suppliers, and consumers. Interviews were selected to provide a representative cross section, considering the various sizes of city and county building departments, climatic conditions and geographic locations throughout the state. A private consulting firm was retained to assist in the collection of data and the preparation of recommendations.

D. CONCLUSIONS

Within the report are many findings, observations and recommendations concerning the impact of the California energy insulation standards on enforcement agencies, designers, builders and developers, manufacturers and suppliers, consumers and the building process in general.

The impact of the standards on construction costs and energy savings varies considerably because of the wide variation in prior insulation practices and climatic conditions in California. In mild climate the estimated impact on a typical 1500 square foot house with only R-11 ceiling insulation would be $335 additional cost and 29 percent energy savings. In colder climate the estimated impact on the same house, except with R-11 wall insulation also, would be $1235 additional cost and 33 percent energy savings.

The report concludes with a series of recommendations covering all levels of government and the building process. Most recommendations are directed towards the State which promulgates the regulations and is responsible for their implementation. The more important recommendations and conclusions are summarized as follows:

1. FEDERAL LEVEL

Educational Material Development: The Federal government should sponsor the development of educational material for all sectors of the building industry including building regulatory personnel at all levels, architects, engineers and building designers, and contractors and subcontractors. Courses should be developed at the Federal level because energy conservation is a national need and must be rapidly implemented. It is more economical for one agency to develop training courses, avoiding duplication of effort at the State level.

2. STATE LEVEL

(a) Legislative: Legislation enabling the development of energy conservation standards should stipulate that both prescriptive and performance standards be developed.

The legislation should also provide funding for a continuing program of technical assistance to local building departments for enforcement of energy standards.

(b) Development of Standards: A public advisory committee representing affected groups should be used to provide input and assist in the development of energy standards.

Notification and public dissemination of proposed standards should be of the highest priority to develop maximum interest and input.

(c) Implementation of Standards: Extensive effort must be made to make the public aware of the standards.

A comprehensive ongoing educational program with appropriate technical aids is necessary for uniform implementation and enforcement.

(d) Improvement of California Standards: Studies should be conducted on the cost effectiveness of increasing existing insulation requirements and standards relative to cooling. Requirements should be divided into smaller gradations, rather than the present three degree day zones. Efficiency and sizing requirements for heating and cooling systems should be added.

Performance standards should be developed in addition to the present prescriptive standards to provide more design flexibility.

Buyers should be provided with energy conservation information concerning their new home.

3. LOCAL LEVEL

Administrative: Local government should provide adequate staff for effective enforcement of energy standards. California legislation allows recovery of enforcement costs through fees.

Local enforcement officials should communicate with the State, contractors and designers to decrease implementation and enforcement problems. Staff personnel should attend available educational programs to develop a thorough understanding of the standards and facilitate uniform enforcement.

4. FURTHER RESEARCH

Product Approvals: Standards for testing, certification, labeling, installation, and fire resistance of insulating products should be established to assist enforcement and provide needed consumer protection.

NOTE: This report is concerned with residential buildings only. State energy conservation standards for new nonresidential buildings were to become effective on February 6, 1977, but due to litigation, implementation has been delayed. The litigation contends that the standards are prescriptive and not performance standards as specified by the enabling legislation.

II. BACKGROUND

A. LEGISLATION

Legislation was introduced in 1972 by Senator Alquist mandating the Commission of Housing and Community Development, by January 1, 1974, to adopt rules and regulations establishing minimum standards of energy insulation for new hotels, motels, apartment houses, homes, and other residential dwellings. The legislation signed into law by Governor Reagan on November 22, 1972 is shown in Section F.

The legislation stipulated that the following criteria be used in the development of the regulations:

1. The Commission of Housing and Community Development shall adopt such rules and regulations establishing minimum standards of energy insulation which are reasonably necessary to conserve fuel resources. The rules and regulations adopted by the Commission shall meet or exceed the standards which are required by the Federal Housing Administration in "Minimum Property Standards for One and Two Living Units" which are in effect at the time the Commission adopts such rules and regulations. However, the Commission shall develop rules and regulations independent of such standards for hotels, motels, and apartment houses which are more than three stories in height.

2. The Director of Housing and Community Development shall appoint an advisory committee to assist the Commission in the establishment of energy insulation regulations. The advisory committee shall consist of two architects in private practice; two scientists having professional and technical experience in the field of energy conservation or use; one general building contractor; three representatives from a city, county, or city and county; the Secretary of the Human Relations Agency; the State Architect; and the Secretary of the Resources Agency.

The members of the advisory committee shall serve without compensation, but each member shall be reimbursed for his necessary traveling and other expenses incurred in the performance of his duties.

3. The rules and regulations adopted by the Commission shall apply in all parts of the State, including but not limited to, charter cities.

4. Any State agency, city, county, or city and county may adopt standards of energy insulation for new buildings which are more restrictive than those adopted by the Commission if:

   a. The governing body of a city or county makes an express finding that such modifications are reasonably necessary because of local conditions.

   b. The finding be made available as a public record.

5. The rules and regulations adopted by the Commission shall be enforced within its jurisdiction by the building department of every city, county, or city and county. No certificate of occupancy or similar certification shall be issued by such a building department unless the structure at least satisfies the minimum energy insulation standards adopted.

6. The energy insulation standards shall apply only to new hotels, motels, apartment houses, homes, and other residential dwellings on which actual site preparation and construction has not commenced prior to the effective date of the rules and regulations adopted by the Commission.

7. Funding for the development and implementation of these standards was $35,000.

B. DEVELOPMENT AND ADOPTION OF THE REGULATIONS

General Legislation Requirements

The general requirements of the legislation mandated that the Commission of Housing and Community Development adopt minimum energy insulation standards for new residential buildings and that an advisory committee be appointed to assist in the development of these standards. Specific legislative requirements will be noted where applicable in the following.

Advisory Committee Members

In addition to requiring that an advisory committee be appointed, the legislation specified that the committee consist of two architects in private practice; two scientists having professional and technical experience in the field of energy conservation or use; one general building contractor; two specialty contractors; three representatives from a city, county, or city and county; and three representatives from State agencies, namely, the Secretary of the Resources Agency.

During the same time period, a separate legislative bill was passed which required the Commission of Housing and Community Development to adopt minimum noise insulation standards for all residential buildings except for detached, single-family dwellings. This legislation also required that an advisory committee be appointed. The makeup specified for this committee was very similar to that required of the advisory committee for the energy insulation standards. Because of this, and the fact that both standards involved insulation and would be applicable to the same types of buildings, it appeared, at the time, that it would be beneficial to form a combined advisory committee. Therefore, the advisory committee which was appointed consisted of 16 members and was to develop both the energy insulation standards and the noise insulation standards. As the development of the standards progressed, it became apparent that energy and noise did not have much in common. The advisory committee had to become familiar with the technical aspects of each subject, which were completely different. Coupling this with the general lack of needed information placed a fair-sized burden on the committee members. Even though the committee meetings were divided into two sessions, one dedicated to each subject, at times, there was confusion among the committee members and the audience attending the meetings as to what information, data, or discussion went with which subject. It probably would have been to everyone's advantage if the two committees had not been combined.

The utilization of an advisory committee provided an excellent opportunity to obtain the expertise needed for the development of the standards. The committee represented most of the various interest groups affected, namely the designers, builders, suppliers, and enforcement officials. The committee chairman planned, led, and controlled the meetings, established subcommittees as necessary, and assigned specific work tasks. Usually, the committee meetings were relatively short compared to the amount of work needed to be done; therefore, work was asked of the committee members between meetings. The data necessary for the development of the standards, in many cases, was not readily available; and a substantial amount of work was necessary to research and collect the required information.

Regulation-Adoption Process

The development and adoption of energy insulation standards for the State of California involved the following:

1. Public advisory committee meetings.
2. Public fact-finding seminars.
3. Public hearings.
4. Public hearings which were also meetings of the Commission of Housing and Community Development at which standards could be adopted.
5. Public meeting of the Building Standards Commission.

The advisory committee meetings were basically working committee meetings to develop energy insulation standards for residential buildings. The meetings were open to the public, and public attendance and input was encouraged. These meetings were held both prior to and after the fact-finding seminars and public hearings.

The fact-finding seminars were informal, public meetings to obtain additional data and public input on the proposed standards. Two were held, one in the northern and one in the southern part of the State. Unlike the regular advisory committee meetings, these meetings were strictly for public input.

Adoption of regulations by a State agency in California is governed by the provision of the Administrative Procedures Act. This requires formal, public hearings on the regulations proposed for adoption. The notice of public hearing has to be published in a newspaper of general circulation 30 days prior to the hearings. The purpose of the public hearings is to obtain testimony on the regulations, as proposed for adoption. Based on this testimony, the adopting authority decides whether or not to adopt the proposed regulations. The adopting authority for the energy insulation standards for residential buildings was the Commission of Housing and Community Development. Two such public hearings were held on the proposed energy insulation standards for residential buildings; one was in the northern part of the State and the other, in the southern. In addition, a third public hearing was held in conjunction with a meeting of the Commission at which the energy insulation standards were proposed for adoption. However, due to public input the Commission elected not to adopt the energy insulation standards at this meeting. This required more advisory committee meetings and a fourth public hearing held in conjunction with a Commission meeting. At this meeting, the Commission did adopt the energy insulation standards.

Since the energy insulation standards contained building standards, approval was required and obtained from the Building Standards Commission subsequent to adoption by the Commission of Housing and Community Development. Basically, the function of the Building Standards Commission is, in this case, to check for overlap and conflict with other building standards contained in State regulations.

Advisory Committee Meetings

The advisory committee appointed to assist in the development of energy insulation standards held their first meeting May 30, 1973. In the nine months which followed, a total of 14 advisory committee meetings were held. Overall attendance of the meetings by the advisory committee was approximately 63 percent. The individual attendance ranged from a high of 100 percent to a low of 11 percent. The legislation specified that the committee would serve without compensation for their time from the State but would be reimbursed for travel and other expenses incurred in performance of their duties. The lack of compensation could have attributed to the low-attendance record in some cases. The majority of the committee members were either in business for themselves or employed by a private business. Therefore, in addition to losing the services of the individual while attending meetings, the business probably paid the individual's salary during that time. A point to consider when utilizing an advisory committee is that some provision should be made to replace members who are consistently absent. Absent members are not a benefit to the committee or the standards being developed.

Public attendance and input to advisory committee meetings is also an important aspect in the development of standards. Such development requires information and data which is often not readily available. Input from the public can be of great assistance to an advisory committee, especially input from organizations or associations representing the various interest groups which ultimately will be affected by the standards, such as builders, product manufacturers, architects, engineers, and the building officials who must enforce the standards. Ideally, with participation and input from these groups, the resulting standards will be workable for all involved, thereby eliminating some of the problems which occur after the standards become effective.

Public notification of the advisory committee meetings to develop energy insulation standards for residential buildings was accomplished by advertising in a trade newspaper and by mailing to interested parties.
The mailing list was developed from the meeting-attendance sheets and individual requests to be placed on the mailing list. The attendance by the public at the committee meetings varied, increasing as the time for adoption approached. At the first eight meetings, public attendance averaged 10 people per meeting. During the period of the next three advisory committee meetings, two fact-finding seminars and two public hearings on the proposed standards were also held. The seminars and public hearings apparently increased exposure and interest, for public attendance at the advisory committee meetings increased to an average of 27 persons per meeting. At this point in time, the proposed standards were presented for adoption at a meeting of the Commission of Housing and Community Development. However, the Commission did not adopt the standards presented; consequently, the advisory committee held three more meetings prior to the next Commission meeting. At these three meetings,

the average public attendance per meeting was 48.

The advisory committee meetings were held at various locations in order to provide equal opportunity for attendance of the meetings. The lack of public attendance at the advisory committee meetings, especially at the initial meetings, points out the need for public notification and dissemination of information to obtain the interest of the public. This, possibly, could have been accomplished to a greater degree with assistance from the organizations or associations which represent industry, building officials, architects, and engineers, etc.

Staff assistance to the advisory committee during development of the energy insulation standards was substantial. A great deal of time and effort was required to handle meeting accommodations, minutes, draft standards, correspondence and other essentials, generally needed in a short time period. This element is vital to the functioning of an advisory committee.

Development of the Standards

Relative to the content of the standards which were to be developed, the legislation mandated the following basic requirements:

1. The Commission of Housing and Community Development shall adopt such rules and regulations establishing minimum standards of energy insulation for new hotels, motels, apartment houses, homes, and other residential dwellings as the Commission determines are reasonably necessary to conserve fuel resources.

2. The rules and regulations adopted by the Commission shall meet or exceed the standards required by the Federal Housing Administration in the Minimum Property Standards for One and Two Living Units in effect at the time the Commission adopts such rules and regulations.

3. The Commission shall develop rules and regulations independent of such standards for hotels, motels, and apartment houses more than three stories in height.

The initial advisory committee meeting basically covered orientation and organization. It is important that the committee members understand the objectives with which they are charged, the time frame in which the objectives must be accomplished, and the process by which regulations are adopted. Since the members of the committee have other responsibilities in addition to being on an advisory committee, the frequency and location of meetings should be discussed in order that they may be planned for.

The following are some of the initial areas of question and discussion:

1. How many cities or counties have existing energy regulations?

2. If local regulations exist, to what extent are they enforced?

3. Would the standards developed pursuant to this legislation be correlated with other code-writing authorities in order to achieve uniformity?

4. What are the current FHA standards?

5. What standards, relative to energy insulation, are being used for construction not conducted under FHA programs?

6. Would the committee be required to prepare an environmental-impact report regarding the energy insulation standards?

7. Should the energy insulation standards be concerned with the mechanical systems within the building?

It was realized that more progress would be made if subcommittees were established to concentrate the efforts of the committee members to specific areas. The subcommittees would schedule their own meetings and report their findings and recommendations at the regular advisory committee meetings. Eventually, a total of four subcommittees were established to cover the following topics:

1. Data needs.
2. Enforcement problems.
3. Energy insulation standards.
4. Energy design manual.

The subcommittees dealing with data needs and enforcement problems were established at the first advisory committee meeting. The remaining two subcommittees were established at subsequent meetings when their need arose.

Concerning the question of the environmental-impact report, it was determined that the committee would not have to prepare one, since the capacity of the committee was limited to recommendations on the proposed standards. The authority adopting the regulations would be responsible for determining its necessity.

In developing the standards, the advisory committee had, in addition to the legislative requirements, the following objectives in mind:

1. The standards should substantially reduce the heat loss and heat gain of an insulated building as compared with current, typical California construction.

2. The standards should be kept as simple as possible to ease the implementation problems of the designer, builder, and the local building department who must enforce them.

3. The standards should, whenever possible, allow design flexibility.

4. The standards should be compatible with present California residential-construction techniques so as to minimize the impact on the builder.

5. While energy conservation was the prime objective, the standards should, if possible, result in a savings for the homeowner.

After a series of advisory committee meetings, the fact-finding seminars and public hearings, the Commission of Housing and Community Development did adopt minimum energy insulation standards for new residential buildings in California. These standards, which were adopted on February 22, 1974, are shown in Section G.

The following covers the pertinent considerations and problems encountered by the advisory committee during the development of the standards.

One of the early problems encountered concerned the FHA Minimum Property Standards for One and Two Family Dwellings related to thermal insulation. It was learned from an FHA representative that the enforcement of the existing standards was difficult and they were being revised to the format of the Minimum Property Standards for Multifamily Housing. Since the legislation required the standards being developed to be at least as stringent as the FHA standards in effect at the time the California standards are adopted, the advisory committee had a problem in the sense they did not know what the FHA standards would be at that time. The committee decided to follow the format of the Multifamily Housing Standards with the hope that at a later date they would be informed of the content of the revised FHA standard for One and Two Family Dwellings.

The committee then began a review of the Minimum Property Standards for Multifamily Housing. They favored the approach of specifying maximum U values for the various components of construction rather than maximum allowable heat-loss and heat-gain figures for the total building which require detailed energy calculations. One of the prime concerns of the committee was that the standards to be developed must define energy insulation requirements in the simplest and most straight-forward manner possible. This would be necessary to achieve effective implementation of the standards, both from the design and enforcement aspects.

There was agreement that insulation of walls, ceilings, and floors in low-rise, light-framed, residential construction is the most effective, single action to significantly reduce thermal-energy requirements. It was determined that the energy insulation standards developed for this class of buildings would not include regulations for the mechanical systems necessary to heat or cool the building.

Since the legislation specified the standards for residential buildings more than three stories in height be developed independent of the FHA standards, it was originally felt that the standards developed for high-rise buildings might be different than those for single-family dwellings and other low-rise residential buildings. The committee agreed that a performance standard for high-rise, residential buildings in terms of annual energy usage per square foot would provide the maximum design flexibility. The need for simple methods of calculating energy usage was recognized from both the design and enforcement aspects. It was generally agreed that the thermal loads for high-rise, residential buildings are dominated by the building envelope; and possibly, the more straightforward, peak-load energy calculations could be applied if it was possible to correlate the peak loads and the annual building energy consumption.

A private firm was contracted to perform a study which would hopefully provide, within the time and funding available, a basis for the committee to establish initial standards for high-rise buildings. However, the study proved to be too limited by the time and funding constraints. The results of the study indicated, that because of the limited data obtained, correlation efforts were inconclusive. It also indicated that annual energy budgets apparently could be developed for specific locations and building envelope descriptions; and using these budgets, maximum peak-heating and cooling loads could be established. Since the study did not provide conclusive results and since the majority of the energy usage is dependent upon the building envelope, the committee decided the criteria establised for low-rise buildings should also be used for high-rise buildings. This concept was followed, except for glazing areas which will be discussed later.

The energy insulation standards developed by the Committee were divided into subsections covering the following items:

a. Purpose.
b. Application and scope.
c. Alternate materials, method of construction, design, or insulating system.
d. Definitions.
e. Thermal design standards for ceilings and walls.
f. Thermal design standards for glazing.
g. Floor section, foundation walls, and slabs-on-grade.
h. Infiltration.
i. Loose fill.
j. Design temperature.
k. Pipe insulation.
l. Compliance.

These subsections include insulation items covered in the FHA Minimum Property Standards for Multifamily Housing, plus other items the advisory committee felt necessary.

Subsection (a) defines the purpose of the standards and specifies which buildings must conform to the standards.

Subsection (b) defines the effective date of the standards. It allowed one year after the date of adoption for the standards to become effective. It also specified that the standards would be applicable to all applications for building permits made subsequent to the effective date of the standards. The legislation specified that the standards apply to all dwellings on which actual site preparation and construction had not commenced prior to the effective date of the standards. The advisory committee did not favor this approach because of the possibility a builder with approved plans and a building permit may have to redesign his building because of the energy insulation standards becoming effective. With the approach taken, any redesign needed because of the energy insulation standards would be made prior to the plans being approved and the building permit issued.

Subsection (c) was written to allow for alternate provisions with the approval of the Building Official. It was recognized that there would be cases when it would be difficult to comply with all of the specific requirements of the standards and that a provision must be considered to allow for approval of alternative designs or construction, if the alternative is equivalent in effectiveness.

Subsection (d) contains definitions which were believed necessary for understanding and implementing the standards.

Subsection (e) contains the thermal design standards established for walls and ceilings. The maximum U factors selected were based on typical wood-framed wall and ceiling construction since it is representative of the majority of residential construction in California. The FHA Minimum Property Standards for Multifamily Housing allowed higher U values for flat roof decks and masonry walls than for framed construction; however, it was decided that these higher allowable U values should not be considered, since the primary purpose of the standards being developed was to conserve energy. Therefore, the maximum U values established should not vary with the type of construction. The thermal lag effect for walls with mass was discussed, but it was decided that more study would be needed before a benefit for mass-type walls would be considered.

The requirements for framed-wall and ceiling construction contained in the FHA standards varied depending upon the building location in specified heating or cooling zones. After reviewing these requirements, it was determined that one set of U values for walls and ceilings independent of climatic zones would be established for the entire State. Elimination of dependency upon climatic zones would greatly simplify the standards for walls and ceilings. The maximum U values selected from the FHA Minimum Property Standards for Multifamily Housing were 0.05 for ceilings and 0.07 for walls. However, the 0.07 value for walls presented a problem, since the typical California residential construction is 2 x 4 studs with stucco exterior and gypsum wallboard interior. The problem was that the 0.07 U value could not be attained with typical insulating materials in the cavity created by the studs. Considering the objective of not changing typical construction, a maximum U value of 0.08 was used for walls as it is attainable with the use of an R-11 insulation in the cavity. When the revised FHA Minimum Property Standards for One and Two Family Dwellings were later published, the maximum U value for framed-wall construction was also 0.08.

The 0.05 and 0.08 U values did not consider the effects of occasional framing members such as studs and joists. This created considerable input and discussion. It was pointed out that if the effects of framing were considered in a typical wood-framed wall, the actual U value would be approximately 0.094; and therefore, not considering the effects of the framing members discriminates against walls constructed in such a manner that the insulation is not penetrated by framing members. This would also be applicable to ceilings. Consequently, an addition was made to the proposed standards which allowed the higher U values of 0.095 for walls and 0.06 for ceilings when the insulation is installed so that it is not penetrated by framing members.

Subsection (f) is related to the thermal design standards for glazing, which was given considerable attention. It was felt that the FHA Minimum Property Standards for Multifamily Housing did not adequately cover the heat loss and heat gain through the glazing, since they did not place a limit on the amount of glazing used and only required insulating glass to a limited extent. In establishing the thermal design standards for glazing, the following points were considered and determined necessary for energy conservation:

1. A basic limit for glazing area must be established; and when it is exceeded, treatment of the building must be required to limit the heat loss and heat gain of the exterior wall. It was determined that a basic glazing area limit of 20 percent of the exterior-wall area for low-rise buildings three stories or less would provide architectural freedom and not pose any problem for the majority of buildings in this category. It was suggested that high-rise buildings normally have more glazing, but because multiple-dwelling units are contained in one building, they are more energy efficient. A brief study of high-rise residential buildings indicated that they did generally have more than 20 percent of the exterior wall area in glazing. Subsequently, it was decided to set the basic glazing limit for high-rise buildings at 40 percent of the exterior wall area.

2. Buildings located in areas over 4,500 degree days must be required to use special glazing. Special was defined as glazing which has a maximum U factor of 0.70. This value was set just high enough to include all insulating glass listed in the ASHRAE Handbook of Fundamentals.

3. Relative to heat gain, buildings which are cooled must use tinted glazing if the basic glazing limit is exceeded. Walls with a northerly orientation were exempted from the tinted glazing requirement. The maximum shading coefficient acceptable for tinted glass was established at 0.75 and decreased to 0.55 after July 1, 1976. The reason for the time delay before requiring the 0.55 value was to allow time for this product to become available. A shading option to tinted glass was also provided.

Subsection (g) contains the insulation requirements for floor sections, foundation walls, and slabs-on-grade. The requirements established were basically the same as those contained in the FHA Minimum Property Standards for Multifamily Housing with the following exceptions:

1. The FHA standards contained a table of maximum U values for floor sections over unheated spaces which varied, dependent upon four winter degree-day zones. Separate values were also specified for structural slabs and wood or steel framed floors. It was determined there should not be a differentiation between types of construction and that two degree-day zones would simplify the standard to the extent that either underfloor insulation was required, or it was not. In addition, it was felt it would cost only slightly more to insulate to the lower 0.08 U value than the less energy-efficient 0.10 U value.

2. The table of maximum U values for foundation walls of heated basements or heated crawl spaces was also simplified to two degree-day zones, where insulation was either required or it was not.

Subsection (h) was established to limit air infiltration. The FHA Minimum Property Standard for Multifamily Housing did not contain weather-stripping requirements.

Subsection (i), concerning loose-fill insulation, is the same as that contained in the FHA Minimum Property Standards for Multifamily Housing, except for the angle at which soffit baffles are to be installed. The FHA standards had 60 degrees, and the committee agreed to 45 degrees. It is likely neither is correct, because if the baffle is installed at a steeper angle than the roof sheathing, either the vent area is reduced or a portion of the ceiling next to the vent is not insulated. Which problem actually occurs depends on how close the baffle is placed to the vent. A problem that arose with this subsection is that it specifies that the baffles be in place at the time of the framing inspection. In some cases, the insulation contractor installs the baffles immediately prior to placing the insulation, which is after the framing inspection.

Subsection (j), related to design temperatures, is the same as contained in the FHA Minimum Property Standards for Multifamily Housing except the summer design temperature and the summer design dry bulb percent were raised to be slightly less stringent.

Subsection (k) was written to limit the heat loss from steam and steam condensate piping and all continuously circulating domestic or heating hot-water piping located in unconditioned spaces. This topic was not covered in the FHA standards.

Subsection (l) requires a card be posted in the building certifying that the insulation has been installed in conformance with the requirements of the standards.

A subsection to cover the insulation of air ducts was considered. It was agreed that the requirements contained in the Uniform Mechanical Code should be used. Since the California State Housing Law Regulations adopt, by reference, the Uniform Mechanical Code, the duct-insulation requirements contained in this code were already in effect. Also, it would not be necessary to repeat or reprint these requirements in the energy insulation standards since enforcement officials and builders were already familiar with the Uniform Mechanical Code.

The preceding basically covers the content of the standards as they were adopted on February 22, 1974. At this point in time, the advisory committee had fulfilled its function relative to the legislative requirements and no longer formally existed. However, the Energy Design Manual subcommittee did continue work in that respective area. It was realized that there was a need for a manual which would assist building officials, designers, contractors, and others in the implementation and interpretation of the energy insulation standards which were adopted.

In the period since the initial adoption date, several changes to the standards were also adopted by the Commission of Housing and Community Development. Section H contains the amended energy insulation standards effective on April 25, 1976. In some cases, the changes were made to incorporate elements of the FHA Minimum Property Standards for One and Two Family Dwellings regarding building insulation, which were published in the Federal Register of November 22, 1974. In other cases, changes were made based on better input data or to ease design or enforcement problems. The pertinent contents of the changes were as follows:

The second paragraph of Subsection (a) was eliminated because of possible misinterpretation. It was also determined that eliminating the paragraph took nothing away from the standards. The intent of the paragraph was to point out that a building which is both heated and cooled would have to comply with the standards for each condition. A possible misinterpretation was, for example, if the conditions for a heated building were the most critical, the requirements for cooled buildings would not have to be considered, or vice-versa.

Subsection (b), concerning the application and scope, was revised to specify the actual effective date of the standards. The change was made simply for clarification.

Subsection (c), related to alternate provisions, was changed to include a paragraph similar to that contained in the FHA Standards which stated that "Where the stated U value of any one component of roof deck, ceiling, wall, or floor cannot be practically obtained, such U value may be increased to the minimum figure attainable and the U value for other components decreased until the overall heat loss of the building does not exceed the total resulting from conformance to the stated U values." This also helped clarify the intent of this subsection to allow trade-offs between the various components of construction. Also, the portion of this subsection concerning approval of alternative designs was expanded to specifically include credit for designs utilizing nondepleting energy systems. This revision was made because of numerous inquiries as to the intent of the initial wording of the subsection. It was agreed that the use of nondepleting energy systems should be encouraged; and when they are used, the energy obtained from these systems could be used as a credit against energy lost or gained, for example, through glazing.

Subsection (d)(2), which contains the definition for degree day, was revised to clarify that it is related to the annual heating load and not just the winter season of the year. This was done by including the word "annual" and eliminating the word "winter" in the definition. The degree days for specific geographical areas in California were also adopted in an appendix referenced by the degree-day definition. The degree days adopted were for locations where specific weather data was known.

Subsection (d)(14) was added to provide a definition for basic glazing area. The definiton itself was added to simplify the wording of subsection (f) which was also revised. The subject of glazing became a controversial topic and the basic limits for glazing were changed twice before the adoption of the basic glazing area as 20 percent of the gross floor area for low-rise buildings and 40 percent of the exterior wall area for high-rise buildings. The other two changes were an attempt to define the basic glazing area such that the same criteria would be applicable to both low and high-rise buildings. The first change defined the basic glazing area as 20 percent of the exterior wall area plus 10 percent of perimeter walls separating individual dwelling units. However, this method involved a number of calculations, especially for a high-rise building with numerous configurations of dwelling units. Consequently, a second change to simplify the calculations was made, which defined the basic glazing area as 16 percent of the gross floor area for both low and high-rise buildings. This was the basic glazing area criteria when the energy insulation standards went into effect February 22, 1975. However, it didn't take long for the building industry to express their concern that the 16 percent figure was too restrictive. The eventual result was the adoption of the basic glazing area as 20 percent of the gross floor area for low-rise buildings and 40 percent of the exterior wall area for high-rise buildings. This was based on two brief glazing studies and the standards initially adopted, which set the basic limits for glazing at 20 percent of the exterior wall area for low-rise buildings and 40 percent of the exterior wall area for high-rise buildings. It was desirable that the limit for low-rise buildings be in terms of gross floor area instead of the exterior wall area, since the gross floor area for single family dwellings is normally calculated and shown on the plans, while the exterior wall area is not. The glazing studies showed that most residences had less than 20 percent of the gross floor area in glazing and that, in general, 20 percent of the gross floor area was about 20 percent of the exterior wall area. It was also felt that the building industry could live with the 20 percent limitation before having to consider other treatment to limit the heat loss of the building.

Subsection (d)(15) was added to define glazing area as including the sash area. This was added to obtain some consistency in calculating the basic glazing area, since some included it while others didn't. Since the heat loss through the framing is about the same as the heat loss through the glass, it was determined that the framing or sash should be counted in the basic glazing area.

Subsection (e) containing the thermal design standards for ceilings and walls was amended to include higher maximum U values for walls based on construction weight. This change was made based on studies performed, which showed that mass in walls provides a thermal benefit and that the U values specified for the various construction weights were equivalent to the 0.095 U factor of the typical wood-framed wall.

Subsection (f) related to the thermal design standards for glazing was also revised. The basic limits for glazing were removed from this subsection and defined in the definitions as the basic glazing area. Parts (1) and (2) were revised to contain the glazing standards for heated buildings located in areas below and above 4,500 degree days, respectively. Although reworded, the requirements were basically the same as before, except that for buildings located in areas over 4,500 degree days and the basic glazing area is exceeded, treatment is required to limit the heat loss to that which would occur with the basic glazing area in special glazing. The initial standard for this same building would have required treatment to limit the heat loss to that which would have occurred with the basic glazing area in single glazing. The difference being the single glazing. It didn't make sense, when the building required special glazing, to compare its heat loss to the heat loss of a building with single glazing. To do this would have the same effect as increasing the basic-glazing area for buildings located in areas over 4,500 degree days. Part (3) of this subsection concerns cooled buildings and tinted glazing or shading requirements. This part was revised because it would be more equitable to the builder if tinted glazing or shading be required only for the portion of the glazing in excess of the basic glazing area. Previously, one building might have required tinted glazing, while a building of the same size located next door did not. Yet the building which did not require tinted glazing could have more glass exposed to the sun than the building that required tinted glazing.

Subsection (g), containing the insulation requirements for floor sections, foundation walls, and slabs-on-grade was revised to include maximum U-value requirements for foundation walls of crawl spaces used as supply or return-air plenums, and a maximum allowable edge heat loss for heated slabs-on-grade. These items were covered in the revised FHA Minimum Property Standards for One and Two Family Dwellings. Relative to the crawl-space plenums, the FHA standards specified an allowable heat loss per linear foot of foundation wall, but it was determined it would be simpler to specify a maximum U value for the foundation wall which would be equivalent. Table 17-B containing the requirements for floor sections over unheated spaces was revised such that underfloor was not required under 3,000 degree days. The FHA standard did not require underfloor insulation under 2,500 degree days; however, it was contended that underfloor insulation was not cost effective in areas less than 3,000 degree days. In areas above 3,000 degree days, the revised Table 17-B had the same requirements as the FHA standards. FHA later published a local acceptable standard for California which essentially removed the requirement for underfloor insulation in the 2,500 to 3,000 degree-day range.

Subsection (h) was amended to require that all manufactured windows and sliding-glass doors be certified and labeled as meeting the air infiltration requirements of the American National Standards Institute.

Subsection (k) concerning pipe insulation was amended to clarify that the maximum heat loss of 50 Btu/hour per linear foot included the 2-inch pipe size.

Subsection (m) concerning additions to existing buildings was added. Several inquiries were received as to whether or not new additions, alterations, or relocated buildings were required to meet the requirements of the energy insulation standards. The legislation specified that the standards would be applicable to all new residential buildings and did not address additions, alterations, or relocated buildings. It was determined that if the existing building was required to be constructed in conformance with the standards, then it made sense that an addition to that building be required to comply with the standards.

C. ENFORCEMENT AND IMPLEMENTATION

The legislation specifically stated that the energy insulation standards adopted by the Commission of Housing and Community Development shall be enforced within its jurisdiction by the building department of every city, county, or city and county. The legislation further stated that no certificate of occupancy or similar certification that the residential building is habitable shall be issued by such a building department unless the structure at least satisfies the minimum energy insulation standards.

This enforcement procedure is further covered by the State Housing Law contained in the California Health and Safety Code, Division 13, Part 1.5, and is typical for all building regulations for residential buildings. Chapter 5 of this law relates to administrative and enforcement of regulations for residential buildings. Articles 1 and 2, in part, read as follows:

Chapter 5. Administration and Enforcement

Article 1. Enforcement Agencies

17960. The building department of every city or county shall enforce within its jurisdiction all the provisions of this part and rules and regulations promulgated thereunder pertaining to the erection, construction, reconstruction, movement, enlargement, conversion, alteration, repair, removal, demolition, or arrangement of apartment houses, hotels, or dwellings.

17961. The housing department or, if there is no housing department, the health department, of every city or county shall enforce within its jurisdiction all the provisions of this part and rules and regulations promulgated thereunder pertaining to the maintenance, sanitation, ventilation, use, or occupancy of apartment houses, hotels, or dwellings.

17966. Cities or counties may contract with the department for assistance by the department in the enforcement of the applicable provisions of this part and the rules and regulations promulgated thereunder within such cities or counties by the department. Such contracts shall contain provisions for the payment of the costs of such enforcement, or portions thereof, as may be determined by the department.

Article 2. Inspection

17970. Any officer, employee, or agent of an enforcement agency may enter and inspect any building or premises whenever necessary to secure compliance with, or prevent a violation of, any provision of this part and rules and regulations promulgated thereunder which the enforcement agency has the power to enforce.

17971. The owner, or authorized agent of any owner, of any building or premises may enter the building or premises whenever necessary to carry out any instructions, or perform any work required to be done pursuant to this part and rules and regulations promulgated thereunder.

17972. No person authorized by this article to enter buildings shall enter any dwelling between the hours of 6 o'clock p.m. of any day and 8 o'clock a.m. of the succeeding day, without the consent of the owner or the occupants of the dwelling, nor enter any dwelling in the absence of the occupants without a proper written order executed and issued by a court having jurisdiction to issue the order.

In California, there are over 500 city and county building departments which enforce building regulations, including the energy insulation standards for residential buildings.

Up to the time of the enactment of the energy insulation standards, the regulations enforced by building departments dealt with health and safety items only. Most residential buildings constructed in California were provided with some insulation in the roof/ceiling even though there were no regulations requiring this insulation. In most cases, the installation of energy insulation was not checked during plan check or during the inspection of the building.

During the advisory committee meetings when the energy insulation standards were being developed, considerable input was received regarding the enforcement of these standards by local enforcement officials. This concern was shared by the advisory committee to the extent that an enforcement subcommittee was established to develop positive steps in assisting the enforcement of the standards and to foresee possible problem areas.

The main concerns of the enforcement subcommittee were:

1. That the standards would be implemented uniformly throughout the State.
2. That the cost of the enforcement of the standards would be minimal to the consumer.
3. That the enforcement officials understand the terminology used in the standards.

The enforcement subcommittee, after considering all options available recommended that an energy design manual be developed to assist in the implementation of the standards. This manual would be made available to all enforcement officials, free of charge, and to builders, engineers, architects, and consumers for a nominal charge to cover printing and handling costs. The manual was to include basic heat-transfer theory, recommended installation procedures, and California climate data. In addition, the manual was to contain sufficient basic data and theory to be used as a training aide.

The second recommendation of the enforcement subcommittee was that the regulations require that a compliance certificate be provided upon completion of the installation of insulation. This compliance certificate shall be completed and executed by the insulation applicator and by the builder certifying that the insulation has been installed in conformance with the requirements of these regulations. The insulation compliance card shall be posted at a conspicuous location within the building.

The third recommendation of the enforcement subcommittee was to have the standards become effective one year after the date of adoption of the standards. This one-year period would provide sufficient time for builders, engineers and architects, enforcement agencies, and consumers to become familiar with the standards and to allow for a smooth transition period for compliance with the standards.

D. ENERGY DESIGN MANUAL

The Energy Design Manual for Residential Buildings was developed for the purpose of assisting builders, enforcement agencies, engineers, architects, and consumers in implementing the energy insulation standards.

The subcommittee members charged with providing input for the development of the manual consisted of representatives of the building industry, utility representatives, suppliers, insulation contractors, enforcement officials, and designers. Each of these subcommittee members, having his own field of expertise, provided sufficient input to the department to develop a manual that has basic heat-transfer theory as well as information on the installation of thermal materials.

Due to the lack of sufficient funding, this subcommittee had several meetings and spent a great deal of their time without compensation.

The manual contains the following 11 chapters dealing with such items as basic heat-transfer theory, California climate design conditions, glazing, insulation installation, and calculation procedures.

CHAPTER 1

Chapter 1 includes a brief discussion of the purpose, authority, and enforcement requirements of the legislation and regulations. A copy of the standards also are provided in this chapter to provide the user with a complete document.

CHAPTER 2

Chapter 2 discusses the basic properties of heat, the heat-transfer processes, types of insulation, insulation placement, and related considerations such as vapor barriers and ventilation.

CHAPTER 3

Chapter 3 provides a list of definitions which are necessary for the user to understand the standards and the heat-transfer process in general.

CHAPTER 4

Chapter 4 lists the U-factor requirements of the standards for walls, floors, and ceilings. A complete discussion is also included on the term "U factor" and its relationship to the thermal resistance of a combination of materials. A basic example for calculating the U factor for a wall with and without insulation is also included. This chapter also has reprints of tables from the 1972 ASHRAE Handbook of Fundamentals containing the data needed to perform the calculations noted.

CHAPTER 5

Chapter 5 contains U-factor and R-value data relative to some of the more typical wall, ceiling, and floor assemblies used in residential construction in California.

The purpose of this chapter is to provide the Building Official and designer with data relative to some of the more typical wall, ceiling, and floor assemblies used in residential construction in California. While it is impossible to depict every conceivable type of construction, these assemblies are representative of those commonly in use. The resistance values used are taken from the tables contained in Chapter 4 of the manual. Variations in thickness of materials or changes in materials can be taken into consideration using the technique outlined in Chapter 4.

In most cases, these assemblies are organized so that the insulation resistance required to meet the standard is shown in the right-hand column. It is anticipated that plans submitted for approval will show sectional drawings of the proposed construction assemblies with the type and R value of the insulation clearly described. The plan checker should thus be able to quickly determine if a proposed typical construction assembly conforms to the standards.

CHAPTER 6

Chapter 6 contains maps of the degree-day districts in California and provides a list of the design conditions for various reporting stations within those districts. The State has been separated into 22 districts to facilitate plotting of the various reporting stations within each district.

The energy insulation standards reference heating degree-day zones which are important in the application and enforcement of the standards.

The first zone includes those geographic areas which have 2,500 or less heating degree days. Buildings to be located in this zone will not require the insulation of foundation walls of heated basements or heated crawl spaces pursuant to Section 1094(g) and Table 17-C. Buildings to be located in areas which have over 2,500 heating degree days will require conformance to Section 1094(g) and Table 17-C relating to the insulation of foundation walls of heated basements or heated crawl spaces.

The second zone includes those geographic areas which have 3,000 or less heating degree days. Buildings to be located in this zone will not require floor insulation pursuant to Section 1094(g) and Table 17-B.

The third zone includes those geographic areas which have between 3,000 and 4,500 heating degree days. Buildings to be located in this zone will require floor insulation sufficient to obtain a maximum U value of 0.10 for the floor section pursuant to Section 1094(g) and Table 17-B.

Section 1094(d)(2) states that the degree day for specific, geographical areas in California shall be those in Appendix T25-A. The specific degree days for the reporting stations listed have been adopted by the Commission of Housing and Community Development. However, the 2,500, 3,000 and

4,500 heating degree-day lines shown on the district maps may not be completely definable for a specific location, boundary, or topographical demarcation. In order to better delineate these degree-day lines, local enforcement agencies may develop local maps which will better define the exact location of the heating degree-day lines. In many localities, this has already been accomplished.
The data contained in this chapter were obtained from various sources with the purpose of obtaining the maximum number of reporting stations for each district. The data listed came from two basic sources, the U.S. Department of Commerce Climatography Publication for the United States and from utility company reporting stations. All of the reporting stations had at least 10 years of data on which to base their degree days.

CHAPTER 7

Chapter 7 covers the thermal design standards for glazing and includes tables of transmission coefficients for glazing, shading coefficients for glazing and louvered sun screens, profile angles and solar azimuths on August 21 for various latitudes in California.

Examples of determining compliance with the thermal design standards for glazing are included for both high-rise and low-rise residential buildings, along with a graphical example for determining the amount of shading produced by a roof overhang.

CHAPTER 8

Chapter 8 provides a guide to the proper installation of insulation. The chapter also lists the Federal specifications applicable to various types of insulation materials. These Federal specifications have not been adopted into the California energy insulation standards, but are listed in the manual merely as guidelines. If any one, single weakness exists in the present standards, it is the lack of any particular standards for testing the thermal properties of the insulation products. Even adoption of the Federal specifications would only solve a portion of the problem since most of the Federal specifications allow several optional test standards to be used.

This chapter also provides guides to the installation of various types of insulation, such as batt, reflective, foam, and pneumatic insulation.

CHAPTER 9

Chapter 9 discusses pipe and duct insulation and includes tables and a method for calculating the thickness of insulation required. Charts and tables for determining insulation for underground recirculating hot-water piping is also included in this chapter.

CHAPTER 10

Chapter 10 discusses weatherstripping as required by the energy insulation standards. This chapter includes details of the basic types of weatherstripping most commonly used in residential types of construction in California.

CHAPTER 11

Chapter 11 discusses Section 1094(c) as this section relates to alternate materials, methods of construction, designs, or insulating systems and provides examples of alternate calculations. This chapter was not included in the initial manual. However, it became apparent that many did not know how to approach problems when alternative designs were called for. When confronted with such situations as open beam ceilings or excessive glazing area, many designers were unable to find solutions using alternative designs. Not until April, 1976, when Chapter 11 was incorporated into the manual, did the full intent of the alternative design provisions get conveyed to the designer and enforcement officials.

The first draft of the manual was completed in early February, 1975, just prior to the effective date of the standards. This delay of releasing the manual to building officials, builders, and the public presented problems in both the enforcement and design of new residential buildings.

Even though this manual was only a guide, it soon became a basic tool in the implementation of the standards and remains so today. Without this document, implementation of these standards may have been an impossible task.

E. TRAINING AND PLAN CHECKING

As the development of the energy insulation standards progressed, it became apparent that a training program for enforcement officials, builders, engineers, and consumers would be necessary in order to have orderly implementation of the standards. During public hearings, concern was expressed over the standards due to the lack of knowledge by parties directly affected by the standards.

It was decided to develop a training program using the Energy Design Manual as the main training tool. The Department was left with the task of developing a statewide training program with a very limited budget.

The total funding available for training was $5,000 including any costs for printing of the Energy Design Manual. It was estimated that approximately 4,000 manuals would be needed to serve all parties affected by these standards. The estimated cost for printing 4,000 Energy Design Manuals was approximately $4,300, which would leave only $700 for training if the manuals were distributed at no charge. Because of the costs involved in printing the manuals, it was decided to provide local enforcement agencies with manuals free of charge and to charge other interested parties a sufficient sum to cover printing, mailing, and handling costs. It was estimated that approximately 1,000 manuals would be needed for local enforcement agencies, libraries, and governmental agencies. After subtracting the costs for these manuals about $4,000 remained for a training program.

Another problem was the timing of the training program. The standards were adopted on February 22, 1974, and would become effective one year thereafter. Work on the Energy Design Manual did not begin until after the standards were adopted. It was estimated that the manual would be completed in early September; and allowing time for printing, the manual could be available by October at the earliest. With an October delivery date, the manual would be available for only four months of training prior to the effective date of the standards.

The Energy Design Manual did not become available to the public until April 1975; however, 1,000 copies of a draft of the manual were available in February 1975. This delay in the availability of the manual further complicated the proposed training program.

With these obstacles of funding and timing of training documents being of prime consideration, the Department proceeded on the development of a statewide training program.

It was decided that the following criteria would be used in setting up the training program:

1. The training sessions would begin no later than September, 1975.

2. The main emphasis of the training would be directed toward building inspectors who enforce the standards. It was felt that if the enforcement officials could develop a thorough understanding of the standards, uniform implementation would be obtained. In addition, these trained officials could provide assistance to builders and consumers in their jurisdictions.

3. The instructors of these courses would consist of Department staff and advisory committee members.

4. The Department would try to notify all groups and individuals who would be affected by these standards.

5. The Department would make an effort to have a Department representative familiar with the standards at any public meeting concerning energy.

After the first few training sessions were held, it became apparent that the following changes would be needed in the program:

1. The sessions would have to start with basic heat transfer theory due to the general lack of familiarity with heat transfer terminology. Such subjects as U-value, R value, conduction, radiation, convection,

and degree day were, for the most part, not understood by most people who attended the sessions.

2. The training sessions were too short (2 to 4 hours). It was evident that very little could be accomplished during these short sessions. The sessions should be extended to a minimum of eight hours. Possibly a two-day session would be more beneficial. This of course, became a problem due to timing of the implementation of the standards, lack of funding, and a limited number of instructors.

3. It was also learned that builders, developers, and some consumers were very strongly opposed to the energy insulation standards. The main objections appeared to be the additional cost for housing due to the standards, since previously insulation was not mandatory in California. Also, design flexibility would be reduced especially in the amount of glazing used. Most people who attended the sessions were not familiar with the development of the standards or the standards themselves.

It soon became apparent that the training program which had been developed was completely inadequate to inform and train all affected parties to understand and use the standards. Several all-day sessions were incorporated into the training program which eliminated some of the apparent problems; however, due to the time available, a sufficient number of these sessions could not be provided.

When the energy insulation standards became effective, certain implementation problems still existed; however, many of the problems concerning understanding of the standards had been partially eliminated. The major problems were concerned with the following areas:

1. Unawareness of the standards by the general public, builders, and designers.

2. Design flexibility has been limited due to the restrictions on glazing.

3. Increased costs due to the standards.

4. General reluctance on the part of the public to accept the need of such standards.

Most of these areas which were problems at the time the standards became effective have now been resolved and the standards are generally accepted by the public. There appears to be little opposition to the standards; in fact, many builders, especially on custom homes, are providing energy-saving features in excess of the standards.

When the Energy Design Manual became available, the Department was beseiged with requests for the manual. The manual soon became a training, enforcement, and design tool for the standards. About 5,000 copies of the manual were distributed.

F. LEGISLATIVE BILL

SENATE BILL NO. 277

CHAPTER 1136

An act to add Chapter II (commencing with Section 19870) to Part 3 of Division 13 of the Health and Safety Code, relating to energy insulation, and making an appropriation therefor.

Approved by Governor November 22, 1972, Filed with Secretary of State November 22, 1972.

LEGISLATIVE COUNSEL'S DIGEST

SB 277, Alquist. Energy insulation.

Requires the Commission of Housing and Community Development, by January 1, 1974, to adopt rules and regulations establishing minimum standards of energy insulation for new hotels, motels, apartment houses, homes, and other residential dwellings which shall meet or exceed those prescribed by Federal Housing Administration requirements at the time the commission adopts such rules and regulations.

Requires the commission to develop rules and regulations independent of such standards for hotels, motels, and apartment houses more than 3 stores in height.

Requires the Director of Housing and Community Development to appoint an advisory committee of specified persons to assist the commission in the establishment of energy insulation regulations.

Requires the building department of every city, county, or city and county to enforce the provisions of this act and rules and regulations adopted pursuant thereto.

Prohibits the issuance of a certificate of occupancy or similar certification that prescribed structures are habitable unless the structure at least satisfies such minimum energy insulation standards.

Appropriates $35,000 to the department for the purposes of this act.

The people of the State of California do enact as follows:

SECTION 1. Chapter 11 (commencing with Section 19870) is added to Part 3 of Division 13 of the Health and Safety Code, to read:

CHAPTER 11. ENERGY INSULATION REGULATION

19870. As used in this chapter, "energy insulation" means the protection from heat loss or heat gain to conserve the fuel resources used to heat or cool residential and commercial buildings.

19871. By January 1, 1974, the Commission of Housing and Community Development shall adopt such rules and regulations establishing minimum standards of energy insulation for new hotels, motels, apartment houses, homes, and other residential dwellings as the commission determines are reasonably necessary to conserve fuel resources. The rules and regulations adopted by the commission shall meet or exceed the standards which are required by the Federal Housing Administration in "Minimum Property Standards for One and Two Living Units" which are in effect at the time the commission adopts such rules and regulations. However, the commission shall develop rules and regulations independent of such standards for hotels, motels, and apartment houses which are more than three stories in height.

19872. The Director of Housing and Community Development shall appoint an advisory committee to assist the commission in the establishment of energy insulation regulations. The advisory committee shall consist of two architects in private practice, two scientists having professional and technical experience in the field of energy conservation or use, one general building contractor, as defined in Section 7057 of the Business and Professions Code, two specialty contractors classified in Chapter 8 (commencing with Section 700) of Title 16 of the California Administrative Code, three representatives from a city, county, or city and county, the Secretary of the Human Relations Agency, the State Architect, and the Secretary of the Resources Agency. Members of the advisory committee shall serve without compensation, but each member shall be reimbursed for his necessary traveling and other expenses incurred in the performance of his duties.

19873. The provisions of this chapter and the rules and regulations adopted by the commission pursuant to this chapter shall apply in all parts of the state, including, but not limited to, charter cities.

19874. Any state agency, city, county, or city and county may adopt standards of energy insulation for new buildings which are stricter than those established under this chapter by the commission, except that any such changes or modification shall be adopted in accordance with the requirements prescribed in Sections 17958.5 and 17958.7.

19875. The provisions of this chapter and the rules and regulations adopted pursuant to this chapter shall be enforced within its jurisdiction by the building department of every city, county, or city and county. No certificate of occupancy or similar certification that a newly constructed hotel, motel, apartment house, home, or other residential dwelling is habitable shall be issued by such a building department unless the structure at least satisfies the minimum energy insulation standards established pursuant to this chapter.

19876. The provisions of this chapter shall apply only to new hotels, motels, apartment houses, homes, and other residential dwellings on which actual site preparation and construction has not commenced prior to the effective date of rules and regulations adopted pursuant to this chapter. Nothing in this chapter shall prohibit the enforcement of existing energy insulation standards, adopted prior to the effective date of this chapter, as to new hotels, motels, apartment houses, homes, and other residential dwellings on which actual site preparation and construction has commenced prior to the effective date of rules and regulations adopted pursuant to this chapter.

19877. All rules and regulations adopted by the commission under the authority of this chapter shall be adopted pursuant to Chapter 4.5 (commencing with Section 11371) of Part 1 of Division 3 of Title 2 of the Government Code.

SECTION 2. There is hereby appropriated from the General Fund to the Department of Housing and Community Development the sum of thirty-five thousand dollars ($35,000) for the purposes of Chapter 11 (commencing with Section 19870) of Part 3 of Division 13 of the Health and Safety Code.

G. INITIAL STANDARDS (Adopted February 22, 1974)

CALIFORNIA ADMINISTRATIVE CODE

Title 25, Chapter 1, Subchapter 1

Article 5. Energy Insulation Standards

1094. Energy Insulation Standards

(a) Purpose. The purpose of this article is to establish minimum uniform energy insulation standards. All new hotels, motels, apartment houses, lodging houses, dwellings, and other residential buildings which are heated or mechanically cooled shall be constructed to comply with the following regulations.

A building which is both heated and cooled shall be insulated against the most severe climatic condition for the location and type of structure involved.

(b) Application and Scope. These regulations shall apply to all applications for building permits made subsequent to the effective date of these regulations.

These regulations shall become effective one year after adoption by the Commission of Housing and Community Development.

(c) Alternate Materials, Method of Construction, Design or Insulating System. The provisions of this article are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein provided that any such alternate has been approved.

The Building Official may approve any such alternate provided he finds that the proposed design complies with the provisions of this article in that the material, method of construction, design or insulating system offered is, for the purpose intended at least equivalent in effectiveness to the requirements of this article. The Building Official shall require that sufficient evidence or proof be submitted to substantiate any claims made regarding the installation and use of any such alternate, including testing of the final installation.

(d) Definitions. For the purposes of this section, the following definitions shall apply:

(1) Cooling Systems - A system for cooling air by mechanical or other means and discharging such air into a dwelling unit. This definition shall not include evaporative cooling.

(2) Degree Day - A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 65°F, there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F. The degree day for specific geographical areas in California shall be those adopted by the Commission of Housing and Community Development.

(3) Exterior Wall Area - The gross area of wall surfaces adjacent to heated or cooled spaces, including glazing and doors, exposed to ambient climatic temperatures, measured for a dwelling unit or group of units served by a heating or cooling system.

(4) Glazing - All transparent or translucent materials in exterior openings.

(5) High Rise - Any building containing four or more stories of dwelling space, excluding basements and parking or nonhabitable areas in subterranean or ground levels.

(6) Shading Coefficient - A ratio of the solar heat gain through an unshaded glazing system to that of a single light of double strength window glass under the same set of conditions.

(7) Special Glazing - Glazing which has a maximum U factor of 0.70 for all glazed surfaces.

(8) Thermal Conductance (C-factor) - The time rate of heat flow through a homogeneous material of other than one-inch thickness or through a nonhomogeneous construction such as an air space expressed in BTU/hr., square foot, degree F temperature difference.

(9) Thermal Conductivity (K-factor) - The time rate of heat flow through one square foot of a homogeneous material one inch thick when there is a temperature difference of one degree F between the opposite faces of the material expressed in BTU/hr., square foot, degree F per inch.

(10) Thermal Resistance (R) - The measure of the resistance of a material or building component to the passage of heat. The resistance (R) of mass-type insulations shall not include any value for reflective facing.

(11) Tinted Glazing - Glazing which shall be permanently tinted or permanently surface coated by the manufacturer of the glazing material and shall provide a maximum shading coefficient as hereinafter specified.

(12) U Factor - The total heat flow through a given construction assembly, air to air, expressed in BTU/hr., per square foot, per degree F temperature difference.

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

where R_t equals the sum of the resistance (R) for the individual components of the assembly. U factors shall be calculated according to ASHRAE methods.

(13) Unheated Spaces - Any space exposed to ambient temperatures and not provided with a heat supply capable of maintaining a minimum temperature of $50^{o}F$.

(e) Thermal Design Standards for Ceiling and Walls. The design of the opaque surfaces of the structure, exposed to ambient conditions, shall provide a maximum U factor of 0.05 for ceilings and 0.08 for walls and spandrels and shall not consider the effects of occasional framing members such as studs and joists. When all of the thermal insulation is installed so that it is not penetrated by framing members, the U factor of the walls shall not exceed 0.095 and 0.06 for ceilings calculated to include all components of construction.

(f) Thermal Design Standards for Glazing.

(1) The basic limits for glazing, as a percentage of the area of exterior walls, shall be 20% for low-rise buildings and 40% for high-rise buildings. Glazing shall be in accordance with Subsections (2), (3), and (4) below; or for buildings exceeding the basic limits, treatment of the building may be utilized which will limit the design heat loss and heat gain for each exterior wall to that which would be allowed for the same exterior wall with not more than the basic limit of single glazing.

(2) Heated buildings or structures located in 0-4500 degree day areas shall be provided with special glazing when the glazing exceeds the basic limit. Buildings located in areas over 4500 degree days shall be provided with special glazing in all exterior wall areas.

(3) Cooled buildings shall be provided with tinted glazing when the glazing exceeds the basic limit. This provision applies to all wall and roof exposures except those wall areas oriented within 22½ degrees of true North. Permanent external shading to allow not more than 50% direct solar glazing exposure, taken on September 21 at 9:00 a.m., noon, and 3:00 p.m. solar time, may be utilized in lieu of tinted glazing.

(4) Tinted glass shall have a maximum shading coefficient of 0.75. This maximum shall be decreased to 0.55 for all permit applications filed after July 1, 1976.

(g) Floor Section, Foundation Walls and Slabs-On-Grade. For floors over unheated spaces, unheated basements, unheated garages, or ventilated crawl spaces with operable louvers, the "U" values of floor section shall not exceed the value shown in Table No. 17-B.

Foundation walls of heated basements or heated crawl spaces shall be insulated to provide a "U" value not to exceed the values shown in Table No. 17-C. Insulation may be omitted from floors over heated basement areas or heated crawl spaces.

For slab-on-grade floors, the edge heat loss around the perimeter of heated spaces shall not exceed a maximum value per linear foot of exposed edge of 42 B.t.u.h. for heated slabs. Calculations of heat loss around slab edges shall be made using the following formula:

$$H = F \times P$$

WHERE:

H = Heat loss of the slab edge in B.t.u.h.

F = Heat loss coefficient from Table No. 17-D in B.t.u.h. per linear foot of exposed edge.

P = Perimeter of exposed slab edge (linear feet).

TABLE NO. 17-B

Maximum "U" Values of Floor Sections Over
Unheated Basements, Unheated Garage or Crawl Spaces

HEATING DEGREE DAYS	MAXIMUM "U" VALUE
2500 or less	No requirement
Over 2500	.08

NOTE: A basement or garage shall be considered unheated unless it is provided with a positive heat supply to maintain a minimum temperature of 50°F.

TABLE NO. 17-C

Maximum "U" Values of Foundation Wall Sections
of Heated Basement or Heated Crawl Spaces

HEATING DEGREE DAYS	MAXIMUM "U" VALUES
2500 or less	No requirement
Over 2500	.15

NOTE: A crawl space is considered heated when it has a positive heat supply to maintain a minimum temperature of 50°F.

TABLE NO. 17-D

Slab Edge Heat Loss Coefficients
(Btuh per Linear Foot)

Winter Design Temperature	Total Width of Insulation (inches)	F for Unheated Slab R=5.0	R=3.75	R=2.50	F for Heated Slab R=5.0	R=3.75	R=2.50
-30 or colder	24	34			46		
-20 to -29	24	32			44		
-20 to -24	24	30			41		
-15 to -19	24	28			39		
-10 to -15	24	27	40		37		
- 5 to - 9	24	25	38		35		
Zero to - 4	24	24	36		32	48	
+ 5 to + 1[1]	24	22	33		30	45	
+10 to + 6[1]	18	21	31	42	25	38	50
+15 to +11[1]	12	21	31	42	25	38	50

[1]Where winter design temperatures are warmer than +15F, perimeter insulation is not required. If installed in these areas (edge only), use values shown for +15F to +11F above. If not installed, use value of F = 45 for unheated and F = 60 for heated slabs.

(h) All doors and windows opening to the exterior or to unconditioned areas such as garages shall be fully weatherstripped, gasketed, or otherwise treated to limit infiltration.

(i) Loose Fill. Blown or poured type loose fill may be used in attic spaces where the slope of the roof is not less than 2½ feet in 12 feet and there is at least 30 inches of clear headroom at the roof ridge. ("Clear Headroom" is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing.") When eave vents are installed, adequate baffling of the vent opening shall be provided to deflect the incoming air above the surface of the material and shall be installed at the soffit on a 45-degree angle. Baffles shall be in place at the time of framing inspection. When loose-fill insulation is proposed, the R value of the material required to meet these regulations shall be shown on the building plans.

(j) Design Temperature. Inside winter design temperature shall be not less than $70^{o}F$, and summer design temperature not greater than $78^{o}F$. Heat loss and heat gain calculations shall be made using the winter design dry bulb at 99 percent and summer design dry bulb at 2½ percent shown in the current ASHRAE Handbook of Fundamentals.

(k) Insulation. All steam and steam condensate return piping and all continuously circulating domestic or heating hot water piping which is located in attics, garages, crawl spaces or unheated spaces other than between floors or in interior walls shall be insulated to provide a maximum heat loss of 50 BTU/hr. per linear foot for piping up to 2" and 100 BTU/hr. per linear foot for larger sizes.

(l) Compliance. Upon completion of the installation of insulation, a card certifying that the insulation has been installed in conformance with the requirements of these regulations shall be completed and executed by the insulation applicator and by the builder. This insulation compliance card shall be posted at a conspicuous location within the dwelling.

H. AMENDED STANDARDS (Effective April 25, 1976)

CALIFORNIA ADMINISTRATIVE CODE
Title 25, Chapter 1, Subchapter 1

Article 5. Energy Insulation Standards

1094. Energy Insulation Standards. Energy insulation standards shall be in accordance with the applicable requirements of California Administrative Code, Title 24, Part 6, Division T25, Chapter 1, Subchapter 1, Article 5, Section T25-1094, which reads as follows:

T25-1094. Energy Insulation Standards. (a) Purpose. The purpose of this Article is to establish minimum uniform energy insulation standards. All new hotels, motels, apartment houses, lodging houses, dwellings and other residential buildings which are heated or mechanically cooled shall be constructed to comply with this Article.

(b) Application and Scope. These regulations shall apply to all applications for building permits made subsequent to the effective date of these regulations.

These regulations shall become effective on February 22, 1975.

(c) Alternate Materials, Method of Construction, Design or Insulating System. The provisions of this Article are not intended to prevent the use of any material, method of construction, design, or insulating system not specifically prescribed herein provided that any such alternate has been approved.

The U value of any component of ceiling, floor, roof deck or wall, including glazing, may be increased, and the U value for other components, decreased until the overall heat gain or heat loss of the building does not exceed the total resulting from conformance to the stated U values.

The Building Official may approve any alternate design including designs utilizing nondepleting energy systems such as solar or wind provided he finds that the proposed design complies with the provisions of this Article in that the material, method of construction, design or insulating system does not use more depletable energy than the requirements of this Article.

The Building Official shall require that sufficient evidence or documentation be submitted to substantiate any claims made regarding the installation and use of any such alternate and may require testing of the final installation.

NOTE: Basic glazing area may be adjusted if in compliance with Subsection (c) above.

(d) Definitions. For the purpose of this section, the following definitions shall apply:

(1) Cooling Systems - A system for cooling air by mechanical or other means and discharging such air into a dwelling unit. This definition shall not include evaporative cooling.

(2) Degree Day - A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65^{o}F, there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65^{o}F. The degree day for specific geographical areas in California shall be those in Appendix T25-A.

(3) Exterior Wall Area - The gross area of wall surfaces adjacent to heated or cooled spaces, including glazing and doors, exposed to ambient climatic temperatures, measured for a dwelling unit or group of units served by a heating or cooling system.

(4) Glazing - All transparent or translucent materials in exterior openings.

(5) High Rise - Any building containing four or more stories of dwelling space, excluding basements and parking or nonhabitable areas in subterranean or ground levels.

(6) Shading Coefficient - A ratio of the solar heat gain through an unshaded glazing system to that of a single light of double strength window glass under the same set of conditions.

(7) Special Glazing - Glazing which has a maximum U factor of 0.70 for all glazed surfaces.

(8) Thermal Conductance (C-factor) - The time rate of heat flow through a homogeneous material of other than one-inch thickness or through a nonhomogeneous construction such as air space expressed in BTU/hr., square foot, degree F temperature difference.

(9) Thermal Conductivity (K-factor) - The time rate of heat flow through one square foot of a homogeneous material one inch thick when there is a temperature difference of one degree F between the opposite faces of the material expressed in BTU/hr., square foot, degree F per inch.

(10) Thermal Resistance (R) - The measure of the resistance of a material or building component to the passage of heat. The resistance value (R) of mass-type insulations shall not include any value for reflecting facing.

(11) Tinted Glazing - Glazing which shall be permanently tinted or permanently surface coated by the manufacturer of the glazing material and shall provide a maximum shading coefficient as hereinafter specified.

(12) U Factor - The total heat flow through a given construction assembly, air to air, expressed in BTU/hr., per square foot, per degree F temperature difference.

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

R_t equals the sum of the resistance (R) for the individual components of the assembly. U factors shall be calculated according to ASHRAE Methods.

(13) Unheated Spaces - Any space exposed to ambient temperatures and not provided with a heat supply capable of maintaining a minimum temperature of 50°F.

(14) Basic Glazing Area - The basic glazing area for low-rise buildings shall be 20% of the gross floor area and 40% of the exterior wall area for high-rise buildings. The gross floor area shall not include parking garages, unheated basements, corridors, or passageways exposed to exterior ambient temperatures.

(15) Glazing Area. The area of glazing in exterior openings including the sash area.

(e) Thermal Design Standards for Ceilings and Walls. The design of the opaque surfaces of the structure, exposed to ambient conditions, shall provide a maximum U factor of 0.05 for ceilings and 0.08 for walls and spandrals, when the effects of occasional framing members such as studs and joists are not considered. In lieu of the above, when the effects of all elements of the wall or ceiling construction, including occasional framing members such as studs and joists, are considered or when all of the thermal insulation is installed so that it is not penetrated by framing members, the U factor shall not exceed 0.095 for walls and 0.06 for ceilings.

For buildings located in areas of 3500 degree days or less and the effects of all elements of the wall construction are considered, the U factor shall not exceed 0.12 for walls with a construction weight of 26 through 40 pounds per square foot or a U factor not exceeding 0.16 for walls with a construction weight greater than 40 pounds per square foot.

(f) Thermal Design Standards for Glazing.

(1) For heated buildings located in areas of 4500 degree days or less, where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed.

(2) Heated buildings located in areas over 4500 degree days shall be provided with special glazing for all exterior glazing. Where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area in special glazing.

(3) Cooled buildings shall utilize tinted glazing when the total glazing area exceeds the basic glazing area. The glazing area on walls oriented within 22½ degrees of true North need not be included in the total glazing area. The required tinted glazing area shall not be less than the difference between the total glazing area and the basic glazing area. Permanent

external shading to allow not more than 50% direct solar exposure on the glazing, taken on August 21, at 9:00 a.m., noon and 3:00 p.m. solar time, may be utilized in lieu of tinted glass. Tinted glazing or permanent external shading on walls oriented with 22½ degrees of true North shall not be considered as part of the required tinted glazing area.

(4) Tinted glazing shall have a maximum shading coefficient of 0.75. This maximum shall be decreased to 0.55 for all permit applications filed after July 1, 1976.

(g) Floor Section, Foundation Walls, Crawl Space Plenum Walls and Slabs-on-Grade. For floors over unheated spaces, unheated basements, unheated garages, or ventilated crawl spaces with operable louvers, the "U" values of floor section shall not exceed the value shown in Table No. 17-B.

Foundation walls of heated basements or heated crawl spaces above grade shall be insulated to provide a "U" value not to exceed the values shown in Table No. 17-C. Insulation may be omitted from floors over heated basement areas or heated crawl spaces if foundation walls are insulated.

When a crawl space is not used as a supply or return plenum, the crawl space perimeter wall shall be insulated to provide a maximum "U" value of 0.15.

For slab-on-ground floors, the edge heat loss around the perimeter of heated spaces shall not exceed a maximum value per linear foot of exposed edge of 42 B.t.u.h. for unheated slabs and 50 B.t.u.h. for heated slabs. Calculations of heat loss around slab edges shall be made using the following formula:

$$H = F \times P$$

WHERE:

H = Heat loss of the slab edge in B.t.u.h.

F = Heat loss coefficient from Table No. 17-D in B.t.u.h. per linear foot of exposed edge.

P = Perimeter of exposed slab edge (linear feet).

TABLE NO. 17-B

Maximum "U" Values of Floor Sections Over
Unheated Basements, Unheated Garage or Crawl Spaces

HEATING DEGREE DAYS	MAXIMUM "U" VALUE
3000 or less	No requirement
3001 to 4500	.10
Over 4500	.08

NOTE: A basement or garage shall be considered unheated unless it is provided with a positive heat supply to maintain a minimum temperature of 50°F.

TABLE NO. 17-C

Maximum "U" Values of Foundation Wall Sections
of Heated Basement or Heated Crawl Spaces

HEATING DEGREE DAYS	MAXIMUM "U" VALUES
2500 or less	No requirement
Over 2500	.15

NOTE: A crawl space is considered heated when it has a positive heat supply to maintain a minimum temperature of 50°F.

<u>TABLE NO. 17-D</u>

Slab Edge Heat Loss Coefficients
(Btuh per Linear Foot)

Winter Design Temperature	Total Width of Insulation (inches)	F for Unheated Slab			F for Heated Slab		
		R=5.0	R=3.75	R=2.50	R=5.0	R=3.75	R=2.50
-30 or colder	24	34			46		
-20 to -29	24	32			44		
-20 to -24	24	30			41		
-15 to -19	24	28			39		
-10 to -15	24	27	40		37		
- 5 to - 9	24	25	38		35		
Zero to - 4	24	24	36		32	48	
+ 5 to + 1[1]	24	22	33		30	45	
+10 to + 6[1]	18	21	31	42	25	38	50
+15 to +11[1]	12	21	31	42	25	38	50

[1]Where winter design temperatures are warmer than +15F, perimeter insulation is not required. If installed in these areas (edge only), use values shown for +15F to +11F above. If not installed, use value of F = 45 for unheated and F = 60 for heated slabs.

(h) All swinging doors and windows opening to the exterior to unconditioned areas such as garages shall be fully weatherstripped, gasketed, or otherwise treated to limit infiltration. All manufactured windows and sliding glass doors shall meet the air infiltration standards of the 1972 American National Standards Institute (A134.1, A134.2, A134.3 and A134.4), when tested in accordance with ASTM E283-73 with a pressure differential of 1.57 lbs/ft^2 and shall be certified and labeled.

(i) Loose Fill. Blown or poured type loose fill may be used in attic spaces where the slope of the roof is not less than 2½ feet in 12 feet and there is at least 30 inches of clear headroom at the roof ridge. ("Clear Headroom" is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing.) When eave vents are installed, adequate baffling of the vent opening shall be provided to deflect the incoming air above the surface of the material and shall be installed at the soffit on a 45-degree angle. Baffles shall be in place at the time of framing inspection. When loose-fill insulation is proposed, the R value of the material required to meet these regulations shall be shown on the building plans.

(j) Design Temperature. Inside winter design temperature shall be not less than 70^{o}F, and summer design temperature not greater than 78^{o}F. Heat-loss and heat-gain calculations shall be made using the winter design dry bulb at 99 percent and summer design dry bulb at 2½ percent shown in the current ASHRAE Handbook of Fundamentals.

(k) Pipe Insulation. All steam and steam condensate return piping and all continuously circulating domestic or heating hot water piping which is located in attics, garages, crawl spaces or unheated spaces other than between floors or in interior walls shall be insulated to provide a maximum heat loss of 50 BTU/hr. per linear foot for piping up to and including 2" and 100 BTU/hr. per linear foot for larger sizes.

(l) Compliance. Upon completion of the installation of insulation, a card certifying that the insulation has been installed in conformance with the requirements of these regulations shall be completed and executed by the insulation applicator and by the builder. This insulation compliance card shall be posted at a conspicuous location within the dwelling.

(m) Additions to Existing Buildings. Additions to existing hotels, motels, apartment houses, lodging houses, dwellings and other residental buildings shall be constructed to comply with this Article if the existing building was required to be constructed in conformance with this Article.

APPENDIX T25-A

Heating Degree Day Table

CITIES	ANNUAL DEGREE DAYS
Alderpoint	3,290
Alpine	2,104
Alturas	6,785
Antioch	2,627
Auburn	3,047
Bakersfield	2,122
Barrett Dam	2,363
Barstow	2,496
Beaumont	2,790
Berkeley	2,850
Bishop	4,275
Blythe	1,076
Bonita	1,857
Borrego Springs	1,262
Brawley	1,161
Burney	6,249
Cabrillo National Monument	1,653
Calaveras Big Trees	5,736
Campo	3,247
Chico	2,795
Chula Vista	2,229
Cloverdale	2,666
Colfax	3,441
Colusa	2,788
Concord	2,766
Corona	1,875
Crescent City	4,545
Culver City	1,711
Cuyamaca	4,649
Daggett	2,203
Davis	2,819
Death Valley	1,205
Delano	2,220
Edwards A.F.B.	3,123
El Cajon	1,920
El Capitan Dam	1,397
El Centro	1,216
Elk Valley	5,404
Elsinore	2,101
Encinitas	1,952
Escondido	2,052
Eureka	4,679
Fairfield	2,434
Fairmont	3,327
Fillmore	2,377
Folsom	2,899

CITIES	ANNUAL DEGREE DAYS
Fort Bidwell	6,365
Fort Bragg	4,424
Fort Jones	5,614
Fremont	2,906
Fresno	2,611
Gilroy	2,808
Hanford	2,642
Healdsburg	2,700
Henshaw Dam	3,652
Hetch Hetchy	4,797
Hollister	2,725
Huntington Beach	2,361
Imperial	1,060
Independence	2,995
Inyokern	2,570
Ione	2,728
Jackson	2,760
Julian Wynola	4,085
King City	2,655
Laguna Beach	2,262
Lake Arrowhead	5,200
Lakeport	3,716
La Mesa	1,492
Lemoore	2,960
Lindsay	2,619
Livermore	2,781
Lodi	2,785
Long Beach	1,803
Los Angeles	2,061
Los Banos	2,267
Los Gatos	2,794
Madera	2,485
Maricopa	2,165
Mariposa	3,116
Markeeville	7,884
Marysville	2,377
McCloud	6,007
Mecca	1,117
Mendota	2,555
Merced	2,697
Mineral	7,192
Modesto	2,767
Mojave	2,590
Monterey	2,985
Napa	2,690
Needles	1,072
Nellie	4,745
Nevada City	4,488
Novato	2,815
Oakdale	2,832
Oak Grove	3,516

CITIES	ANNUAL DEGREE DAYS
Oakland	2,906
Oceanside	2,092
Orland	2,830
Oroville	2,597
Oxnard	2,352
Palmdale	3,088
Palm Springs	1,232
Palo Alto	2,869
Palomar Mt. Observatory	3,868
Pasadena	1,694
Paso Robles	2,890
Patterson	2,368
Petaluma	2,966
Pittsburgh	2,633
Placerville	4,161
Point Loma	1,860
Pomona	2,166
Porterville	2,563
Portola	7,055
Quincy	5,852
Ramona Spaulding	2,223
Red Bluff	2,688
Redding	2,610
Redlands	2,052
Redwood City	2,596
Richmond	2,644
Riverside	2,089
Roseville	2,899
Sacramento	2,782
St. Helena	2,833
Salinas	2,959
San Bernardino	2,018
San Clemente	1,877
San Diego	1,439
San Fernando	1,800
San Francisco	3,080
San Jacinto	2,376
San Jose	2,656
San Juan Capistrano	1,646
San Luis Obispo	2,582
San Mateo	2,655
San Rafael	2,619
Santa Ana	1,496
Santa Barbara	2,290
Santa Clara	2,566
Santa Maria	2,985
Santa Rosa	2,980
Scotia	3,954
Sierraville	6,953
Sonora	3,086
South San Francisco	3,061

CITIES	ANNUAL DEGREE DAYS
Stockton	2,690
Stony Gorge Res.	3,124
Susanville	6,248
Tahoe City	8,162
Tahoe Valley	8,198
Thousand Oaks	2,425
Tracy	2,616
Truckee	8,208
Twentynine Palms	2,006
Ukiah	3,030
Vacaville	2,812
Vallejo	2,598
Visalia	2,546
Vista	1,760
Warner Springs	3,470
Weaverville	4,935
Weed	5,870
Willits	4,160
Willows	2,807
Woodland	2,447
Yosemite	4,800
Yreka	5,393
Yuba City	2,386

III. SURVEY FINDINGS AND ANALYSIS

A. INTRODUCTION

The California residential energy insulation standards were adopted on February 22, 1974, and became effective one year later, on February 22, 1975. These standards affected the various groups involved in the building process. To assist these groups in the implementation and interpretation of the standards, an energy design manual became available at approximately the same time the standards became effective.

Studies were conducted to determine the problems encountered in the implementation, enforcement, and design aspects of the standards. Data was collected by surveying those involved in the building process, namely, enforcement officials, builders and developers, architects and engineers, manufacturers and suppliers, and consumers. Interviews were selected to provide a representative cross section, considering the various sizes of city and county building departments, various climatic conditions and various geographic locations throughout the state.

The consulting firm of Melvyn Green and Associates, Inc., El Segundo, California, was retained to assist in the collection of data and the preparation of recommendations. Mr. Green's report, "The California Residential Energy Regulations -- Their Impact on the Building Process", discusses his survey methodology and findings, and presents recommendations based on the findings.

An independent survey was performed by the Department of Housing and Community Development, at interview locations not covered by the consultant. This provided a broader data base and the opportunity to compare the findings of the two surveys.

The findings have been summarized and are presented as follows: Prior insulation practices; enforcement agencies; builders and developers; architects and engineers; manufacturers and suppliers; consumers.

The findings represent the opinions and experiences of the individuals interviewed only, and should not be construed to mean that all others agree with these opinions.

B. PRIOR INSULATION PRACTICES

Prior to the standards becoming effective, insulation practices varied throughout the state. Floors were not insulated and insulating glass generally was not used. Insulation in the walls and ceilings varied from no insulation in either, insulation in the ceiling only, to some insulation in both. The latter probably occurred only in colder areas of the state or in higher priced custom homes. The R values of the insulation used, ranged from R-7 to R-11 to R-19. R-19 insulation was limited to use in the ceiling and then only in the colder areas.

The following tables show what appears to have been the prior insulation practices in California for tract and custom homes. These tables are based on the survey data representing average construction, and should not be construed to apply to all homes.

PRIOR INSULATION PRACTICES FOR TRACT HOMES IN CALIFORNIA

Degree Days	Roof-Ceiling Insulation	Wall Insulation	Floor Insulation	Weather-Stripping	Insulated Glazing
0-3000	None to R-7	None	None	None	None
3001-4500	R-7 to R-11	None	None	None	None
Above 4500	R-11 to R-19	R-11	None	None	None

PRIOR INSULATION PRACTICES FOR CUSTOM HOMES IN CALIFORNIA

Degree Days	Roof-Ceiling Insulation	Wall Insulation	Floor Insulation	Weather-Stripping	Insulated Glazing
0-3000	R-7 to R-11	R-7 to R-11	None	None	None
3001-4500	R-7 to R-11	R-11	None	None	None
Above 4500	R-11 to R-19	R-11	None	None	None

C. ENFORCEMENT AGENCIES

The energy insulation standards for new residential buildings in California are enforced by the local city and county enforcement agencies, which generally is the building department. The two principal functions of these agencies to assure compliance with the standards are plan review and field inspections. As a result, it is the local enforcement agency which has the daily contact with the builders and designers and is confronted with the questions and problems.

Most of the questions regarding the standards are answered at the building department level. The Energy Design Manual is used as a reference for information when needed. Sometimes, other enforcement agencies are consulted and occasionally questions are referred to the State for answer.

At this time, the standards are generally accepted by the public and are thought to save energy. Most of the initial resistance has passed. Relative to the initial resistance, one agency suggested that the standards should have been eased into by first requiring that walls and ceilings be insulated, then at a later date implementing the glazing standards, and so forth. On the other hand, changes to the standards in the early stages caused confusion, for both the enforcement agencies and the public. However, the changes made the standards less restrictive and decreased compliance problems.

Plan Review

Plans, and calculations when required, are checked for compliance with the energy insulation standards. Generally the R value of the insulation for the walls, roof and floor is required to be shown on the plans. Seldom is it required on the plans to indicate that aluminum windows must be labeled to show compliance with the air infiltration requirements of ANSI 134.1; weatherstripping requirements; or the exact elements to be insulated, such as the wall between the garage and dwelling, dormers, etc. It is assumed that the field inspector will check these items.

About 95 percent of the dwellings constructed meet the specific or prescriptive requirements of the standards. The remaining 5 percent utilize the alternative of providing heat loss analysis calculations to show the equivalency of the designed house. The most prevalent reason for utilizing this alternative is excessive glazing. Other reasons include open beam ceilings and unconventional construction, such as log cabins, etc.

Generally, glazing areas in excess of that prescribed, which is 20 percent of the gross floor area for low-rise buildings, can be attributed to geographic areas with a view. A few agencies report having as much as 40 percent designed buildings, while others have not had any designed buildings. In some cases, when the builder or designer is confronted with the need to perform calculations because of excessive glazing, he simply reduces the glazing area to the prescribed amount.

Some rural areas report that the heat loss analyses submitted are poorly performed and people qualified to do these calculations are hard to find.

Inspection

Approximately one-fourth to one-third of the enforcement agencies do not inspect the installation of insulating products. These agencies accept the certificate of installation signed by the builder and installer, with spot checks in some cases. The majority of the enforcement officials feel the certificate means full compliance with the standards, whereas in reality, no one certifies compliance with the glazing and weatherstripping requirements. Reasons for not inspecting generally relate to manpower and time involved. It was felt that since the certificate of installation was required, inspection was not mandatory. One agency thought that building departments should not be required to enforce items not related to health and safety. Hostility toward state mandated regulations was also mentioned. The remainder of the enforcement agencies are inspecting the installation of the insulating products. The inspection requirements varied somewhat throughout the state. About half of enforcement agencies conducting inspections require at least one additional insulation inspection, usually between the framing and sheetrock inspections. Additional inspections may also be required for underfloor and open beam ceiling insulation. Agencies not requiring additional inspections, indicate they cover these items during normal inspections, which in cases is, inspect what you can. Frequently a copy of the signed certificate of installation is required prior to the final inspection.

The insulating products are generally inspected for labels giving the R value of the material. Rigid board insulations are not always so labeled. Some agencies were not aware of the requirements for weatherstripping or labels on aluminum windows, and thus were not inspecting for these items. The window labels sometimes get removed during clean-up before the final inspection.

Specific inspection problems for wood frame buildings include insulation overlooked behind showers and tubs, behind and under stairways, and in plywood shear walls. It is also difficult to inspect the supports (wires or staples) for the underfloor insulation without crawling under the building. Attic eave vent baffles are not always installed at the framing stage.

Many field reports note poor workmanship in the installation of insulation and weatherstripping. Friction fit insulation batts in walls have sometimes blown out or sagged before being covered. Underfloor insulation is difficult to install and must be supported or adequately stapled in place and be protected from the weather. In colder climates problems with condensation have occurred under insulated floors. Foil type insulation must be properly expanded, and each layer separated from the others. Poor workmanship or mishandling by other trades (repairs or changes to electrical, plumbing, etc.) may significantly reduce the effectiveness of the insulation.

Administration

Fee increases to offset the increased plan check and inspection tasks required, varied widely. Frequently the enforcement agency relied on the increased valuation provided by the insulation for additional income to cover the required services. Other cities and counties increased their fees in varying ways, such as:

a. $.02 per square foot.
b. Lump sum fee - $20.00.

c. Ten percent increase in fees.

d. Seven dollars per inspection.

Although extra time is required to enforce the standards, few agencies reported hiring additional personnel. Local governing bodies appear reluctant to allow the building department to hire extra personnel because of new standards, even when income is adequate to support the position. As a result, when work is added, priorities on what gets done change.

Adequacy of Standards

Enforcement agencies generally felt the standards were adequate. Some thought they should also cover additions to existing buildings, HVAC systems, water heating and other energy consuming elements within the building.

Some enforcement agencies required additions to be insulated even though the state standards do not require it. Generally the glazing area was not considered in these cases. It was suggested that small additions and glazing be exempt.

In some areas, the requirements for slab and underfloor insulation were considered too restrictive because of the difficulty of installation. Conversely, floors over open spaces should always be insulated. (Cantilevered or pile supported systems).

In areas where degree day zones adjoin, the significant change in the requirements between zones is questioned. An example is along the Eel River in Humboldt County. One side of the river is less than 4500 degree days, while the other is slightly over 4500 degree days. The local enforcement agencies expressed the opinion that there is a significant increase in requirements in a short distance and perhaps a more gradual scale would be appropriate.

Product Standards and Acceptance

Generally the enforcement agencies are not familiar with the insulation testing and labeling procedure. Few were aware that insulation is labeled and tested under a voluntary standard as compared to the independent laboratory testing and inspection process for traditionally regulated building products.

Enforcement officials are concerned over the lack of independent testing and certification of insulation. They are also concerned about other standards, such as flammability, that affect insulation. Thus, potentially acceptable products may be kept off the market because of lack of acceptance by local officials; and conversely, poor products may be inadvertently accepted. Consensus is that a product certification and labeling program would be very helpful for plan checking and inspection, and also provide needed consumer protection.

Educational

Virtually all local enforcement agencies interviewed received some training relative to the regulations, usually at a state-conducted seminar or a building officials meeting. Some reported joint meetings with contractors associations or architectural groups. The training was generally brief and related to the regulations and their content. Information received at seminars or classes was used for training of other personnel within the agency. Many who attended seminars stated that the technical content of the class materials was not at the level they would have preferred.

One-man enforcement agencies were frequently unable to attend any class or seminar since they had no one to relieve them. Traveling long distances to training sessions also presented attendance problems because of the time involved.

Training is still needed for both enforcement officials and the public, and should include a review of the standards, heat loss calculations for designed homes, and also relate to field practices and inspection problems. Training should also be provided if major changes are made to the standards.

An area of significance is the manner in which the local agencies implemented the standards. The building department seemed to be the principal vehicle for educating the contractors about the regulations. Some contractors associations have sponsored seminars, but most contractors learned of the standards through the local building department. Several building departments met with the local contractors, to develop an inspection sequence to have the minimum construction cost and time impact for the contractor, while assuring compliance with the standards. The initial six months of the program was the most difficult period for implementation. Much of this related to the changing of glazing limitations occuring during that period. Local enforcement agencies resent having to act as front man for the State, and felt the State should take responsibility for the education of architects, designers and contractors. However, a frequent comment was that the energy conservation standards were the easiest to implement of all recent State mandated regulations since the contractors and homeowners could see the return on their investment.

Nearly all the enforcement agencies were familiar with the Energy Design Manual for residential buildings and found it to be useful. In a few cases, the manual is treated as the law instead of a guideline, and if a material, method, or assembly is not contained in the manual, it is not permitted. The only complaint relative to the manual was that it was not available soon enough.

Suggested changes to the manual were:

a. Provide a simplified version.
b. Provide more data on insulating materials.
c. Provide more examples for average construction.
d. Provide example calculations for log cabin type buildings.
e. Develop simple rules of thumb for trade-offs.
f. Provide specific insulation installation details.
g. Provide construction details for open beam ceilings, underfloor and slab insulation and unvented roof panels.

D. BUILDERS AND DEVELOPERS

The builder is the individual in the design/construction process who must ultimately execute the work required by the standards and represented in the drawings and specifications. Builders must understand both the requirements and the intent of the standards in order to put them into effective practice. Builders often feel they are not receiving enough assistance from the State. Many feel that insufficient efforts are made to communicate with them.

In general, it is the builder who also acts as developer who expresses need for help with design information. Builders who perform only general contracting services are likely to only follow the drawings and not participate in decisions regarding their contents.

Design

Builders reported that almost all houses comply with the prescriptive design requirements. Where compliance problems arise, the design is generally changed to meet the prescriptive requirements. Builders of higher quality tracts and custom houses use alternative heat loss calculations more frequently; especially in areas where the view is a saleable commodity. A few use the alternative method for all houses.

Design practice has been affected, and various minor problems and complaints were voiced with respect to this. Some problem has been encountered in satisfying the requirements where open beam ceilings are used. Conflicting calculations for heat loss have been provided by different individuals, resulting in trouble and confusion for builders. Design problems are also occurring in areas of high humidity; the specified details may result in significant moisture problems. Builders are not typically installing smaller HVAC units, even though the buildings are better insulated.

Construction

Most builders had no trouble with implementation of the regulations. Variation in enforcement and interpretations among enforcement agencies made the job difficult. Compliance with the standards did not cause any difficulties due to scheduling problems. Occasionally, delays in inspection were experienced.

In general, product availability appears to be good, although some complaints of shortages and profiteering were made. Some of the window manufacturers had not been able to deliver on schedule. Some insulating materials have been in short supply, specifically fiberglass and rockwool.

With respect to labor availability, there were no complaints about insufficient numbers of subcontractors, although there was some grumbling about "sloppy work". Predictably, areas with a limited construction season have more problems with delays and scheduling than do those where construction is possible year-round.

Adequacy of Standards

The standards are generally felt to be acceptable, although typical complaints recur within environmental zones, showing patterns which point to deficiencies in regional applicability of the standards. In the coastal area, one builder said that the standards are too restrictive in the immediate vicinity of the ocean and too lax inland; and another that they are generally too lax. In the central area, glazing limitations are felt to be too restrictive, but the rest of the standards are well accepted. More complaints occurred in the severe-climate zones; the general consensus in mountain areas is that insulation requirements are inadequate, and in desert areas, that the glazing and orientation provisions do not really address the problem; and that the insulation requirements are designed to save on heating energy rather than air conditioning.

Most builders were not entirely satisfied with the standards, but few had suggestions for changes. The suggestions received show no pattern or consensus. Opinions ranged from advocacy of a laissez-faire policy on the part of government to a belief that the standards should be made more restrictive in selected areas.

Product Standards

Product labeling is considered satisfactory, and builders generally consider the performance of labeled products to be consistent with manufacturers claims. Some variability in window quality was noted.

At high altitudes, double-glazed windows have disintegrated or exploded due to pressure differences. Other problems have been encountered statewide with deterioration of urethane insulation, inadequate performance of blown-in insulation and unreliability of solar products. This last problem is so severe that most builders would not consider installing solar energy devices until independent and reliable testing for such products is initiated. Many builders would like to see independent testing and certification of all energy conservation products.

Educational

Very few builders attended training sessions relative to the standards. In some areas it was available and others not. Accessibility of the small amount of training offered was a complaint. Relative to the need for additional training, emotions were mixed.

The severe-climate zones were characterized by need for considerable training and education. In one mountain area this has been provided. The building department and the contractors association both conducted seminars for contractors, and various manufacturers also provided training.

Most of the builders interviewed were not familiar with the Energy Design Manual, or did not use it because it was not needed. Either the building complied with the standard design requirements, or the necessary information was obtained from the building department, or the designs were done by architects or engineers.

E. ARCHITECTS AND ENGINEERS

The architectural and engineering profession is marked by a wide range of attitudes and practices regarding the standards. For the most part, they are now well acquainted with the standards and have made the appropriate adjustments in their practice. Some feel comfortable working with the standards while others feel that the standards restrict the range of potential solutions to design and energy problems. The involvement of an architect or engineer in the design of single-family dwellings is quite minimal. It is estimated that their services are used for less than 20 percent of the single-family dwellings constructed. However, their services are generally used in the design of multi-family dwellings.

Design

Most architects and engineers make use of the alternative heat loss analysis. It was found consistently that the reason for utilizing alternative design provisions was to provide more glass area -- for view, feelings of openness, and natural light. Some designers have developed consistent approaches to design trade-offs when glass areas exceed twenty percent of the floor area. Some go to double glazing, while others find it more economical to insulate under floors to compensate for increased window area.

The most frequently mentioned design problem imposed by the standards involves the detailing of an open-beamed (vaulted, cathedral) ceiling. Concrete block is rarely used now because of the difficulty in achieving wall insulation requirements. In the mountain areas, underfloor insulation posed significant problems due to moisture accumulation; alternative design details were called for. The architect of a high-rise hotel noted difficulty in developing a system to satisfy the roof insulation requirement.

Design problems and confusion were caused by changes made to the standards in the early stages of implementation. Problems were also created by nonuniform interpretation by enforcement agencies, probably caused by inadequate training relative to the standards. It was suggested that the State publish interpretations to achieve more uniform enforcement.

In a small number of instances, new solutions to energy conservation are being sought through solar energy and other unconventional systems dealing with very sophisticated calculations. These designs, which operate independently of conventional heating and cooling systems, usually far exceed the energy conservation levels achieved by those designs which conform to the minimum requirements of the standards. However, there is concern that solar systems are not approved by anyone and may not work as they should. Few enforcement agencies understand them. Plans and calculations for solar systems should be signed by a professional.

Adequacy of Standards

Most agreed that the standards are generally adequate. Several felt that additions to existing buildings should be included. Some felt that underfloor and slab on grade insulation should be required in areas below 3,000 degree days because of significant potential energy savings. A majority agreed that the square footage allotment of glazing areas for both the heating and cooling seasons is adequate, despite the fact most architects increased window area over the prescriptive design maximums. This apparent contradiction might be explained by the difference between professional judgment vs. their clients demands. Exfiltration provisions were suggested. Fans, perhaps, could be required to use positive closing devices. Fireplaces could be required to obtain air directly from outside the building envelope, thereby reducing air infiltration loss created by negative pressures. Despite reported energy savings, smaller mechanical systems generally are not used. It was therefore suggested that the standards include requirements relative to the sizing of the mechanical systems.

Several who work frequently with heat loss analyses feel a performance standard would be more desirable than the prescriptive standards now in force. If the State is trying to promote energy conservation, a performance approach would yield a clearer picture as to which structures are energy efficient and which are not. A performance approach would also allow designers to take advantage of many environmental design constraints currently ignored - siting, orientation, window placement, building massing, micro climate, etc. The regulations as now written do not recognize the fact that windows are the greatest friend as well as the greatest foe of internal thermal stability. When window area and orientation are thoughtfully designed, greater energy savings can be realized. As now written, the standards seem to say "the less glass the better", and have spawned such "no-think" solutions as using single pane up to the allotted twenty percent and double pane for the glass areas exceeding the limit. Or, more commonly, designers assume an energy-conscious design will result from limited glass area regardless of window orientation. The prescriptive nature of the standards has caused design decisions which are not cost beneficial.

On the other hand, the opinion was expressed that the standards are pretty good now, so do not make them more complicated by adding life cycle cost analysis, etc.

Insulating Products

Apart from an occasional insulation shortage, products needed to meet the standards are generally available. Batts and rigid insulation are usually labeled, while blown-in insulation often is not. Blown-in insulation also is subject to careless application and consequent reduced "R" values. Some interviewed were not familiar with window labeling practices. Other problems mentioned included the difficulty of operating double-paned sliding glass doors, and deterioration of aluminum-frame window seals which result in increased air infiltration. Except for remote areas, the data relative to the thermal properties of insulating material has generally been readily available. Generally the data and figures furnished by manufacturers are relied on, as no alternative test data are available.

Educational

Many architects learned about the energy insulation standards when applying for a building permit; one architect was told by his developer-client. As a result, many designs had to be re-worked to adjust glass areas when the standards first went into effect. The AIA is looked to by many architects to provide notification of relevant new laws as well as seminars and training, if necessary. The AIA has stated that its membership was notified of the standards in advance and was offered seminars on the topic. However, with one exception, none of the architects interviewed received any training directly related to the standards. Most read either the Energy Design Manual or the standards in order to become acquainted with the new law. Others have attended seminars on general energy conservation topics given by various building trade organizations and the AIA. Architects doing solar design rely on ASHRAE publications and mechanical engineers as their primary sources of information.

Most were familiar with the Energy Design Manual and found it useful. However, they frequently complained that the manual was not circulated within the profession and many did not know where to obtain a copy. Suggested changes to the Energy Design Manual were:

a. Expansion of the materials list.
b. Expansion of the listing of California cities to include all cities, preventing errors in assigning degree-day values to small communities.
c. Replacement of current shade angle calculations with page 442 of ASHRAE Handbook of Fundamentals (1972).
d. Development of alternative high-rise roof insulation systems.
e. Development of alternative underfloor insulation systems for moisture-prone climates.

F. MANUFACTURERS AND SUPPLIERS

The effects of the standards on the insulation and glazing industries were very different. The window manufacturers said they already had windows which met the performance criteria before the effective date of standards. Problems arose with lower quality models, which were dropped or redesigned. The insulation manufacturers and subcontractors, on the other hand, were not required to change their products -- they only had to certify that their products were capable of certain levels of resistance and label them accordingly. Glazing and insulation manufacturers do not make products for specific geographical areas, but rather manufacture fairly uniform products which are adapted to various regions. Certain specifications, particularly on glazing products, may be more common in certain areas; i.e., solar bronze glass in a hot summer area requiring air conditioning. But for the most part, regional differences in product use are determined more by designers and contractors than by the manufacturers.

Insulation subcontractors liked the standards, and were well prepared for their implementation. Insulation industry associations were a significant force in formulating the content and scope of the standards, and in their adoption. The industry as a whole has not experienced any unusual shortages of materials, but increased demand has caused an allocation system to be set-up in order to distribute the products statewide. Prior use of insulation by general contrac and builders was erratic enough to allow individual subcontractors to order as much as they thought they needed. However, some insulation subcontractors in the southern part of the State expect shortages in the near future if a shortage of energy reduces production of insulation, or if an increase in the housing starts strains supplies already being allocated. Complaints seem to be centered around competitors' products.

Window manufacturers were generally opposed to the standards and any new restrictions. The loudest complaints were in the area of equity of compliance; i.e., they were complying but their competition was not. Inspection practices regarding windows and their labels are very inconsistent -- many local enforcement agencies were not inspecting for labels, and the window manufacturers noted that "inequal inspection creates an unfair market". Most indicated that they already had, or would have windows utilizing dual glazing. Demand for dual glazing has increased because of the standards, but in some cases, consumers request it for energy conservation.

A mechanical contractor and supplier reports that it is standard practice to design the HVAC system for the most critical home in a tract. The home with the critical orientation, and greatest heat loss is used for sizing the equipment in the rest of the homes in the tract. This means that most of the homes would have oversized equipment. Heating equipment sizes usually cannot be reduced since the standard equipment sizing is controlled by the air conditioner size. Therefore, the heating system is generally oversized because of the air conditioning unit.

Adequacy of Standards

Window manufacturers consistently regarded the glazing standards as too restrictive. They observed that an air conditioned house with windows which eliminated heat gain to reduce cooling loads, worked to the detriment of the heating system in the winter. One suggestion, to remedy this situation, also heard from some builders, was to eliminate the original cooling restrictions, leaving only heating requirements, and instead place a performance specification on the cooling unit itself.

Among the insulation subcontractors, there was general agreement as to the adequacy of the standards. Suggestions for changes include requiring new additions to conform to the minimum standards, as well as a requirement for underfloor insulation in areas with lower degree-day ratings.

Product Standards

Both the insulation and glazing industries were concerned with their competitors product.

There was a general desire for standardization in the testing and labeling procedures and more stringent inspection and certification methods to help eliminate fly-by-night operations which reflect poorly on the industry.

Educational

Training was received through various industry associations. The need was expressed for more uniform education for building inspectors concerning installation of products, because of the wide variation of opinion among building officials as to what methods constitute a proper installation on the site. More education was also requested for the building industry as a whole; again, because of general confusion concerning heat loss calculations and air conditioning specifications.

The Energy Design Manual was used to advise customers. Complaints were that the manual was not available soon enough, and it needs some clarification for less sophisticated personnel.

G. CONSUMERS

The California Residential Energy Insulation Standards were designed to reduce energy consumption in the heating and cooling of residential buildings -- and to benefit, ultimately, the consumer as well as the State as a whole. Therefore, in this study, it was thought important to conduct several representative interviews with occupants of residential buildings constructed after the effective date of the standards, recognizing that the information thus gathered might be limited by the average consumer's lack of technical sophistication in the field of energy conservation, as well as his late entry into, and lack of control in the building process. Exceptions to these patterns would most likely occur in cases of custom-home building, where an early and often more active collaboration exists between the builder and homeowner.

With some exception, homeowners did not have a clear cut awareness of the standards *per se*. Most, however, did have observations on the energy-conserving (or, more often, consuming) characteristics of their homes.

Ceilings and Walls

In general, the tract home and condominium buyers had to inquire of the builder as to the type of ceiling and/or wall insulation that was installed in the building. This information was not routinely part of the sales pitch, perhaps due to the fact that the housing market in California today is largely a sellers market. None of the homeowners intended to upgrade the value of the ceiling and/or wall insulation at the present time. One homeowner complained that the inspection procedures had failed to force the correction of inadequate wall insulation in the first three houses of the tract in which he had purchased his home. Also, he and another expressed dissatisfaction with the unevenness of the blown-in ceiling insulation. Another told of plans to install an attic vent fan to relieve overheating in the summertime.

Windows, Doors, Weatherstripping

Windows and doors presented different problems. In general, they were not initially perceived at the time of purchase as part of the total insulation picture. Yet, problems with air infiltration, excessive heat transfer, and window placement were frequently reported. A desert area homeowner was forced to add shade screens to clerestory windows to reduce summer heating of the house. She also remarked on the inadequacy of tinted windows in the summertime.

"They feel hot all over unless you keep the air conditioning on". Another remarked that her south-facing sliding doors and windows resulted in additional needed warmth in the winter, but these same windows and doors had to be heavily shaded (with venetian-type blinds) in the summer to reduce excessive heat. Another had to ask their builder to install weatherstripping around the double front doors -- and they complain of continued air leakage where the double doors meet. Cold spots were reported at single glazed window and door openings. It is unclear whether this is a transfer of cold through the thin glass, air leakage, or simply a greater awareness of cold spots in a house with insulated walls versus a house with non-insulated walls. A mountain area contractor reported a homeowners observation of fewer cold spots in his new home which was not only insulated, but double-glazed throughout.

Heating and Air Conditioning

Several interesting comments emerged on the subject of heating and air conditioning. The desert area homeowner keeps the air conditioning at 88 degrees in the summertime when the house is unoccupied, and she estimates that the cooling operates constantly at this setting. One homeowner has installed dampers on the heating vents leading to the second floor as ample heat rises from the first floor. According to this homeowner, heating bills are less than those of similar neighboring homes. Another also commented on the lack of need for second-floor heating. It was difficult for most of the homeowners to assess whether the standards had resulted in reduced HVAC costs. This was due, primarily, to the non-comparability of their current homes and the homes previously occupied. A mountain area homeowner, however, had lived in a similar but less insulated home previously, and he reported substantial energy savings. The desert area homeowner felt that the standards resulted in no HVAC savings.

Adequacy of Standards

All of the homeowners interviewed felt that the regulations could be strengthened. Windows, doors, and weatherstripping -- the most visible features of the insulating package -- were most often mentioned as problem areas. The standards are passive and obscure with regard to their ultimate beneficiaries, the consumer/homeowner. Enforcement of some elements of the standards appears weak in areas. The standards seem not to address the special cooling need of homes in very hot summer areas. There appears to be a consumer readiness for home energy conservation, but this is tempered by the consumers lack of sophistication in energy conservation matters.

IV. IMPACT ANALYSES

A. COST IMPACT

The cost impact of the California energy insulation standards affected many groups in the construction industry, enforcement agencies, and consumers to varying degrees.

Enforcement agencies were burdened with additional plan checking and inspection costs. Time and manpower was needed to become familiar with the standards.

Contractors and developers had to learn the standards, and in some cases change designs to comply with the requirements of the standards. Obtaining the necessary materials and supplies, and delays in the obtaining plan approval also caused problems and increased costs.

Suppliers had to obtain products which would meet the standards, and provide data to the enforcement agencies and contractors which would allow the use of these products.

Architects and engineers had to become familiar with the standards and develop designs which would meet the standards.

The consumer had to pay for the insulating products and the additional costs of design and enforcement. However, the energy savings over the life of the structure will more than offset these initial costs.

All of these groups were affected to some degree with additional costs due to these standards. The cost impact on each group will be covered separately. Many of the costs cannot be defined by exact dollar amounts, but are discussed in general terms.

Enforcement Agencies

The cost impact on enforcement agencies varies depending on the degree of enforcement, insulation requirements based on climatic conditions, and the types of residential buildings constructed within the jurisdiction.

The two principal regulatory functions to assure compliance with the energy insulation standards are plan review and inspection.

Generally the additional plan review time required was absorbed into the workload of the existing staff. It was estimated that the additional time required was approximately 15 minutes, depending on the complexity of the structure and whether or not the design would meet the prescriptive portion of the standards. If the structure had excess glazing or some other feature requiring alternative design heat loss calculations, the plan check time would be increased considerably. However, based on data from the survey, the alternative design provision was used on less than 5 percent of the homes constructed.

The most significant cost to local enforcement agencies was for inspection of the structures for compliance with the approved plans and the standards.

Over two-thirds of the enforcement agencies are performing construction inspections with the remainder accepting the Certificate of Installation signed by the builder and insulation installer. The reason given for not inspecting frequently related to budget, staff and workload.

Where inspections are conducted, approximately one-half of the agencies require at least one additional insulation inspection after the framing inspection. When underfloor or rigid roof insulation is required, additional inspections may be necessary. Ceiling insulation, windows, duct and piping insulation and weatherstripping are usually inspected during the final inspection, therefore an additional inspection is not required.

It is estimated that each additional inspection costs the local enforcement agency an average of $7.00 to $10.00, depending on duration and the travel involved. Estimated costs to the enforcement agency per single family dwelling to obtain compliance with the standards are:

Average Plan Checking Cost	Inspections	
	Below 3000 Degree Days	Above 3000 Degree Days
$5.00	$10.00	$20.00

The total average enforcement cost to verify compliance with the energy standards per single family dwelling in areas having less than 3000 degree days would be $15.00 and for areas having more than 3000 degree days would be $25.00.

Fee increases to offset these costs varied widely. Frequently the enforcement agency relied on the increased valuation provided by the insulation for additional income to cover the required services. Other cities and counties increased their fees in varying ways, such as:

a. $.02 per square foot.

b. Lump sum fee - $20.00

c. Ten percent increase in fees.

d. Seven dollars per inspection.

Most enforcement agencies relied on increased valuation to help cover costs. Based on the building permit fees using total valuation as listed in the 1973 Uniform Building Code, an increase of $1000.00 in valuation would mean a $3.00 increase in the building permit fee. This increase is based on a total valuation of $25,000 to $50,000. The building permit fee would be $112.00 for the first $25,000 plus $3.00 for each additional $1,000 or fraction thereof, to and including $50,000. On an average the enforcement agency, using the total valuation method would obtain an additional $3.00 for verifying compliance with the energy insulation standards.

Using the total valuation method would therefore only cover approximately 20 percent of the costs incurred in enforcing the standards. The other fee increases noted previously would just cover the costs of enforcement. Few of the agencies interviewed had authority to increase personnel, and most simply stated that the increased workload simply "added to the burden" and the new work was performed at the expense of other work.

Contractors and Developers

The cost impact on the contractor and developer is difficult to assess and relate a precise dollar value. The cost of housing was usually increased to cover the addition of insulating materials. The increase is passed on to the consumer which in turn may affect his ability to qualify for a loan or make the increased loan payment for the home. The number of home buyers affected by this is difficult to assess, but it did undoubtedly drop some consumers out of the home buying market. This in turn reduces the contractors and developers market for homes.

Another cost, which is difficult to evaluate, is the possible necessity of changing designs to comply with the standards. Many contractors and developers used large amounts of glazing, open beam ceilings and other features which would not meet the specifics of standards without changes in design. Some reduced glazing areas and dropped the open beam ceiling option from their standard designs. Others are staying with their basic designs, but are now using heat loss calculations and increasing the amount of insulation to comply with the standards.

The initial confusion of interpretations among various enforcement jurisdictions has some cost impact on builders. This problem appears to have been eliminated and no longer is a serious cost factor.

Another potential problem is product availability. Some builders are experiencing difficulty in obtaining insulating products. If a shortage of insulation products develops, increased costs and construction delays could result, which in turn increases the cost of housing and reduces the market.

Manufacturers and Suppliers

Effects of the standards were found to have been very different for the insulation and glazing industries. In most cases, the standards created an additional demand for their products.

The window manufacturers, in most cases, were required to re-evaluate their products for compliance with the standards. The amount of revamping necessary depended on the level of product quality maintained before the standards became effective.

The standards created a new market for insulated glass in California. Prior to the standards, the use of insulated glazing was almost unheard of; however, demand has increased to the point where at least two window manufacturers have set up plants to produce insulated glass only. One window supplier interviewed stated that 75 percent of his business is now insulated glazing.

All window manufacturers reported increases in costs, both research and development, and final wholesale and retail costs, which in turn has resulted in stiffer competition. Manufacturers also observed that the small window manufacturers, unable to develop financial capital necessary to research and develop new lines, are forced out of the market. Most window manufacturers indicated that costs were passed on to the consumer.

The impact on the insulation manufacturers and suppliers was mostly positive, due to the increased demand for insulation products and insulation installers; however, certain problems did develop. Insulation subcontractors found that with the implementation of the standards, demand outstripped supply, and manufacturers were forced to establish quotas for areas and individual subcontractors. Capital margins shrank, and the smaller subcontractors found it difficult to meet stiffer competition.

Some insulation manufacturers have had to test their products to determine its thermal characteristics.

However, other than the above noted problems, the cost impact of the standards was minimal for manufacturers and suppliers of insulating and window products.

Architects and Engineers

The cost impact on architects and engineers varied depending on prior practices. Many architects incorporated insulation in their designs prior to the standards, therefore the standards had minimal impact. However, where designs had excess glazing, open beam ceilings or other unique features, the architect was faced with redesigns or alternative heat loss calculations.

Few of the architects have raised their fees or specifically identified a fee for designing a structure to comply with the standards.

Consumer

The cost impact on the consumer varies depending on the climatic conditions, prior insulation practices of the contractor, type of insulation used, design options requested by the consumer, and enforcement costs. All of these items play an important rôle in estimating first costs and pay back period for the consumer.

Taking these factors into account, it is possible to estimate the cost impact of the energy insulation standards on the consumer for a given home. If, for example, a 1500 square foot single family residence with no insulation was considered typical, then the estimated cost impact on the consumer to comply with the standards in the various degree days areas would be as follows:

AVERAGE COST IMPACT OF ENERGY INSULATION
STANDARDS FOR A 1500 SQ. FT. SINGLE FAMILY RESIDENCE*

Degree Days	Wall Insulation	Roof-Ceiling Insulation	Underfloor Insulation	Weather-stripping	Insulated Glazing	Enforce-ment	Total
0-3000	$175	$375	0	$30	0	$10	$590
3001-4500	$175	$375	$325	$30	0	$10	$915
over 4500	$175	$375	$375	$30	$700	$10	$1665

*NOTE:

This table is based on a 1500 sq. ft. uninsulated single family residence with the following:

1. Conventional construction with fifteen percent of the gross floor area in glazing.

2. Wood floor with vented crawl space.

3. Enforcement costs are average.

The cost impact of the wall insulation, roof-ceiling insulation and weatherstripping are shown constant since the requirements are the same throughout the state. Over 3000 degree days costs increase due to the requirement of underfloor insulation. The next breakpoint which also increases costs considerably is the area over 4500 degree days, due to the requirement for increased underfloor insulation and insulated glazing. The requirement for insulated glazing is the most costly for the consumer.

It should be noted that these costs are average costs and are based on bringing a uninsulated home into compliance with the standards. If the home was insulated prior to the standards, the costs impact would be reduced considerably. The cost data includes contractor markup. However, the figures will vary depending on the type of insulation used. Duct insulation was not included in the costs since it was required prior to the energy insulation standards.

The first cost to the consumer is also affected by the design options which he may request. Such items as open beam ceilings, glazing in excess of the amount allowed by the standards, unique construction, such as log, adobe, and masonry, may increase the first cost to the consumer. However, the indication is that these design options affect less than 10 percent of the homes constructed in the state. Therefore the cost impact can be considered as minimal.

B. ENERGY IMPACT

The impact of these standards on energy savings is difficult to assess due to the wide variance in construction techniques, prior insulation practices, and the degree day climatic range in California, which varies from approximately 900 degree days in the desert areas to a maximum of over 8000 degree days in the higher elevation areas.

Typical construction for low rise apartment buildings and single-family dwellings is light frame construction with 7/8 inch stucco exterior, no sheathing and 1/2 inch gypsum wallboard interior. Based on the interviews conducted, it appears that the average tract home in California before the standards, was insulated only in the ceiling with either R-7 or R-11 insulation. Tract homes located in the higher degree day areas were insulated in both the walls and ceiling. Most custom homes in California were previously insulated in both the walls and ceiling.

In order to develop estimated savings for heating, considering prior insulation practices and a dwelling which is insulated to comply with the present standards, the following prototypical single family dwelling will be used in three different degree day zones:

Configuration: 30' x 50'

Total Area: 1500 sq. ft.

Number of Floors: 1

Total Height: 13 ft.

Exterior Wall Construction: 7/8" stucco over wire backed paper; 2x4 stud framing @ 16" O.C.; varying insulation; 1/2" gypsum wallboard.

Fenestration: 15% of the gross floor area.

Roof Construction: Asphalt shingles; 1/2" plywood sheathing; varying insulatic 1/2" gypsum wallboard; vented attic; roof slope: 4 in 12.

Floor Construction: 2 x joists @ 16" O.C.; varying insulation; 5/8" plywood subfloor; 1/4" particleboard underlayment and linoleum.

The heat loss for the prototypical dwelling constructed in conformance with the California energy insulation standards is shown in Table IV-A.

TABLE IV-A

CALIFORNIA TYPICAL DWELLING

R of Insulation Wall-Ceiling-Floor	Heat Loss - Btu/hr F <3000 DD	3001-4500 DD	>4500 DD*
11-19-0	821		
11-19-7		718	
11-19-11			600

*With insulated glazing.

Table IV-B shows the estimated energy savings for heating of the California typical dwelling in each of the degree day zones noted.

Table IV-B also shows the heat loss of the prototypical dwelling constructed with varying degrees of insulation, reflecting prior insulation practices. The estimated saving was derived by comparing these losses to the heat loss of the California typical dwelling shown in Table IV-A.

TABLE IV-B

ESTIMATED SAVINGS

R of Insulation Wall-Ceiling-Floor	Heat Loss - Btu/hr F <3000 DD	3001-4500 DD	>4500 DD*	Savings (Heating) % <3000 DD	3001-4500 DD	>4500 DD
11-19-0	836	843	852	2	15	30
11-11-0	885	892	901	7	20	33
7-11-0	907	914	923	9	21	35
7-7-0	964	971	980	15	26	39
0-19-0	1109	1116	1125	26	36	47
0-11-0	1158	1165	1174	29	38	49
0-7-0	1215	1222	1231	32	41	51
0-0-0	1925	1932	1941	57	63	69

*Without insulated glazing.

It should be clearly noted that the percent savings in Table IV-B applies to heating only and not the overall energy savings. Duct losses have not been included in the heat loss calculations since the requirements for duct insulation have not been affected by the energy insulation standards.

Table IV-B clearly shows the energy impact of the energy insulation standards and provides a comparison as to the effect of standards with prior insulation practices in California.

V. RECOMMENDATIONS

The following recommendations result from analysis of the data collected. The result is a series of recommendations covering all levels of government and the building process. Most recommendations are directed towards the State since it is the promulgator of the regulations, and has overall responsibility for the implementation of energy conservation standards.

A. FEDERAL ROLE

The Federal Government should provide funds for the development of educational material that may be deployed through both the public and private sectors. Courses should be developed for all sectors of the building industry including regulatory personnel at all levels; architects, engineers, building designers, and contractors and subcontractors. This program should make the public aware of the need for energy conservation. The goal would be to minimize resistance to the standards by those affected and involved in the building process.

Funding for training should be provided at the Federal level since energy conservation is a national priority. Further, certain elements of energy conservation standards have a negative impact upon certain industry groups, thereby eliminating any incentive for the private sector to develop adequate training courses. This may be verified by the number of seminars, and publications efforts presented by insulation manufacturers and the lack of broad based information relative to labeling of windows and glazing limitations.

B. STATE GOVERNMENT

1. Legislative: Legislation enabling the development of energy conservation standards should stipulate that both prescriptive and performance standards be developed.

Prescriptive standards should not be limited to the envelope of the building, but should include energy standards for plumbing, electrical, and climate control systems as well.

Performance standards should be developed as an alternative to prescriptive standards, stipulating the maximum allowable energy consumption per gross square foot of floor area, per square foot of envelope area or some similar measurement.

The legislation should fund continuing technical assistance to local building departments which enforce the standards. This program should include training in enforcement procedures, forms and procedures for review of building plans and specifications, the development of an energy conservation manual, and the establishment of a plan review section.

2. Development and Adoption of Standards: The utilization of an advisory committee to assist in the development of energy standards provides an excellent opportunity to obtain the necessary expertise and data on current construction practices and the effects of such standards on housing in general. The committee should represent the various groups affected by the standards such as designers, builders, suppliers, enforcement officials, financial representatives, and consumer groups. The members should be familiar with energy conservation techniques and heat-transfer terminology and should be currently practicing in their field of expertise. The members, prior to their appointment, should be briefed as to the amount of time which will be required during the development of the standards.

There should also be funding for consultants to the advisory committee. Even if the advisory committee concept is not used, funds for consultants should be provided. Due to the lack of funding, most of the data used in the development of the California standards were obtained by Department staff or by advisory committee members themselves. There were instances where consultants with expertise in a particular area could have supplied additional information eliminating some of the problems in the first set of standards developed. Consultants would also have allowed the advisory committee members more time to review the standards as they progressed.

The lack of public attendance at advisory committee meetings points out the need for additional notification and dissemination of information to obtain the interest of the public. This possibly could be accomplished to a greater degree with assistance from organizations representing industry, building officials, architects, engineers, consumer groups, and full newspaper coverage. In addition, public meetings should be held at various geographic locations to provide greater accessability to the meetings by the public. Input from the public can be of great assistance to an advisory committee, especially from organizations or associations representing the various groups ultimately affected by the standards. Ideally, with participation and input from these groups, the resulting standards will be workable for all involved, thereby eliminating some of the problems occuring after the standards become effective.

3. Administrative: Improve dissemination of standards and technical aid to all sectors of the building industry. A number of comments were received from architects and contractors that the first they heard of the standards was when they went to the building department for a permit. The State should work with other State regulatory agencies that can communicate to the broad building sector, including the Boards of Registration for Architects and Professional Engineers, and the Contractors' State License Board. Each of these boards' newsletters reaches all licensed individuals. Liason should be maintained with professional societies and contractors' organizations.

4. Supporting Implementation Information: There is a total lack of information for local enforcement agencies relative to the costs of implementing energy standards. The State should study, identify and make available for the information and use by local agencies, information relative to the following:

(a) Cost impact of the standards - How much will the additional inspection and plan review cost the city.

(b) Plan check and inspection aids for the several geographic regions of the State to assist local agencies in implementation of the standards.

5. Communication Channels: Two-way communication between State and local enforcement agencies should be established by a toll free phone number, staffed by individuals competent to answer technical questions. Local agencies, now reluctant to call long distance, could obtain assistance from a centralized information source.

6. Implementation and Enforcement:

(a) Public Awareness. An extensive effort must be made to make the public aware of energy standards prior to their implementation. The need for energy conservation measures must also be addressed. The goal is to minimize resistance to the standards by those affected. Resistance to California's standard declined as time passed, probably due to increased awareness of the standards and need for energy conservation.

(b) Education and Training. A comprehensive educational and training program is necessary for uniform implementation and enforcement of energy standards.

Such a program must be made available to all affected by the standards, including enforcement officials, architects, engineers, developers, contractors, manufacturers and suppliers. This is especially needed by the officials who enforce the standards and have the daily contact with those who must comply with them. The training sessions should be confined to small geographic areas to minimize travel.

Energy related items are new to many. Therefore, a training program must begin with basic principles of heat transfer. It should cover the requirements of the standards and also relate to field practices and inspection problems.

The Energy Design Manual related to California's energy standards proved to be a needed and useful tool. It doubles as a training aid and a guideline for the enforcement officials and others involved. The purpose of the manual is to facilitate a better understanding of the standards, show example calculation methods, and hopefully produce uniform interpretations of the standards.

A simplified handout should be developed, depicting conventional construction and what is required for conformance with the prescriptive requirements of the standards. The finding of the survey indicated that about 95 percent of the residential construction in California complies with the prescriptive requirements of the standards. In many of these cases, much of the information contained in the Energy Design Manual is not needed by the builder. To him, the manual is too complicated, since what he needs to know could be pictured on two or three pages. Such a handout would greatly assist both the enforcement agency and the builder. If the prescriptive requirements of the standards are not met, then the Energy Design Manual can be used to obtain the more detailed information.

There is also a need for education related to good construction practices and details for the insulation of open beam ceilings, floors, slabs and unvented roof panels. Industry research and development of new and/or better methods are needed.

7. Improvement of Standards:

(a) Comprehensive Requirements. The standards now in effect deal primarily with the envelope of the building. They should be broadened to include standards for HVAC and solar energy systems, thereby providing the consumer with a more complete energy package. Such items as equipment sizing, equipment efficiency, and the design of supply and return air ducts should be incorporated.

(b) Building Additions. Additions to existing buildings should be required to comply with the standards.

(c) Insulation Requirements. Insulation should be required for cantilevered and other floor systems which are directly exposed to exterior conditions. The cost effectiveness of increasing existing insulation requirements should be studied.

(d) Performance Standards. In addition to the so-called prescriptive standards, performance standards should also be developed. One complaint expressed by designers is that the present California standards are prescriptive and do not provide design flexibility. The present standards provide for alternative designs, but even with this provision, designers claim unnecessary calculations are required. Performance standards should therefore be developed to stipulate the maximum allowable energy consumption per gross square foot of floor area, per square foot of envelope area, or some similar measurement. Presently, very few designers use the alternative procedure except to obtain more glazing area than prescribed, or to utilize unconventional construction. The alternative-design procedure is used on less than 10 per cent of the structures; therefore, the prescriptive standards are the dominant design method. It is essential to have simple, clear and workable prescriptive standards.

(e) Desert Regions. Glazing and insulation requirements are inadequate to meet special cooling needs of desert regions. Window placement and orientation, siting, and sun angles need to be considered.

(f) Sliding Scale of Requirements. Rather than group insulation requirements to three distinctive degree-day categories, a practice which creates arbitrary discontinuities in the standards, a system for instituting insulation requirements in smaller gradations should be considered.

(g) Requirements for Certificate of Compliance. The Certificate of Compliance should be modified to include certifying compliance with glazing, labeling, and weatherstripping requirements, or eliminated as a requirement since it has only confused field enforcement personnel.

(h) User Information. So that buyers and owners of new homes be made aware of the regulations and their energy conserving implications, the standards should require this information, perhaps as part of a general energy conservation information packet, to be given to the consumer. Information concerning devices and equipment requiring maintenance to assure energy conserving efficiency should be included.

(i) Degree Days. Technical advice should be available to local enforcement agencies, particularly counties, to enable them to develop their own degree day data for different areas of the county.

C. LOCAL GOVERNMENT

1. Staffing: Local government officials, elected and managerial, should understand the need for energy conservation and that its effective implementation will rely on the efforts of local government. The lack of adequate staff to inspect construction was cited by a number of cities (large and small), as the

reason they accepted a certificate of compliance in lieu of field inspection of energy conserving building elements.

2. Communications: Local enforcement agencies should be encouraged to develop better communication with contractors and designers to ease implementation of energy standards. Some communities developed their inspection procedures in concert with contractors groups, others keep contractors informed of pending standards. This should help in securing compliance.

3. Relations with the State: Local enforcement agencies should be encouraged to provide input, both formally and informally, to the State regarding standards, implementation problems and technical problems (see State suggestions).

4. Equal Enforcement Needed: Local enforcement agencies should uniformally enforce the standards. Material manufacturers complained of complying with the standards only to see their competitors, who know that a specific city may not be inspecting for complying windows, underbid them by supplying noncomplying windows.

5. Technical:

(a) Inspection Sequence. Local enforcement agencies should be encouraged to require a minimum of one additional called inspection after rough-in to inspect insulation. Additional called inspections for floor and rigid roof insulation should be specified when appropriate.

(b) Types of Energy Conservation Materials. Local enforcement agencies should be encouraged to develop reference libraries of available products. This would provide information for plan reviewers and inspectors as well as contractors and homeowners.

(c) Educational. Staff personnel at all levels should be encouraged to take educational offerings relative to energy conservation. Local officials should be encouraged to provide time off, tuition reinbursement, etc., as required for personnel to attend such classes. Staff should understand not only the standards, but the basic software concepts of energy conservation such as siting, orientation, shading, etc.

D. FURTHER RESEARCH

The following topic which needs immediate study and development to assist in providing viable implementation and enforcement of any energy conservation standards.

Product Approval and Standards: This aspect must be strengthened to improve acceptance of energy conservation products. Testing, certification, labeling, installation and fire resistance of insulating products has been overlooked in the California standards and should be considered in any energy standard developed.

The R value for various insulating materials is open to self-certification by the manufacturer, or it is based on R values listed in engineering handbooks. Insulation producers have used various test standards to determine their products insulating value. Similar products are advertised and sold with a wide range of R values. Uniform test procedures and certification methods need to be established.

Also, some products are not properly labeled, creating field inspection problems. Labeling criteria needs to be established.

Installation of insulating products is also important to the effectiveness of product. Installation instructions should be required.

APPENDIX A

ENERGY DESIGN MANUAL

for

Residential

Buildings

STATE OF CALIFORNIA

DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

DIVISION OF CODES AND STANDARDS

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STATE OF CALIFORNIA

Edmund G. Brown, Jr.
Governor

Business and Transportation Agency

Donald E. Burns
Secretary

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Arnold C. Sternberg
Director

James M. Hicks, Jr., Chief
Division of Codes and Standards

Arthur E. Dreyer
Assistant Chief

April, 1976

ENERGY DESIGN MANUAL
FOR
RESIDENTIAL BUILDINGS

TABLE OF CONTENTS

FIRST PRINTING. . . . . FEBRUARY, 1975
SECOND PRINTING . . . . APRIL, 1976

PREFACE

This energy design manual has been written to assist the implementation of energy insulation standards for new residential buildings which become effective on February 22, 1975.

Senate Bill 277, which mandated these standards, was authored by Senator Alfred E. Alquist in 1972 before the energy crisis had become a major economic factor in the lives of the citizens of California. Senator Alquist's foresight has made California a leader in developing energy conservation standards in the United States.

We have attempted to present the material in the simplest possible language. The manual discusses up-to-date methods for calculating required insulation, installation procedures and typical insulation systems. It is not intended to solve all the problems relating to insulation but is written to provide basic knowledge.

Costs of installing insulation to conform to these standards has not been discussed in this manual. However, in all cases and in all geographic areas of California the savings to the consumer in energy costs will more than offset the cost of insulation amortized over the economic life of the building. The payback period varies from seven to ten years depending on geographical location. In addition, the savings in energy will allow more housing to be constructed in the future.

The Department of Housing and Community Development wishes to express its gratitude to the members of the advisory committee who spent many hours assisting the Department in the development of these standards. These members include:

Cabell Gwathmey	Bob Renz
Donald Hardison	Alfred Goldberg
Thomas C. Campbell	Charles Gyselbrecht
Ronald Doctor	Frank H. Ogawa
Jerome Weingart	Earl W. Brian
Ian M. Williamson	Fredrick B. Hodges
I. "Bud" Hardesty	Norman B. Livermore, Jr.
Wayne E. Mullin	John C. Worsley

In addition, the Department wishes to thank the following members of the Energy Design Manual Subcommittee who also donated many hours in gathering data for this manual:

Thomas C. Campbell	Tony Di Angelo
Bob Renz	J. R. Roberson
Cabell Gwathmey	Robert Nelson
Charles Gyselbrecht	Dan Simmons
Ed Schleiger	John T. Malarky
J. C. Penka	Larry Moeller

The Department staff which assisted in the development of this manual are Roger Lorenz, Martin Pohll and Cal Jepsen.

CHAPTER 1

SCOPE

This chapter includes the purpose, authority, enforcement, regulations and discusses the other chapters included in this Energy Design Manual. It should be noted that this manual is only a guide to assist in the implementation of the Energy Insulation Standards.

PURPOSE

The purpose of these regulations is to establish minimum uniform energy insulation standards for all new hotels, motels, apartment houses, lodging houses, dwellings, and other residential buildings which are heated or mechanically cooled. The regulations apply only to new residential buildings and to new additions to existing residential buildings if the existing building was required to be constructed in conformance with these regulations. The regulations do not apply to alterations to existing buildings or to relocated buildings. Sections 103(b) and 103(c) of the 1973 Uniform Housing Code and Sections 104 and 105 of the 1973 Uniform Building Code would not be applicable for the Energy Insulation Standards.

AUTHORITY

Senate Bill 277, authored by Senator Alquist, approved by the Governor and filed with the Secretary of State on November 22, 1972, required the Commission of Housing and Community Development to adopt rules and regulations establishing minimum standards of energy insulation for new hotels, motels, apartment houses, homes and other residential dwellings as the Commission determines are reasonably necessary to conserve fuel resources. These regulations were adopted by the Commission on February 22, 1974 and became effective on February 22, 1975. The regulations shall apply to all applications for building permits made subsequent to the effective date of the regulations.

ENFORCEMENT

The regulations shall be enforced by the building departments of every city, county, or city and county, and no certificate of occupancy shall be issued unless the structure at least satisfies such minimum energy insulation regulations.

Any state agency, city, county or city and county may adopt standards of energy insulation for new buildings which are more restrictive than those established by the Commission, except, that any such changes or modifications shall be adopted in accordance with the requirements prescribed in Sections 17958.5 and 17958.7 of the Health and Safety Code which states the following:

17958.5 In adopting the ordinances or regulations pursuant to Section 17958, a city or county may make such changes or modifications in the requirements contained in regulations adopted pursuant to Section 17922 as it determines are reasonably necessary because of local conditions.

17958.7 The governing body of a city of county before making any modifications or changes pursuant to Section 17958.5 shall make an express finding that such modifications or changes are needed. Such a finding shall be available as a public record and a copy, together with the modification or change, filed with the department. Nothing contained in this part shall be construed to require the governing body of any city or county to alter in any way building regulations enacted on or before November 23, 1970.

ENERGY INSULATION STANDARDS

The Energy Insulation Standards have been adopted in the California Administrative Code, Title 25, Chapter 1, Subchapter 1 (State Housing Law Regulations), Article 5, Section 1094, and in the California Administrative Code, Title 24, Part 6, Division T25, Chapter 1, Subchapter 1 (State Housing Law Regulations), Article 5, Section T25-1094.

California Administrative Code, Title 25
Chapter 1, Subchapter 1

Article 5. Energy Insulation Standards

1094. Energy Insulation Standards. Energy insulation standards shall be in accordance with the applicable requirements of California Administrative Code, Title 24, Part 6, Division T25, Chapter 1, Subchapter 1, Article 5, Section T25-1094, which reads as follows:

T25-1094. Energy Insulation Standards. (a) Purpose. The purpose of this Article is to establish minimum uniform energy insulation standards. All new hotels, motels, apartment houses, lodging houses, dwellings, and other residential buildings which are heated or mechanically cooled shall be constructed to comply with this Article.

(b) Application and Scope. These regulations shall apply to all applications for building permits made subsequent to the effective date of these regulations.

These regulations shall become effective on February 22, 1975.

(c) Alternate Materials, Method of Construction, Design or Insulating System. The provisions of this Article are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein provided that any such alternate has been approved.

The U value of any component of ceiling, floor, roof deck or wall, including glazing, may be increased, and the U value for other components decreased until the overall heat gain or heat loss of the building does not exceed the total resulting from conformance to the stated U values.

The Building Official may approve any alternative design including designs utilizing nondepleting energy systems such as solar or wind provided he finds that the proposed design complies with the provisions of this Article in that the material, method of construction, design or insulating system does not use more depletable energy than the requirements of this Article.

The Building Official shall require that sufficient evidence or documentation be submitted to substantiate any claims made regarding the installation and use of any such alternate and may require testing of the final installation.

NOTE: Basic glazing area may be adjusted if in compliance with Subsection (c) above.

(d) Definitions. For the purposes of this section, the following definitions shall apply:

(1) Cooling Systems - A system for cooling air by mechanical or other means and discharging such air into a dwelling unit. This definition shall not include evaporative cooling.

(2) Degree Day - A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65°F, there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F. The degree day for specific geographical areas in California shall be those in Appendix T25-A.

(3) Exterior Wall Area - The gross area of wall surfaces adjacent to heated or cooled spaces, including glazing and doors, exposed to ambient climatic temperatures, measured for a dwelling unit or group of units served by a heating or cooling system.

(4) Glazing - All transparent or translucent materials in exterior openings.

(5) High Rise - Any building containing four or more stories of dwelling space, excluding basements and parking or nonhabitable areas in subterranean or ground levels.

(6) Shading Coefficient - A ratio of the solar heat gain through an unshaded glazing system to that of a single light of double strength window glass under the same set of conditions.

(7) Special Glazing - Glazing which has a maximum U factor of .70 for all glazed surfaces.

(8) Thermal Conductance (C-Factor) - The time rate of heat flow through a homogeneous material of other than one inch thickness or through a nonhomogeneous construction such as an air space expressed in BTU/hr., square foot, degree F temperature difference.

(9) Thermal Conductivity (K-Factor) - The time rate of heat flow through one square foot of a homogeneous material one inch thick when there is a temperature difference of one degree F between the opposite faces of the material expressed in BTU/hr., square foot, degree F per inch.

(10) Thermal Resistance (R) - The measure of the resistance of a material or building component to the passage of heat. The resistance value (R) of mass-type insulations shall not include any value for reflective facing.

(11) Tinted Glazing - Glazing which shall be permanently tinted or permanently surface coated by the manufacturer of the glazing material and shall provide a maximum shading coefficient as hereinafter specified.

(12) U Factor - The total heat flow through a given construction assembly, air to air, expressed in BTU/hr., per square foot, per degree F temperature difference.

$$U = \frac{1}{R_t} \quad \text{where}$$

R_t equals the sum of the resistance (R) for the individual components of the assembly. U factors shall be calculated according to ASHRAE Methods.

(13) Unheated Spaces - Any space exposed to ambient temperatures and not provided with a heat supply capable of maintaining a minimum temperature of 50°F.

(14) Basic Glazing Area - The basic glazing area for low rise buildings shall be 20% of the gross floor area and 40% of the exterior wall area for high rise buildings. The gross floor area shall not include parking garages, unheated basements, corridors, or passageways exposed to exterior ambient temperatures.

(15) Glazing Area. The area of glazing in exterior openings including the sash area.

(e) Thermal Design Standards for Ceilings and Walls. The design of the opaque surfaces of the structure, exposed to ambient conditions, shall provide a maximum U factor of 0.05 for ceilings and 0.08 for walls and spandrels, when the effects of occasional framing members such as studs and joists are not considered. In lieu of the above, when the effects of all elements of the wall or ceiling construction, including occasional framing members such as studs and joists, are considered or when all of the thermal insulation is installed so that it is not penetrated by framing members, the U factor shall not exceed 0.095 for walls and 0.06 for ceilings.

For buildings located in areas of 3500 degree days or less and the effects of all elements of the wall construction are considered, the U factor shall not exceed 0.12 for walls with a construction weight of 26 through 40 pounds per square foot or a U factor not exceeding 0.16 for walls with a construction weight greater than 40 pounds per square foot.

(f) Thermal Design Standards for Glazing.

(1) For heated buildings located in areas of 4500 degree days or less, where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed.

(2) Heated buildings located in areas over 4500 degree days shall be provided with special glazing for all exterior glazing. Where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area in special glazing.

(3) Cooled buildings shall utilize tinted glazing when the total glazing area exceeds the basic glazing area. The glazing area on walls oriented within 22½ degrees of true North need not be included in the total glazing area. The required tinted glazing area shall not be less than the difference between the total glazing area and the basic glazing area. Permanent external shading to allow not more than 50% direct solar exposure on the glazing, taken on August 21, at 9:00 a.m., noon and 3:00 p.m. solar time, may be utilized in lieu of tinted glass. Tinted glazing or permanent external shading on walls oriented within 22½ degrees of true North shall not be considered as part of the required tinted glazing area.

(4) Tinted glazing shall have a maximum shading coefficient of 0.75. This maximum shall be decreased to 0.55 for all permit applications filed after July 1, 1976.

(g) Floor Section, Foundation Walls, Crawl Space Plenum Walls and Slabs-On-Grade. For floors over unheated spaces, unheated basements, unheated garages, or ventilated crawl spaces with operable louvers, the "U" values of floor section shall not exceed the value shown in Table No. 17-B.

Foundation walls of heated basements or heated crawl spaces above grade shall be insulated to provide a "U" value not to exceed the values shown in Table No. 17-C. Insulation may be omitted from floors over heated basement areas or heated crawl spaces if foundation walls are insulated.

When a crawl space is used as a supply or return plenum, the crawl space perimeter wall shall be insulated to provide a maximum "U" value of 0.15.

For slab-on-ground floors, the edge heat loss around the perimeter of heated spaces shall not exceed a maximum value per linear foot of exposed edge of 42 B.t.u.h. for unheated slabs and 50 B.t.u.h. for heated slabs. Calculations of heat loss around slab edges shall be made using the following formula:

$$H = F \times P$$

WHERE:

H = Heat loss of the slab edge in B.t.u.h.

F = Heat loss coefficient from Table No. 17-D in B.t.u.h. per linear foot of exposed edge.

P = Perimeter of exposed slab edge (linear feet).

TABLE NO. 17-B

Maximum "U" Values of Floor Sections Over Unheated Basements, Unheated Garage or Crawl Spaces

Heating Degree Days	Maximum "U" Value
3000 or less	No requirement
3001 to 4500	.10
Over 4500	.08

NOTE: A basement or garage shall be considered unheated unless it is provided with a positive heat supply to maintain a minimum temperature of 50°F.

TABLE NO. 17-C

Maximum "U" Values of Foundation Wall Sections of Heated Basement or Heated Crawl Spaces

Heating Degree Days	Maximum "U" Value
2500 or less	No requirement
Over 2500	.15

NOTE: A crawl space is considered heated when it has a positive heat supply to maintain a minimum temperature of 50° F.

TABLE NO. 17-D

Slab Edge Heat Loss Coefficients (Btuh per Linear Foot)

Winter Design Temperature	Total Width of Insulation (Inches)	F for Unheated Slab			F for Heated Slab		
		R=5.00	R=3.75	R=2.50	R=5.00	R=3.75	R=2.50
-30 or colder	24	34			46		
-25 to -29	24	32			44		
-20 to -24	24	30			41		
-15 to -19	24	28			39		
-10 to -15	24	27	40		37		
- 5 to - 9	24	25	38		35		
Zero to -4	24	24	36		32	48	
+ 5 to + 1	24	22	33		30	45	
+10 to + 6[1]	18	21	31	42	25	38	50
+15 to +11[1]	12	21	31	42	25	38	50

[1]Where winter design temperatures are warmer than +15F perimeter insulation is not required. If installed in these areas (edge only) use values shown for +15F to +11F above. If not installed, use value of F = 45 for unheated and F = 60 for heated slabs.

(h) All swinging doors and windows opening to the exterior to unconditioned areas such as garages shall be fully weatherstripped, gasketed or otherwise treated to limit infiltration. All manufactured windows and sliding glass doors shall meet the air infiltration standards of the 1972 American National Standards Institute (A134.1, A134.2, A134.3 and A134.4), when tested in accordance with ASTM E 283-73 with a pressure differential of 1.57 lbs/ft^2 and shall be certified and labeled.

(i) Loose Fill. Blown or poured type loose fill may be used in attic spaces where the slope of the roof is not less than 2½ feet in 12 feet and there is at least 30 inches of clear headroom at the roof ridge. ("Clear Headroom" is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing.) When eave vents are installed, adequate baffling of the vent opening shall be provided to deflect the incoming air above the surface of the material and shall be installed at the soffit on a 45-degree angle. Baffles shall be in place at the time of framing inspection. When loose fill insulation is proposed, the R value of the material required to meet these regulations shall be shown on the building plans.

(j) Design Temperature. Inside winter design temperature shall be not less than 70°F, and summer design temperature not greater than 78°F. Heat loss and heat gain calculations shall be made using the winter design dry bulb at 99 percent and summer design dry bulb at 2½ percent shown in the current ASHRAE Handbook of Fundamentals.

(k) Pipe Insulation. All steam and steam condensate return piping and all continuously circulating domestic or heating hot water piping which is located in attics, garages, crawl spaces or unheated spaces other than between floors or in interior walls shall be insulated to provide a maximum heat loss of 50 BTU/hr. per linear foot for piping up to and including 2" and 100 BTU/hr. per linear foot for larger sizes.

(l) Compliance. Upon completion of the installation of insulation, a card certifying that the insulation has been installed in conformance with the requirements of these regulations shall be completed and executed by the insulation applicator and by the builder. This insulation compliance card shall be posted at a conspicuous location within the dwelling.

(m) Additions to Existing Buildings. Additions to existing hotels, motels, apartment houses, lodging houses, dwellings and other residential buildings shall be constructed to comply with this Article if the existing building was required to be constructed in conformance with this Article.

APPENDIX T25-A
Heating Degree Day Table

CITIES	ANNUAL DEGREE DAYS
Alderpoint	3,290
Alpine	2,104
Alturas	6,785
Antioch	2,627
Auburn	3,047
Bakersfield	2,122
Barrett Dam	2,363
Barstow	2,496
Beaumont	2,790
Berkeley	2,850
Bishop	4,275
Blythe	1,076
Bonita	1,857
Borrego Springs	1,262
Brawley	1,161
Burney	6,249
Cabrillo National Monument	1,653
Calaveras Big Trees	5,736
Campo	3,247
Chico	2,795
Chula Vista	2,229
Cloverdale	2,666
Colfax	3,441
Colusa	2,788
Concord	2,766
Corona	1,875
Crescent City	4,545
Culver City	1,711

CITIES	ANNUAL DEGREE DAYS
Cuyamaca	4,649
Daggett	2,203
Davis	2,819
Death Valley	1,205
Delano	2,220
Edwards A.F.B.	3,123
El Cajon	1,920
El Capitan Dam	1,397
El Centro	1,216
Elk Valley	5,404
Elsinore	2,101
Encinitas	1,952
Escondido	2,052
Eureka	4,679
Fairfield	2,434
Fairmont	3,327
Fillmore	2,377
Folsom	2,899
Fort Bidwell	6,365
Fort Bragg	4,424
Fort Jones	5,614
Fremont	2,906
Fresno	2,611
Gilroy	2,808
Hanford	2,642
Healdsburg	2,700
Henshaw Dam	3,652
Hetch Hetchy	4,797
Hollister	2,725
Huntington Beach	2,361
Imperial	1,060
Independence	2,995
Inyokern	2,570
Ione	2,728
Jackson	2,760
Julian Wynola	4,085
King City	2,655
Laguna Beach	2,262
Lake Arrowhead	5,200
Lakeport	3,716
La Mesa	1,492
Lemoore	2,960
Lindsay	2,619
Livermore	2,781
Lodi	2,785
Long Beach	1,803
Los Angeles	2,061
Los Banos	2,267
Los Gatos	2,794
Madera	2,485
Maricopa	2,165

CITIES	ANNUAL DEGREE DAYS
Mariposa	3,116
Markleeville	7,884
Marysville	2,377
McCloud	6,007
Mecca	1,117
Mendota	2,555
Merced	2,697
Mineral	7,192
Modesto	2,767
Mojave	2,590
Monterey	2,985
Napa	2,690
Needles	1,072
Nellie	4,745
Nevada City	4,488
Novato	2,815
Oakdale	2,832
Oak Grove	3,516
Oakland	2,906
Oceanside	2,092
Orland	2,830
Oroville	2,597
Oxnard	2,352
Palmdale	3,088
Palm Springs	1,232
Palo Alto	2,869
Palomar Mt. Observatory	3,868
Pasadena	1,694
Paso Robles	2,890
Patterson	2,368
Petaluma	2,966
Pittsburgh	2,633
Placerville	4,161
Point Loma	1,860
Pomona	2,166
Porterville	2,563
Portola	7,055
Quincy	5,852
Ramona Spaulding	2,223
Red Bluff	2,688
Redding	2,610
Redlands	2,052
Redwood City	2,596
Richmond	2,644
Riverside	2,089
Roseville	2,899
Sacramento	2,782
St. Helena	2,833
Salinas	2,959
San Bernardino	2,018

CITIES	ANNUAL DEGREE DAYS
San Clemente	1,877
San Diego	1,439
San Fernando	1,800
San Francisco	3,080
San Jacinto	2,376
San Jose	2,656
San Juan Capistrano	1,646
San Luis Obispo	2,582
San Mateo	2,655
San Rafael	2,619
Santa Ana	1,496
Santa Barbara	2,290
Santa Clara	2,566
Santa Maria	2,985
Santa Rosa	2,980
Scotia	3,954
Sierraville	6,953
Sonora	3,086
South San Francisco	3,061
Stockton	2,690
Stony Gorge Res.	3,124
Susanville	6,248
Tahoe City	8,162
Tahoe Valley	8,198
Thousand Oaks	2,425
Tracy	2,616
Truckee	8,208
Twentynine Palms	2,006
Ukiah	3,030
Vacaville	2,812
Vallejo	2,598
Visalia	2,546
Vista	1,760
Warner Springs	3,470
Weaverville	4,935
Weed	5,870
Willits	4,160
Willows	2,807
Woodland	2,447
Yosemite	4,800
Yreka	5,393
Yuba City	2,386

Again it should be pointed out that the Energy Insulation Standards are minimum for the State of California. The intent of these standards is not to limit types of building practices or design but to conserve energy. Section 1094(c) allows the Building Official the flexibility of approving any alternate materials, method of construction, design or insulating system provided he finds that the proposed design is at least equivalent in the conservation of energy as the requirements of the Energy Insulation Standards.

The state-of-the-art of energy conservation standards are progressing so rapidly that some information found in engineering association publications, manufacturers specifications, and regulatory agency regulations may be more up-to-date than information contained in this manual. Every effort will be made to incorporate into this manual new developments as they are promulgated.

The following chapters of this manual cover specific elements which form the nucleus of the Energy Insulation Standards. A brief summary of each chapter is listed below.

Chapter 2

Chapter 2 discusses the basic properties of heat, the heat transfer processes, types of insulation, insulation placement and related considerations such as vapor barriers and ventilation.

Chapter 3

Chapter 3 includes definitions and an explanation of the terminology used in the Energy Insulation Standards.

Chapter 4

Chapter 4 discusses the term "U" Factor which is the basic criteria of the standards. This chapter includes sample heat transfer calculations and tables from the 1972 ASHRAE Handbook of Fundamentals, which contain the data needed to perform the calculations noted.

Chapter 5

Chapter 5 contains U Factor data relative to some of the more typical wall, ceiling, and floor assemblies used in residential construction in California. While it is impossible to depict every conceivable type of construction, these assemblies are representative of those normally used.

Chapter 6

Chapter 6 contains maps of the Degree Day Districts in California and provides the design conditions for various reporting stations within those Districts.

Chapter 7

Chapter 7 covers the thermal design standards for glazing included in the regulations. This chapter includes sample basic glazing area calculations and tables from the 1972 ASHRAE Handbook of Fundamentals relating to shading coefficients and shading devices.

Chapter 8

Chapter 8 provides a reliable guide to the proper installation of insulation, and includes the types of materials available, common application practices and suggested inspection procedures.

Chapter 9

Chapter 9 discusses pipe and duct insulation and includes tables and a method for calculating the thickness of insulation required.

Chapter 10

Chapter 10 discusses weatherstripping as required by the Energy Insulation Standards. This chapter includes details of the basic types of weatherstripping most commonly used in residential type construction in California.

Chapter 11

Chapter 11 discusses Section 1094(c) as this section relates to alternate materials, methods of construction, designs or insulating systems and provides examples of alternate calculations.

CHAPTER 2

THE PROPERTIES OF HEAT

GENERAL

Heat is energy. Through locked doors, closed windows, solid walls and ceilings, it comes and goes. This seemingly impossible feat is not accomplished by illusions or sleight of hand, but in accordance with the basic laws of physics. Worst of all, this loss of energy happens, without regard to economic values or the scarcity of precious energy resources.

Heat is measured in British Thermal Units (BTU). A BTU is the amount of heat required to raise the temperature of one pound of water (about one pint) one degree Fahrenheit. This is approximately equivalent to the amount of heat generated by burning an ordinary wooden kitchen match.

Heat is mobile. It always moves in one direction - warm to cold. The actual rate of this flow depends on the size of the temperature difference and the amount of resistance offered to this flow by materials such as those in a building's wall.

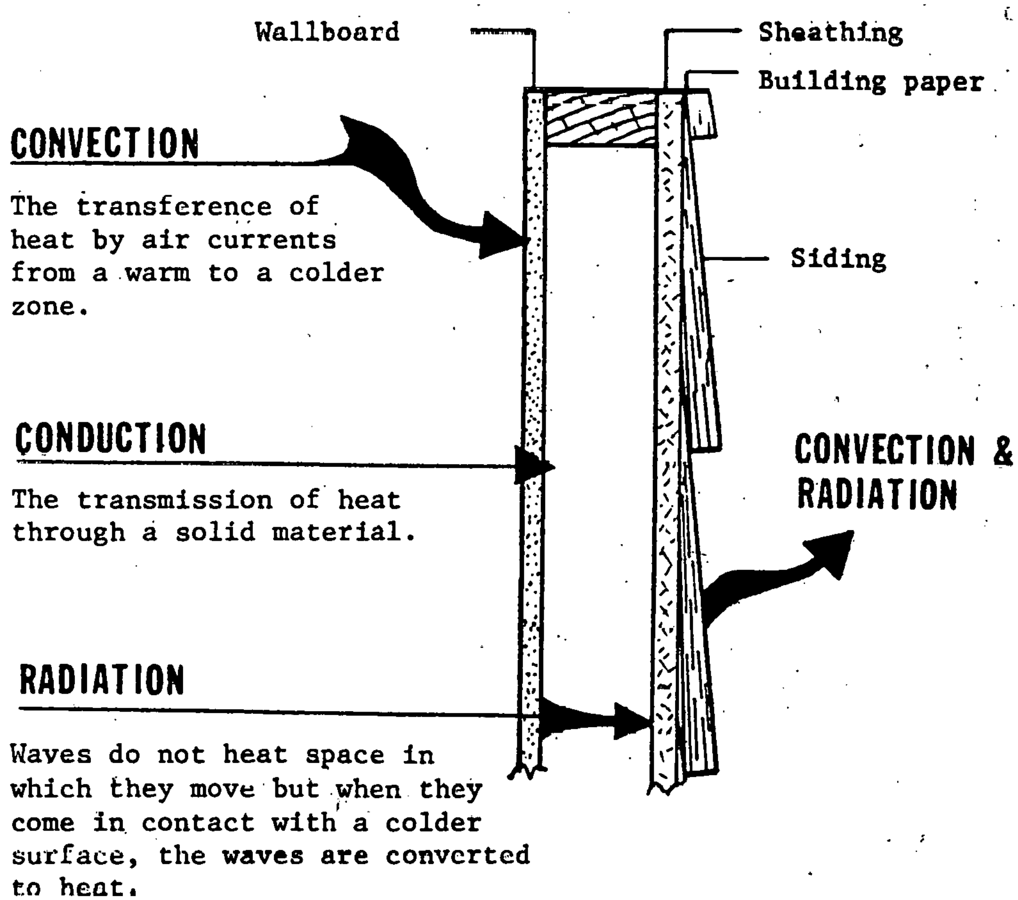
Heat travels in one or a combination of three different ways: conduction, convection, and radiation. By conduction, heat flows directly through solid materials such as wood, plaster, glass, etc. The handle of a saucepan becomes hot because heat is conducted from the bottom of the pan to the handle. Thermal conductivity varies greatly among various substances and thicknesses of solids. For example, the conductivity of copper is 2,300 times that of asbestos sheeting.

By convection, heat moves on air currents from a warm zone to a cold zone, even inside the small spaces of tightly sealed walls. Air touching the warm side of a wall is heated, and the air rises. Air near the cold side of the wall is cooled, and that air sinks. In the circulation process, heat is transferred. Unaided circulation of air over a heated surface is known as natural convection. If the heated air is circulated by a fan or other mechanism, the process is called forced convection.

By radiation, heat may be transmitted from a heat source to a surface, even across a perfect vacuum. Radiated energy waves do not heat the space in which they move, but when they encounter a cooler surface these waves are converted to heat. In this mode, radiant energy of the sun crosses millions of miles of space to warm the earth. Similarly, heat may enter or leave a structure by radiation.

All three of the heat transfer processes are involved (Figure 2-1) as heat passes through a wall. In the typical wall shown, heat is transferred from the room to the interior finish by radiation/convection and through the interior finish by conduction. It is transferred across the stud space by radiation and convection. Convection is also a factor, since air warmed on the interior side, moves upward on the warmer side, and air cooled by the sheathing, moves downward on the cooler side of the stud space. Conduction, again, transfers heat through the sheathing/exterior finish materials and the studs. Heat then leaves the outer surface of the sheathing by a combination of radiation to cooler surroundings and convection as outside air moves across the surface.

FIGURE 2-1



INSULATION

Insulation is designed to keep heat in and also to keep unwanted heat out. Mass type insulation material fills the air spaces in walls, ceilings and floors, greatly reducing heat transfer by convection. Air in the spaces no longer can move freely, so heat has no large convection currents to follow. Other forms of insulation materials are applied over the studs lowering heat transfer by conduction. The degree of insulating efficiency of a material is mainly a function of the number of air cells it contains -- an exception to this is aluminum foil which insulates by reflecting radiant heat only. The addition of a reflective surface (such as metal foil) to mass type insulation material will enable it to resist radiation provided the foil is facing an air space. It is important to note that, as stated in the regulations, the resistance value (R) of mass-type insulations shall not include any value for reflective facing.

All insulation materials, except the reflective type, use the principle of entrapped air to retard the flow of heat. Non-reflective or "mass type" materials are manufactured in several forms: loose fill, flexible batts and blankets, and rigid boards. Reflective insulation is almost exclusively aluminum foil.

Loose fill insulation consists of particles, granules, or fibrous materials that are poured or blown into place. This material is generally made from a mineral wool (rock, glass, or slag) or a cellulose material (wood pulp or macerated paper) and consists of randomly piled fibers that form small voids or air spaces.

Flexible insulation, made from the same materials as loose fill, is manufactured in batts (short sections) and in blankets (continuous rolls) usually faced on one side with a vapor barrier material such as asphalt-coated kraft paper or an aluminum foil. Flanges along the edges of the roll allow the insulation to be nailed or stapled to the studs or joists.

Rigid insulation is available in structural panels ranging from 2 by 8 to 4 by 12 feet, and from 1/2 to 3 inches thick. Many rigid insulation panels double as structural material, as wall sheathing or decking for built-up roofing, and is practically the only material that can be used to insulate an open-beamed ceiling with no attic. Many of the rigid panels offer a variety of finishes on one side so they can be laid directly on the beams to form a finished ceiling or applied to the inside of existing walls. The panels are usually tongue and groove to assure a tight fit, and they often have a vapor barrier under the finish on the inner side.

Reflective insulation is frequently used alone, usually in rolls of two or more layers separated by air spaces when expanded to fit between studs. This type of insulation differs from the "mass-type" in that it does not use air entrapped in small cells to retard heat flow. Instead, it takes advantage of the insulating value of enclosed air spaces coupled with reflective surfaces.

INSULATION R VALUES

What amount of insulation is necessary to meet the required standards? In the past, inches of insulation were used to indicate the effectiveness of an insulation material. But as already mentioned there are a number of different insulating materials possessing a wide variety of physical characteristics. This required that another system of comparison had to be developed and it logically was based on how much resistance to heat flow each material offered. These resistance values are termed R values. The R number takes into account the factors of thickness and thermal conductivity (K). The greater the R value, the greater the insulating value.

R value labeling is required by Federal Specifications HH-I-521E and HH-I-515B. All batts and blankets have R values printed on the vapor barrier and the package. Blown and poured insulations are packaged in bags, labeled with the recommended installed densities, thicknesses, and corresponding maximum coverages per bag required to meet specified resistances.

INSULATION PLACEMENT

Insulation in the home can only be effective when properly placed. The following locations should be insulated (Figure 2-2). The numbers below correspond to those indicated in Figure 2-2.

1. Exterior walls. Sometimes portions of walls surrounding heated spaces are overlooked such as: the wall between a living space and an unheated garage or storage room; dormer walls; the portion of wall above the ceiling of an adjacent section of a split-level home. Insulation should also be placed between jambs and framing.

2. Ceilings with cold spaces above, and dormer ceilings. Each attic access panel should be insulated by stapling a piece of blanket insulation to its top.

3. Knee walls when adjacent to heated spaces.

4. Between collar beams, leaving open space above for ventilation.

5. Around the perimeter of a slab on grade.

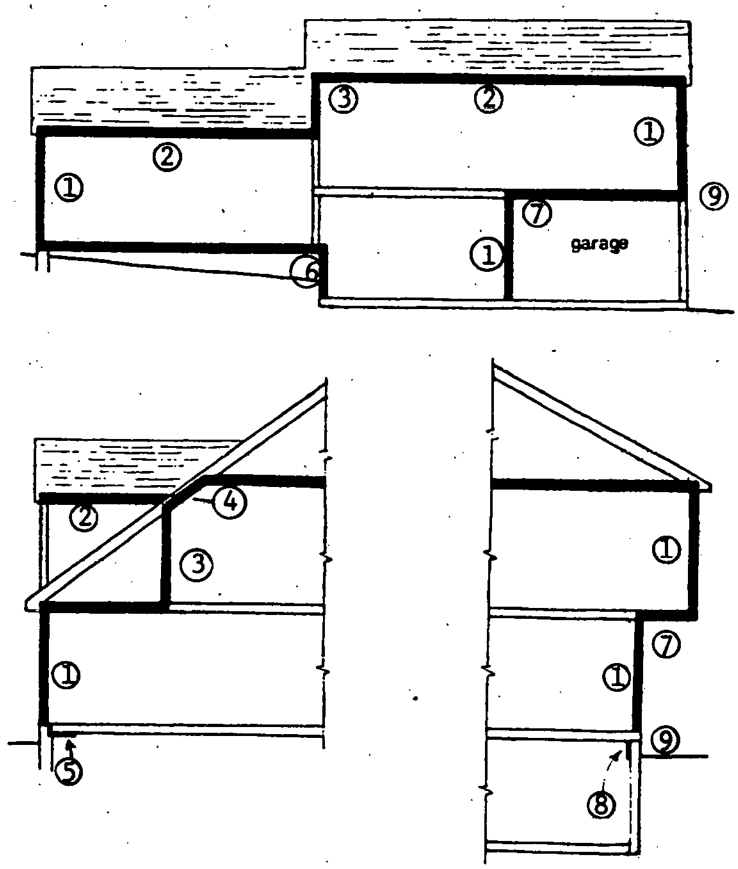
6. Floors above vented crawl spaces. When a crawl space is used as a plenum, insulation is applied to crawl space walls instead of the floor above.

7. Floors over an unheated or open space such as over a garage or a porch. The cantilevered portion of a floor.

8. Walls of heated basements above grade.

9. In back of header joists.

FIGURE 2-2



The application of insulation in apartments follows the same general guidelines as those used for a single family home. In addition, there are some other locations which should be insulated such as: walls of unheated stairwells common to living units; floors of living units over boiler or other heat producing mechanical equipment rooms; floors of conditioned spaces over unheated entrances or halls; and walls of living units which are adjacent to incinerator and elevator shafts.

Thermal insulation also has some desirable acoustical properties. When used in apartment applications it contributes to the reduction of airborne and impact noise.

RELATED CONSIDERATIONS

Besides the insulation itself there are other related factors which should be considered when insulating a home.

Vapor barriers can be important. Homes should be protected from moisture produced within. Vapor barriers are not required by these standards and the following are recommendations only.

A vapor barrier or vapor barrier-faced insulation should not be installed over existing insulation when installing additional insulation in an attic floor.

In all homes, the activities of living produce great amounts of water vapor. Steam from cooking pots, moist air from shower stalls and bathrooms, and exhaust from clothes dryers contribute to the rise in humidity inside a house, especially in winter. This water vapor easily penetrates plaster and other interior finishes, and if it is allowed to enter the construction assembly, it is likely to be cooled below its dew-point. The resulting condensation can saturate the insulation or exterior sheathing, possibly damaging the wall assembly, and reducing the effectiveness of the insulation.

Vapor barriers are placed on the side of the wall, ceiling or floor that is warm in winter. Most blanket forms of insulation usually have vapor barriers already attached. If no vapor barrier is supplied on the insulation, then the following materials may be substituted:

1. Polyethylene sheeting: 2 mils or thicker in walls and ceiling, and 4 mils or thicker as ground covers under slabs or over crawl space earth.

2. Foil-backed gypsum board.

3. Waterproofed laminated asphalt coated paper.

4. Similar film, sheets, or materials with comparable vapor resistant qualities.

Vapor barriers are not needed on the warm side of ceiling insulation where the attic is ventilated.

Exterior Openings--windows and doors contribute to heat loss by conduction through the door, the glass, the frame and also by leakage between openable window panes and between the frame and structure. They should be weather-stripped and the building siding should be carefully sealed to the frames. Factory built insulated windows in which two or more panes are separated by hermetically sealed air spaces, or storm windows and doors will reduce conduction heat losses. This will be discussed in greater detail in Chapter 10.

Duct insulation is required to prevent heat loss or gain from a duct when the air passing through it is warmer or cooler than the air surrounding it. Supply air ducts installed in unconditioned spaces, such as crawl spaces, attached garages, etc., shall be insulated as described in Chapter 9.

Attic Ventilation--the need for attic ventilation is two-fold: the reduction of summer heat build-up and prevention of winter moisture condensation.

The principal source of summertime attic heat is direct sunlight on the roof of the home. This is radiated heat, and even on a cloudy day there is an appreciable amount transmitted to a roof. This solar heat on the roof material is transmitted, in turn, to the attic floor -- or to the surface of the ceiling insulation. The portion of the heat that reaches the living area through the attic is proportional to the difference between attic floor and room ceiling temperatures. Adequate attic ventilation can substantially reduce this temperature difference.

Besides attics, ventilation is recommended in roof/ceilings and crawl spaces.

Where determined necessary by the Building Official due to atmospheric or climatic conditions, enclosed attics and enclosed rafter spaces formed where ceilings are applied direct to the underside of roof rafters, shall have cross ventilation for each spearate space by ventilating openings protected against the entrance of rain and snow. The net free ventilating area shall be not less than 1/150 of the area of the space ventilated, except that the area may be 1/300 provided at least 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.

Experience has shown it is preferable to provide half of the required area at the ridge and one quarter at each soffit or eave.

Crawl Space Ventilation--underfloor areas shall be ventilated by an approved mechanical means or by openings in exterior foundation walls. Such openings shall have a net area of not less than 1 1/2 square feet for each 25 linear feet of exterior wall. Openings shall be located as close to corners as practicable and shall provide cross ventilation on at least two approximately opposite sides. They shall be covered with corrosion resistant wire mesh not less than 1/4 inch nor more than 1/2 inch in any dimension.

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CHAPTER 3

DEFINITIONS

The following definitions are provided as assistance to the user of this manual who may be unfamiliar with some of the specialized terminology.

AIR, AMBIENT: Generally speaking, the air surrounding an object.

AIR, OUTSIDE: External air; atmosphere exterior to refrigerated or conditioned space; ambient (surrounding) air.

BASIC GLAZING AREA: The basic glazing area for low rise buildings shall be 20% of the gross floor area and 40% of the exterior wall area for high rise buildings. The gross floor area shall not include parking garages, unheated basements, corridors, or passageways exposed to exterior ambient temperatures.

BRITISH THERMAL UNIT (BTU): The Btu is a measure of heat. It is, approximately, the heat required to raise the temperature of a pound of water from 59F to 60F.

CONDUCTION: The process of heat transfer through a material by direct molecular contact of the particles of the material.

CONVECTION, NATURAL: Circulation of gas or liquid (usually air or water due to differences in density resulting from temperature changes.

COOLING SYSTEMS: A system for cooling air by mechanical or other means and discharging such air into a dwelling unit. This definition shall not include evaporative cooling.

DECLINATION OF SUN: The angle above or below the equatorial plane. It is plus if north of the plane, and minus if below. Celestial objects are located by declination.

DEGREE DAY: A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65 deg. F, there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65 deg. F. The degree day for specific geographical areas in California shall be those shown in Appendix T25-A.

EFFECTIVE EMISSIVITY (E): A term denoting the ability of an air space to transmit radiant energy based upon the characteristics of the surfaces of the air space.

EMISSIVITY (e): The capacity of a material to emit radiant energy. Emittance is the ratio of the total radiant flux emitted by a body to that emitted by an ideal black body at the same temperature.

EXTERIOR WALL AREA: The gross area of wall surfaces adjacent to heated or cooled spaces, including glazing and doors, exposed to ambient climatic temperatures, measured for a dwelling unit or group of units served by a heating or cooling system.

FAHRENHEIT: A thermometric scale in which 32 deg. denotes freezing and 212 deg. the boiling point of water under normal pressure at sea level (14.696 psi).

GLAZING: All transparent or translucent materials in exterior openings.

GLAZING AREA: The area of glazing in exterior openings including the sash area.

HEAT TRANSMISSION (Q): The time-rate of heat flow usually refers to conduction, convection and radiation combined. Usually expressed in BTU/hr.

HIGH RISE: Any building containing four or more stories of dwelling space, excluding basements and parking or nonhabitable areas in subterranean or ground levels.

INFILTRATION: Air flowing inward as through a wall, crack, etc.

INSULATION, FILL: Granulated, shredded, or powdered material, prepared from vegetable, animal, or mineral origin.

INSULATION (THERMAL): A material having a relatively high resistance to heat flow, and used principally to retard the flow of heat.

SHADING COEFFICIENT: A ratio of the solar heat gain through an unshaded glazing system to that of a single light of double strength window glass under the same set of conditions.

SPECIAL GLAZING: Glazing which has a maximum U factor of .70 for all glazed surfaces.

SURFACE FILM CONDUCTANCE, (f_o or f_i): The time rate of heat flow per unit area under steady conditions between a surface and a fluid (air) for unit temperature difference between the surface and the fluid (air).

THERMAL CONDUCTANCE (C-FACTOR): The time rate of heat flow through a homogeneous material of other than one inch thickness or a homogeneous construction such as air space expressed in BTU/hr., square foot, degree F temperature difference.

THERMAL CONDUCTIVITY (K-FACTOR): The time rate of heat flow through one square foot of a homogeneous material one inch thick when there is a temperature difference of one degree F between the opposite faces of the material expressed in BTU/hr., square foot, degree F per inch.

THERMAL RESISTANCE (R): The measure of the resistance of a material or building component to the passage of heat. The resistance value (R) of mass-type insulations shall not include any value for reflective facing.

TINTED GLAZING: Glazing which shall be permanently tinted or permanently surface coated by the manufacturer of the glazing material and shall provide a maximum shading coefficient as hereinafter specified.

TRANSMISSION: In thermodynamics, a general term for heat travel; properly, heat transferred per unit of time.

TRANSMITTANCE, THERMAL (U FACTOR): The time rate of heat flow per unit area under steady conditions from the fluid on the warm side of a barrier to the fluid on the cold side, per unit temperature difference between the two fluids.

U FACTOR: The total heat flow through a given construction assembly, air to air, expressed in BTU/hr., per square foot, per degree F temperature difference.

$$U = \frac{1}{R_t} \quad \text{where}$$

R_t equals the sum of the resistance (R) for the individual components of the assembly. U factors shall be calculated according to ASHRAE Methods.

UNHEATED SPACES: Any space exposed to ambient temperatures and not provided with a heat supply capable of maintaining a minimum temperature of 50 deg. F.

VAPOR BARRIER: A moisture-impervious layer applied to the surfaces enclosing a humid space to prevent moisture travel to a point where it may condense due to lower temperature.

VENTILATION: The process of supplying or removing air, by natural or mechanical means, to or from any space. Such air may or may not have been conditioned.

WALL SECTION: Cross section of wall arranged chiefly to reveal conductivity characteristics.

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CHAPTER 4

"U" FACTORS

REQUIREMENTS

Section 1094(e) and 1094(g) of the regulations establish the maximum U factors for building sections. Following are the maximum U factors established for the building sections listed. Refer to Chapter 1 for the specific requirements of the regulations and the applicability of the following.

Walls and Spandrels	0.08	(Insulation between framing and the effects of framing not considered)
Ceilings	0.05	
Walls and Spandrels	0.095	(Insulation not penetrated by framing or the effects of framing considered)
Ceilings	0.06	
Walls (26 to 40 psf)	0.12	(Areas with 3500 or less degree days and all elements on construction considered)
Walls (over 40 psf)	0.16	
Floors	0.10	(Areas with 3001 to 4500 degree days)
Floors	0.08	(Areas over 4500 degree days)

WHY THE U FACTOR

Let us discuss briefly the significance of the term, U factor.

By definition: "U Factor - (is) the total heat flow through a given construction assembly, air to air, expressed in BTU/Hr., per square foot, per degree F temperature difference.

$$U = \frac{1}{R_T} \text{ where}$$

R_T equals the sum of the resistances (R) for the individual components of the assembly." Thus, the total heat flow is inversely proportional to the total resistance of the assembly.

The objective of the regulations is to conserve energy in new buildings in California. The Heat Loss (Q) in any building is a function of its size and shape (areas of floors, walls and roofs), the design temperature and the components of the floor, walls and roof.

The Heat Loss (Q) through a particular section of a building is proportional to the U Factor (U), the Area (A) of the section and the Temperature Difference (ΔT or $t_i - t_o$) and may be calculated from the formula:

$Q = U \cdot A \cdot (t_i - t_o)$ or,....................(Formula 4-1)

$Q = U \cdot A \cdot \Delta T$.............................(Formula 4-2)

Note: The formulas used in this discussion are based upon appropriate sections of ASHRAE 1972 Handbook of Fundamentals.

This calculation is <u>not required</u> for a residential building which meets the specific requirements of these regulations, but would be needed to substantiate an alternative design which is at least equivalent in the conservation of energy. In analyzing the terms of Formula 4-1 or 4-2, the Area (A) of the particular surface, (wall or roof) is determined by the architectural size and shape of the building.

It is important to remember that about 90 percent of the total heat loss (or gain) in any residential building takes place at the exterior building surfaces.

The Temperature Difference (t_i-t_o or ΔT) is pretty much beyond our control as it is based upon the geographical location of the building site where outside temperature (t_o) is a function of the climate. The inside temperature (t_i) is the constant design temperature as established in Section 1094(j) of the regulations.

Therefore, the most direct way to decrease the Heat Loss (Q) is to decrease the U Factor of the exterior building sections. In other words, if we lower the U Factor, we lower the heat loss. This is the reason these regulations specify maximum U Factors, rather than requiring a heat loss calculation for buildings which meet the specific requirements of these regulations.

WHAT MAKES UP A U FACTOR

If we look at a typical wall section (Fig. 4-1) we realize that in losing heat through the wall, the heat must flow through each of the materials in the assembly in turn (series), and the loss of heat is retarded, depending on the insulation value (K factor) of the material and its thickness (x). The heat flow through a specific material of a specific thickness is known as Conductance (C).

The conductance values for many common construction materials are listed in Table 4-3; and when they are not listed for the actual thickness involved, they may be calculated using the K Factor values in Table 4-3 as follows:

$$C = \frac{K}{x} \text{ (Btu/hr sq ft F)} \qquad \text{(Formula 4-3)}$$

where: K = K Factor (Btu/hr sq F in.)

x = Thickness (Inches)

In addition to flowing through each of the structural components, heat must also flow through three components of the wall (Fig. 4-1) which retard its passage. These are:

Inside Air Film (f_i)............................(From Table 4-1)
Air Space (C_a) (3½" thick)......................(From Table 4-2)
Outside Air Film (f_o)...........................(From Table 4-1)

Every surface exposed to air has a layer of "dead air" clinging to it known as the "air film." The air film has insulation properties which vary with the orientation of the surface and the reflectiveness of the material involved, and the air velocity along the surface. There is a higher insulation value for an inside air film than one on the outside of the building as the action of the wind wipes away some of the outside air film reducing its insulation properties.

The insulation value of air films and air spaces is also determined by the orientation and the reflectiveness of the film or air space. Reflectiveness is measured by the term "Surface Emissivity" (e). Most building materials are dull or dark colored and have e = 0.90. Aluminum foils and glossy white surfaces have e = 0.05. Values for air films are given in Table 4-1.

Similarly, air spaces have insulation values which are dependent on their orientation, thickness, and reflectiveness. Values for the Conductances (C) and Resistances (R) of air spaces are given in Tables 4-2A, 2B and 2C.

It is not possible to determine the value of the U Factor by adding up the values of the Conductances (C). Instead the U Factor is computed, as in electricity by summing up the reciprocals of the conductances, as follows:

$$U = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}} \text{......................(Formula 4-4)}$$

These terms $\frac{1}{C_1}$ etc., are known as Resistances (R_1) etc., so that:

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

Substituting in the above:

$$U = \frac{1}{R_1 + R_2 + R_3 + R_4} \text{......................(Formula 4-5)}$$

Many resistance values may be taken directly from Tables 4-3A and 4-3B or may be calculated from the K Factors and thicknesses:

$$R = \frac{1}{C} = \frac{1}{\frac{K}{x}} = \frac{x}{K} \text{..............................(Formula 4-6)}$$

Therefore, in order to calculate a U Factor, one merely needs to know the resistance value (R) of the component or its K Factor (K) and its thickness (x).

LET'S CALCULATE A U FACTOR

Again, referring to Fig. 4-1, and using Formula 4-4, we find that the U Factor is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{x_1}{K_1} + \frac{1}{C_a} + \frac{x_2}{K_2} + \frac{x_3}{K_3} + \frac{1}{f_o}}$$

or, using Formula 4-5:

$$U = \frac{1}{R_i + R_1 + R_a + R_2 + R_3 + R_o} = \frac{1}{R_t}$$

where:

1) $\frac{1}{f_i} = R_i =$ Resistance of Inside Air Film (Table 4-1)

2) $\frac{x_1}{K_1} = R_1 =$ Resistance of 1/2" gypsum board (Table 4-3)

3) $\frac{1}{C_a} = R_a =$ Resistance of 3-1/2" vert. air space (Table 4-2C)

4) $\frac{x_2}{K_2} = R_2 =$ Resistance of building paper (Table 4-3)

5) $\frac{x_3}{K_3} = R_3 =$ Resistance of 7/8" stucco (Table 4-3)

6) $\frac{1}{f_o} = R_o =$ Resistance of outside air film (Table 4-1)

Example: Resistance of an Air Space

To determine the Thermal Resistance (R) of a 4" vertical air space, use Table 4-1 and Table 4-2C.

Step 1 — See Table 4-1, Section B.

Step 2 — Select type of surface (aluminum foil, light; building materials; etc.). For our example determine the thermal resistance of a 4" air space in a 2 x 4 stud wall (exterior - stucco with building paper; interior - gypsum board). Type of surface will be - "Building Materials."

Step 3 — Determine Emissivity (E). Both surfaces in the example have an emissivity of .90. Therefore, the effective emissivity will be .82.

Step 4 — See Table 4-2C.

Step 5 — Position of Air Space - Determine position of air space - in our example the air space is vertical.

Step 6 — Direction of Heat Flow - If the air space is vertical, the heat flow will be horizontal.

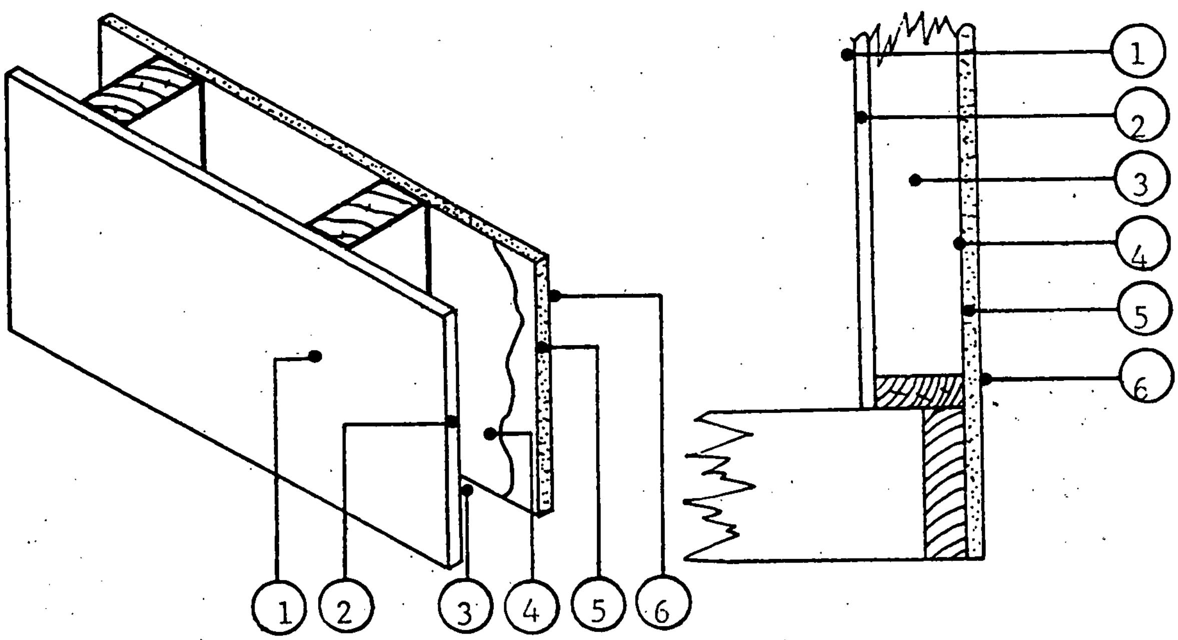
Step 7 — Air Space Mean Temperature - For Southern California, a mean temperature of approximately 50°F is reasonable, as is a temperature difference of either 10° or 30°. These two figures will vary according to the local climate. Using a mean temperature of 50°F and a temperature difference of 10° and moving horizontally to the vertical column headed by a value of E of .82, one arrives at a Thermal Resistance for a 4" air space of 1.01.

Note: Table 4-1 is Table 1, Section B, Page 357, and Table 4-2 is Table 2B, Page 359, both from ASHRAE 1972 Handbook of Fundamentals.

In calculating the U Factor for the wall shown in Figure 4-1, keep in mind that a U = 0.08 maximum is required and is equal to:

$$R_T = \frac{1}{0.08} = 12.5 \text{ units}$$

FIGURE 4-1



	Construction	Resistance (R)		
1)	Inside Air Film (still air, e = 0.90)	R_i	=	0.68
2)	Gypsum Wallboard (1/2")	R_1	=	0.45
3)	3-1/2" Air Space (E = 0.82)	R_a	=	1.01
4)	Building Paper	R_2	=	0.06
5)	7/8" Stucco	R_3	=	0.18
6)	Outside Air Film (15 mph wind)	R_o	=	0.17
		R_T	=	2.55

$$U = \frac{1}{R_T} = \frac{1}{2.55} = 0.392$$

This U Factor does not meet the regulations so changes to the assembly must be made, such as adding insulation in the cavity. By adding R-11 insulation in the stud space, the value of the air space is lost, because the cavity is filled with insulation resulting in the following:

Original Total Resistance		R_T =	2.55
Subtract:	Air Space	$- R_a$ =	1.01
		R_t =	1.54
Add:	R-11 Insulation	$+ R_I$ =	11.00
		R_T =	12.54

$$U = \frac{1}{12.54} = 0.0797$$

This U Factor is less than 0.08 and meets the requirements of the regulations.

These calculations may be performed with any combination of materials, adding in or taking out the appropriate R values for the materials.

It should be noted that most of the regulation is written in such a way that it is not necessary to calculate the average U Factor of the wall, taking into account the heat flow through the framing members. If it is desired, or required by the regulation, to consider the effects of all elements of the wall or ceiling construction, including occasional framing members such as studs and joists, the principles presented in the ASHRAE Handbook of Fundamentals should be used. Figure 4, page 350 of the 1972 ASHRAE Handbook of Fundamentals contains a method for calculating the average U value adjusted for the effects of framing based on the U value of the insulated section, the U value at the framing and the percentage of framing in the section.

Several commonly used wall, ceiling, and floor assemblies have been worked out and are in Chapter 5.

It should be pointed out that in the typical wall, ceiling and floor assemblies in Chapter 5, only the resistance values for permanent building components may be considered in calculating U factors. While other interior coverings such as carpeting, draperies, etc., may provide some insulation, there is no reasonable assurance that such non-permanent materials or equipment will be maintained for the life of the building, and for this reason, the value of linoleum or asphalt tile is used in the sample calculations.

Table 4-1 .... Surface Conductances and Resistances for Air

All conductance values expressed in Btu per (hr) (sq ft) (F deg temp diff)

SECTION A. Surface Conductances and Resistances

Position of Surface	Direction of Heat Flow	Non-reflective $\epsilon = 0.90$ f_i	Non-reflective $\epsilon = 0.90$ R	Reflective $\epsilon = 0.20$ f_i	Reflective $\epsilon = 0.20$ R	Reflective $\epsilon = 0.05$ f_i	Reflective $\epsilon = 0.05$ R
STILL AIR							
Horizontal.....	Upward	1.63	*0.61*	0.91	*1.10*	0.76	*1.32*
Sloping—45 deg	Upward	1.60	*0.62*	0.88	*1.14*	0.73	*1.37*
Vertical.......	Horizontal	1.46	*0.68*	0.74	*1.35*	0.59	*1.70*
Sloping—45 deg	Downward	1.32	*0.76*	0.60	*1.67*	0.45	*2.22*
Horizontal.....	Downward	1.08	*0.92*	0.37	*2.70*	0.22	*4.55*
MOVING AIR		f_o	R	f_o	R	f_o	R
(Any Position) 15 mph Wind (for winter)	Any	6.00	0.17				
7½ mph Wind (for summer)	Any	4.00	0.25				

SECTION B. Reflectivity and Emissivity Values of Various Surfaces[c] and Effective Emissivities of Air Spaces

Surface	Reflectivity in Percent	Average Emissivity ϵ	Effective Emissivity E of Air Space: With one surface having emissivity ϵ and other 0.90	Effective Emissivity E of Air Space: With both surfaces of emissivity ϵ
Aluminum foil, bright....	92 to 97	0.05	0.05	0.03
Aluminum sheet.........	80 to 95	0.12	0.12	0.06
Aluminum coated paper, polished..............	75 to 84	0.20	0.20	0.11
Steel, galvanized, bright..	70 to 80	0.25	0.24	0.15
Aluminum paint.........	30 to 70	0.50	0.47	0.35
Building materials: wood, paper, glass, masonry, nonmetallic paints.....	5 to 15	0.90	0.82	0.82

[a] For ventilated attics or spaces above ceilings under summer conditions (heat flow down) see Table 7.
[b] Conductances are for surfaces of the stated emissivity facing virtual black-body surroundings at the same temperature as the ambient air. Values are based on a surface-air temperature difference of 10 deg and for surface temperature of 70 F.
[c] See also Chapter 2, Table 4.

Table 4-2A.... Thermal Conductances and Resistances of a Plane[a,b,g] Air Space* (¾ in. Air Space)

Position of Air Space	Direction of Heat Flow	Mean Temp,[c] F	Temp Diff,[c] F deg	C, E[c,d] = 0.03	C, 0.05	C, 0.2	C, 0.5	C, 0.82	R[e], E[d] = 0.03	R, 0.05	R, 0.2	R, 0.5	R, 0.82
Horiz.	Up	90	10	0.42	0.44	0.61	0.96	1.32	*2.39*	*2.26*	*1.63*	*1.05*	*0.76*
		50	30	0.58	0.60	0.73	1.0	1.24	*1.72*	*1.67*	*1.37*	*1.0*	*0.78*
		50	10	0.43	0.45	0.59	0.86	1.15	*2.33*	*2.23*	*1.71*	*1.16*	*0.87*
		0	20	0.55	0.56	0.66	0.86	1.07	*1.83*	*1.79*	*1.52*	*1.16*	*0.93*
		0	10	0.45	0.46	0.56	0.76	0.98	*2.23*	*2.16*	*1.78*	*1.31*	*1.02*
		−50	20	0.58	0.59	0.66	0.80	0.95	*1.73*	*1.71*	*1.52*	*1.25*	*1.05*
		−50	10	0.47	0.48	0.55	0.70	0.85	*2.11*	*2.07*	*1.81*	*1.44*	*1.18*
45° Slope	Up	90	10	0.33	0.36	0.53	0.87	1.24	*3.01*	*2.81*	*1.90*	*1.15*	*0.81*
		50	30	0.50	0.51	0.65	0.92	1.20	*2.02*	*1.95*	*1.54*	*1.09*	*0.83*
		50	10	0.34	0.36	0.50	0.77	1.06	*2.94*	*2.78*	*2.02*	*1.30*	*0.94*
		0	20	0.46	0.48	0.58	0.78	0.99	*2.16*	*2.27*	*1.74*	*1.29*	*1.01*
		0	10	0.36	0.37	0.47	0.67	0.88	*2.81*	*2.71*	*2.13*	*1.49*	*1.13*
		−50	20	0.50	0.51	0.58	0.72	0.88	*1.99*	*1.96*	*1.72*	*1.38*	*1.14*
		−50	10	0.38	0.39	0.46	0.60	0.75	*2.66*	*2.59*	*2.19*	*1.67*	*1.33*
Vertical	Horiz.	90	10	0.28	0.31	0.48	0.82	1.19	*3.54*	*3.28*	*2.10*	*1.22*	*0.84*
		50	30	0.34	0.36	0.49	0.76	1.04	*2.95*	*2.80*	*2.04*	*1.32*	*0.96*
		50	10	0.27	0.29	0.42	0.70	0.99	*3.72*	*3.48*	*2.36*	*1.43*	*1.01*
		0	20	0.31	0.32	0.42	0.62	0.84	*3.23*	*3.10*	*2.38*	*1.60*	*1.19*
		0	10	0.25	0.27	0.37	0.57	0.78	*3.96*	*3.76*	*2.73*	*1.76*	*1.28*
		−50	20	0.32	0.33	0.40	0.54	0.69	*3.15*	*3.06*	*2.51*	*1.85*	*1.44*
		−50	10	0.24	0.25	0.32	0.46	0.61	*4.23*	*4.07*	*3.16*	*2.18*	*1.64*
45° Slope	Down	90	10	0.29	0.31	0.48	0.82	1.19	*3.51*	*3.24*	*2.09*	*1.21*	*0.84*
		50	30	0.29	0.31	0.44	0.71	0.99	*3.47*	*3.27*	*2.27*	*1.41*	*1.01*
		50	10	0.26	0.28	0.42	0.69	0.98	*3.82*	*3.57*	*2.40*	*1.45*	*1.02*
		0	20	0.26	0.27	0.37	0.58	0.79	*3.83*	*3.65*	*2.67*	*1.74*	*1.27*
		0	10	0.23	0.25	0.35	0.55	0.76	*4.28*	*4.04*	*2.88*	*1.82*	*1.31*
		−50	20	0.25	0.26	0.33	0.47	0.62	*4.05*	*3.90*	*3.05*	*2.13*	*1.61*
		−50	10	0.21	0.22	0.29	0.43	0.58	*4.84*	*4.63*	*3.48*	*2.33*	*1.72*

(¾ in. Thickness[b]; Thermal Conductance — C, Value of E[c,d]; Thermal Resistance[e] — R, Value of E[d])

[a] Spaces of uniform thickness bounded by moderately smooth surfaces.
[b] Interpolation between ¾ and 4-inch thick air spaces gives values of conductance that are within ± 5.0 percent of the data, except for those values as indicated by the table of maximum departures following Table 2. For more precise values, the reference should be consulted.
[c] Interpolation, and moderate extrapolation, of conductance values are permissible for other values of mean temperature, temperature difference, and effective emissivity E. Conductance values for 0 and −50 F mean temperatures were extrapolated from the experimental data using a dimensionless correlation.
[d] Effective emissivity of space, E, is given by $1/E = 1/\epsilon_1 + 1/\epsilon_2 - 1$, where ϵ_1 and ϵ_2 are the emissivities of the surfaces of the air space. (See Section B of Table 4-1).
[e] The resistance values were determined from the relationship $R = 1/C$ prior to rounding off the conductance value to two decimal places for tabulation.
[*] Based on National Bureau of Standards data presented in Housing Research Paper No. 32, Housing and Home Finance Agency, 1954 (Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.).
[f] The conductances of horizontal spaces with heat flow downward are substantially independent of temperature difference.
[g] See text section, Caution, re BMS 151.

Table 4-2B. . . . . Thermal Conductances and Resistances of a Plane[a,b,g] Air Space*
(¾, 1½, and 4 in. Air Space, Heat Flow Down)

Position of Air Space	Direction of Heat Flow	Air Space Thickness, in.	Air Space Mean Temp, F	¾ inch Thickness[b] Thermal Conductance — C Value of E 0.03	0.05	0.2	0.5	0.82	Thermal Resistance — R Value of E 0.03	0.05	0.2	0.5	0.82
Horiz.	Down[f]	¾	90	0.28	0.31	0.48	0.82	1.19	3.56	3.25	2.08	1.21	0.84
			50	0.26	0.28	0.42	0.69	0.98	3.80	3.55	2.39	1.44	1.02
			0	0.23	0.25	0.35	0.55	0.76	4.28	4.04	2.88	1.82	1.31
			−50	0.21	0.22	0.29	0.43	0.58	4.84	4.63	3.48	2.33	1.72
		1½	90	0.17	0.19	0.36	0.71	1.07	5.96	5.24	2.78	1.42	0.93
			50	0.16	0.17	0.31	0.59	0.88	6.41	5.74	3.21	1.71	1.14
			0	0.14	0.15	0.25	0.45	0.67	7.18	6.59	3.97	2.21	1.50
			−50	0.12	0.13	0.20	0.34	0.50	8.23	7.63	4.95	2.90	2.08
		4	90	0.10	0.12	0.30	0.64	1.01	9.02	8.08	3.38	1.56	0.99
			50	0.09	0.11	0.25	0.52	0.81	10.7	8.94	4.02	1.91	1.23
			0	0.08	0.09	0.19	0.39	0.61	12.4	10.9	5.20	2.54	1.65
			−50	0.07	0.08	0.15	0.29	0.45	14.0	12.3	6.57	3.40	2.24

Table 4-2C. . . . . . Thermal Conductances and Resistances of a Plane Air Space* (4 in. Air Space)[b]

Position of Air Space	Direction of Heat Flow	Air Space Mean Temp,[c] F	Air Space Temp Diff,[c] F deg	Thermal Conductance — C Value of E[c,d] 0.03	0.05	0.2	0.5	0.82	Thermal Resistance[e] — R Value of E[d] 0.03	0.05	0.2	0.5	0.82
Horiz.	Up	90	10	0.34	0.36	0.53	0.88	1.24	2.94	2.75	1.87	1.14	0.80
		50	30	0.47	0.48	0.62	0.89	1.17	2.14	2.06	1.62	1.13	0.85
		50	10	0.35	0.37	0.50	0.78	1.07	2.88	2.73	1.99	1.29	0.94
		0	20	0.44	0.45	0.55	0.75	0.98	2.28	2.22	1.81	1.33	1.03
		0	10	0.36	0.37	0.47	0.67	0.89	2.77	2.67	2.11	1.48	1.12
		−50	20	0.46	0.47	0.54	0.68	0.84	2.17	2.12	1.84	1.46	1.20
		−50	10	0.38	0.39	0.46	0.60	0.75	2.64	2.57	2.18	1.66	1.33
45° Slope	Up	90	10	0.31	0.33	0.51	0.85	1.21	3.22	3.00	1.98	1.18	0.82
		50	30	0.43	0.45	0.58	0.85	1.14	2.32	2.22	1.71	1.17	0.88
		50	10	0.31	0.33	0.47	0.74	1.04	3.18	3.00	2.13	1.34	0.96
		0	20	0.40	0.41	0.51	0.71	0.93	2.60	2.42	1.95	1.40	1.08
		0	10	0.32	0.34	0.44	0.64	0.85	3.09	2.97	2.49	1.57	1.17
		−50	20	0.42	0.43	0.50	0.64	0.79	2.39	2.33	2.00	1.56	1.26
		−50	10	0.34	0.35	0.42	0.56	0.71	2.97	2.89	2.40	1.79	1.41
Vertical	Horiz.	90	10	0.27	0.29	0.46	0.81	1.17	3.73	3.44	2.16	1.24	0.91
		50	30	0.36	0.38	0.52	0.78	1.07	2.74	2.62	1.94	1.28	0.94
		50	10	0.27	0.29	0.43	0.70	0.99	3.69	3.45	2.34	1.43	1.01
		0	20	0.34	0.35	0.45	0.65	0.87	2.98	2.86	2.22	1.53	1.16
		0	10	0.28	0.29	0.39	0.59	0.81	3.59	3.42	2.55	1.69	1.24
		−50	20	0.35	0.36	0.43	0.57	0.72	2.89	2.82	2.35	1.76	1.39
		−50	10	0.29	0.30	0.37	0.51	0.67	3.45	3.34	2.70	1.95	1.50
45° Slope	Down	90	10	0.21	0.23	0.40	0.74	1.11	4.84	4.36	2.50	1.34	0.90
		50	30	0.28	0.29	0.43	0.70	0.98	3.61	3.39	2.33	1.44	1.02
		50	10	0.21	0.23	0.36	0.64	0.93	4.79	4.41	2.75	1.57	1.08
		0	20	0.26	0.27	0.37	0.57	0.78	3.92	3.73	2.71	1.75	1.27
		0	10	0.21	0.23	0.33	0.53	0.74	4.67	4.39	3.05	1.89	1.35
		−50	20	0.26	0.27	0.34	0.48	0.64	3.82	3.68	2.92	2.06	1.57
		−50	10	0.22	0.23	0.30	0.45	0.60	4.47	4.29	3.29	2.24	1.67

ble 4-3A· · .... Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a]

(For Industrial Insulation Design Values, see Table 3B)

These constants are expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference). Conductivities (k) are per inch thickness, and conductances (C) are for thickness or construction stated, not per inch thickness

Material	Description	Density (Lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat, Btu per (lb) (F deg)
BUILDING BOARD[c]	Asbestos-cement board	120	75	4.0	—	0.25	—	
BOARDS, PANELS,	Asbestos-cement board ... 1/8 in.	120	75	—	33.00	—	0.03	
SUBFLOORING,	Asbestos-cement board ... 1/4 in.	120	75	—	16.50	—	0.06	
SHEATHING,	Gypsum or plaster board ... 3/8 in.	50	75	—	3.10	—	0.32	
WOODBASED PANEL	Gypsum or plaster board ... 1/2 in.	50	75	—	2.25	—	0.45	
PRODUCTS[12]	Plywood	34	75	0.80	—	1.25	—	0.29
	Plywood ... 1/4 in.	34	75	—	3.20	—	0.31	0.29
	Plywood ... 3/8 in.	34	75	—	2.13	—	0.47	0.29
	Plywood ... 1/2 in.	34	75	—	1.60	—	0.62	0.29
	Plywood or wood panels ... 3/4 in.	34	75	—	1.07	—	0.93	0.29
	Insulating board							
	Sheathing, regular density ... 1/2 in.	18	75	—	0.76	—	1.32	0.31
	... 25/32 in.	18	75	—	0.49	—	2.06	0.31
	Sheathing intermediate density . 1/2 in.	22	75	—	0.82	—	1.22	0.31
	Nail-base sheathing ... 1/2 in.	25	75	—	0.88	—	1.14	0.31
	Shingle backer ... 3/8 in.	18	75	—	1.06	—	0.94	0.31
	Shingle backer ... 5/16 in.	18	75	—	1.28	—	0.78	0.31
	Sound deadening board ... 1/2 in.	15		—	0.74	—	1.35	0.30
	Tile and lay-in panels, plain or acoustic	18	75	0.40	—	2.50	—	0.32
	... 1/2 in.	18	75	—	0.80	—	1.25	0.32
	... 3/4 in.	18	75	—	0.53	—	1.89	0.32
	Laminated paperboard	30	75	0.50	—	2.00	—	
	Homogeneous board from repulped paper	30	75	0.50	—	2.00	—	0.28
	Hardboard							
	Medium density siding ... 7/16 in.	40	75	—	1.49	—	0.67	0.28
	Other medium density	50	75	0.73	—	1.37	—	0.31
	High density, service temp. service, underlay	55	75	0.82	—	1.22	—	0.33
	High density, std. tempered	63	75	1.00	—	1.00	—	0.33
	Particleboard							
	Low density	37	75	0.54	—	1.85	—	0.31
	Medium density	50	75	0.94	—	1.06	—	0.31
	High density	62.5	75	1.18	—	0.85	—	0.31
	Underlayment ... 5/8 in.	40	75	—	1.22	—	0.82	0.29
	Wood subfloor ... 3/4 in.		75	—	1.06	—	0.94	0.34
BUILDING PAPER	Vapor—permeable felt	—	75	—	16.70	—	0.06	
	Vapor—seal, 2 layers of mopped 15 lb felt	—	75	—	8.35	—	0.12	
	Vapor—seal, plastic film	—	75	—	—	—	Negl.	

Table 4-3A·········Conductivities, Conductances, and Resistances of Building and Insulating Materials— (Design Values)[a] (*Continued*)

Material	*Description*	*Density (Lb per Cu Ft)*	*Mean Temp F*	*Conductivity (k)*	*Conductance (C)*	*Resistance[b] (R)* Per inch thickness (1/k)	*Resistance[b] (R)* For thickness listed (1/C)	*Specific Heat, Btu per (lb) (F deg)*
FINISH FLOORING MATERIALS	Carpet and fibrous pad.............	—	75	—	0.48	—	*2.08*	
	Carpet and rubber pad.............	—	75	—	0.81	—	*1.23*	0.34
	Cork tile.......................⅛ in.	—	75	—	3.60	—	*0.28*	
	Terrazzo........................1 in.	—	75	—	12.50	—	*0.08*	
	Tile—asphalt, linoleum, vinyl, rubber.	—	75	—	20.00	—	*0.05*	0.30
INSULATING MATERIALS	Mineral Fiber, fibrous form processed from rock, slag, or glass							
BLANKET AND BATT	approx.[e] 2–2¾ in...............	—	75	—	—	—	*7*[d]	0.18
	approx.[e] 3–3½ in...............	—	75	—	—	—	*11*[d]	0.18
	approx.[e] 5¼–6½ in...............	—	75	—	—	—	*19*[d]	0.18
BOARD AND SLABS	Cellular glass.....................	9	75	0.40	—	*2.50*	—	0.24
	Glass fiber, organic bonded..........	4–9	75	0.25	—	*4.00*	—	0.19
	Expanded rubber (rigid).............	4.5	75	0.22	—	*4.55*	—	
	Expanded polystyrene extruded, plain.....................	1.8	75	0.25	—	*4.00*	—	0.29
	Expanded polystyrene extruded, (R-12 exp.).....................	2.2	75	0.20	—	*5.00*	—	0.29
	Expanded polystyrene extruded, (R-12 exp.) (Thickness 1 in. and greater)..	3.5	75	0.19	—	*5.26*	—	0.29
	Expanded polystyrene, molded beads.	1.0	75	0.28	—	*3.57*	—	0.29
	Expanded polyurethane[f] (R-11 exp.)	1.5	75	0.16	—	*6.25*	—	0.38
	(Thickness 1 in. or greater).........	2.5						0.38
	Mineral fiber with resin binder.......	15	75	0.29	—	*3.45*	—	0.17
	Mineral fiberboard, wet felted							
	Core or roof insulation............	16–17	75	0.34	—	*2.94*	—	
	Acoustical tile....................	18	75	0.35	—	*2.86*	—	
	Acoustical tile....................	21	75	0.37	—	*2.70*	—	
	Mineral fiberboard, wet molded							
	Acoustical tile[g].....................	23	75	0.42	—	*2.38*	—	
	Wood or cane fiberboard							
	Acoustical tile[g]...............½ in.	—	75	—	0.80	—	*1.25*	0.30
	Acoustical tile[g]...............¾ in.	—	75	—	0.53	—	*1.89*	0.30
	Interior finish (plank, tile)	15	75	0.35	—	*2.86*	—	0.32
	Insulating roof deck							
	Approximately..............1½ in.	—	75	—	0.24	—	*4.17*	
	Approximately...............2 in.	—	75	—	0.18	—	*5.56*	
	Approximately...............3 in.	—	75	—	0.12	—	*8.33*	
	Wood shredded (cemented in preformed slabs)................	22	75	0.60	—	*1.67*	—	0.38
LOOSE FILL	Cellulose insulation (milled paper or wood pulp).....................	2.5–3	75	0.27	—	*3.70*	—	0.33
	Sawdust or shavings................	8.0–15	75	0.45	—	*2.22*	—	0.33
	Wood fiber, softwoods..............	2.0–3.5	75	0.30	—	*3.33*	—	0.33
	Perlite, expanded..................	5.0–8.0	75	0.37	—	*2.70*	—	
	Mineral fiber (rock, slag or glass)							
	approx.[e] 3 in...................	—	75	—	—	—	*9*[d]	0.18
	approx.[e] 4½ in..................	—	75	—	—	—	*13*[d]	0.18
	approx.[e] 6¼ in..................	—	75	—	—	—	*19*[d]	0.18
	approx.[e] 7½ in..................	—	75	—	—	—	*24*[d]	0.18
	Silica aerogel......................	7.6	75	0.17	—	*5.88*	—	
	Vermiculite (expanded).............	7.0–8.2	75	0.47	—	*2.13*	—	
		4.0–6.0	75	0.44	—	*2.27*	—	
ROOF INSULATION[h]	Preformed, for use above deck							
	Approximately...............½ in.	—	75	—	0.72	—	*1.39*	
	Approximately...............1 in.	—	75	—	0.36	—	*2.78*	
	Approximately..............1½ in.	—	75	—	0.24	—	*4.17*	
	Approximately...............2 in.	—	75	—	0.18	—	*5.56*	
	Approximately..............2½ in.	—	75	—	0.15	—	*6.67*	
	Approximately...............3 in.	—	75	—	0.12	—	*8.33*	
	Cellular glass......................	9	75	0.40	—	*2.50*	—	0.24
MASONRY MATERIALS CONCRETES	Cement mortar.....................	116		5.0	—	*0.20*	—	
	Gypsum-fiber concrete 87½% gypsum, 12½% wood chips................	51		1.66	—	*0.60*	—	
	Lightweight aggregates including expanded shale, clay or slate; expanded slags; cinders; pumice; vermiculite; also cellular concretes	120		5.2	—	*0.19*	—	
		100		3.6	—	*0.28*	—	
		80		2.5	—	*0.40*	—	
		60		1.7	—	*0.59*	—	
		40		1.15	—	*0.86*	—	
		30		0.90	—	*1.11*	—	
		20		0.70		*1.43*		

Table 4-3A...... Conductivities, Conductances, and Resistances of Building and Insulating Materials— (Design Values)[a] (*Continued*)

Material	Description	Density (Lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[a] (R) Per inch thickness (1/k)	Resistance[a] (R) For thickness listed (1/C)	Specific Heat, Btu per (lb)(F deg)
MASONRY MATERIALS CONCRETES (*Continued*)	Sand and gravel or stone aggregate (oven dried)	140		9.0	—	0.11	—	
	Sand and gravel or stone aggregate (not dried)	140		12.0	—	0.08	—	
	Stucco	116		5.0	—	0.20	—	
MASONRY UNITS	Brick, common[i]	120	75	5.0	—	0.20	—	
	Brick, face[i]	130	75	9.0	—	0.11	—	
	Clay tile, hollow:							
	1 cell deep ... 3 in.	—	75	—	1.25	—	0.80	
	1 cell deep ... 4 in.	—	75	—	0.90	—	1.11	
	2 cells deep ... 6 in.	—	75	—	0.66	—	1.52	
	2 cells deep ... 8 in.	—	75	—	0.54	—	1.85	
	2 cells deep ... 10 in.	—	75	—	0.45	—	2.22	
	3 cells deep ... 12 in.	—	75	—	0.40	—	2.50	
	Concrete blocks, three oval core:							
	Sand and gravel aggregate ... 4 in.	—	75	—	1.40	—	0.71	
	... 8 in.	—	75	—	0.90	—	1.11	
	... 12 in.	—	75	—	0.78	—	1.28	
	Cinder aggregate ... 3 in.	—	75	—	1.16	—	0.86	
	... 4 in.	—	75	—	0.90	—	1.11	
	... 8 in.	—	75	—	0.58	—	1.72	
	... 12 in.	—	75	—	0.53	—	1.89	
	Lightweight aggregate (expanded shale, clay, slate or slag; pumice) 3 in.	—	75	—	0.79	—	1.27	
	4 in.	—	75	—	0.67	—	1.50	
	8 in.	—	75	—	0.50	—	2.00	
	12 in.	—	75	—	0.44	—	2.27	
	Concrete blocks, rectangular core.[j]							
	Sand and gravel aggregate							
	2 core, 8 in. 36 lb.[k]	—	45	—	0.96	—	1.04	
	Same with filled cores[l]	—	45	—	0.52	—	1.93	
	Lightweight aggregate (expanded shale, clay, slate or slag, pumice):							
	3 core, 6 in. 19 lb.[k]	—	45	—	0.61	—	1.65	
	Same with filled cores[l]	—	45	—	0.33	—	2.99	
	2 core, 8 in. 24 lb.[k]	—	45	—	0.46	—	2.18	
	Same with filled cores[l]	—	45	—	0.20	—	5.03	
	3 core, 12 in. 38 lb.[k]	—	45	—	0.40	—	2.48	
	Same with filled cores[l]	—	45	—	0.17	—	5.82	
	Stone, lime or sand	—	75	12.50	—	0.08	—	
	Gypsum partition tile:							
	3 × 12 × 30 in. solid	—	75	—	0.79	—	1.26	
	3 × 12 × 30 in. 4-cell	—	75	—	0.74	—	1.35	
	4 × 12 × 30 in. 3-cell	—	75	—	0.60	—	1.67	
METALS	(See Chapter 30, Table 3, 1972 ASHRAE Handbook of Fundamentals)							
PLASTERING MATERIALS	Cement plaster, sand aggregate	116	75	5.0	—	0.20	—	
	Sand aggregate ... 3/8 in.	—	75	—	13.3	—	0.08	
	Sand aggregate ... 3/4 in.	—	75	—	6.66	—	0.15	
	Gypsum plaster:							
	Lightweight aggregate ... 1/2 in.	45	75	—	3.12	—	0.32	
	Lightweight aggregate ... 5/8 in.	45	75	—	2.67	—	0.39	
	Lightweight agg. on metal lath. 3/4 in.	—	75	—	2.13	—	0.47	
	Perlite aggregate	45	75	1.5	—	0.67	—	
	Sand aggregate	105	75	5.6	—	0.18	—	
	Sand aggregate ... 1/2 in.	105	75	—	11.10	—	0.09	
	Sand aggregate ... 5/8 in.	105	75	—	9.10	—	0.11	
	Sand aggregate on metal lath .. 3/4 in.	—	75	—	7.70	—	0.1	
	Vermiculite aggregate	45	75	1.7	—	0.59	—	
ROOFING	Asbestos-cement shingles	120	75	—	4.76	—	0.21	
	Asphalt roll roofing	70	75	—	6.50	—	0.15	
	Asphalt shingles	70	75	—	2.27	—	0.44	
	Built-up roofing ... 3/8 in.	70	75	—	3.00	—	0.33	0.35
	Slate ... 1/2 in.	—	75	—	20.00	—	0.05	
	Wood shingles, plain a plastic film faced	—	75	—	1.06	—	0.94	0.31
SIDING MATERIALS (ON FLAT SURFACE)	Shingles							
	Asbestos-cement	120	75	—	4.76	—	0.21	
	Wood, 16 in., 7½ exposure	—	75	—	1.15	—	0.87	0.31

Table 4-3A .... Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a] (*Concluded*)

Material	Description	Density (Lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat Btu per (lb) (F deg)
SIDING MATERIALS (ON FLAT SURFACE) (*Continued*)	Wood, double, 16-in., 12-in. exposure	—	75	—	0.84	—	*1.19*	0.31
	Wood, plus insul. backer board. 7/16 in.	—	75	—	0.71	—	*1.40*	0.31
	Siding							
	Asbestos-cement, 1/4 in., lapped	—	75	—	4.76	—	*0.21*	
	Asphalt roll siding	—	75	—	6.50	—	*0.15*	
	Asphalt insulating siding (1/2 in. bd.)	—	75	—	0.69	—	*1.46*	
	Wood, drop, 1 × 8 in.	—	75	—	1.27	—	*0.79*	0.31
	Wood, bevel, 1/2 × 8 in., lapped	—	75	—	1.23	—	*0.81*	0.31
	Wood, bevel, 3/4 × 10 in., lapped	—	75	—	0.95	—	*1.05*	0.31
	Wood, plywood, 3/8 in., lapped	—	75	—	1.59	—	*0.59*	0.29
	Aluminum or Steel[m], over sheathing							
	Hollow-backed	—	—	—	1.61	—	*0.61*	
	Insulating-board backed nominal 3/8 in.	—	—	—	0.55	—	*1.82*	
	Insulating-board backed nominal 3/8 in. foil backed	—	—	—	0.34	—	*2.96*	
	Architectural glass	—	75	—	10.00	—	*0.10*	
WOODS	Maple, oak, and similar hardwoods	45	75	1.10	—	*0.91*	—	0.30
	Fir, pine, and similar softwoods	32	75	0.80	—	*1.25*	—	0.33
	Fir, pine, and similar softwoods . . 3/4 in.	32	75	—	1.06	—	*0.94*	0.33
	. . 1 1/2 in.	32	75	—	0.53	—	*1.89*	0.33
	. . 2 1/2 in.	32	75	—	0.32	—	*3.12*	0.33
	. . 3 1/2 in.	32	75	—	0.23	—	*4.35*	0.33

Notes for Table 4-3A

[a] Representative values for dry materials is selected by the ASHRAE Committee 2.4 on Insulation. They are intended as design (not specification) values for materials of building construction in normal use. For conductivity of a particular product, the user may obtain the value supplied by the manufacturer or secure the results of unbiased tests.

[b] Resistance values are the reciprocals of C before rounding off C to two decimal places.

[c] See also Insulating Materials, Board.

[d] Includes paper backing and facing if any. In cases where the insulation forms a boundary (highly reflective or otherwise) of an air space, refer to Tables 1 and 2, to obtain the insulating value of air space for the appropriate effective emissivity and temperature conditions of the space.

[e] Conductivity varies also with fiber diameter. See also Factors Affecting Thermal Conductivity and Fig. 1, Chapter 17. Insulation is produced by different densities, therefore, there is a wide variation in thickness for the same R-value between various manufacturers. No effort should be made to relate any specific R-value to any specific thickness. The commercial thicknesses generally available range from 2 to 7 in.

[f] These are values for aged board stock. For discussion on the change in conductivity with age of Refrigerant 11 expanded urethane see Chapter 17, Factors Affecting Thermal Conductivity.

[g] Insulating values of acoustical tile vary depending on density of the board and on the type, size, and depth of the perforations. An average conductivity k value is 0.40.

[h] The U. S. Department of Commerce, *Simplified Practice Recommendation for Thermal Conductances Factors for Performed Above-Deck Roof Insulation*, No. R 257-55, recognizes the specification of roof insulation on the basis of the C values shown. Roof insulation is made in thicknesses to meet these values. Therefore, thickness supplied by different manufacturers may vary depending on the conductivity k value of the particular material.

[i] Face brick and common brick do not always have these specific densities. When the density is different from that shown, there will be a change in the thermal conductivity.

[j] Data on rectangular core concrete blocks differs from the above data on oval core blocks due to core configuration, different mean temperatures and possibly differences in unit weights. Weight data on the oval core blocks tested is not available.

[k] Weights of units approximately 7 5/8 in. high and 15 5/8 in. long. These weights are given as a means of describing the blocks tested, but conductance values are all for one square foot of area.

[l] Vermiculite, perlite or mineral wool insulation. Where insulation is used vapor barriers or other precautions must be considered to keep insulation dry.

[m] Values for metal siding applied over flat surfaces vary widely depending upon the amount of ventilation of air space beneath the siding, whether the air space is reflective or nonreflective, and on the thickness, type, and application of insulating backing-board used. Values given are averages intended for use as design guide values and were obtained from several guarded hot-box tests (ASTM C236) on hollow-backed types and on types made using backer-board of wood-fiber, foamed plastic, and glass fiber. Departures of ±50 percent, or more, from the values given may occur.

Table 4-3A...Supplement

Material	Description	Resistance (R) for thickness listed
Wood Roofing Assemblies	Shingles (½ in. avg. butt thickness)	0.94
(Resistances listed are for the total assembly)	Tapered medium shakes with 30 lb. felt shingled between each course. (5/8 in. avg. butt thickness)	1.15
	Tapered heavy shakes with 30 lb. felt shingled between each course. (1 in. avg. butt thickness)	1.69

Table 4-3B ..... **Thermal Conductivity (*k*) of Industrial Insulation (Design Values)[a] (For Mean Temperatures Indicated)**

Expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference per in.)

Form	Material (Composition)	Accepted Max Temp for Use,* F	Typical Density (lb/cu ft)	Typical Conductivity k at Mean Temp F													
				−100	−75	−50	−25	0	25	50	75	100	200	300	500	700	900
BLANKETS & FELTS	MINERAL FIBER (Rock, Slag, or Glass) Blanket, Metal Reinforced	1200	6–12									0.26	0.32	0.39	0.54		
		1000	2.5–6									0.24	0.31	0.40	0.61		
	Mineral Fiber, Glass Blanket, Flexible, Fine-Fiber Organic Bonded	350	0.65				0.25	0.26	0.28	0.30	0.33	0.36	0.53				
			0.75				0.24	0.25	0.27	0.29	0.32	0.34	0.48				
			1.0				0.23	0.24	0.25	0.27	0.29	0.32	0.43				
			1.5				0.21	0.22	0.23	0.25	0.27	0.28	0.37				
			2.0				0.20	0.21	0.22	0.23	0.25	0.26	0.33				
			3.0				0.19	0.20	0.21	0.22	0.23	0.24	0.31				
	Blanket, Flexible, Textile-Fiber Organic Bonded	350	0.65				0.27	0.28	0.29	0.30	0.31	0.32	0.50	0.68			
			0.75				0.26	0.27	0.28	0.29	0.31	0.32	0.48	0.66			
			1.0				0.24	0.25	0.26	0.27	0.29	0.31	0.45	0.60			
			1.5				0.22	0.23	0.24	0.25	0.27	0.29	0.39	0.51			
			3.0				0.20	0.21	0.22	0.23	0.24	0.25	0.32	0.41			
	Felt, Semi-Rigid Organic Bonded	400	3–8						0.24	0.25	0.26	0.27	0.35	0.44			
		850	3	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.35	0.55			
	Laminated & Felted Without Binder	1200	7.5											0.35	0.45	0.60	
	VEGETABLE & ANIMAL FIBER Hair Felt or Hair Felt plus Jute	180	10						0.26	0.28	0.29	0.30					
BLOCKS, BOARDS & PIPE INSULATION	ASBESTOS Laminated Asbestos Paper	700	30									0.40	0.45	0.50	0.60		
	Corrugated & Laminated Asbestos Paper 4-ply	300	11–13								0.54	0.57	0.68				
	6-ply	300	15–17								0.49	0.51	0.59				
	8-ply	300	18–20								0.47	0.49	0.57				
	MOLDED AMOSITE & BINDER	1500	15–18									0.32	0.37	0.42	0.52	0.62	0.72
	85% MAGNESIA	600	11–12									0.35	0.38	0.42			
	CALCIUM SILICATE	1200	11–13									0.38	0.41	0.44	0.52	0.62	0.72
		1800	12–15												0.63	0.74	0.95
	CELLULAR GLASS	800	9			0.32	0.33	0.35	0.36	0.38	0.40	0.42	0.48	0.55			
	DIATOMACEOUS SILICA	1600	21–22												0.64	0.68	0.72
		1900	23–25												0.70	0.75	0.80
	MINERAL FIBER Glass, Organic Bonded, Block and Boards	400	3–10	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.25	0.26	0.33	0.40			
	Non-Punking Binder	1000	3–10									0.26	0.31	0.38	0.52		
	Pipe Insulation, slag or glass	350	3–4					0.20	0.21	0.22	0.23	0.24	0.29				
		500	3–10					0.20	0.22	0.24	0.25	0.26	0.33	0.40			
	Inorganic Bonded-Block	1000	10–15									0.33	0.38	0.45	0.55		
		1800	15–24									0.32	0.37	0.42	0.52	0.62	0.74
	Pipe Insulation slag or glass	1000	10–15									0.33	0.38	0.45	0.55		
	MINERAL FIBER Resin Binder		15			0.23	0.24	0.25	0.26	0.28	0.29						
	Rigid Polystyrene Extruded, R-12 exp	170	3.5	0.16	0.16	0.15	0.16	0.16	0.17	0.18	0.19	0.20					
	Extruded, R-12 exp	170	2.2	0.16	0.16	0.17	0.16	0.17	0.18	0.19	0.20						
	Extruded	170	1.8	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.25	0.27					
	Molded Beads	170	1	0.18	0.20	0.21	0.23	0.24	0.25	0.26	0.28						
	Polyurethane** R-11 exp	210	1.5–2.5	0.16	0.17	0.18	0.18	0.18	0.17	0.16	0.16	0.17					
	RUBBER, Rigid Foamed	150	4.5						0.20	0.21	0.22	0.23					
	VEGETABLE & ANIMAL FIBER Wool Felt (Pipe Insulation)	180	20						0.28	0.30	0.31	0.33					
INSULATING CEMENTS	MINERAL FIBER (Rock, Slag, or Glass) With Colloidal Clay Binder	1800	24–30									0.49	0.55	0.61	0.73	0.85	
	With Hydraulic Setting Binder	1200	30–40									0.75	0.80	0.85	0.95		
LOOSE FILL	Cellulose insulation (Milled pulverized paper or wood pulp)		2.5–3							0.26	0.27	0.29					
	Mineral fiber, slag, rock or glass		2–5			0.19	0.21	0.23	0.25	0.26	0.28	0.31					
	Perlite (expanded)		5–8	0.25	0.27	0.29	0.30	0.32	0.34	0.35	0.37	0.39					
	Silica aerogel		7.6			0.13	0.14	0.15	0.15	0.16	0.17	0.18					
	Vermiculite (expanded)		7–8.2			0.39	0.40	0.42	0.44	0.45	0.47	0.49					
			4–6			0.34	0.35	0.38	0.40	0.42	0.44	0.46					

[a] Representative values for dry materials as selected by the ASHRAE Technical Committee 2.4 on Insulation. They are intended as design (not specification) values for materials of building construction for normal use. For the thermal resistance of a particular product, the user may obtain the value supplied by the manufacturer or secure the results of unbiased tests.

* These temperatures are generally accepted as maximum. When operating temperature approaches these limits the manufacturer's recommendations should be followed.

** These are values for aged board stock. For discussion on the change in conductivity with age of Refrigerant 11 expanded urethane see section on Factors Affecting Thermal Conductivity, Chapter 17.

Table 4-3C...... Coefficients of Transmission (U) of Windows, Skylights, and Light Transmitting Partitions

Btu per (hr) (sq ft) (F Deg)

PART A—VERTICAL PANELS (EXTERIOR WINDOWS, SLIDING PATIO DOORS, AND PARTITIONS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC SHEET

Description	Exterior[a]		Interior
	Winter	Summer	
Flat Glass			
single glass	1.13	1.06	0.73
insulating glass—double[b]			
3/16 in. air space	0.69	0.64	0.51
1/4 in. air space	0.65	0.61	0.49
1/2 in. air space	0.58	0.56	0.46
1/2 in. air space, low emissivity coating[c]			
emissivity = 0.20	0.38	0.36	0.32
emissivity = 0.40	0.45	0.44	0.38
emissivity = 0.60	0.52	0.50	0.42
insulating glass—triple[b]			
1/4 in. air spaces	0.47	0.45	0.38
1/2 in. air spaces	0.36	0.35	0.30
storm windows			
1 in.–4 in. air space	0.56	0.54	0.44
Glass Block[d]			
6 × 6 × 4 in. thick	0.60	0.57	0.46
8 × 8 × 4 in. thick	0.56	0.54	0.44
—with cavity divider	0.48	0.46	0.38
12 × 12 × 4 in. thick	0.52	0.50	0.41
—with cavity divider	0.44	0.42	0.36
12 × 12 × 2 in. thick	0.60	0.57	0.46
Single Plastic Sheet	1.09	1.00	0.70

[a] See Part C for adjustment for various window and sliding patio door types.
[b] Double and triple refer to the number of lights of glass.
[c] Coating on either glass surface facing air space; all other glass surfaces uncoated.
[d] Dimensions are nominal.
[e] For heat flow up.
[f] For heat flow down.
[g] Based on area of opening, not total surface area.
[h] Refers to windows with negligible opaque area.
[i] Value becomes 1.00 when storm sash is spearated from prime window by a thermal break.

PART B—HORIZONTAL PANELS (SKYLIGHTS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC BUBBLES

Description	Exterior[a]		Interior[e]
	Winter[e]	Summer[f]	
Flat Glass			
single glass	1.22	0.83	0.96
insulating glass—double[b]			
3/16 in. air space	0.75	0.49	0.62
1/4 in. air space	0.70	0.46	0.59
1/2 in. air space	0.66	0.44	0.56
1/2 in. air space, low emissivity coating[c]			
emissivity = 0.20	0.46	0.31	0.30
emissivity = 0.40	0.53	0.36	0.45
emissivity = 0.60	0.60	0.40	0.50
Glass Block[d]			
11 × 11 × 3 in. thick with cavity divider	0.53	0.35	0.44
12 × 12 × 4 in. thick with cavity divider	0.51	0.34	0.42
Plastic Bubbles[g]			
single walled	1.15	0.80	—
double walled	0.70	0.46	—

PART C—ADJUSTMENT FACTORS FOR VARIOUS WINDOW AND SLIDING PATIO DOOR TYPES (MULTIPLY U VALUES IN PARTS A AND B BY THESE FACTORS)

Description	Single Glass	Double or Triple Glass	Storm Windows
Windows			
All Glass[h]	1.00	1.00	1.00
Wood Sash—80% Glass	0.90	0.95	0.90
Wood Sash—60% Glass	0.80	0.85	0.80
Metal Sash—80% Glass	1.00	1.20	1.20[i]
Sliding Patio Doors			
Wood Frame	0.95	1.00	—
Metal Frame	1.00	1.10	—

CHAPTER 5

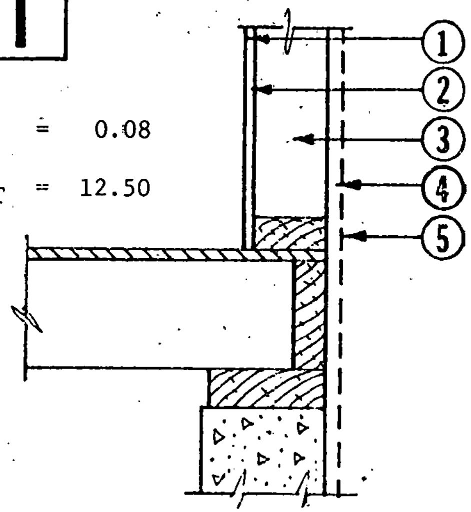
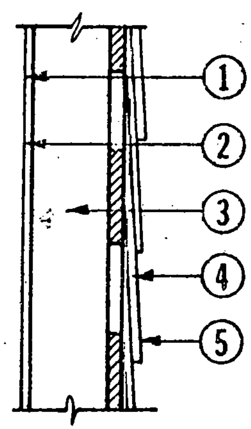
TYPICAL ASSEMBLIES

SCOPE

The purpose of this chapter is to provide the Building Official and Designer with "U" Factor data relative to some of the more typical wall, ceiling, and floor assemblies used in residential construction in California. Resistance values used herein are taken from tables in the ASHRAE Handbook of Fundamentals (1972) reproduced in Chapter 4 of this manual.

While it is impossible to depict every conceivable type of construction, these assemblies are representative of those commonly in use. Minor variations in thickness of materials or changes in materials can be taken into consideration using the technique outlined in Chapter 4.

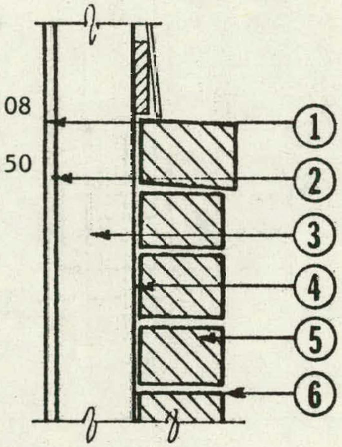
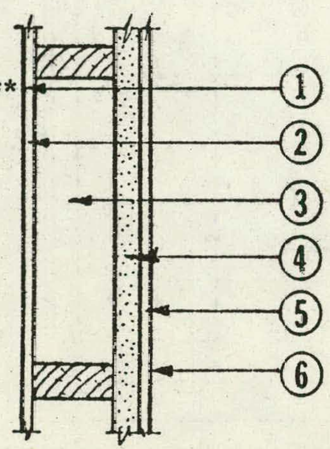
In most cases, these assemblies are organized so that the "Insulation Resistance Required" to meet the standard is shown in the righthand column. It is anticipated that plans submitted for approval will show sectional drawings of the proposed construction assemblies with the type and R value of the insulation clearly described. The plan checker should thus be able to quickly determine that a proposed "typical" construction assembly conforms to the regulations.

WALL SECTION	BASIC WALL WITH ½" GYPSUM WALLBOARD INTERIOR FINISH +	***EXTERIOR FINISH AND/OR EXTERIOR SHEATHING =	R	INSULATION RESISTANCE REQUIRED; R_i
1  U = 0.08 R_T = 12.50	CONSTRUCTION — R 1. Interior air film — 0.68 2. 1/2" gypsum wallboard — 0.45 3. Air space* — 4. Exterior finish — *** 5. Exterior air film — 0.17 R =1.30	7/8" stucco over wire backed paper (R=0.235)	1.54	10.96
		3/8" plywood (R=0.47)	1.77	10.73
		3/4" stucco over 1/2" gypsum wall-board (R=0.60)	1.90	10.60
		3/4" stucco over 3/8" plywood (R=0.62)	1.92	10.58
		3/4" stucco over 1/2" fiberboard (R=1.47)	2.77	9.73
		3/4" stucco over 25/32" fiberboard (R=2.21)	3.51	8.99
2  U = 0.08 R_T = 12.50	CONSTRUCTION — R 1. Interior air film — 0.68 2. 1/2" gypsum wallboard — 0.45 3. Air space* — ---- 4. Wood shingles — 0.87 5. Exterior air film — 0.17 R =2.17	----	2.17	10.33

*No credit given for air space to be filled with insulation

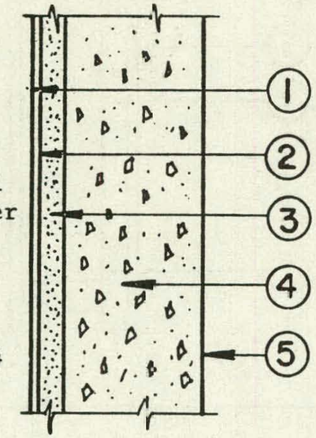
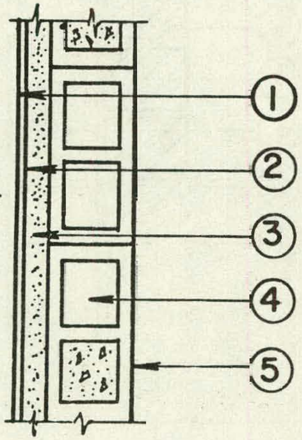
$R_i = R_T - R$

WALLS

WALL SECTION	BASIC WALL WITH ½" GYPSUM WALLBOARD INTERIOR FINISH	+ ***EXTERIOR FINISH AND/OR EXTERIOR SHEATHING	= R	INSULATION RESISTANCE REQUIRED; R_i
3  U = 0.08 R_T = 12.50	CONSTRUCTION — R 1. Interior air film — 0.68 2. 1/2" gypsum wallboard — 0.45 3. Air space* — ---- 4. Bldg. paper — 0.06 5. Common brick**** — 0.80 6. Exterior air film — 0.17 R =2.16	-----	2.16	10.34
		*No credit given for air space to be filled with insulation. ****"R" of brick essentially as for 1" wood siding.		
4  U = 0.095** R_T = 10.52 **Note: Insulation not pene-trated by framing	CONSTRUCTION — R 1. Interior air film — 0.68 2. 1/2" gypsum wallboard — 0.45 3. Air space (3-1/2") — 1.01 4. Insulation required — ---- 5. Exterior finish — *** 6. Exterior air film — 0.17 R =2.31	7/8" stucco over building paper (R=0.235)	2.55	7.97
		3/8" plywood (R=0.47)	2.78	7.74
		Common brick veneer over building paper (R=0.80)	3.11	7.41

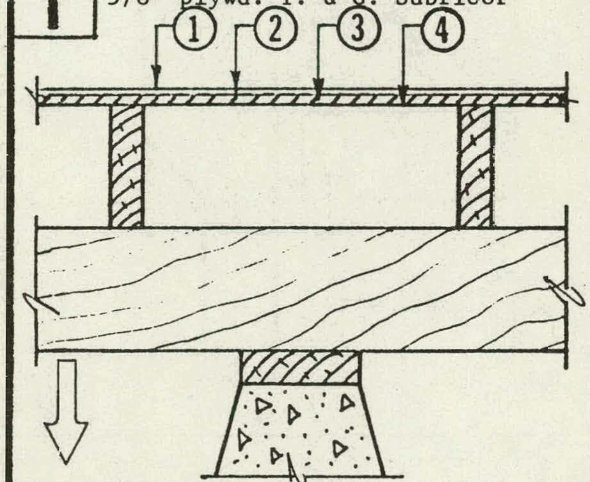
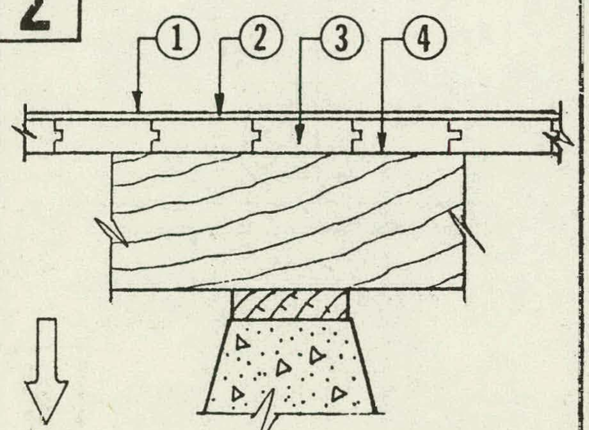
$R_i = R_T - R$

WALLS

WALL SECTION	BASIC WALL WITH ½" GYPSUM WALLBOARD INTERIOR FINISH +	*** STRUCTURAL WALL =	R	INSULATION * RESISTANCE REQUIRED; R_i
5  U = 0.16 ** R_T = 6.25 **Note: Wall weight greater than 40 lbs/ sq ft; less than 3500 degree days. See page 5-14 for other conditions.	CONSTRUCTION — R 1. Interior air film 0.68 2. ½" gypsum wallboard 0.45 3. Insulation required --- 4. Structural wall *** 5. Exterior air film 0.17 R = 1.30	6" Structural concrete (R=0.48)	1.78	4.47*
		3-3/4" common brick 2-1/4" grout, 3-3/4" common brick (R=1.95)	3.25	3.00*
		*If the insulation is penetrated by furring, the effects of the furring must be considered.		
6  U = 0.16 ** R_T = 6.25 **Note: Wall weight greater than 40 lbs/ sq ft; less than 3500 degree days. See page 5-14 for other conditions.	CONSTRUCTION — R 1. Interior air film 0.68 2. ½" gypsum wallboard 0.45 3. Insulation required --- 4. Structural wall *** 5. Exterior air film 0.17 R = 1.30	8" concrete block (100 pcf) Grouted cells (140 pcf) Vertical at 32" o.c. Horizontal at 48" o.c. Other cells filled with vermiculite, R=2.13/in (R=2.51) ****	3.81	2.44*
		8" concrete block (120 pcf) Grouted cells (140 pcf) Vertical at 24" o.c. Horizontal at 48" o.c. Other cells-no insulation (R=1.30) ****	2.60	3.65*
		*If the insulation is penetrated by furring, the effects of the furring must be considered. **** See Page 5-11 for calculation method.		

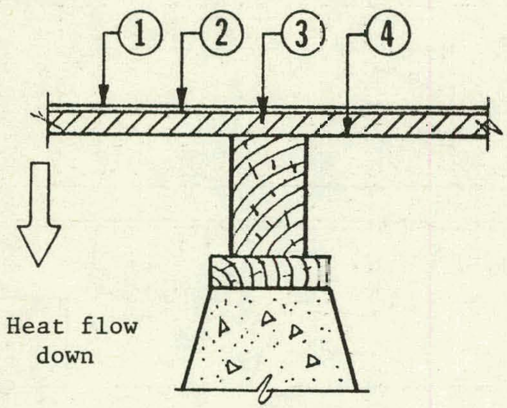
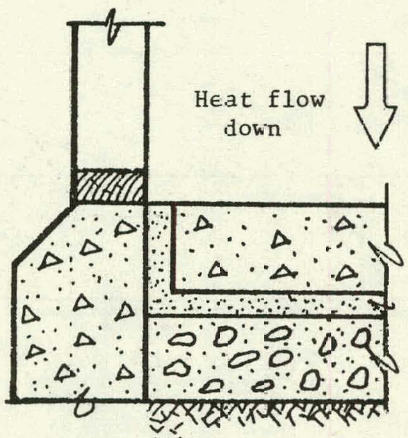
$R_i = R_T - R$

WALLS

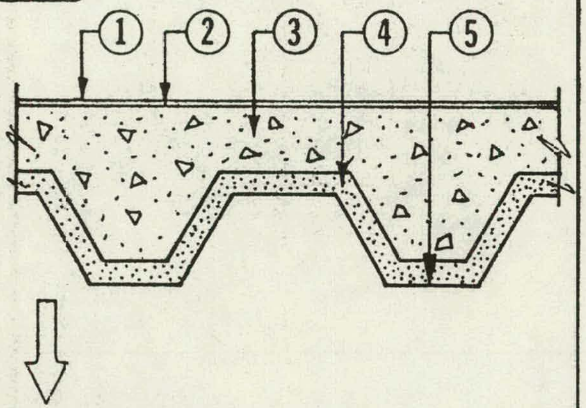
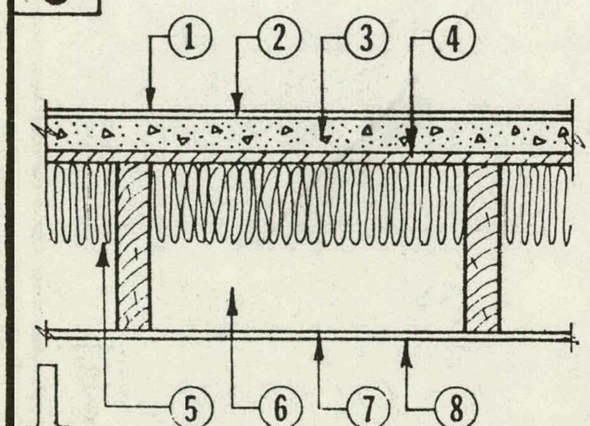
FLOOR SECTION	FLOOR COMPONENTS		R	INSULATION RESISTANCE REQUIRED; R_i	
				U=0.10 R_T=10.0	U=0.08 R_T=12.50
1 5/8" plywd. T. & G. Subfloor  Heat flow down	<u>CONSTRUCTION</u> 1. Interior air film (Still air) 2. 5/16" particle board and linoleum 3. 5/8" plywood subfloor 4. Exterior air film (Still air, heat flow down)	<u>R</u> 0.92 0.46 0.78 0.92 R =3.08	3.08	6.92	9.42
2 2" x 6" (nom) T. & G. Subfloor  Heat flow down	<u>CONSTRUCTION</u> 1. Interior air film (Still air) 2. 5/16" particle board and linoleum 3. 2x6 Subfloor 4. Exterior air film (Still air, heat flow down)	<u>R</u> 0.92 0.46 1.89 0.92 R =4.19	4.19	5.81	8.31

FLOORS

$R_i = R_T - R$

FLOOR SECTION	FLOOR COMPONENTS	R	INSULATION RESISTANCE REQUIRED; R_i	
			U=0.10 R_T=10.0	U=0.08 R_T=12.50
3 1-1/8" plywood T. & G.  	CONSTRUCTION — R 1. Interior air film (Still air) — 0.92 2. Linoleum — 0.05 3. 1-1/8" plywood combination subfloor and underlayment — 1.40 4. Exterior air film (Still air, heat flow down) — 0.92 R =3.29	3.29	6.71	9.21
4  	FOR INSULATION REQUIREMENTS FOR SLABS ON GRADE SEE TABLE NO. 17-D OF THE REGULATIONS			

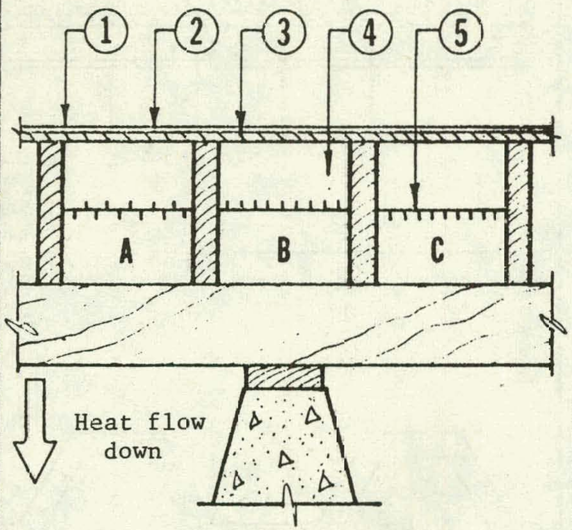
$R_i = R_T - R$

FLOOR SECTION	FLOOR COMPONENTS	R	INSULATION RESISTANCE REQUIRED; R_i	
5  Heat flow down	CONSTRUCTION — R 1. Interior air film (Still air) — 0.92 2. Linoleum on building paper — 0.11 3. 3" Concrete — 0.24 4. Insulation required — ---- 5. Exterior air film (Still air, heat flow down) — 0.92 R =2.19	2.19	U=0.10 R_T=10.0 7.81	U=0.08 R_T=12.50 10.31
6  Heat flow down	CONSTRUCTION — R 1. Interior air film (Still air) — 0.92 2. Linoleum on building paper — 0.11 3. 1-1/2" lightweight concrete — 0.42 4. 5/8" plywood subfloor — 0.78 5. Insulation required — ---- 6. 4" dead air space — 1.23 7. 5/8" gypsum wallboard — 0.56 8. Exterior air film (Still air, heat flow down) — 0.92 R =4.94	4.94	U=0.10 R_T=10.0 5.06	U=0.08 R_T=12.50 7.56

$R_i = R_T - R$

FLOORS

7

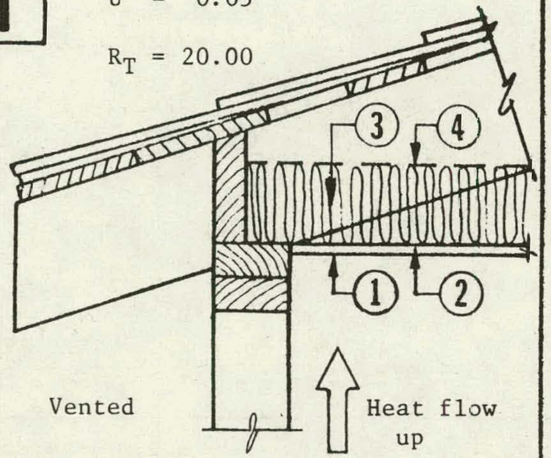
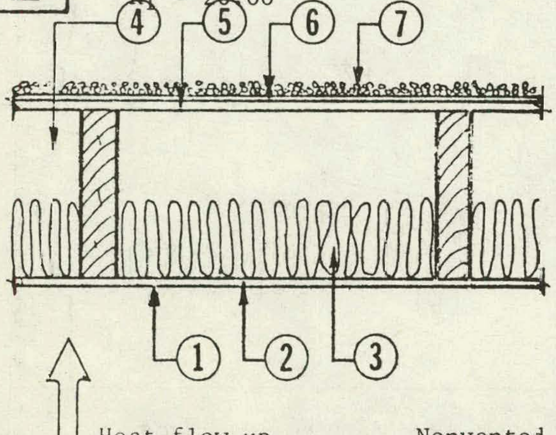


A -Kraft paper - bright aluminum foil both sides
B -Kraft paper - bright aluminum foil top side
C -Kraft paper - bright aluminum foil bottom side

INSULATION (NON-MASS TYPE)

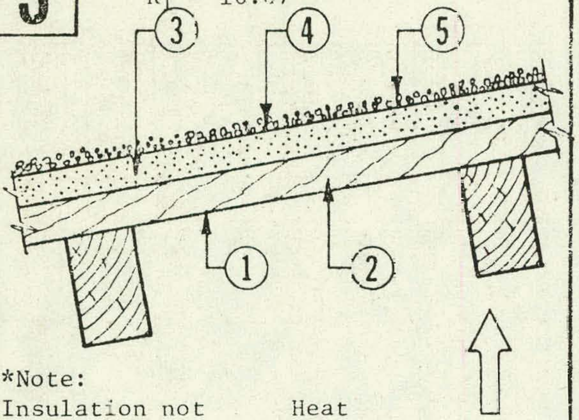
	FLOOR COMPONENTS +		AIR SPACE AND EXTERIOR SURFACE		U and R_T	U
	CONSTRUCTION	R	CONSTRUCTION	R		
A	1. Interior air film (Still air)	0.92	4. 4" reflective air space (Eff. E=.05, Heat flow down	8.94	U=0.064	Complies for U =0.08 and U=0.10
	2. 5/16" part. bd. & linoleum	0.46	5. Exterior air film, reflective (Still air, heat flow down, e=.05)	4.55	R_T=15.65	
	3. 5/8" plywood	0.78				
		R =2.16		R_i=13.49		
B			4. 4" reflective air space (Eff. E=.05, heat flow down)	8.94	U=0.083	Complies for U=0.10
	SAME	2.16	5. Exterior air film non-reflective (Still air, heat flow down, e=.90)	0.92	R_T=12.02	Does not comply for U=0.08
				R_i =9.86		
C			4. 4" non-reflective air space (Eff. E=0.82, heat flow down)	1.23	U=0.126	Does not comply for U=0.08 or U=0.10
	SAME	2.16	5. Exterior air film, reflective (Still air, heat flow down, e=.05)	4.55	R_T=7.94	
				R_i =5.78		

FLOORS

ROOF SECTION	ROOF COMPONENTS	R	INSULATION RESISTANCE REQUIRED; R_i
1 U = 0.05 R_T = 20.00  Vented	CONSTRUCTION — R 1. Interior air film — 0.61 2. 1/2" gypsum wallboard — 0.45 3. Insulation required — ---- 4. Exterior air film - attic (Still air) — 0.61 R =1.67	1.67	18.33
2 U = 0.05 R_T = 20.00  Nonvented	CONSTRUCTION — R 1. Interior air film — 0.61 2. 5/8" gypsum wallboard — 0.56 3. Insulation required — ---- 4. Air Space — 0.85 5. 3/8" plywood — 0.47 6. 3/8" built-up roof — 0.33 7. Exterior air film — 0.17 R = 2.99	2.99	17.01

$R_i = R_T - R$

ROOF / CEILINGS

ROOF SECTION	ROOF COMPONENTS	R	INSULATION RESISTANCE REQUIRED; R_i
3 $U = 0.06$* $R_T = 16.67$  *Note: Insulation not penetrated by framing. Heat flow up	CONSTRUCTION — R 1. Inside air film — 0.61 2. Wood deck (1½") — 1.89 3. Insulation required — ---- 4. 3/8" Built-up roof — 0.33 5. Outside air film — 0.17 R =3.00	3.00	13.67

ROOF/ CEILINGS

$R_i = R_T - R$

CONCRETE BLOCK WALLS

The thermal resistance (R) of concrete block walls with standard 8" x 8" x 16" blocks may be determined using the following procedure and tables. See Wall Section 6 on Page 5-4 for the addition of the thermal resistances of the interior and exterior air films and other surface materials.

PROCEDURE

1. Determine the percent of ungrouted and grouted wall area in the construction from Table 5-1.

2. Calculate the overall thermal conductance (C) and resistance (R) of the concrete block wall as follows:

   C = (percent of ungrouted wall x C factor of ungrouted wall) +
   (percent of grouted wall x C factor of grouted wall) Equation 5-1

   $$R = \frac{1}{C}$$ Equation 5-2

   Where the C factors for the ungrouted and grouted wall construction are taken from Tables 5-2 and 5-3 respectively.

TABLE 5-1
PERCENT UNGROUTED / PERCENT GROUTED
WALL AREA

Grouted Cell Spacing (Inches)					
Horizontal	Vertical				
	48	40	32	24	16
96	76.4 / 23.6	73.3 / 26.7	68.7 / 31.3	61.1 / 38.9	45.8 / 54.2
48	69.4 / 30.6	66.7 / 33.3	62.5 / 37.5	55.6 / 44.4	41.7 / 58.3
40	66.7 / 33.3	64.0 / 36.0	60.0 / 40.0	53.3 / 46.7	40.0 / 60.0
32	62.5 / 37.5	60.0 / 40.0	56.2 / 43.8	50.0 / 50.0	37.5 / 62.5
24	55.6 / 44.4	53.3 / 46.7	50.0 / 50.0	44.4 / 55.6	33.3 / 66.7
16	41.7 / 58.3	40.0 / 60.0	37.5 / 62.5	33.3 / 66.7	25.0 / 75.0

% ungrouted / % grouted

From Table 5-1, the percent of ungrouted and grouted wall areas can be determined for a typical concrete block wall for which the vertical and horizontal grouted cell spacing is known. The number above the diagonal line is the percent of ungrouted wall area and the number below the diagonal line is the percent of grouted wall area. This data is necessary to calculate the overall conductance (C) of the concrete block wall, since the C factors of the ungrouted and grouted portions of the wall are not the same.

TABLE 5-2
C FACTORS - 8" CONCRETE BLOCK
UNGROUTED CELLS

Block Density (lb/cu ft)	Cell Treatment			
	No Insulation	Vermiculite Fill (R=2.13/in)	Perlite Fill (R=2.70/in)	Polyurethane Fill (R=6.25/in)
60	.388	.139	.129	.104
80	.474	.169	.157	.132
100	.565	.207	.198	.168
120	.680	.265	.253	.225

TABLE 5-3
C FACTORS - 8" CONCRETE BLOCK
GROUTED CELLS

Block Density (lbs/cu ft)	Cell Grout Density (lbs/cu ft)				
	140	120	100	80	60
60	.463	.391	.336	.288	.241
80	.588	.478	.405	.342	.285
100	.719	.571	.476	.402	.333
120	.885	.690	.568	.478	.402

The data in Tables 5-2 and 5-3, which are applicable to the standard 8" x 8" x 16" block, were derived using the R values and the parallel and series heat flow methods presented in the ASHRAE Handbook of Fundamentals. The C factors do not include the thermal resistance of the interior and exterior air films or other surface material. See Wall Section 6 on Page 5-4 for the addition of these values.

Interpolation may be used to obtain the C factors of walls for which the R value of the cell treatment or the density of the cell grout is different than those shown in Tables 5-2 and 5-3.

TABLE 5-4
PERCENT OF GROUTED WALL AREA REQUIRED
FOR A CONSTRUCTION WEIGHT OVER 40 LBS/SQ FT

8" Concrete Block Density (lbs/cu ft)	Cell Grout Density (lbs/cu ft)				
	140	120	100	80	60
60 (17)*	47.6	55.5	66.6	83.2	--
80 (22)	32.2	37.6	45.1	56.4	75.2
100 (28)	16.9	19.7	23.6	29.5	39.4
120 (33)	1.5	1.8	2.1	2.7	3.5

*Approximate block weight (53% solid block, oven dry)

Pursuant to Section 1094(e) of the regulations, buildings located in areas of 3500 degree days or less and the effects of all elements of the wall construction are considered, the U factor shall not exceed 0.12 for walls with a construction weight of 26 through 40 pounds per square foot or a U factor not exceeding 0.16 for walls with a construction weight greater than 40 pounds per square foot.

Table 5-4, which is applicable to walls with standard 8" x 8" x 16" blocks, provides the minimum percent of grouted wall area required to obtain a construction weight over 40 lbs/sq ft for various concrete block and grout densities. The weight of the surface treatment is not included. If the percent of grouted wall area obtained from Table 5-1 is greater than that required by Table 5-4, the construction weight of the wall is over 40 lbs/sq ft, therefore, the maximum allowable U factor is 0.16. If the percent of the grouted wall area is less than that shown in Table 5-4, the construction weight of the wall is between 26 and 40 lbs/sq ft and the maximum allowable U factor is 0.12.

EXAMPLE I

8" concrete block (100 lbs/cu ft) with grouted cells (140 lbs/cu ft), vertical at 32" o.c., horizontal at 48" o.c. Other cells filled with vermiculite (R = 2.13/in). The building is located in an area with less than 3500 degree days.

From Table 5-1, the wall is 62.5 percent ungrouted and 37.5 percent grouted.

The overall thermal conductance (C) and resistance (R) are calculated using Equations 5-1 and 5-2 as follows:

$$C = (.625 \times .207) + (.375 \times .719) = .399$$

$$R = \frac{1}{.399} = 2.51$$

From Table 5-4, it can be determined that the concrete block wall used in this example has a construction weight over 40 lbs/sq ft, since the percent of grouted wall area is greater than the 16.9 percent obtained from Table 5-4. Therefore, the maximum allowable U factor of the overall wall construction is 0.16 pursuant to Section 1094(e) of the regulations.

When this wall is used as shown in Wall Section 6, Page 5-4, an insulation resistance of 2.44 is required to comply with Section 1094(e) of the regulations. This may be accomplished with an insulating board with an appropriate R value or with foil backed gypsum wallboard furred to provide a 3/4" reflective air space which provides an air space R value of 2.54 considering the furring.

EXAMPLE II.

8" concrete block (120 lbs/cu ft) with grouted cells (140 lbs/cu ft), vertical at 24" o.c., horizontal at 48" o.c. No insulation in the other cells. The building is located in an area with less than 3500 degree days.

From Table 5-1, the wall is 44.4 percent grouted and 55.6 percent ungrouted.

The overall thermal conductance (C) and resistance (R) are calculated using Equations 5-1 and 5-2 as follows:

$$U = (.556 \times .680) + (.444 \times .885) = .771$$

$$R = \frac{1}{.771} = 1.30$$

From Table 5-4, it can be determined that the concrete block wall used in this example has a construction weight over 40 lbs/sq ft. since the percent of grouted wall area is greater than the 1.5 percent obtained from Table 5-4. Therefore, the maximum allowable U factor of the overall wall construction is 0.16 pursuant to Section 1094(e) of the regulations.

DESIGN CONDITIONS

Pursuant to Section 1094(e) of the regulations, the maximum U factor for walls of mass type construction is dependent upon consideration of the thermal effects of all elements of the wall construction, including occasional framing members, the degree day area and the construction weight of the wall.

The maximum U factor and required total resistance (R_t) for walls with a construction weight over 26 lbs/sq ft under various design conditions are as follows:

	Design Condition	Maximum U	R_t
1.	Areas less than 3500 degree days; wall weight greater than 40 lbs/sq ft; effects of all elements of construction considered.	0.16	6.25
2.	Areas less than 3500 degree days; wall weight 26 through 40 lbs/sq ft; effects of all elements of construction considered.	0.12	8.33
3.	Areas over 3500 degree days; all wall weights; effects of all elements of construction considered.	0.095	10.52
4.	Any of the above cases, when the effects of all elements of construction, such as occasional framing members, are not considered.	0.08	12.50

The design conditions for Wall Sections 5 and 6 shown on Page 5-4 are for a building located in an area with less than 3500 degree days and the wall construction weight is greater than 40 lbs/sq ft. For these examples, the effects of all elements of the wall construction have been considered, therefore, if the insulation required is penetrated by furring, the effects of the furring must be considered. If the effects of the furring are not considered, the maximum U factor for the wall would be 0.08 instead of 0.16.

The thermal effects of the furring can be determined by calculating the overall thermal conductance (C) and resistance (R) as follows:

$$C = \frac{\text{percent of area furred}}{\text{R of furring}} + \frac{\text{percent of area insulated}}{\text{R of insulation}} \qquad \text{Equation 5-3}$$

$$R = \frac{1}{C} \qquad \text{Equation 5-4}$$

For example, with 2" x 2" furring (1½" x 1½" net) at 16" on center, the percent of area furred would be 1.5/16 = .094. Therefore, the percent of area insulated would be 1.0 - .094 = .906. The R value of the furring would be 1.5 x 1.25 (R value per inch of wood) = 1.88. The R value of the insulation would depend on the type of insulation used. The overall thermal resistance (R) of the insulated area can be calculated using Equations 5-3 and 5-4.

The insulation resistance required (R_i) with other design conditions for Wall Sections 5 and 6 can be determined by subtracting the total R value of the construction from the required total resistance (R_t), which is dependent upon the design conditions. The calculation of the total R value of the construction is the same as shown on Page 5-4, since the wall section did not change.

CHAPTER 6

CALIFORNIA DESIGN CONDITIONS

Chapter 6 contains maps of the Degree Day Districts in California and provides a list of the design conditions for various reporting stations within those districts. The state has been separated into 22 districts to facilitate plotting of the various reporting stations within each district.

The Energy Insulation Standards reference heating degree day zones which are important in the application and enforcement of the standards.

The first zone includes those geographic areas which have 2,500 or less heating degree days. Buildings to be located in this zone will not require the insulation of foundation walls of heated basements or heated crawl spaces pursuant to Section 1094(g) and Table 17-C. Buildings to be located in areas which have over 2,500 heating degree days will require conformance to Section 1094(g) and Table 17-C relating to the insulation of foundation walls of heated basements or heated crawl spaces.

The second zone includes those geographic areas which have 3,000 or less heating degree days. Buildings to be located in this zone will not require floor insulation pursuant to Section 1094(g) and Table 17-B.

The third zone includes those geographic areas which have between 3,000 and 4,500 heating degree days. Buildings to be located in this zone will require floor insulation sufficient to obtain a maximum U value of 0.10 for the floor section pursuant to Section 1094(g) and Table 17-B.

The fourth zone includes those geographic areas which have over 4,500 heating degree days. Buildings to be located in this zone will require floor insulation sufficient to obtain a maximum U value of 0.08 for the floor section pursuant to Section 1094(g) and Table 17-B and will also require special glazing pursuant to Section 1094(g)(2).

Section 1094(d)(2) states that the degree day for specific geographical areas in California shall be those in Appendix T25-A. The specific degree days for the reporting stations listed have been adopted by the Commission of Housing and Community Development. However, the 2,500, 3,000 and 4,500 heating degree day lines shown on the district maps may not be completely definable for a specific location, boundary, or topographic demarkation. In order to better delineate these degree day lines, local enforcement agencies may develop local maps which will better define the exact location of the heating degree day lines. In certain localities this has already been accomplished.

CALIFORNIA DEGREE DAY DISTRICTS

District 1	-	Del Norte, Siskiyou, Modoc
District 2	-	Humboldt, Trinity
District 3	-	Shasta, Lassen, Tehama, Plumas
District 4	-	Mendocino, Lake
District 5	-	Glenn, Butte, Colusa, Sutter, Yuba
District 6	-	Sierra, Nevada, Placer, El Dorado
District 7	-	Sonoma, Marin
District 8	-	Napa, Yolo, Solano, Sacramento
District 9	-	Contra Costa, Alameda
District 10, 11	-	San Francisco, San Mateo, Santa Cruz
District 12	-	San Joaquin, Stanislaus, Merced
District 13	-	Amador, Alpine, Calaveras, Tuolumne, Mariposa, Madera, Mono
District 14	-	Santa Clara, San Benito
District 15	-	Monterey, San Luis Obispo
District 16	-	Fresno, Kings, Tulare
District 17	-	Inyo
District 18	-	Kern, Los Angeles
District 19	-	Santa Barbara, Ventura
District 20	-	San Bernardino
District 21	-	Orange, Riverside
District 22	-	San Diego, Imperial

STATE OF CALIFORNIA

Design Conditions

DISTRICT NO. 1

Del Norte County	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Crescent City	4,545	33	69
Elk Valley	5,404		
Siskiyou County			
Fort Jones	5,614		
McCloud	6,007	11	86
Weed	5,870	8	86
Yreka	5,393	13	94
Modoc County			
Alturas	6,785	-1	90
Fort Bidwell	6,365		

DISTRICT NO. 2

Humboldt County			
Alderpoint	3,290		
Eureka	4,679	35	65
Scotia	3,954	34	78
Trinity County			
Weaverville	4,935	16	96

DISTRICT NO. 3

Shasta County			
Burney	6,249	5	90
Redding	2,610	31	101
Lassen County			
Susanville	6,248	4	89
Tehama County			
Mineral	7,192	-1	88
Red Bluff	2,688	31	101

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Plumas County			
Portola	7,055	-1	88
Quincy	5,852	10	93

DISTRICT NO. 4

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Mendocino County			
Fort Bragg	4,424	34	67
Ukiah	3,030	27	96
Willits	4,160	17	89
Lake County			
Lakeport	3,716	25	89

DISTRICT NO. 5

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Glen County			
Orland	2,830	30	101
Stony Gorge Res.	3,124	29	99
Willows	2,807	30	100
Butte County			
Chico	2,795	29	100
Oroville	2,597	30	100
Colusa County			
Colusa	2,788	30	100
Sutter County			
Yuba City	2,386	31	100
Yuba County			
Marysville	2,377	32	100

DISTRICT NO. 6

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Sierra County			
Sierraville	6,953		

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Nevada County			
Nevada City	4,488	20	93
Truckee	8,208	-4	84
Placer County			
Auburn	3,047	31	96
Colfax	3,441	25	89
Roseville	2,899	30	100
Tahoe City	8,162	7	77
El Dorado County			
Placerville	4,161	25	96
Tahoe Valley	8,198	2	84

DISTRICT NO. 7

Sonoma County			
Cloverdale	2,666	31	96
Healdsburg	2,700	30	94
Petaluma	2,966	29	91
Santa Rosa	2,980	29	93
Marin County			
Novato	2,815	30	89
San Rafael	2,619	34	90

DISTRICT NO. 8

Napa County			
Napa	2,690	31	92
St. Helena	2,833	28	95
Yolo County			
Woodland	2,447	30	100
Davis	2,819	30	99
Solano County			
Fairfield	2,434	30	95
Vacaville	2,812	29	98
Vallejo	2,598	29	98
Sacramento County			
Folsom	2,899	30	99
Sacramento	2,782	29	97

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
	DISTRICT NO. 9		
Contra Costa County			
Antioch	2,627	30	93
Concord	2,766	32	92
Pittsburg	2,633	32	93
Richmond	2,644	35	85
Alameda County			
Berkeley	2,850	39	84
Fremont	2,906	30	89
Livermore	2,781	28	97
Oakland	2,906	35	85
	DISTRICT NO. 10		
San Francisco County			
San Francisco	3,080	42	80
	DISTRICT NO. 11		
San Mateo County			
Redwood City	2,596	32	86
San Mateo	2,655	36	87
South San Francisco	3,061	36	79
Santa Crus County			
	DISTRICT NO. 12		
San Joaquin County			
Lodi	2,785	30	97
Stockton	2,690	30	98
Tracy	2,616	30	98
Stanislaus County			
Modesto	2,767	32	98
Oakdale	2,832	28	99
Patterson	2,368	30	100

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Merced County			
Los Banos	2,267	28	100
Merced	2,697	29	99

DISTRICT NO. 13

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Amador County			
Jackson	2,760	31	91
Ione	2,728	28	96
Alpine County			
Markleeville	7,884	8	83
Calaveras County			
Calaveras Big Trees	5,736		
Tuolumne County			
Hetch Hetchy	4,797	18	90
Sonora	3,086	29	96
Mariposa County			
Mariposa	3,116	27	96
Yosemite	4,800	18	90
Madera County			
Madera	2,485	30	100

DISTRICT NO. 14

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Santa Clara County			
Gilroy	2,808	28	94
Los Gatos	2,794	32	89
Palo Alto	2,869	34	88
Santa Clara	2,566	31	88
San Jose	2,656	34	88
San Benito County			
Hollister	2,725	30	91

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
DISTRICT NO. 15			
Monterey County			
King City	2,655	25	93
Monterey	2,985	34	82
Salinas	2,959	32	85
Soledad	2,920	29	90
San Luis Obispo County			
Paso Robles	2,890	26	100
San Luis Obispo	2,582	35	90
DISTRICT NO. 16			
Fresno County			
Fresno	2,611	29	99
Mendota	2,555	29	100
Kings County			
Hanford	2,642	28	100
Lemoore	2,960	29	100
Tulare County			
Lindsay	2,619	30	100
Porterville	2,563	30	100
Visalia	2,546	32	100
DISTRICT NO. 17			
Inyo County			
Bishop	4,275	16	98
Death Valley	1,205	35	116
Independence	2,995	19	96
DISTRICT NO. 18			
Kern County			
Bakersfield	2,122	30	101
Delano	2,220	31	103
Inyokern	2,570	23	102
Maricopa	2,165	32	101
Mojave	2,590	25	100

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Los Angeles County			
Culver City	1,711		
Edwards A.F.B.	3,123	21	102
Fairmont	3,327	28	94
Long Beach	1,803	38	84
Los Angeles	2,061	42	86
Palmdale	3,088	24	101
Pasadena	1,694	35	93
Pomona	2,166	31	96
San Fernando	1,800	34	97

DISTRICT NO. 19

Santa Barbara County			
Santa Barbara	2,290	34	84
Santa Maria	2,985	32	82
Ventura County			
Fillmore	2,377	33	90
Oxnard	2,352	35	80
Thousand Oaks	2,425	32	92

DISTRICT NO. 20

San Bernardino County			
Barstow	2,496	24	102
Daggett	2,203	24	103
Lake Arrowhead	5,200	20	84
Needles	1,072	33	110
Redlands	2,052	34	96
San Bernardino	2,018	32	100
Twentynine Palms	2,006	28	104

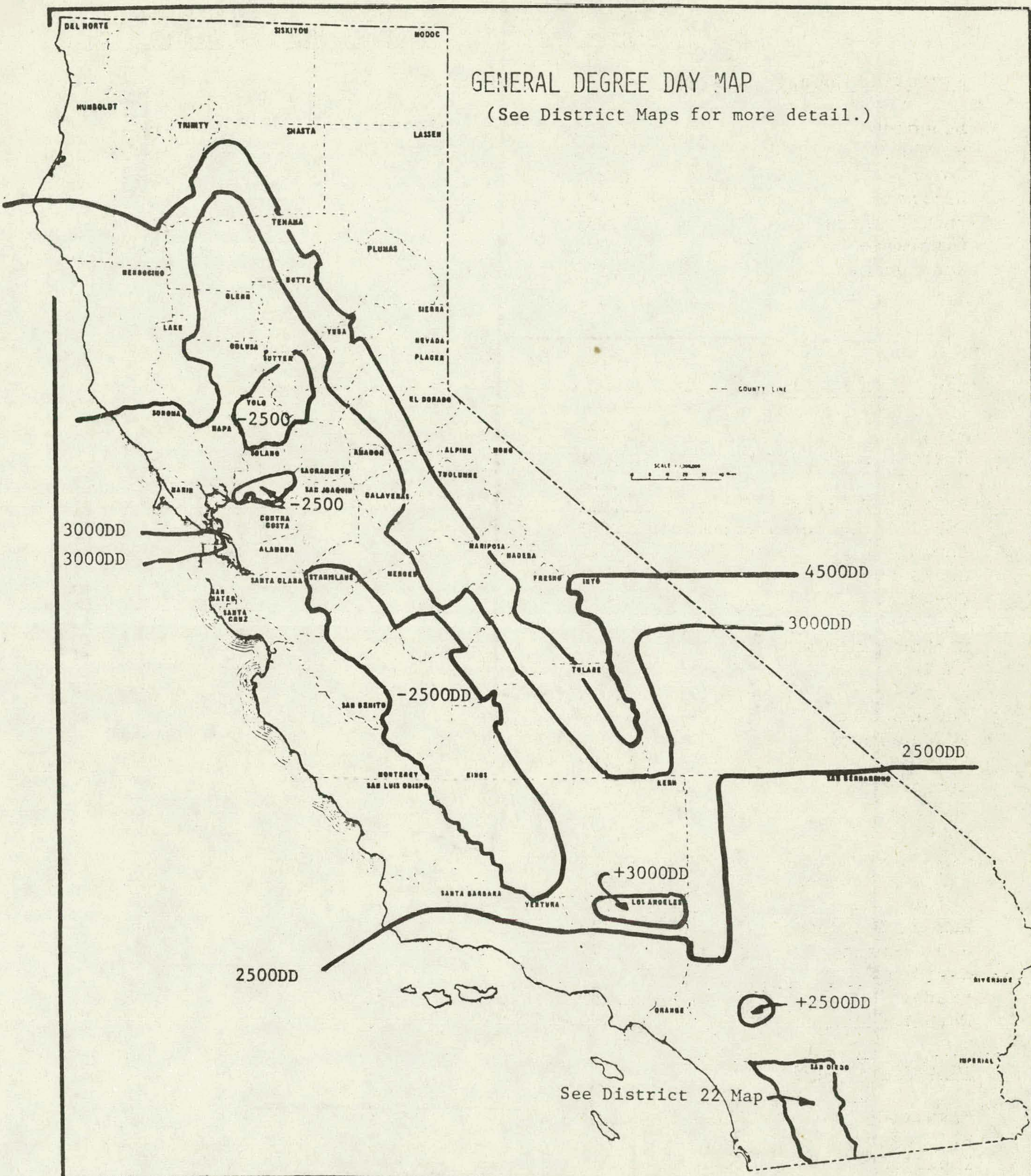
DISTRICT NO. 21

Orange County			
Huntington Beach	2,361	40	81
Laguna Beach	2,262	37	80
San Juan Capistrano	1,646	39	82
Santa Ana	1,496	33	89

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
Riverside County			
Beaumont	2,790	28	96
Blythe	1,076	31	109
Corona	1,875	33	95
Elsinore	2,101	30	99
Palm Springs	1,232	32	108
Riverside	2,089	33	98
San Jacinto	2,376		

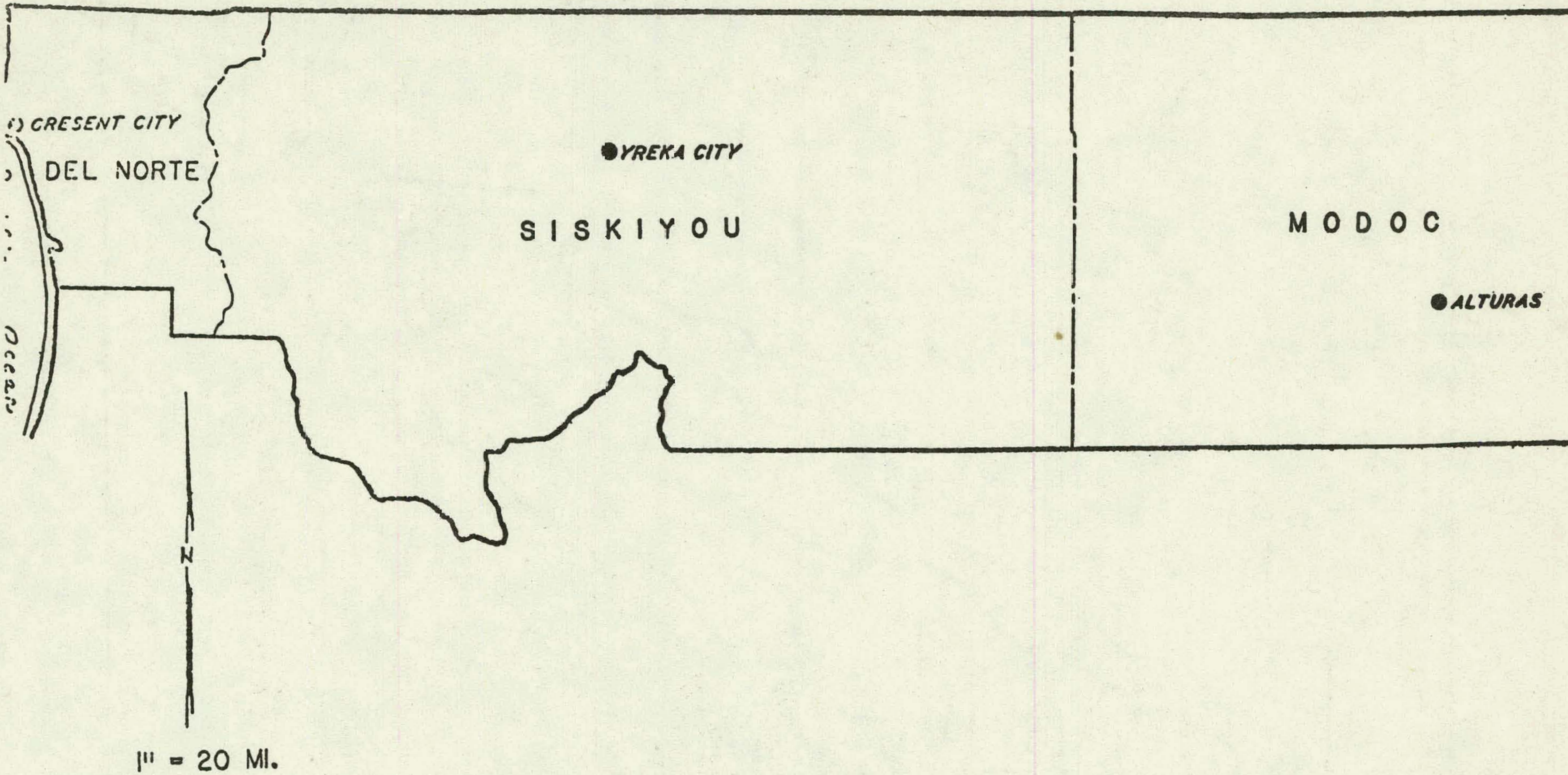
DISTRICT NO. 22

	Annual Heating Degree Days	Winter Design - 99%	Summer Design - 2½%
San Diego County			
Alpine	2,104		
Barrett Dam	2,363		
Bonita	1,857	33	88
Borrego Springs	1,262	28	106
Cabrillo National Monument	1,653		
Campo	3,247		
Chula Vista	2,229	37	78
Cuyamaca	4,649	19	85
El Cajon	1,920	31	95
El Capitan Dam	1,397		
Encinitas	1,952	40	82
Escondido	2,052	33	92
Henshaw Dam	3,652		
Julian Wynola	4,085	19	90
La Mesa	1,492	36	90
Mecca	1,117	30	107
Nellie	4,745		
Oak Grove	3,516	26	95
Oceanside	2,092	38	81
Palomar Mt. Observ.	3,868	23	83
Point Loma	1,860	44	83
Ramona Spaulding	2,223	27	98
San Clemente	1,877	42	78
San Diego	1,439	42	83
Vista	1,760	34	85
Warner Springs	3,470	29	95
Imperial County			
Brawley	1,161	34	109
El Centro	1,216	31	109
Imperial	1,060	35	107


GENERAL DEGREE DAY MAP
(See District Maps for more detail.)
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
BUTTE
GLENN
SIERRA
LAKE
YUBA
NEVADA
COLUSA
PLACER
SUTTER
YOLO
EL DORADO
SONOMA
NAPA
-2500
SOLANO
AMADOR
ALPINE
MONO
SACRAMENTO
TUOLUMNE
MARIN
SAN JOAQUIN
CALAVERAS
-2500
CONTRA COSTA
3000DD
3000DD
ALAMEDA
MARIPOSA
MADERA
SANTA CLARA
STANISLAUS
MERCED
FRESNO
INYO
4500DD
SAN MATEO
SANTA CRUZ
3000DD
TULARE
-2500DD
SAN BENITO
2500DD
MONTEREY
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
COUNTY LINE
+3000DD
SANTA BARBARA
VENTURA
LOS ANGELES
2500DD
ORANGE
+2500DD
RIVERSIDE
IMPERIAL
SAN DIEGO
See District 22 Map

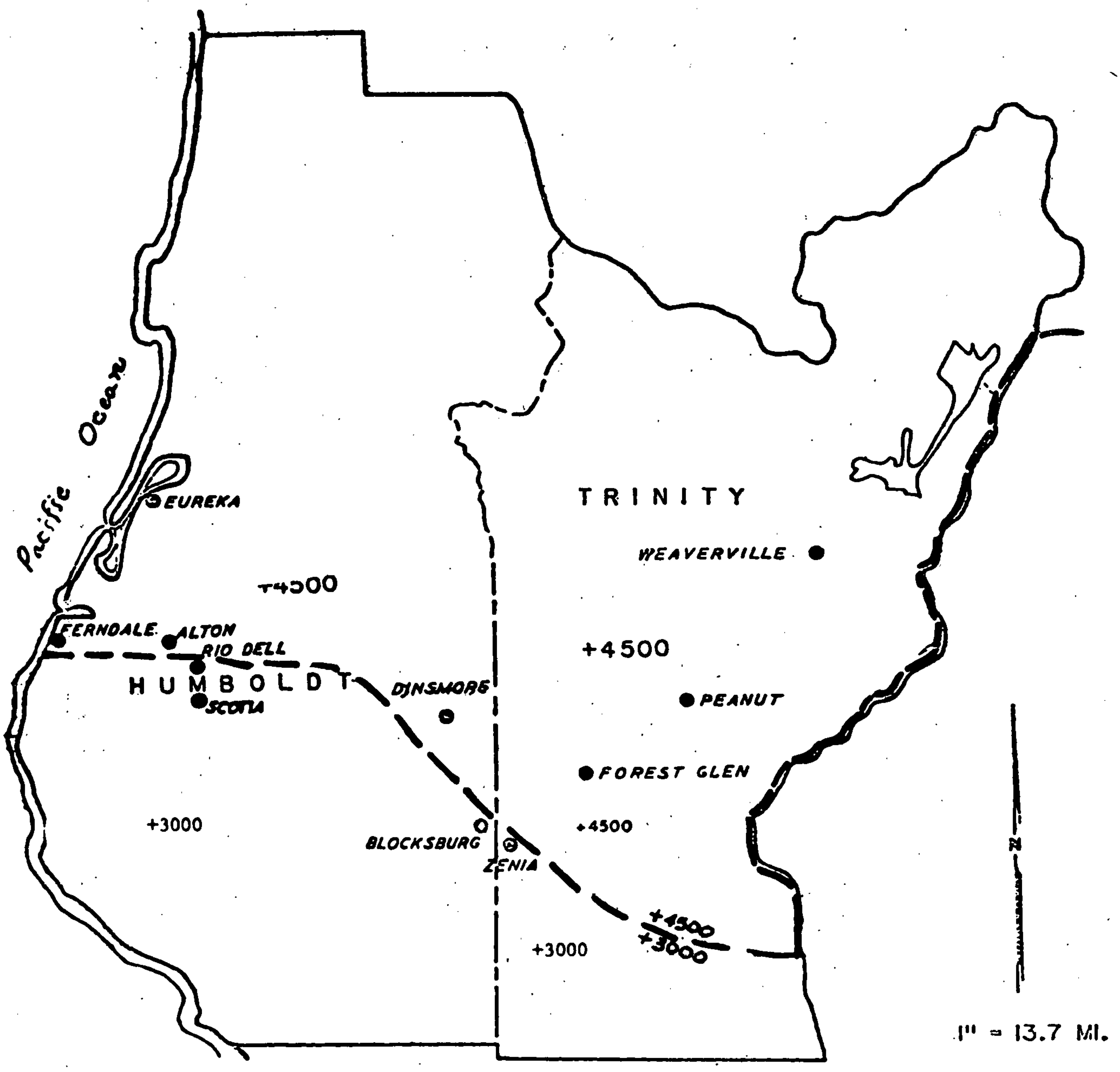
170

6-12



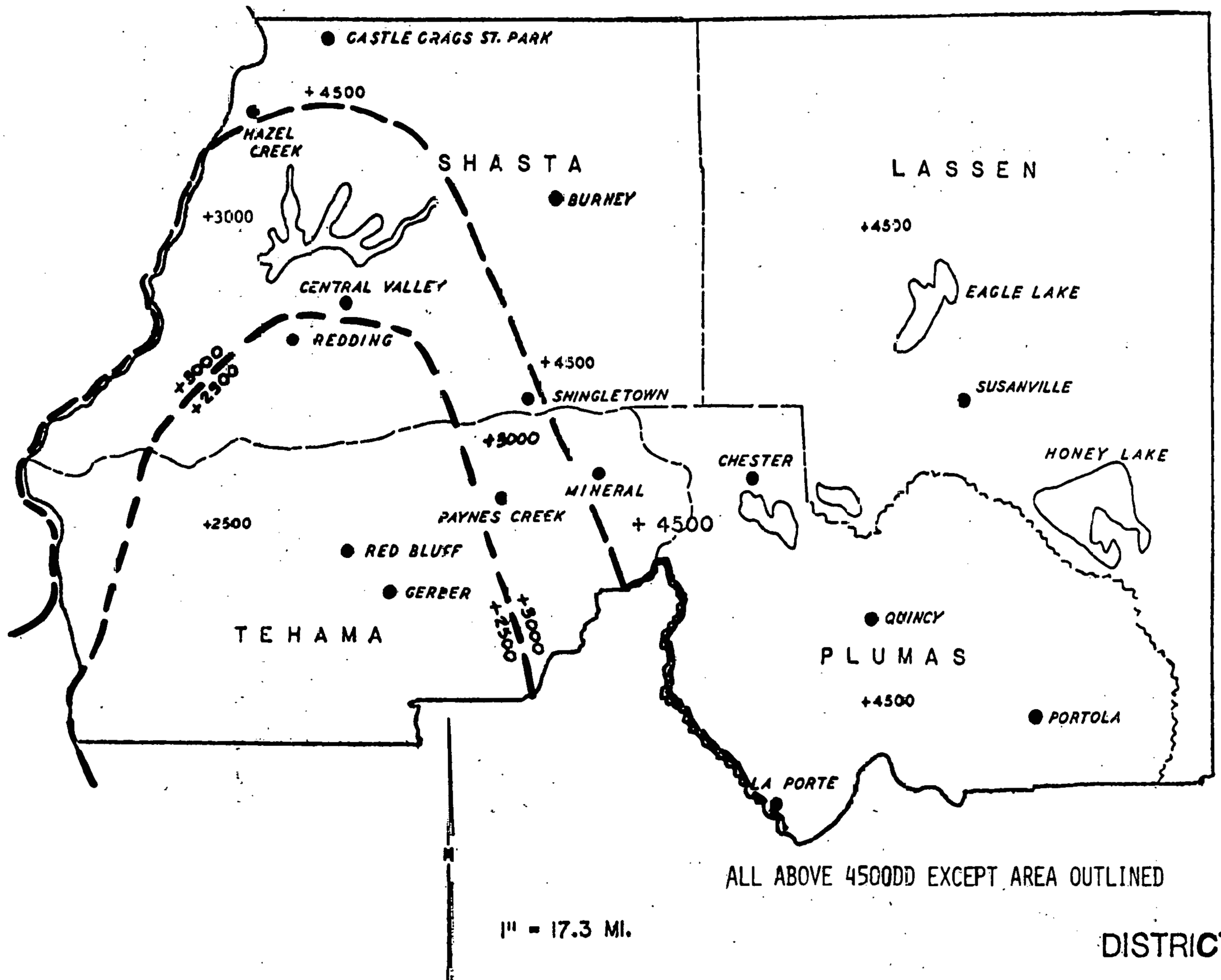
DISTRICT 1

ALL ABOVE 4500DD

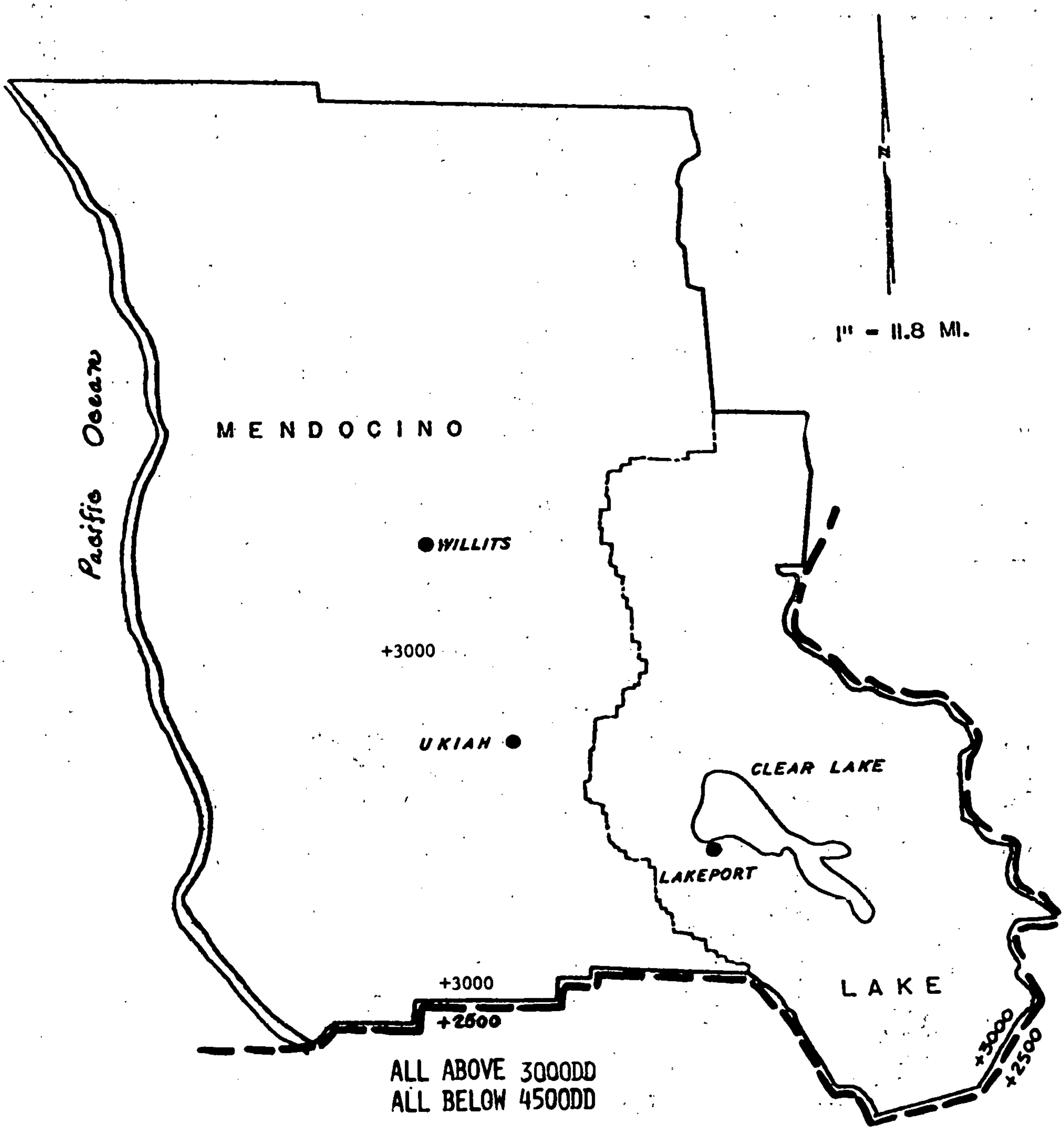


ALL ABOVE 4500DD EXCEPT AREA OUTLINED

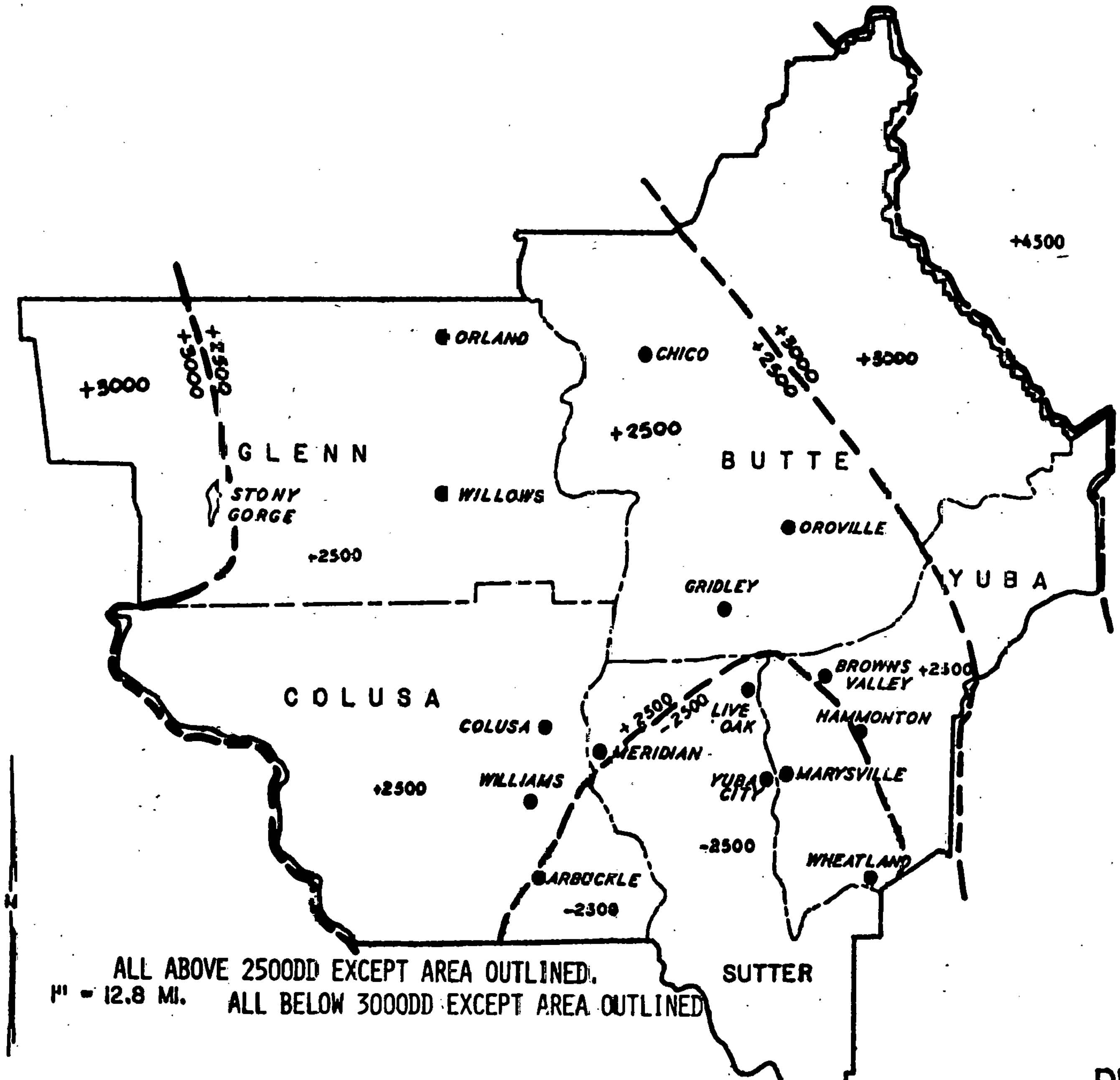
DISTRICT 2


CASTLE CRAGS ST. PARK
+4500
HAZEL CREEK
SHASTA
BURNEY
LASSEN
+3000
+4500
EAGLE LAKE
CENTRAL VALLEY
REDDING
+4500
+3000
+2500
SHINGLETOWN
SUSANVILLE
+3000
CHESTER
HONEY LAKE
MINERAL
PAYNES CREEK
+2500
+ 4500
RED BLUFF
GERBER
+3000
+2500
QUINCY
TEHAMA
PLUMAS
+4500
PORTOLA
LA PORTE
N
ALL ABOVE 4500DD EXCEPT AREA OUTLINED
1" = 17.3 MI.

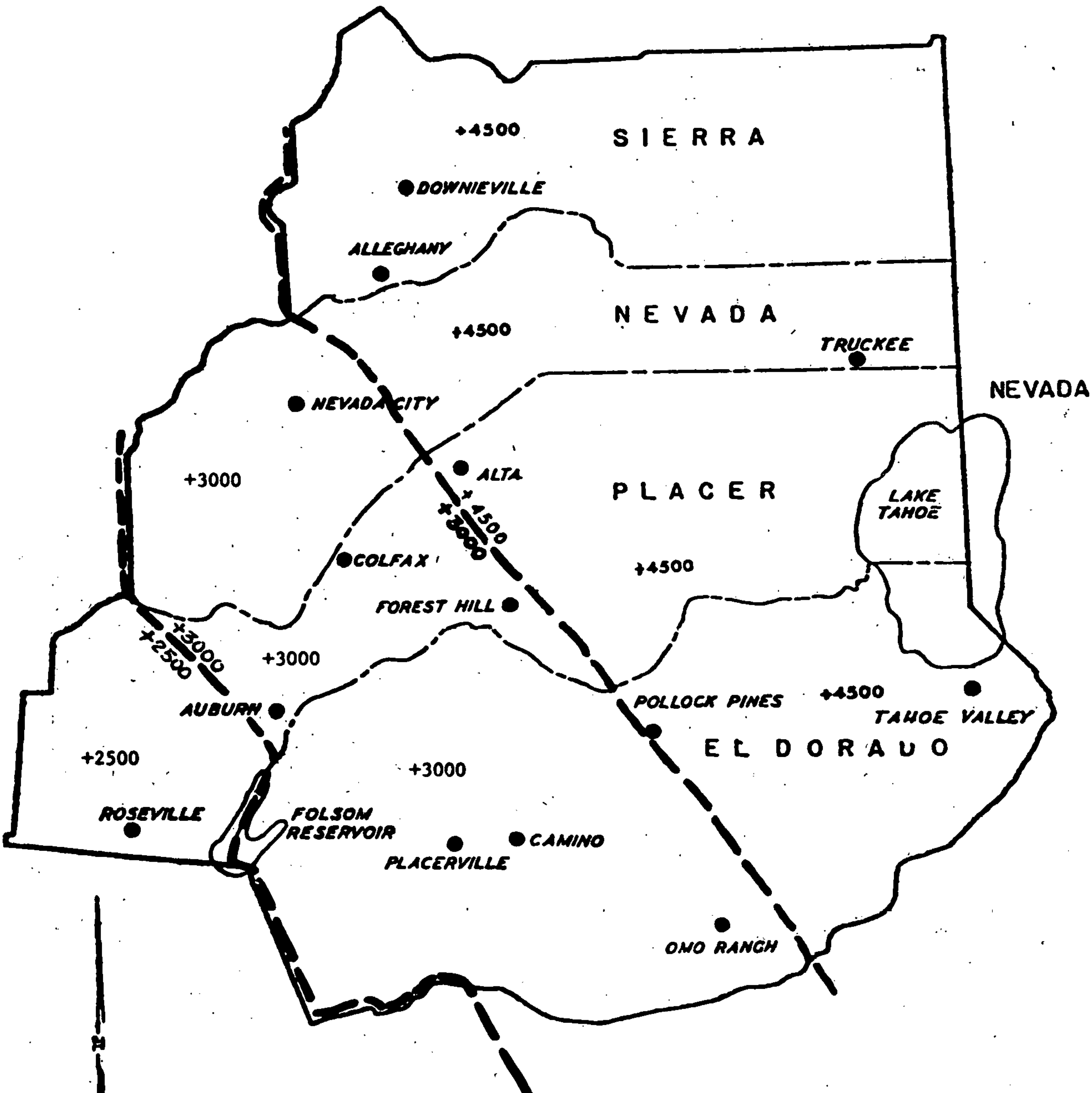
DISTRICT 3


N
1" = 11.8 MI.
Pacific Ocean
MENDOCINO
WILLITS
+3000
UKIAH
CLEAR LAKE
LAKEPORT
LAKE
+3000
+2500
+3000
+2500
ALL ABOVE 3000DD
ALL BELOW 4500DD

DISTRICT 4


+4500
+3000
+2500
+3000
+2500
ORLAND
+3000
CHICO
+3000
+2500
+3000
+2500
GLENN
BUTTE
STONY
GORGE
WILLOWS
OROVILLE
+2500
GRIDLEY
YUBA
BROWNS VALLEY
+2500
COLUSA
COLUSA
+2500
-2500
LIVE OAK
HAMMONTON
MERIDIAN
WILLIAMS
YUBA CITY
MARYSVILLE
+2500
-2500
WHEATLAND
ARBUCKLE
-2300
N
SUTTER
ALL ABOVE 2500DD EXCEPT AREA OUTLINED.
1" = 12.8 MI.
ALL BELOW 3000DD EXCEPT AREA OUTLINED

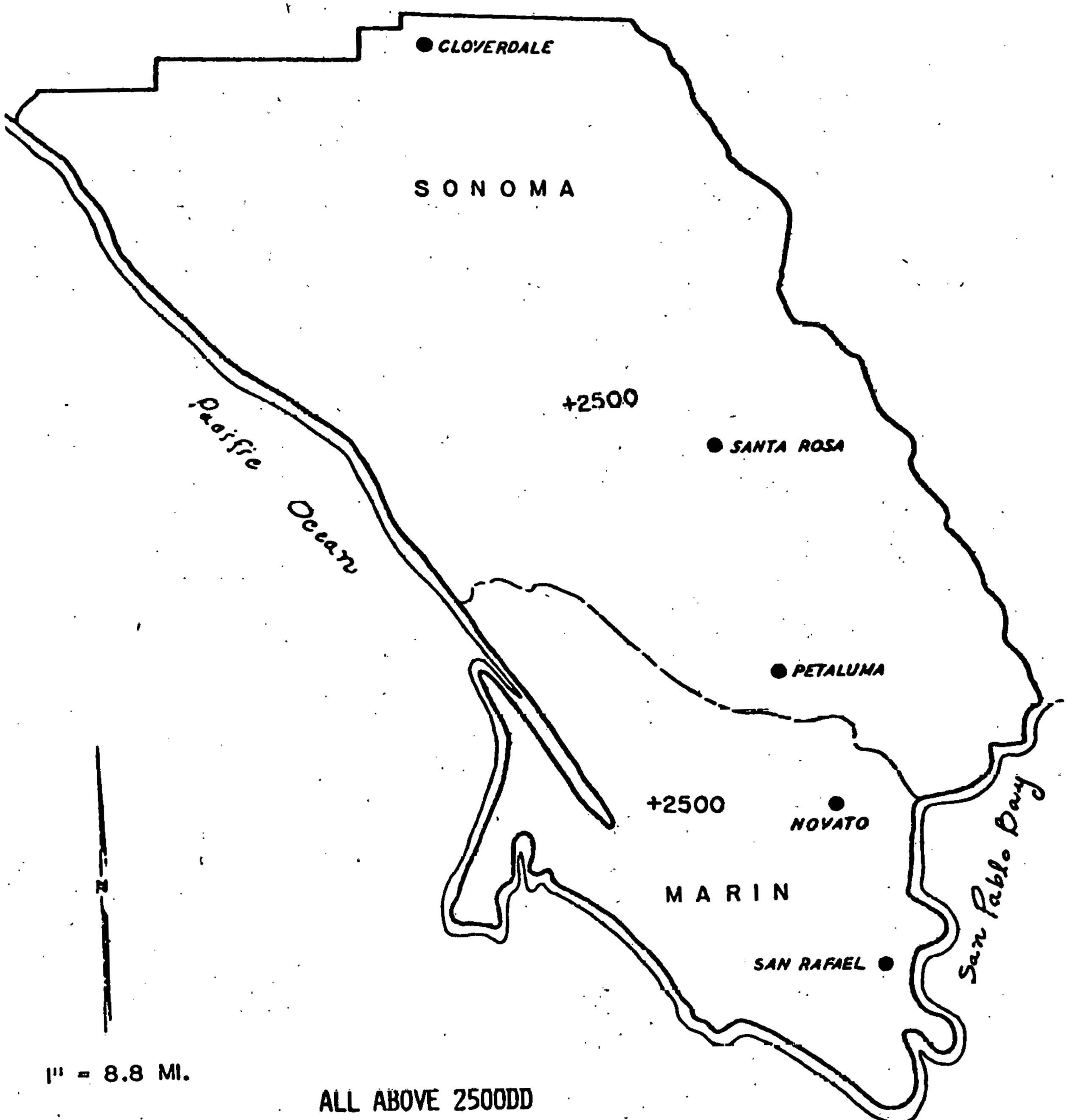
DISTRICT 5



ALL ABOVE 4500DD EXCEPT AREA OUTLINED.

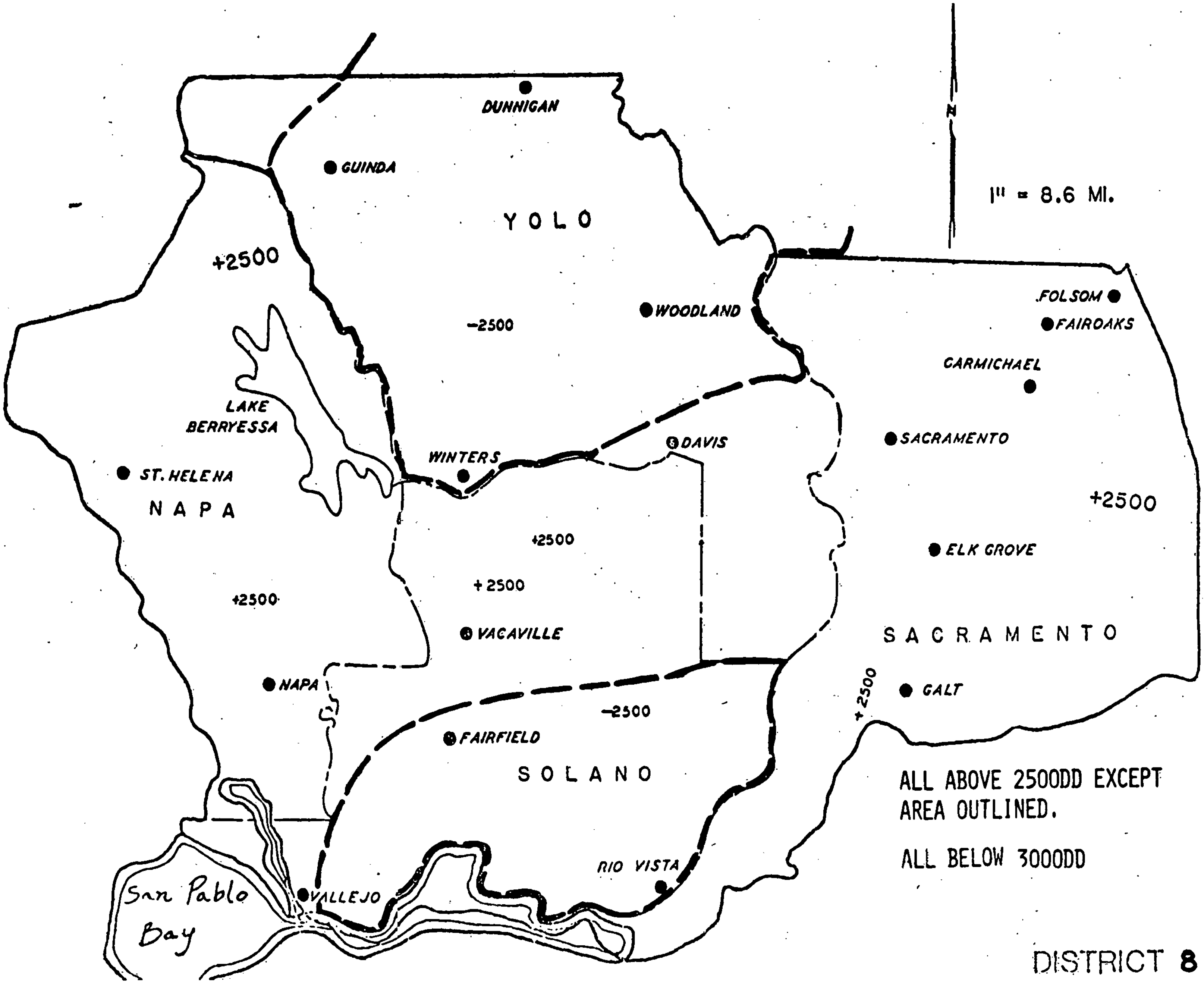
1" = 11.7 MI.

DISTRICT 6

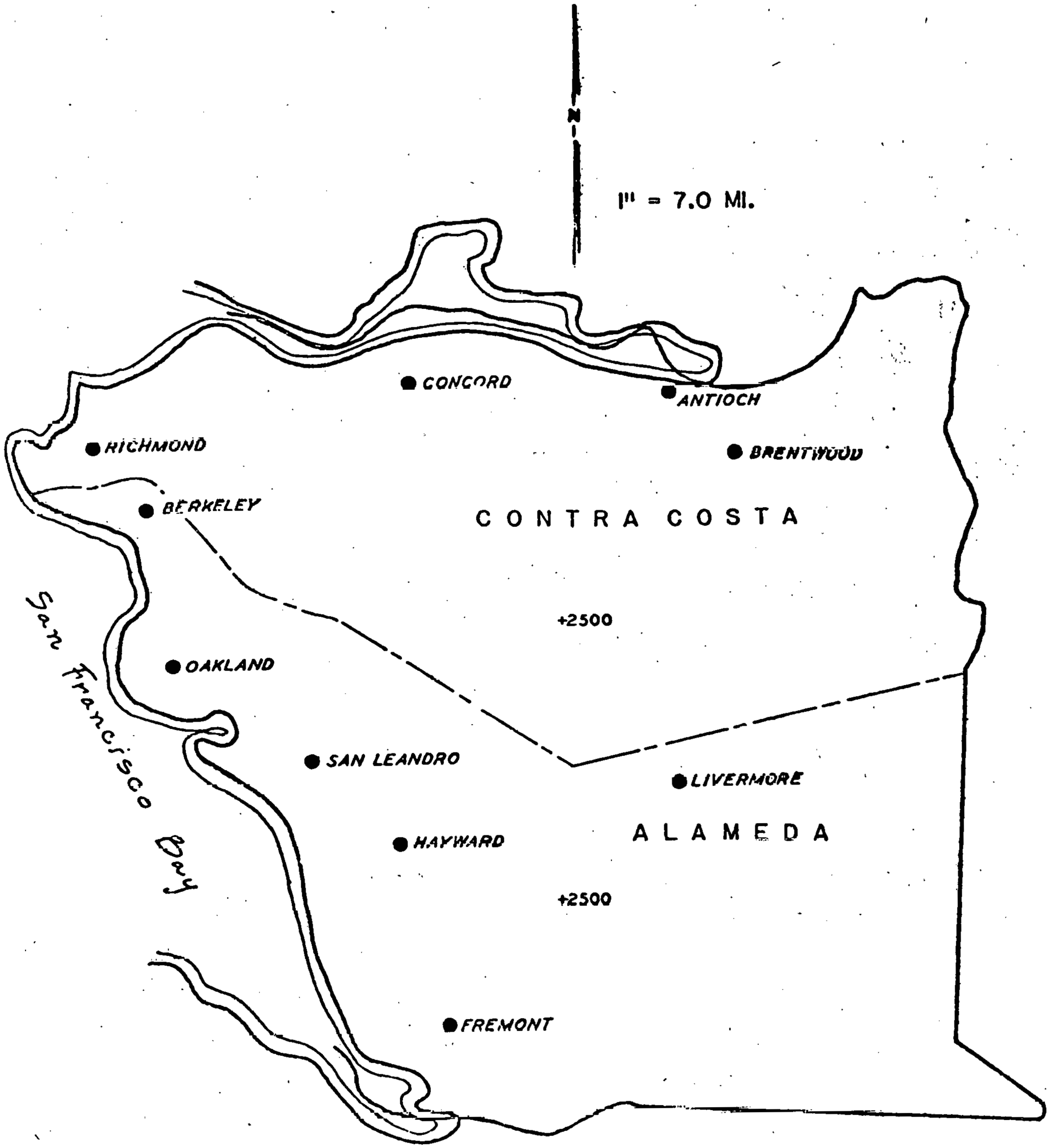


ALL ABOVE 2500DD
ALL BELOW 3000DD

DISTRICT 7

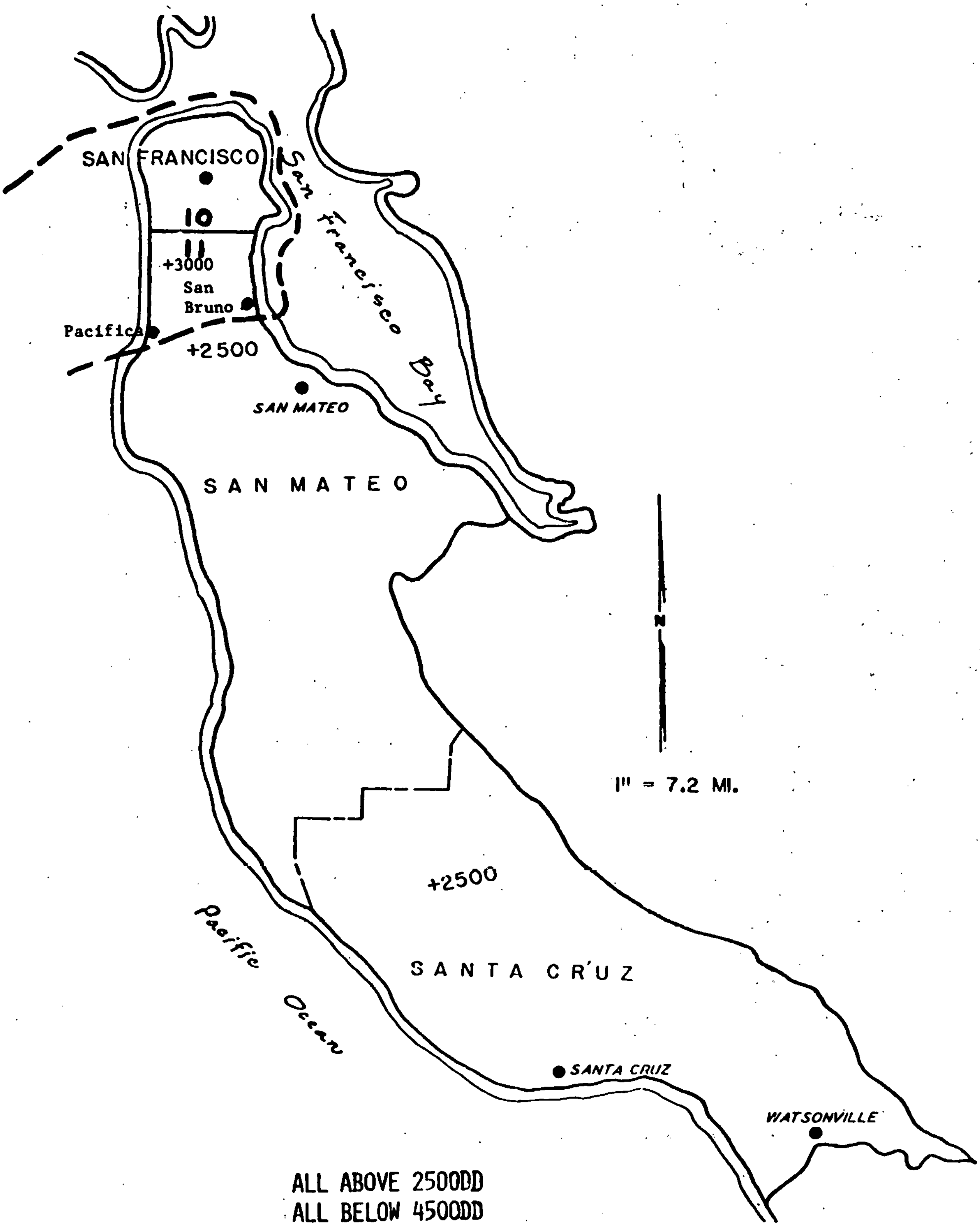

DUNNIGAN
GUINDA
YOLO
+2500
-2500
WOODLAND
1" = 8.6 MI.
N
FOLSOM
FAIROAKS
CARMICHAEL
LAKE
BERRYESSA
DAVIS
SACRAMENTO
WINTERS
ST. HELENA
NAPA
+2500
+2500
+2500
+2500
ELK GROVE
VACAVILLE
SACRAMENTO
NAPA
+2500
GALT
-2500
FAIRFIELD
SOLANO
ALL ABOVE 2500DD EXCEPT
AREA OUTLINED.
ALL BELOW 3000DD
RIO VISTA
San Pablo
Bay
VALLEJO

DISTRICT 8



ALL ABOVE 2500DD
ALL BELOW 3000DD

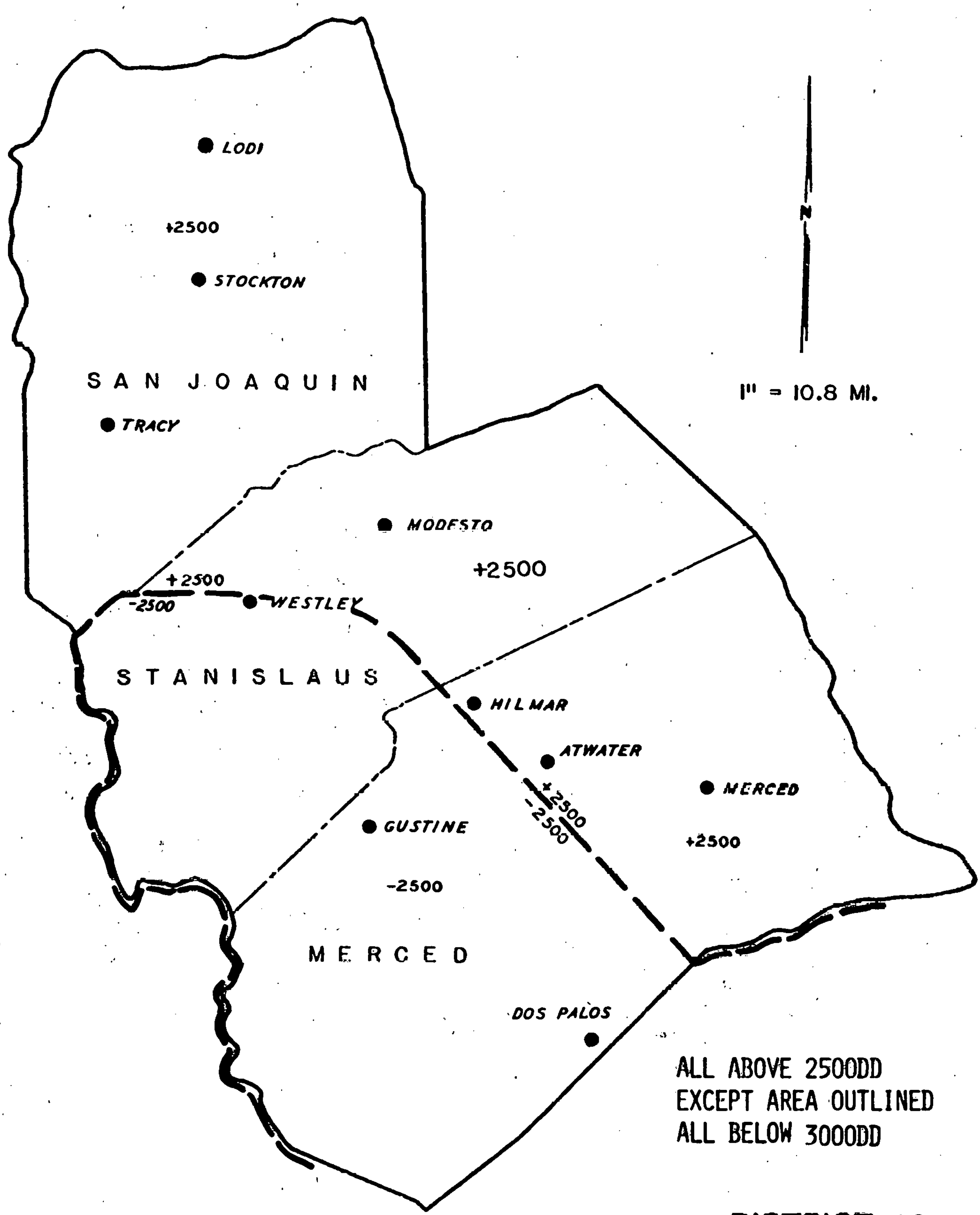
DISTRICT 9



ALL ABOVE 2500DD
ALL BELOW 4500DD

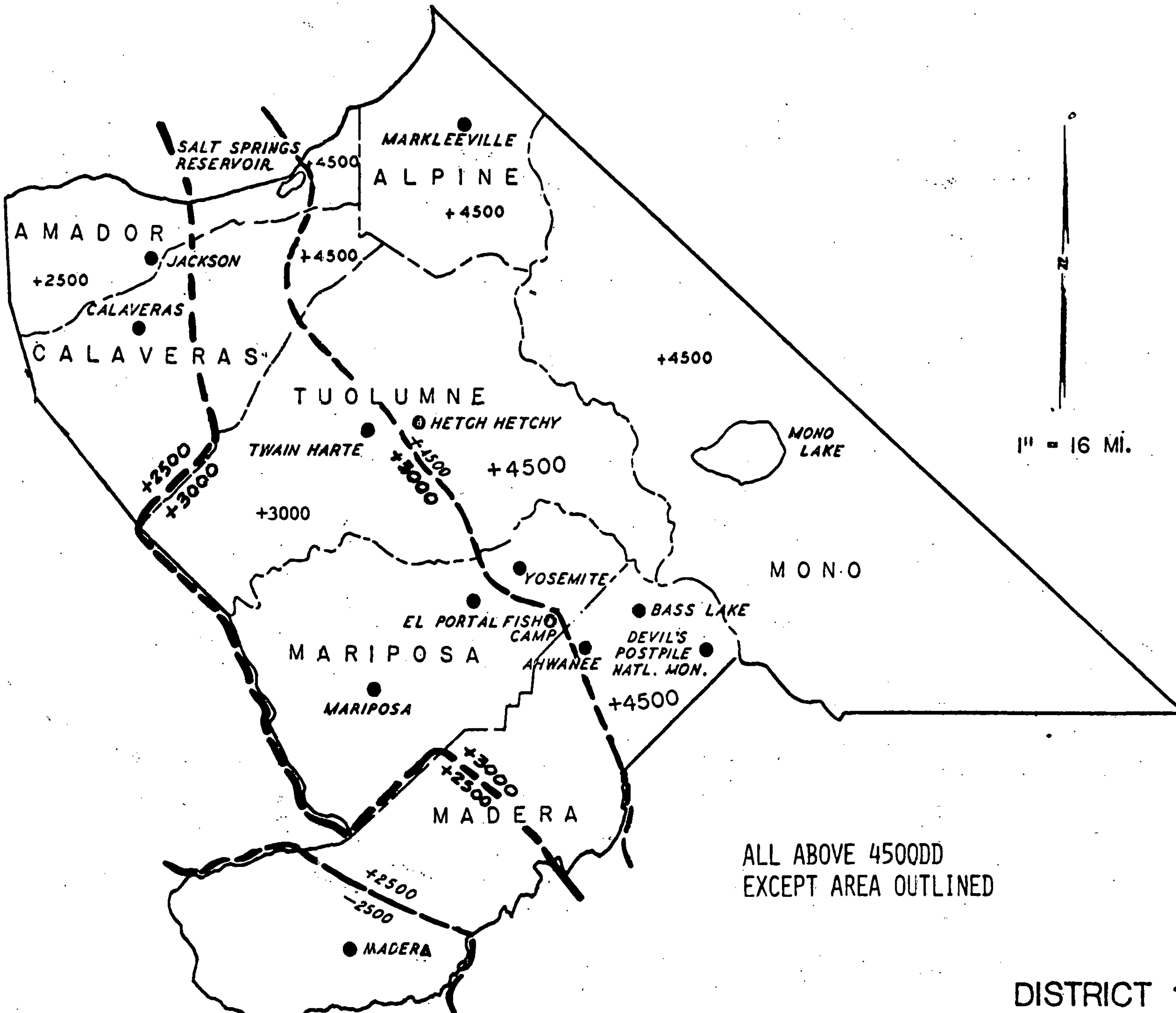
6-21

DISTRICT 10,11



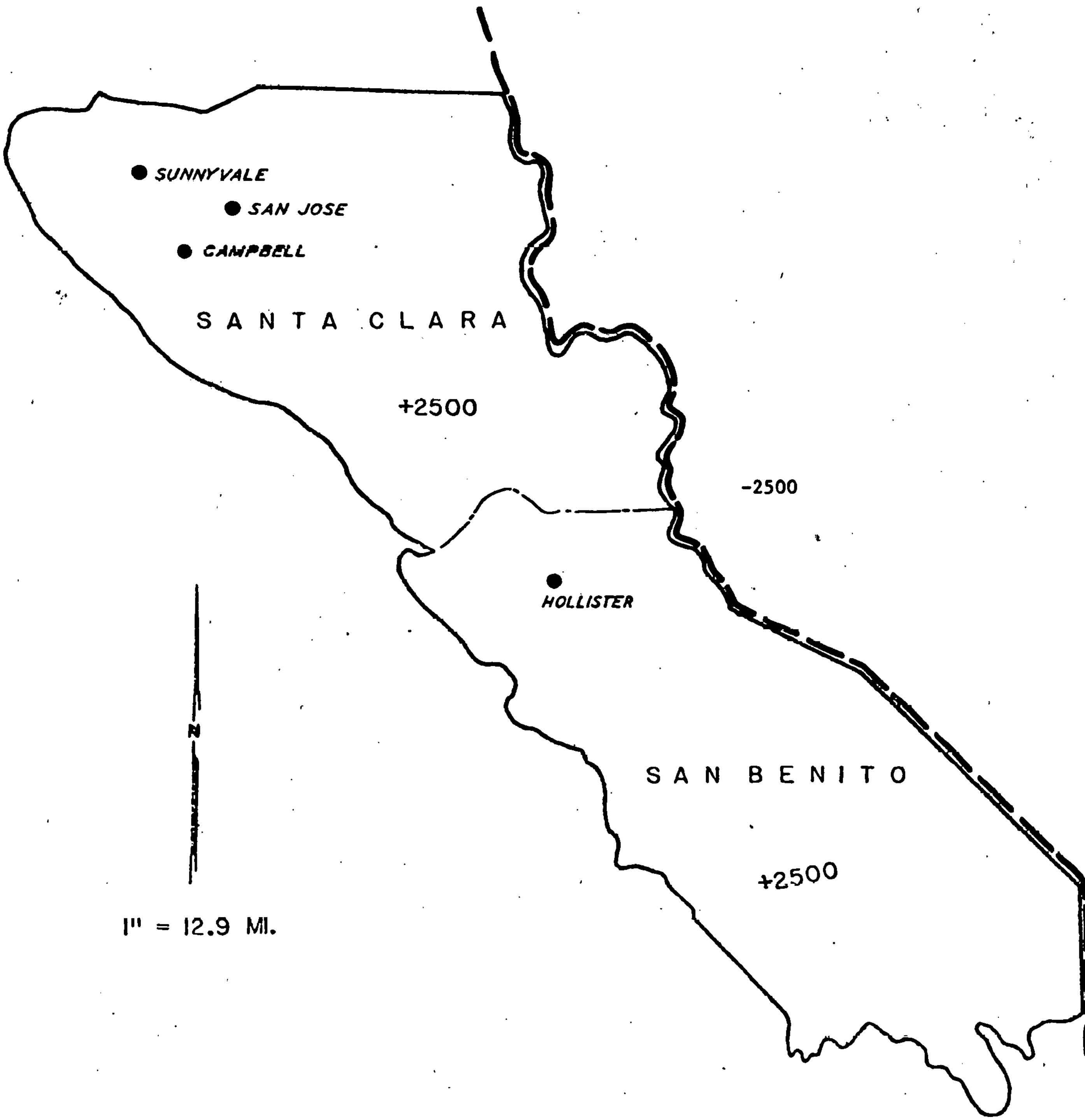
ALL ABOVE 2500DD
EXCEPT AREA OUTLINED
ALL BELOW 3000DD

DISTRICT **12**



ALL ABOVE 4500DD
EXCEPT AREA OUTLINED

DISTRICT **13**



ALL ABOVE 2500DD
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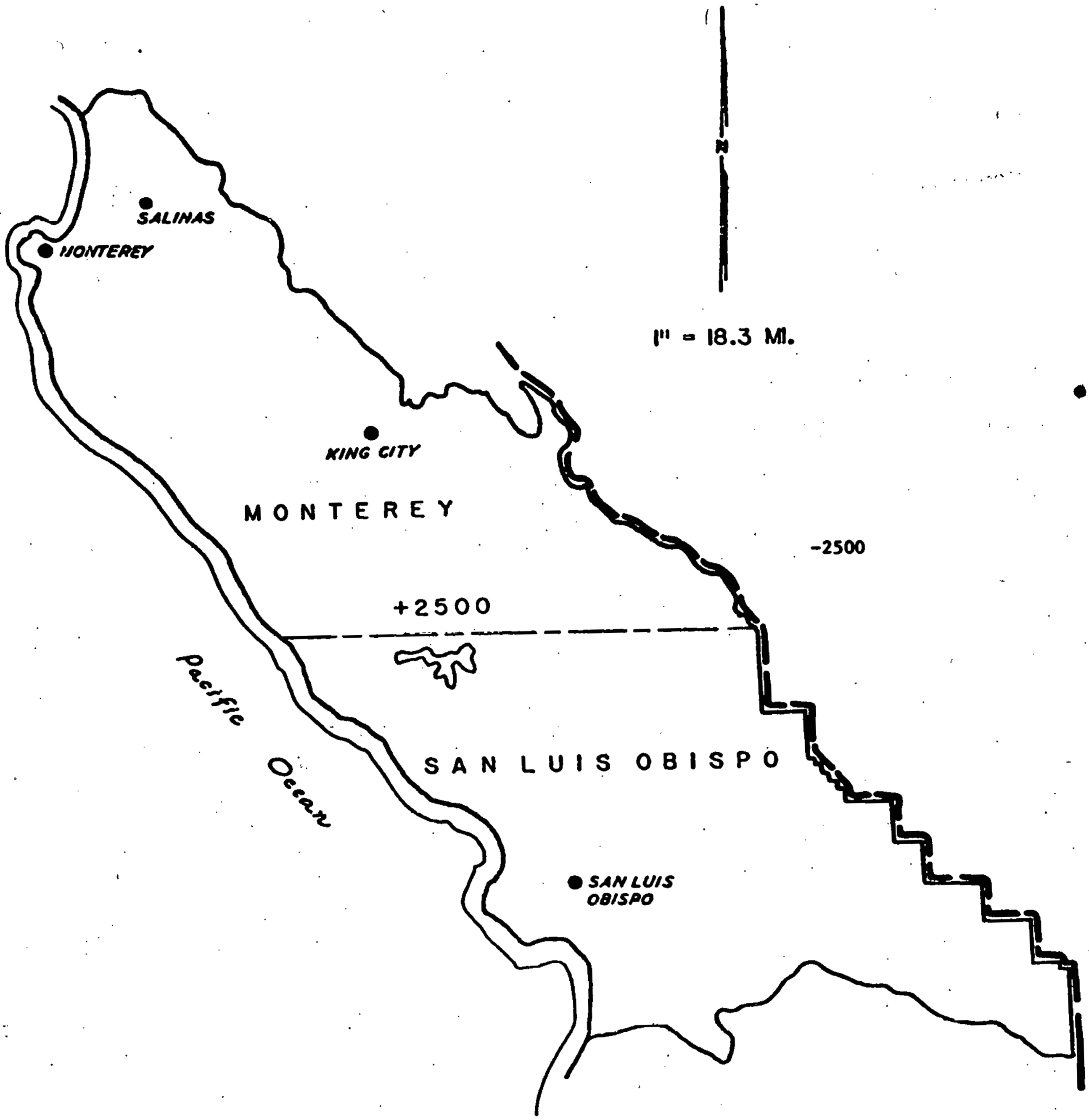

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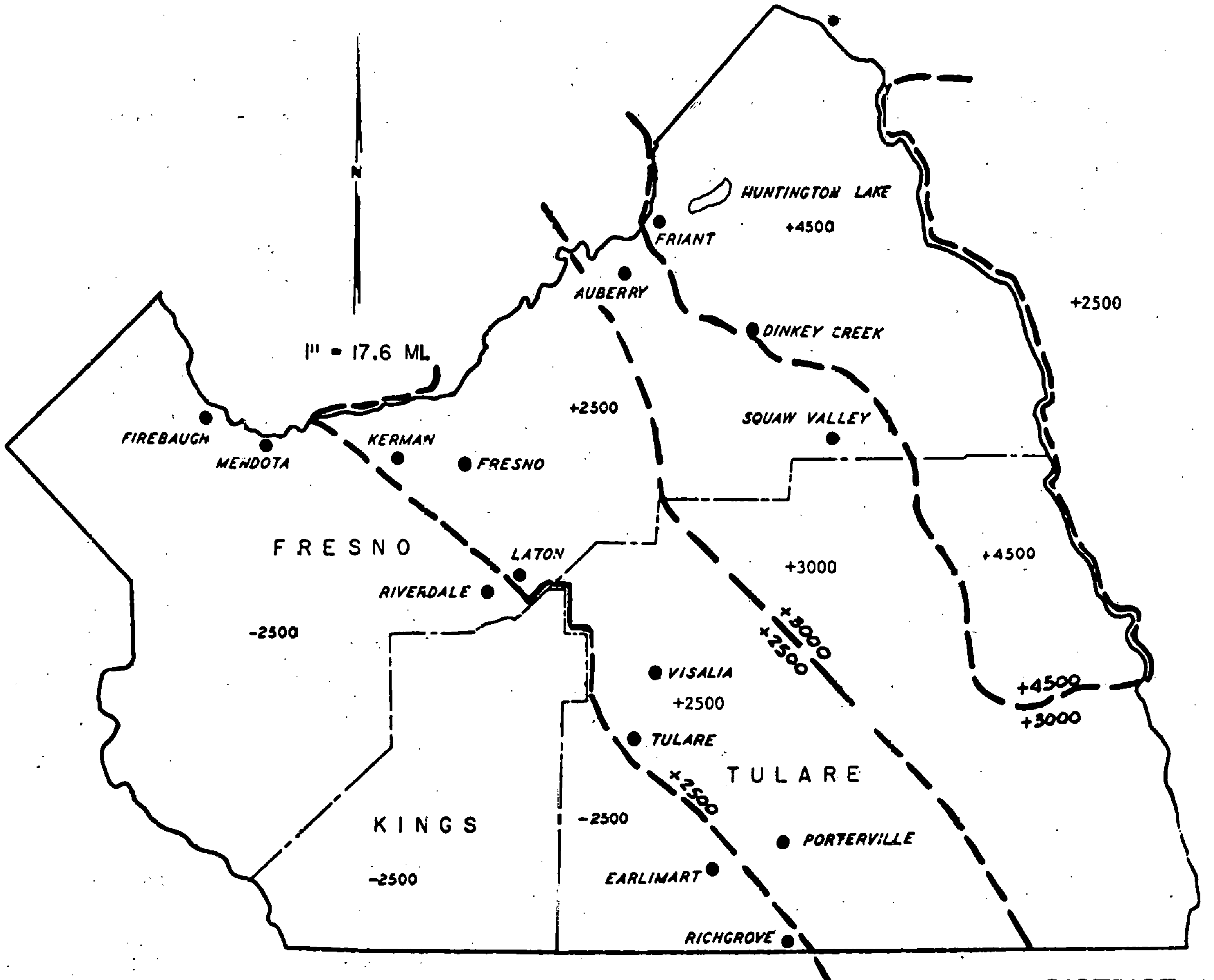
DISTRICT 15



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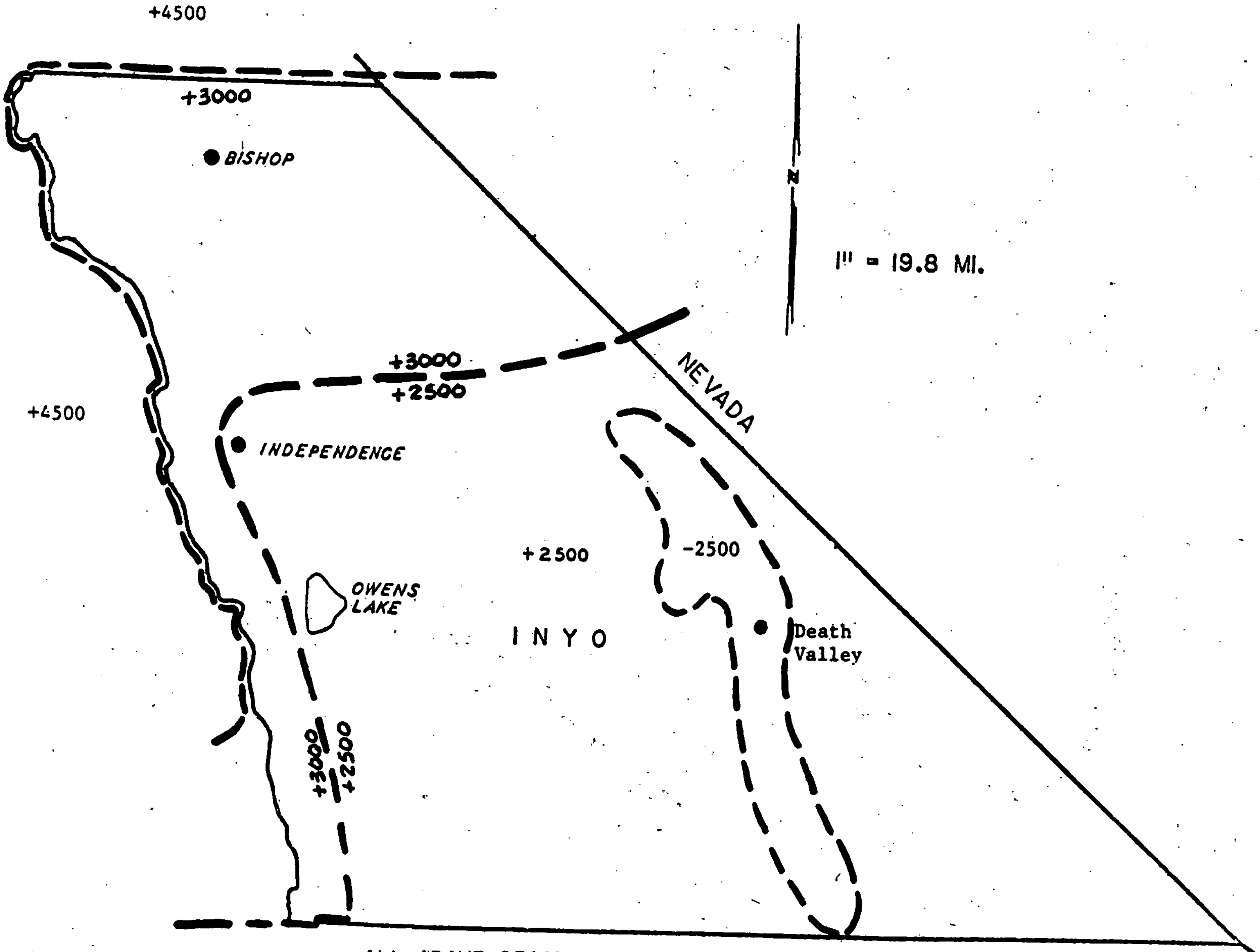
DISTRICT 16



ALL ABOVE 2500DD EXCEPT AREA OUTLINED
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DISTRICT 17

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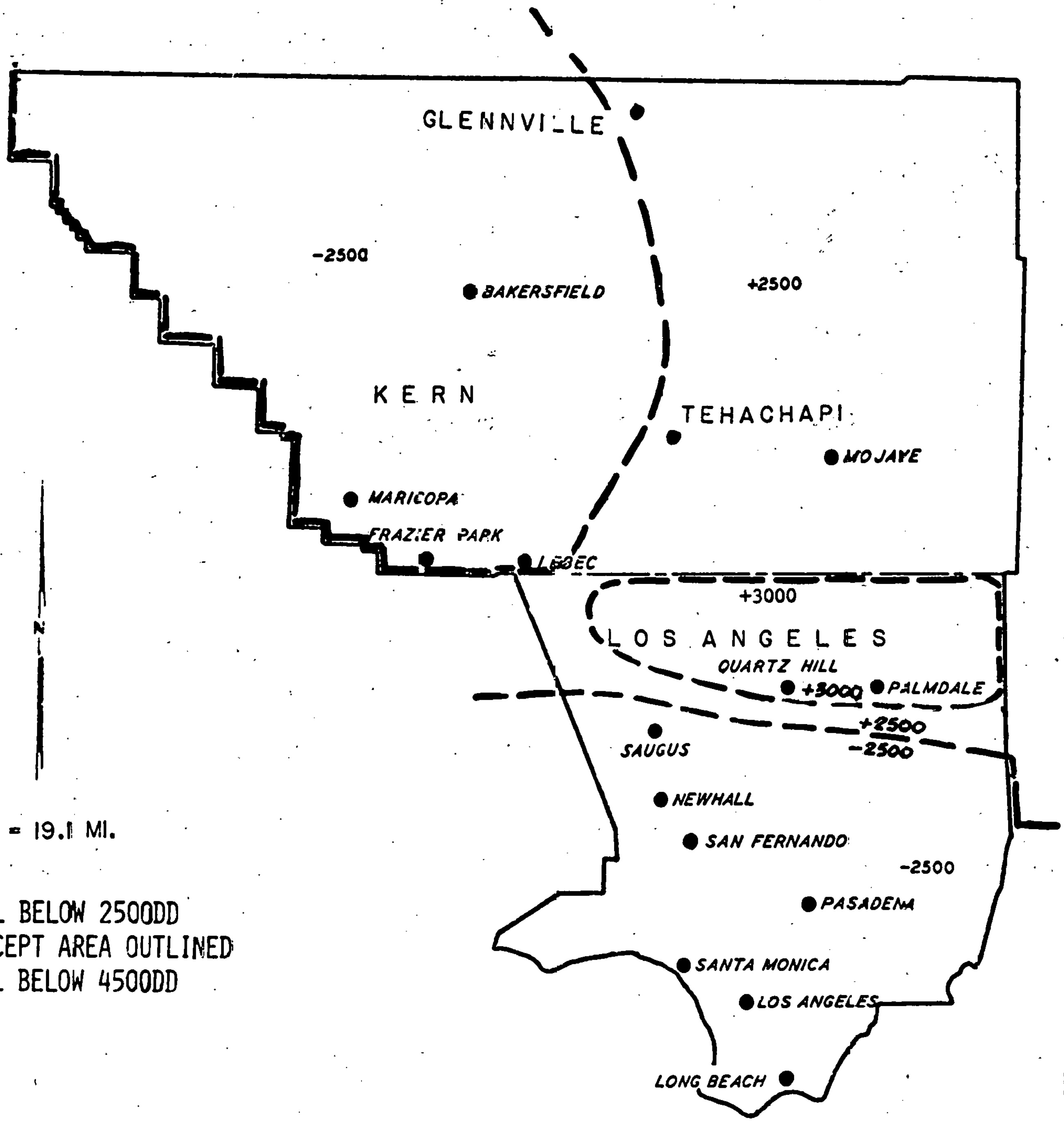
6-28



1" = 19.1 MI.

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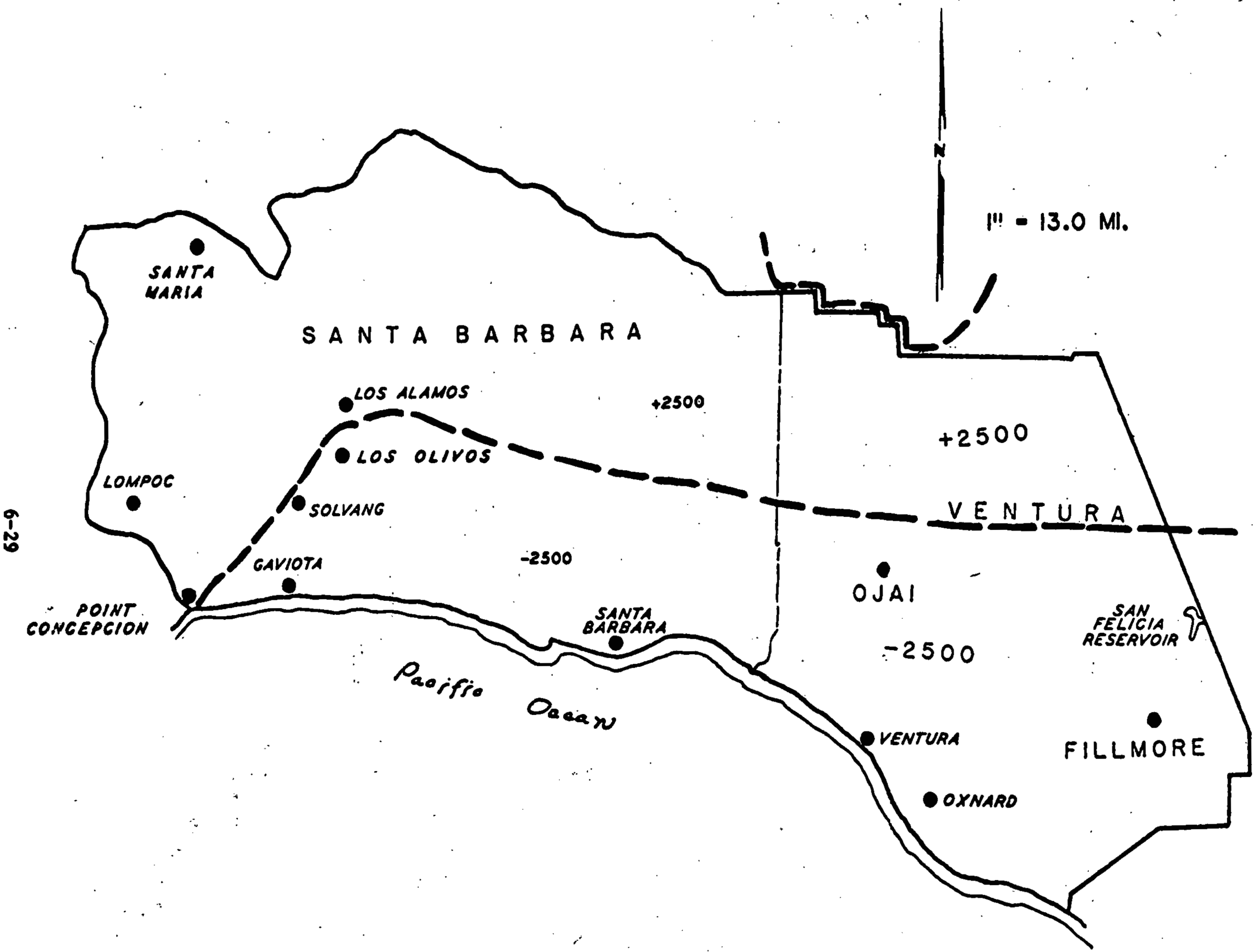

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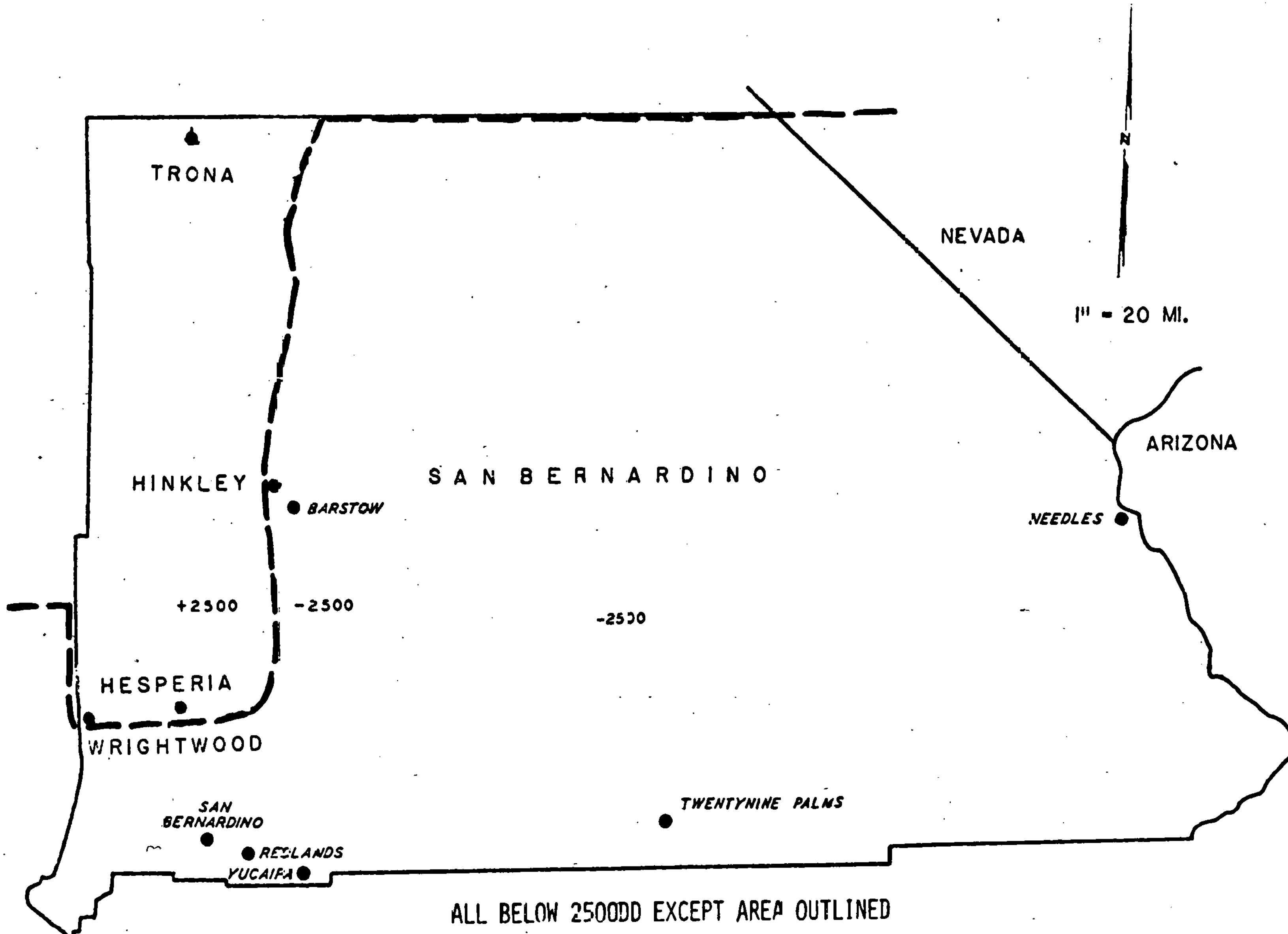
DISTRICT 19



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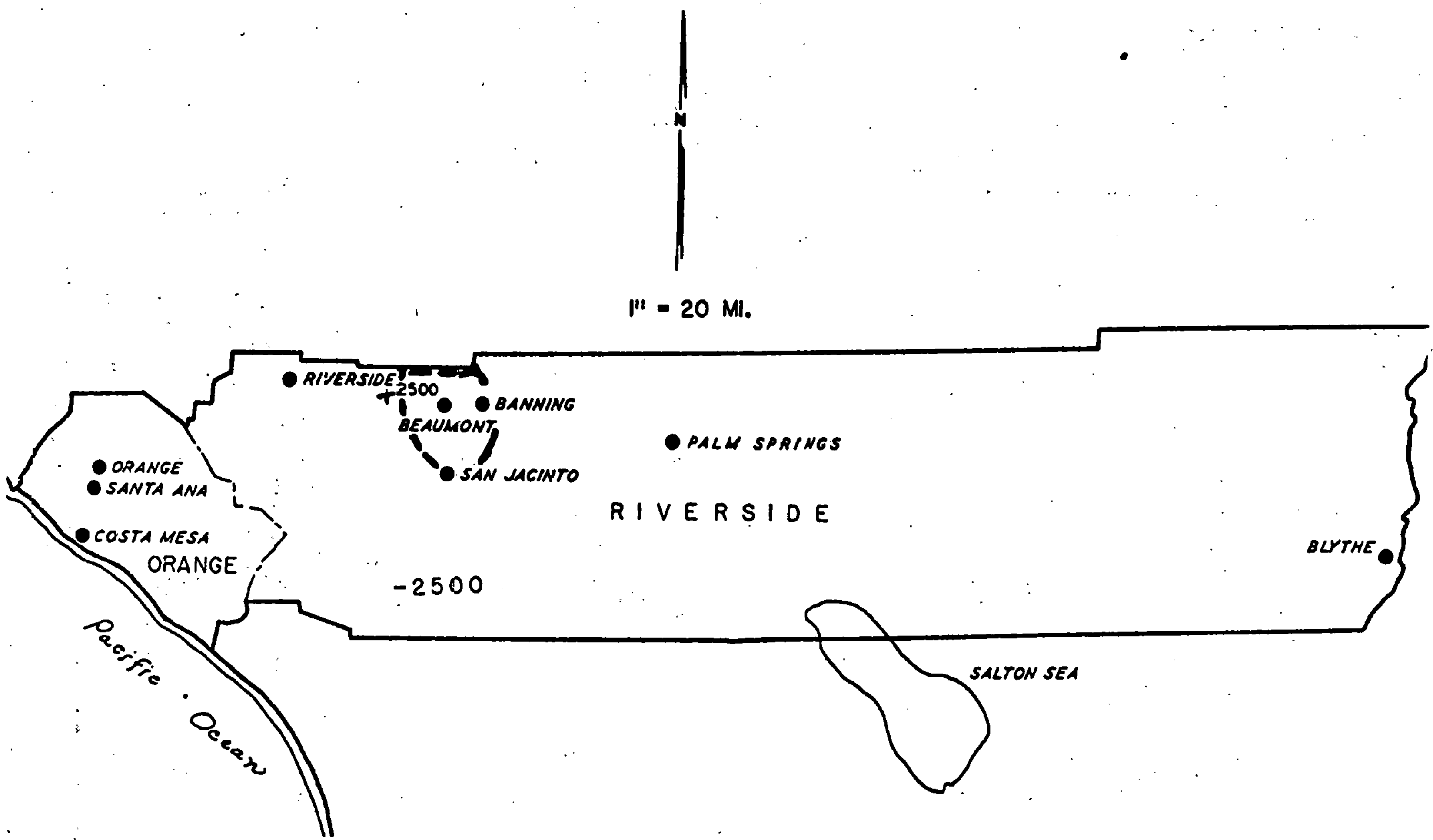
DISTRICT 20



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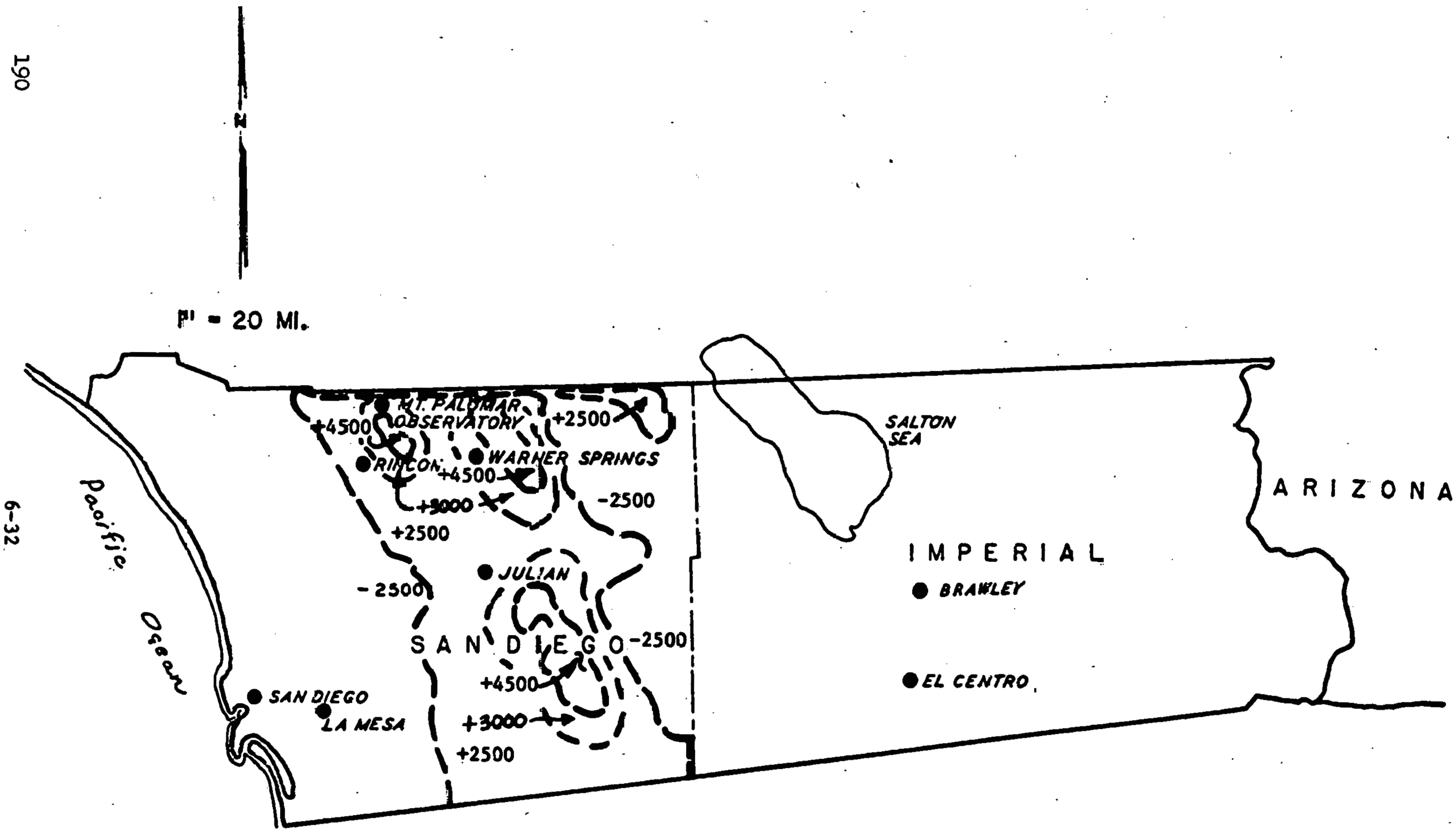
DISTRICT 21



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DISTRICT 22

CHAPTER 7

GLAZING

PURPOSE

The California regulations recognize the importance of glazing as it relates to energy conservation. There are very specific limits placed upon the amount and type of glazing for heated and cooled buildings, and additionally, for heated buildings in the more severe climatic areas of 4500 degree days and higher.

REGULATIONS

The State Regulations relative to glazing are:

1094 (d) (14) Basic Glazing Area - The basic glazing area for low rise buildings shall be 20% of the gross floor area and 40% of the exterior wall area for high rise buildings. The gross floor area shall not include parking garages, unheated basements, corridors, or passageways exposed to exterior ambient temperatures.

1094 (f) Thermal Design Standards for Glazing.

(1) For heated buildings located in areas of 4500 degree days or less, where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed.

(2) Heated buildings located in areas over 4500 degree days shall be provided with special glazing for all exterior glazing. Where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area in special glazing.

(3) Cooled buildings shall utilize tinted glazing when the total glazing area exceeds the basic glazing area. The glazing area on walls oriented within 22½ degrees of true North need not be included in the total glazing area. The required tinted glazing area shall not be less than the difference between the total glazing area and the basic glazing area. Permanent external shading to allow not more than 50% direct solar exposure on the glazing, taken on August 21, at 9:00 a.m., noon and 3:00 p.m. solar time, may be utilized in lieu of tinted glass. Tinted glazing or permanent external shading on walls oriented within 22½ degrees of true North shall not be considered as part of the required tinted glazing area.

(4) Tinted glazing shall have a maximum shading coefficient of 0.75. This maximum shall be decreased to 0.55 for all permit applications filed after July 1, 1976.

A procedure and examples which may be followed to determine whether the proposed building meets the glazing requirements of the regulations are shown later in this Chapter, starting on Page 7-14.

Table 7-1 .... Coefficients of Transmission (*U*) of Windows, Skylights, and Light Transmitting Partitions

Btu per (hr) (sq ft) (F Deg)

PART A—VERTICAL PANELS (EXTERIOR WINDOWS, SLIDING PATIO DOORS, AND PARTITIONS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC SHEET

Description	Exterior[a]		Interior
	Winter	Summer	
Flat Glass			
single glass	1.13	1.06	0.73
insulating glass—double[b]			
3/16 in. air space	0.69	0.64	0.51
1/4 in. air space	0.65	0.61	0.49
1/2 in. air space	0.58	0.56	0.46
1/2 in. air space, low emissivity coating[c]			
emissivity = 0.20	0.38	0.36	0.32
emissivity = 0.40	0.45	0.44	0.38
emissivity = 0.60	0.52	0.50	0.42
insulating glass—triple[b]			
1/4 in. air spaces	0.47	0.45	0.38
1/2 in. air spaces	0.36	0.35	0.30
storm windows			
1 in.–4 in. air space	0.56	0.54	0.44
Glass Block[d]			
6 × 6 × 4 in. thick	0.60	0.57	0.46
8 × 8 × 4 in. thick	0.56	0.54	0.44
—with cavity divider	0.48	0.46	0.38
12 × 12 × 4 in. thick	0.52	0.50	0.41
—with cavity divider	0.44	0.42	0.36
12 × 12 × 2 in. thick	0.60	0.57	0.46
Single Plastic Sheet	1.09	1.00	0.70

[a] See Part C for adjustment for various window and sliding patio door types.
[b] Double and triple refer to the number of lights of glass.
[c] Coating on either glass surface facing air space; all other glass surfaces uncoated.
[d] Dimensions are nominal.
[e] For heat flow up.
[f] For heat flow down.
[g] Based on area of opening, not total surface area.
[h] Refers to windows with negligible opaque area.
[i] Value becomes 1.00 when storm sash is spearated from prime window by a thermal break.

PART B—HORIZONTAL PANELS (SKYLIGHTS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC BUBBLES

Description	Exterior[a]		Interior[e]
	Winter[e]	Summer[f]	
Flat Glass			
single glass	1.22	0.83	0.96
insulating glass—double[b]—			
3/16 in. air space	0.75	0.49	0.62
1/4 in. air space	0.70	0.46	0.59
1/2 in. air space	0.66	0.44	0.56
1/2 in. air space, low emissivity coating[c]			
emissivity = 0.20	0.46	0.31	0.39
emissivity = 0.40	0.53	0.36	0.45
emissivity = 0.60	0.60	0.40	0.50
Glass Block[d]			
11 × 11 × 3 in. thick with cavity divider	0.53	0.35	0.44
12 × 12 × 4 in. thick with cavity divider	0.51	0.34	0.42
Plastic Bubbles[g]			
single walled	1.15	0.80	—
double walled	0.70	0.46	—

PART C—ADJUSTMENT FACTORS FOR VARIOUS WINDOW AND SLIDING PATIO DOOR TYPES (MULTIPLY U VALUES IN PARTS A AND B BY THESE FACTORS)

Description	Single Glass	Double or Triple Glass	Storm Windows
Windows			
All Glass[h]	1.00	1.00	1.00
Wood Sash—80% Glass	0.90	0.95	0.90
Wood Sash—60% Glass	0.80	0.85	0.80
Metal Sash—80% Glass	1.00	1.20	1.20[i]
Sliding Patio Doors			
Wood Frame	0.95	1.00	—
Metal Frame	1.00	1.10	—

Table 7-2 .... Shading Coefficients for Single Glass and Insulating Glass[a]

A. Single Glass

Type of Glass	Nominal Thickness[b]	Solar Trans.[b]	Shading Coefficient $h_o = 4.0$
Regular Sheet	3/32, 1/8	0.87	1.00
Regular Plate/Float	1/4	0.80	0.95
	3/8	0.75	0.91
	1/2	0.71	0.88
Grey Sheet	1/8	0.59	0.78
	3/16	0.74	0.90
	7/32	0.45	0.66
	7/32	0.71	0.88
	1/4	0.67	0.86
Heat-Absorbing Plate/Float[d]	3/16	0.52	0.72
	1/4	0.47	0.70
	3/8	0.33	0.56
	1/2	0.24	0.50

B. Insulating Glass[a]

Type of Glass	Nominal Thickness[c]	Solar Trans.[b] Outer Pane	Solar Trans.[b] Inner Pane	Shading Coefficient $h_o = 4.0$
Regular Sheet Out, Regular Sheet In	3/32, 1/8	0.87	0.87	0.90
Regular Plate/Float Out, Regular Plate/Float In	1/4	0.80	0.80	0.83
Heat-Abs Plate/Float Out, Regular Plate/Float In	1/4	0.46	0.80	0.56

[a] Refers to factory-fabricated units with 3/16, 1/4, or 1/2 in. air space or to prime windows plus storm windows.
[b] Refer to manufacturer's literature for values.
[c] Thickness of each pane of glass, not thickness of assembled unit.
[d] Refers to grey, bronze, and green tinted heat-absorbing plate/float

Table 7-3......Solar Position

32 Degree North Latitude				
Date	Solar Time A.M.	Altitude	Azimuth	Solar Time P.M.
Aug. 21	6	6.5	100.5	6
	7	19.1	92.8	5
	8	31.8	84.7	4
	9	44.3	75.0	3
	10	56.1	61.3	2
	11	66.0	38.4	1
	12	70.3	0.0	12

40 Degree North Latitude				
Date	Solar Time A.M.	Altitude	Azimuth	Solar Time P.M.
Aug. 21	6	7.9	99.5	6
	7	19.3	90.0	5
	8	30.7	79.9	4
	9	41.8	67.9	3
	10	51.7	52.1	2
	11	59.3	29.7	1
	12	62.3	0.0	12

Table 7-4 .... Shading Coefficients for Louvered Sun Screens

Profile Angle, deg	Group 1		Group 2	
	Trans-mittance	SC	Trans-mittance	SC
10	0.23	0.35	0.25	0.33
20	0.06	0.17	0.14	0.23
30	0.04	0.15	0.12	0.21
40 and above	0.04	0.15	0.11	0.20

Profile Angle, deg	Group 3		Group 4	
	Trans-mittance	SC	Trans-mittance	SC
10	0.40	0.51	0.48	0.59
20	0.32	0.42	0.39	0.50
30	0.21	0.31	0.28	0.38
40 and above	0.07	0.18	0.20	0.30

Group 1. Black, width over spacing ratio 1.15/1, 23 louvers per inch.
Group 2. Light color, high reflectance, otherwise same as Group 1.
Group 3. Black or dark color, w/s ratio 0.85/1, 17 louvers per inch.
Group 4. Light color or unpainted aluminum, high reflectance, otherwise same as Group 3.
U-value = 0.85 Btuh/(sq ft)(F deg) for all groups when used with single glazing.

Table 7-5.... Periods for Which Louvered Sun Screens Will Completely Shade Window (see explanation below]

Latitude	Month	N	NE	E	SE	S	SW	W	NW
32 deg North	June	6–6	8+	8+	7+	A	to 5	to 4	to 4
	Aug.	6–6	8+	8+	8+	A*	to 4	to 4	to 4
	Oct.	N.S*	8+	9+	9+	8–4	to 3	to 3	to 4
	Dec.	N.S	8+	10+	11+	10–2	to 1	to 2	to 4
40 deg North	June	6–6	7+	8+	6+	A	to 6	to 4	to 5
	Aug.	6–6	8+	8+	8+	A*	to 4	to 4	to 4
	Oct.	N.S*	8+	9+	10+	9–3	to 2	to 3	to 4
	Dec.	N.S	8+	10+	12+	N**	to 12	to 2	to 4

* Applies for September also. ** Applies for November also.

Explanation of Chart

(7 – 5) means value of 0.20 applies from 7 a.m. to 5 p.m.
(8+) means value applies from 8 a.m. to sunset.
(to 5) means value applies from sunrise to 5 p.m.
(N.S.) means no sun on window.
(A) means value applies for all hours.
(N) means value does not apply for any hours.

EXTERNAL SHADING DEVICES

In general, external shading devices which eliminate all direct radiation and still permit free air movement at the outer fenestration surface will reduce the solar heat gain by as much as 80 percent. In this category are found architectural treatments such as overhangs, wings, screen walls, as well as horizontal and vertical louvers, and vented awnings.

The ability of horizontally louvered devices to intercept the direct component of solar radiation depends upon their geometry and the profile or shadow-line angle Ω between the line normal to the plane of the slats and the projection of the solar ray in the plane perpendicular to the slats. Fig. 7-A shows the geometry of slat-type sunshades, while the definition of the profile angle is explained by Fig. 7-B. The profile angle can be calculated by:

$$\tan \Omega = \tan \beta / \cos \gamma$$

For slat-type sunshades, the transmitted solar radiation consists of straight-through and transmitted-through components. When the profile angle Ω is above the cutoff angle (see Fig. 7-A), straight-through transmission of direct radiation is completely eliminated but the transmitted diffuse and the reflected-through direct components remain. Their magnitude depends upon the reflectance of the surfaces of the sun-shade. Table 7-4 gives Shading Coefficients for several types of louvered sun screens. Commercially available louvered sun screens will exclude direct solar radiation when the profile angle exceeds approximately 20 deg (Groups 1 and 2) or 30 deg (Groups 3 and 4). Table 7-5 lists the hours of the day when this occurs for various latitudes and months.

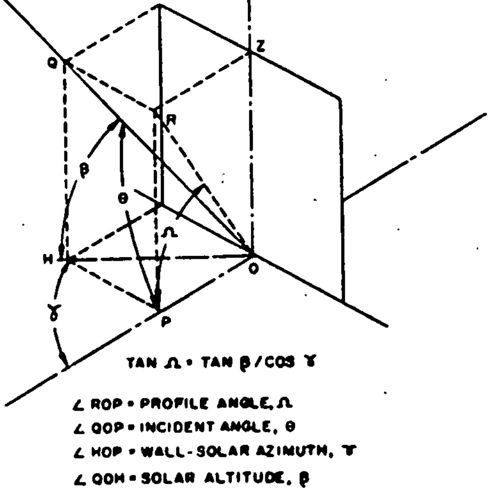

Fig. 7-A .... Profile Angle for South-Facing Slat-Type Sunshades

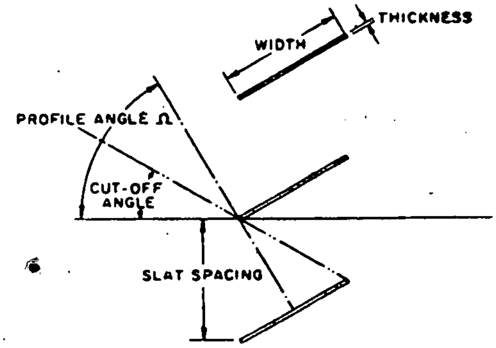

Fig. 7-B.... Geometry of Slat-Type Sunshades

ROOF OVERHANGS AND HORIZONTAL PROJECTIONS

During certain seasons of the year and for some exposures, horizontal projections can result in considerable reductions in solar heat gain by providing shade. This is particularly applicable to South, Southeast, and Southwest exposures during the late spring, summer, and early fall. On East and West exposures during the entire year, and on southerly exposures during the winter, the solar altitude is generally so low that horizontal projections, in order to be effective, would have to be excessively long.

Table 7-6 lists the required projections to produce a shadow height of 10 ft. on a window or wall during the period from April 11 through September 1. The projection required for other shadow heights can be found by direct ratio. The choice of a horizontal projection must be based on architectural practicability and a full understanding of its limitations as well as its ' :-fits.

Table 7-6 .... Length of Horizontal Projection Required for Shading Windows and Walls
(For shading 10 ft down from projection for April 11 through September 1)

Latitude	*Sun Time AM→ ↓*	*Projection in Feet*						*Sun Time*
		N	NE	E	SE	S	SW	
32 Deg North	6 a.m.	15.8	*	*	*	—	—	6 p.m.
	7	--	*	*	*	1.7	—	5
	8	—	10.0	17.3	14.2	3.0	—	4
	9	—	4.6	10.3	10.0	3.8	—	3
	10	—	1.4	6.0	7.3	4.2	—	2
	11	—	—	2.8	5.1	4.2	1.2	1
	12 N	—	—	—	3.0	4.2	3.0	12 N
40 Deg North	6 a.m.	12.0	*	*	*	—	—	6 p.m.
	7	—	*	*	*	1.8	—	5
	8	—	9.7	18.9	16.1	4.3	—	4
	9	—	4.7	11.2	11.6	5.4	—	3
	10	—	1.3	6.5	9.1	5.8	—	2
	11	—	—	3.1	6.5	6.1	2.2	1
	12 N	—	—	—	4.3	6.3	4.3	12 N
		N	NW	W	SW	S	SE	←↑PM

* Projection greater than 20 ft required.

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GRAPHICAL SHADING METHOD

The following illustrates a graphical method of determining the amount of shading produced by a roof overhang on August 21 at 9:00 a.m., noon and 3:00 p.m. Figures 7-C, 7-D, and 7-E follow the procedure outlined below.

The same technique can be used to determine the shading effects of other projections, such as walls.

For this example, assume the building is located in Stockton, which is located at approximately 38° North Latitude, and the elevation orientation is S 10°E.

STEP 1. Determine from Table 7-7c the profile angle and solar azimuth on August 21 at 9:00 a.m., noon and 3:00 p.m. solar time as follows:

9:00 a.m.	Profile angle =	61.1°
	Solar azimuth =	69.7°
Noon	Profile angle =	64.6°
	Solar azimuth =	0°
3:00 p.m.	Profile angle =	78.9°
	Solar azimuth =	69.7°

STEP 2. Draw to scale, the section, elevation and plan views of the wall as shown.

STEP 3. On the section view, draw the profile angle line (Line 1) through Point A, the lower edge of the overhang. The lower extent of the shadow occurs where the profile angle line intersects the wall surface (Point B).

STEP 4. Draw the lower extent of the shadow line on the elevation view (Line 2), which is a horizontal line across the elevation view starting at Point B.

STEP 5. On the plan view, draw the solar azimuth line(s) (Line 3) through the edge(s) of the overhang (Point C). The lateral extent of the shadow is determined by where these lines intersect the wall surface (Point D).

STEP 6. Project a vertical line (Line 4) from Point D up to Line 2. This determines Point E.

STEP 7. On the elevation view, Line 5 from Point E to the edge of the overhang (Point F) is the shadow line.

The area of window shaded can be calculated from dimensions scaled off the elevation view.

For compliance with Section 1094(f)(3) of the regulations, the actual shaded window area must be equal or greater than the required shaded area at each of the three designated times, which are 9:00 a.m., noon, and 3:00 p.m. on August 21.

In this example, the smallest shaded window area occurs at 9:00 a.m. However, since shading on all elevations (except those oriented within 22½ degrees of true North) is considered concurrently at each designated time, 9:00 a.m. may not be the critical time when all elevations are considered.

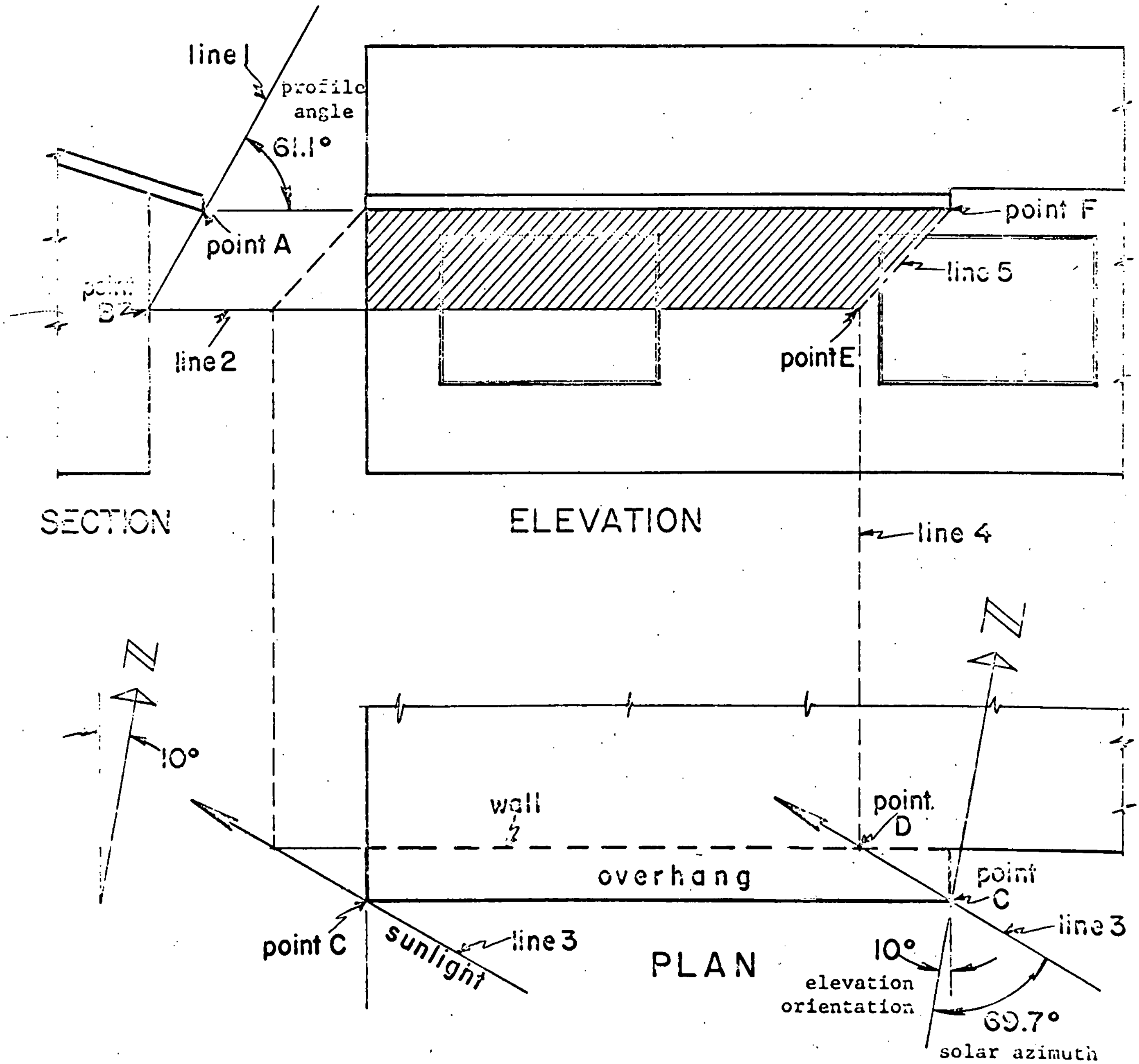


Figure 7-C . . . . Shading at 9:00 a.m.

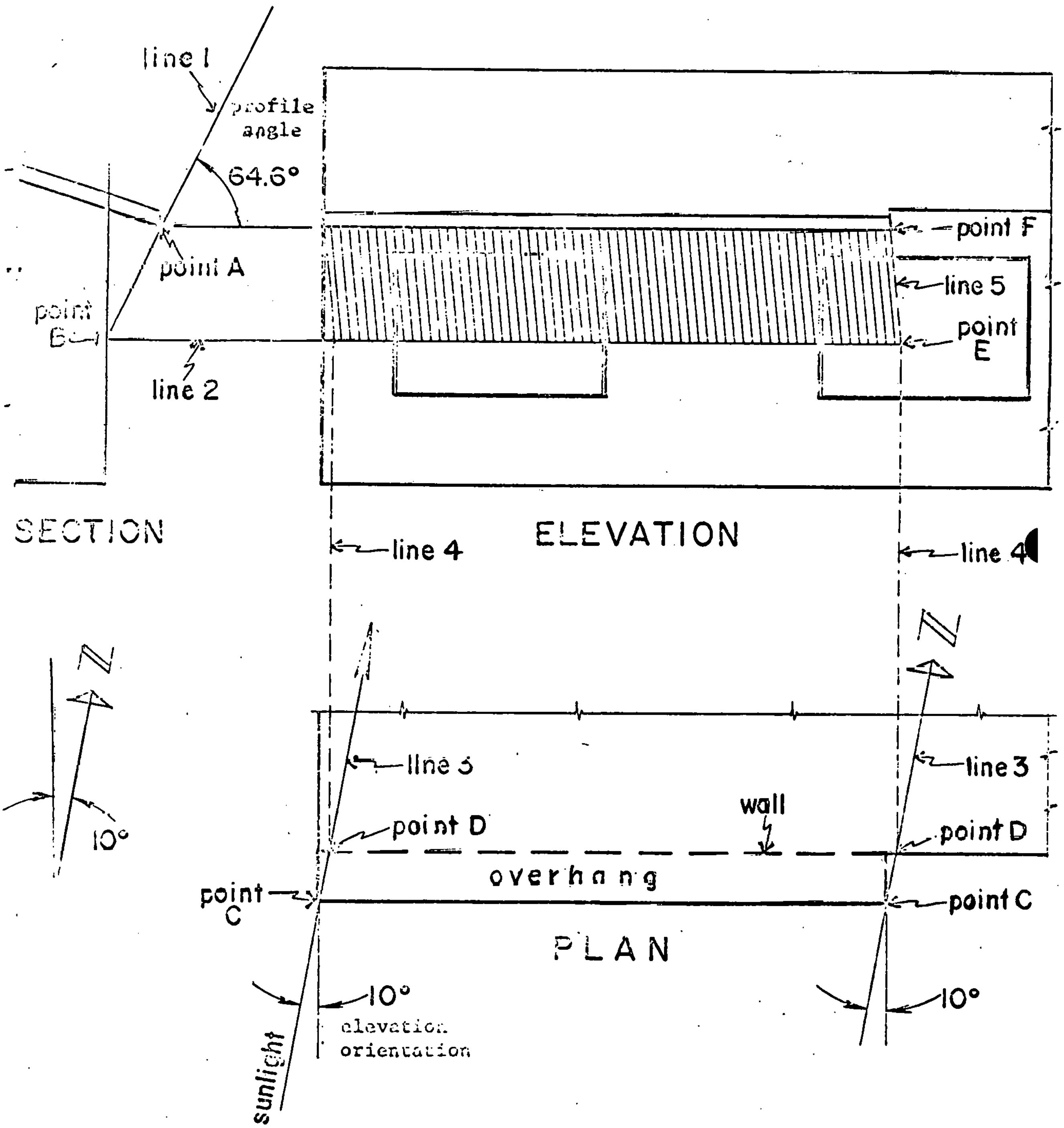


Figure 7-D . . . . Shading at 12:00 Noon

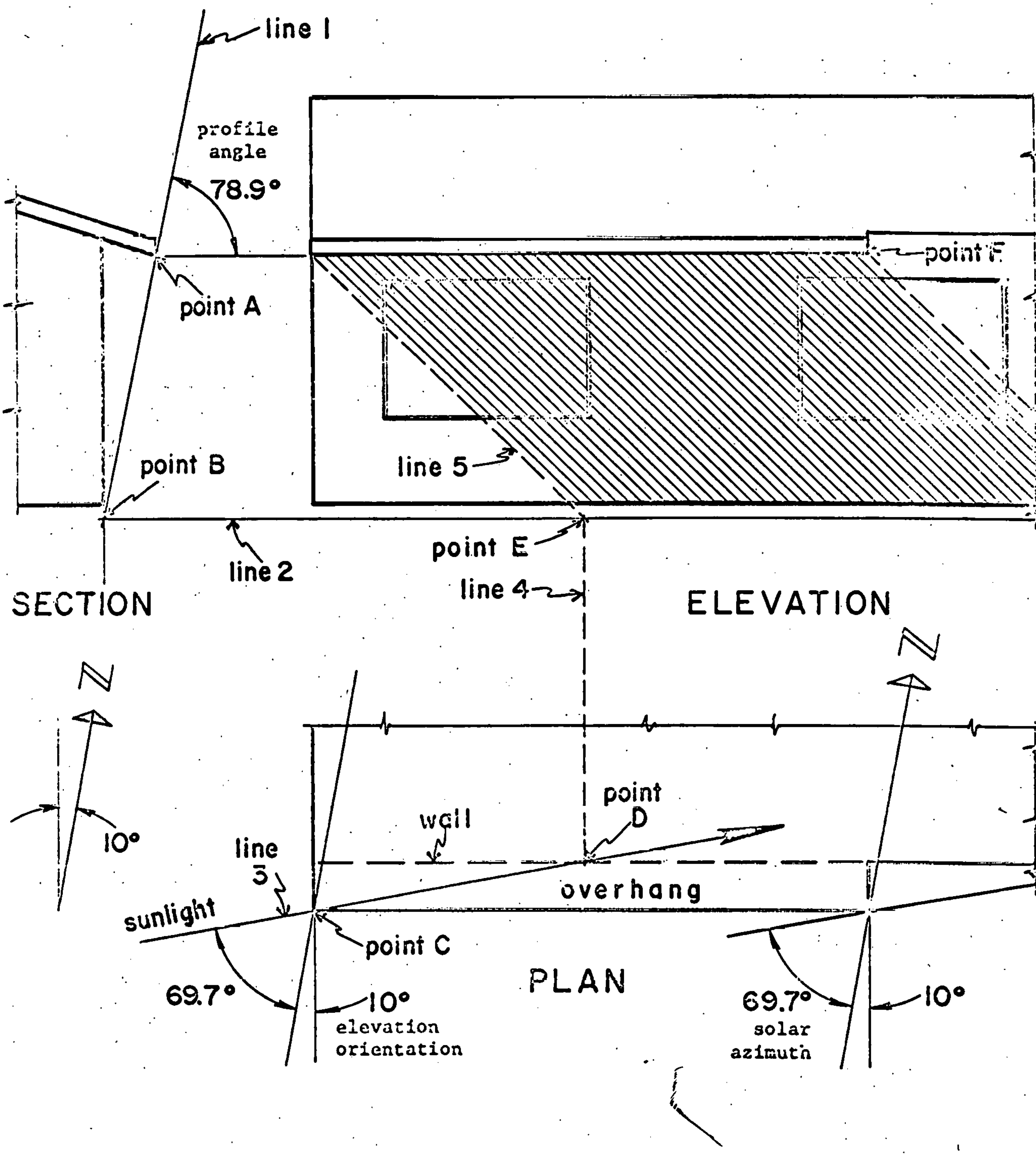


Figure 7-E . . . . Shading at 3:00 p.m.

Table 7-7a. . . . Profile Angle and Solar Azimuth on August 21* (Degrees)

Elevation Orientation (Degrees)	32° North Latitude 9 a.m.	12 noon	3 p.m.	33° North Latitude 9 a.m.	12 noon	3 p.m.	34° North Latitude 9 a.m.	12 noon	3 p.m.
S 150 E	75.1	-	-	75.8	-	-	76.7	-	-
S 140 E	66.6	-	-	67.1	-	-	67.6	-	-
S 130 E	59.6	-	-	59.9	-	-	60.2	-	-
S 120 E	54.1	-	-	54.2	-	-	54.4	-	-
S 110 E	50.0	-	-	50.0	-	-	50.0	-	-
S 100 E	47.1	-	-	47.0	-	-	47.0	-	-
S 90 E	45.3	90.0	-	45.1	90.0	-	44.9	90.0	-
S 80 E	44.4	86.4	-	44.2	86.2	-	43.9	86.0	-
S 70 E	44.4	83.0	-	44.1	82.6	-	43.7	82.2	-
S 60 E	45.3	79.9	-	44.9	79.3	-	44.5	78.7	-
S 50 E	47.1	77.0	-	46.6	76.3	-	46.1	75.7	-
S 40 E	50.0	74.7	-	49.4	73.9	-	48.8	73.0	-
S 30 E	54.1	72.8	-	53.4	71.9	-	52.7	71.0	-
S 20 E	59.6	71.4	-	58.7	70.5	-	57.9	69.5	-
S 10 E	66.6	70.6	84.9	65.7	69.6	83.9	64.7	68.6	82.9
S	75.1	70.3	75.1	74.2	69.3	74.2	73.2	68.3	73.2
S 10 W	84.9	70.6	66.6	83.9	69.6	65.7	82.9	68.6	64.7
S 20 W	-	71.4	59.6	-	70.5	58.7	-	69.5	57.9
S 30 W	-	72.8	54.1	-	71.9	53.4	-	71.0	52.7
S 40 W	-	74.7	50.0	-	73.9	49.4	-	73.0	48.[illegible]
S 50 W	-	77.0	47.1	-	76.3	46.6	-	75.7	46.[illegible]
S 60 W	-	79.9	45.3	-	79.3	44.9	-	78.7	44.5
S 70 W	-	83.0	44.4	-	82.6	44.1	-	82.2	43.7
S 80 W	-	86.4	44.4	-	86.2	44.2	-	86.0	43.9
S 90 W	-	90.0	45.3	-	90.0	45.1	-	90.0	44.9
S 100 W	-	-	47.1	-	-	47.0	-	-	47.0
S 110 W	-	-	50.0	-	-	50.0	-	-	50.0
S 120 W	-	-	54.1	-	-	54.2	-	-	54.4
S 130 W	-	-	59.6	-	-	59.9	-	-	60.2
S 140 W	-	-	66.6	-	-	67.1	-	-	67.6
S 150 W	-	-	75.1	-	-	75.8	-	-	76.6
Solar Azimuth	S 75.0 E	0	S 75.0 W	S 74.1 E	0	S 74.1 W	S 73.2 E	0	S 73.2 W
Elevation Orientation for 90° profile angle	9 a.m. S 15.0 W		3 p.m. S 15.0 E	9 a.m. S 15.9 W		3 p.m. S 15.9 E	9 a.m. S 16.8 W		3 p.m. S 16.8 E

*Note: Elevation orientations which have a 90° profile angle are oriented 90° from the solar azimuth and are completely shaded. Elevation orientations for which the profile angle is not given are oriented more than 90° from the solar azimuth and are, therefore, completely shaded.

Table 7-7b. . . . Profile Angle and Solar Azimuth on August 21* (Degrees)

Elevation Orientation (Degrees)	35° North Latitude 9 a.m.	12 noon	3 p.m.	36° North Latitude 9 a.m.	12 noon	3 p.m.	37° North Latitude 9 a.m.	12 noon	3 p.m.
S 150 E	77.3	-	-	78.0	-	-	78.7	-	-
S 140 E	68.1	-	-	68.6	-	-	69.1	-	-
S 130 E	60.5	-	-	60.8	-	-	61.1	-	-
S 120 E	54.6	-	-	54.7	-	-	54.8	-	-
S 110 E	50.1	-	-	50.1	-	-	50.1	-	-
S 100 E	46.9	-	-	46.8	-	-	46.6	-	-
S 90 E	44.8	90.0	-	44.6	90.0	-	44.4	90.0	-
S 80 E	43.7	85.8	-	43.4	85.6	-	43.1	85.4	-
S 70 E	43.4	81.9	-	43.1	81.5	-	42.7	81.1	-
S 60 E	44.1	78.2	-	43.7	77.6	-	43.2	77.0	-
S 50 E	45.6	75.0	-	45.2	74.2	-	44.6	73.5	-
S 40 E	48.2	72.2	-	47.7	71.4	-	47.0	70.6	-
S 30 E	52.0	70.1	-	51.3	69.2	-	50.6	68.3	-
S 20 E	57.1	68.5	-	56.4	67.6	-	55.5	66.6	-
S 10 E	63.8	67.6	81.9	63.0	66.6	81.0	62.0	65.6	80.0
S	72.2	67.3	72.2	71.3	66.3	71.3	70.2	65.3	70.2
S 10 W	81.9	67.6	63.8	81.0	66.6	63.0	80.0	65.6	62.0
S 20 W	-	68.5	57.1	-	67.6	56.4	-	66.6	55.5
S 30 W	-	70.1	52.0	-	69.2	51.3	-	68.3	50.6
S 40 W	-	72.2	48.2	-	71.4	47.7	-	70.6	47.0
S 50 W	-	75.0	45.6	-	74.2	45.2	-	73.5	44.6
S 60 W	-	78.2	44.1	-	77.6	43.7	-	77.0	43.2
S 70 W	-	81.9	43.4	-	81.5	43.1	-	81.1	42.7
S 80 W	-	85.8	43.7	-	85.6	43.4	-	85.4	43.1
S 90 W	-	90.0	44.8	-	90.0	44.6	-	90.0	44.4
S 100 W	-	-	46.9	-	-	46.8	-	-	46.6
S 110 W	-	-	50.1	-	-	50.1	-	-	50.1
S 120 W	-	-	54.6	-	-	54.7	-	-	54.8
S 130 W	-	-	60.5	-	-	60.8	-	-	61.1
S 140 W	-	-	68.1	-	-	68.6	-	-	69.1
S 150 W	-	-	77.3	-	-	78.0	-	-	78.7
Solar Azimuth	S 72.3 E	0	S 72.3 W	S 71.5 E	0	S 71.5 W	S 70.6 E	0	S 70.6 W
Elevation Orientation for 90° profile angle	9 a.m. S 17.7 W		3 p.m. S 17.7 E	9 a.m. S 18.5 W		3 p.m. S 18.5 E	9 a.m. S 19.4 W		3 p.m. S 19.4 E

*Note: Elevation orientations which have a 90° profile angle are oriented 90° from the solar azimuth and are completely shaded. Elevation orientations for which the profile angle is not given are oriented more than 90° from the solar azimuth and are, therefore, completely shaded.

Table 7-7c. . . . Profile Angle and Solar Azimuth on August 21* (Degrees)

Elevation Orientation (Degrees)	38° North Latitude 9 a.m.	38° 12 noon	38° 3 p.m.	39° North Latitude 9 a.m.	39° 12 noon	39° 3 p.m.	40° North Latitude 9 a.m.	40° 12 noon	40° 3 p.m.
S 150 E	79.5	-	-	80.4	-	-	81.3	-	-
S 140 E	69.7	-	-	70.4	-	-	71.0	-	-
S 130 E	61.5	-	-	61.9	-	-	62.4	-	-
S 120 E	55.0	-	-	55.3	-	-	55.5	-	-
S 110 E	50.1	-	-	50.2	-	-	50.3	-	-
S 100 E	46.6	-	-	46.6	-	-	46.5	-	-
S 90 E	44.2	90.0	-	44.1	90.0	-	44.0	90.0	-
S 80 E	42.9	85.2	-	42.6	85.0	-	42.4	84.8	-
S 70 E	42.4	80.7	-	42.1	80.2	-	41.8	79.8	-
S 60 E	42.8	76.5	-	42.4	75.9	-	42.1	75.3	-
S 50 E	44.1	72.8	-	43.7	72.1	-	43.2	71.4	-
S 40 E	46.4	69.8	-	45.9	68.9	-	45.3	68.1	-
S 30 E	49.9	67.4	-	49.2	66.5	-	48.6	65.5	-
S 20 E	54.7	65.7	89.7	53.9	64.7	88.7	53.1	63.7	87.7
S 10 E	61.1	64.6	78.9	60.2	63.7	77.9	59.3	62.7	76.8
S	69.2	64.3	69.2	68.2	63.3	68.2	67.2	62.3	67.2
S 10 W	78.9	64.6	61.1	77.9	63.7	60.2	76.8	62.7	59.3
S 20 W	89.7	65.7	54.7	88.7	64.7	53.9	87.7	63.7	53.1
S 30 W	-	67.4	49.9	-	66.5	49.2	-	65.5	48.6
S 40 W	-	69.8	46.4	-	68.9	45.9	-	68.1	45.3
S 50 W	-	72.8	44.1	-	72.1	43.7	-	71.4	43.2
S 60 W	-	76.5	42.8	-	75.9	42.4	-	75.3	42.1
S 70 W	-	80.7	42.4	-	80.2	42.1	-	79.8	41.8
S 80 W	-	85.2	42.9	-	85.0	42.6	-	84.8	42.4
S 90 W	-	90.0	44.2	-	90.0	44.1	-	90.0	44.0
S 100 W	-	-	46.6	-	-	46.6	-	-	46.5
S 110 W	-	-	50.1	-	-	50.2	-	-	50.3
S 120 W	-	-	55.0	-	-	55.3	-	-	55.5
S 130 W	-	-	61.5	-	-	61.9	-	-	62.4
S 140 W	-	-	69.7	-	-	70.4	-	-	71.0
S 150 W	-	-	79.5	-	-	80.4	-	-	81.3
Solar Azimuth	S 69.7 E	0	S 69.7 W	S 68.8 E	0	S 68.8 W	S 67.9 E	0	S 67.9 W
Elevation Orientation for 90° profile angle	9 a.m. S 20.3 W		3 p.m. S 20.3 E	9 a.m. S 21.2 W		3 p.m. S 21.2 E	9 a.m. S 22.1 W		3 p.m. S 22.1 E

*Note: Elevation orientations which have a 90° profile angle are oriented 90° from the solar azimuth and are completely shaded. Elevation orientations for which the profile angle is not given are oriented more than 90° from the solar azimuth and are, therefore, completely shaded.

Table 7-7d. . . . Profile Angle and Solar Azimuth on August 21* (Degrees)

Elevation Orientation (Degrees)	41° North Latitude 9 a.m.	41° North Latitude 12 noon	41° North Latitude 3 p.m.	42° North Latitude 9 a.m.	42° North Latitude 12 noon	42° North Latitude 3 p.m.
S 150 E	82.0	-	-	82.7	-	-
S 140 E	71.6	-	-	72.0	-	-
S 130 E	62.7	-	-	62.[illegible]	-	-
S 120 E	55.6	-	-	55.7	-	-
S 110 E	50.3	-	-	50.2	-	-
S 100 E	46.4	-	-	46.2	-	-
S 90 E	43.7	90.0	-	43.5	90.0	-
S 80 E	42.1	84.6	-	41.8	84.3	-
S 70 E	41.4	79.4	-	41.1	79.0	-
S 60 E	41.6	74.7	-	41.2	74.1	-
S 50 E	42.7	70.6	-	42.2	69.9	-
S 40 E	44.7	67.2	-	44.1	66.4	-
S 30 E	47.9	64.6	-	47.2	63.7	-
S 20 E	52.3	62.8	86.7	51.6	61.8	85.9
S 10 E	58.4	61.7	75.8	57.5	60.7	74.9
S	66.2	61.3	66.2	65.3	60.3	65.3
S 10 W	75.8	61.7	58.4	74.9	60.7	57.5
S 20 W	86.7	62.8	52.3	85.9	61.8	51.6
S 30 W	-	64.6	47.9	-	63.7	47.2
S 40 W	-	67.2	44.7	-	66.4	44.1
S 50 W	-	70.6	42.7	-	69.9	42.2
S 60 W	-	74.7	41.6	-	74.1	41.2
S 70 W	-	79.4	41.4	-	79.0	41.1
S 80 W	-	84.6	42.1	-	84.3	41.8
S 90 W	-	90.0	43.7	-	90.0	43.5
S 100 W	-	-	46.4	-	-	46.2
S 110 W	-	-	50.3	-	-	50.2
S 120 W	-	-	55.6	-	-	55.7
S 130 W	-	-	62.7	-	-	62.9
S 140 W	-	-	71.6	-	-	72.0
S 150 W	-	-	82.0	-	-	82.7
Solar Azimuth	S 67.1 E	0	S 67.1 W	S 66.4 E	0	S 66.4 W
Elevation Orientation for 90° profile angle	9 a.m. S 22.9 W		3 p.m. S 22.9 E	9 a.m. S 25.6 W		3 p.m. S 25.6 E

*Note: Elevation orientations which have a 90° profile angle are oriented 90° from the solar azimuth and are completely shaded. Elevation orientations for which the profile angle is not given are oriented more than 90° from the solar azimuth and are, therefore, completely shaded.

PROCEDURE

In order for the designer or the Building Official to determine whether the proposed building meets the requirements of the regulations, there are certain steps which should be followed. These are:

1. Determine basic glazing area for the building based upon the architectural drawings.
2. Determine the degree day zone for the building site.
3. Determine if the building is heated only, or if it is both heated and cooled.
4. For a heated building located in an area of 4500 degree days or less, determine compliance with 1094(f)(1).
5. For a heated building located in an area over 4500 degree days, determine compliance with 1094(f)(2).
6. For a cooled building, determine compliance with 1094(f)(3).

EXAMPLE I

Sample calculations for this example will be based upon:

A four-story, rectangular, heated and air-conditioned, thirteen unit apartment building with an enclosed basement to be located in Sacramento, California.

Figure 7-F details highly simplified basement and above grade floor plans. Note that there is one two-bedroom apartment unit in the basement area, and two two-bedroom units and one three-bedroom unit on each of the four floors above grade, for a total of thirteen units. In addition, we will assume the height above grade to be forty-six feet (ten feet for each floor and six feet of basement above grade), and a foundation four feet below grade. All finished ceiling heights are 8'-0". The construction weight of the exterior wall exceeds 40 pounds per square foot. Clear window glass has been specified for this building.

STEP 1. Determine the basic glazing area. Since this building is over three stories, it is a high rise building pursuant to Section 1094(d)(5) and the basic glazing area is 40% of the exterior wall area.

1-A. Calculate the exterior wall area adjacent to heated or cooled spaces exposed to ambient climatic temperatures.

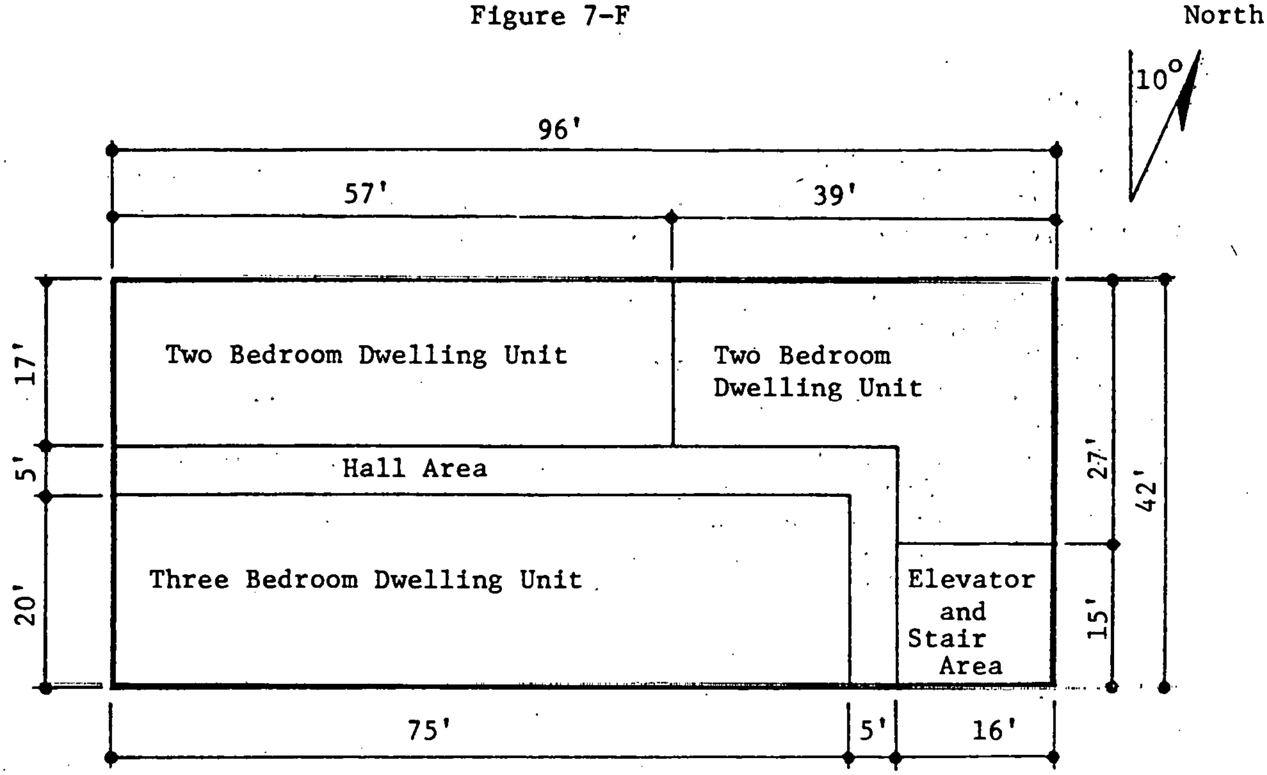
The basement exterior wall area is:

$$6(39 + 27 + 15 + 16 + 5) + 10(25 + 18 + 17) = 1{,}212 \text{ sq ft}$$

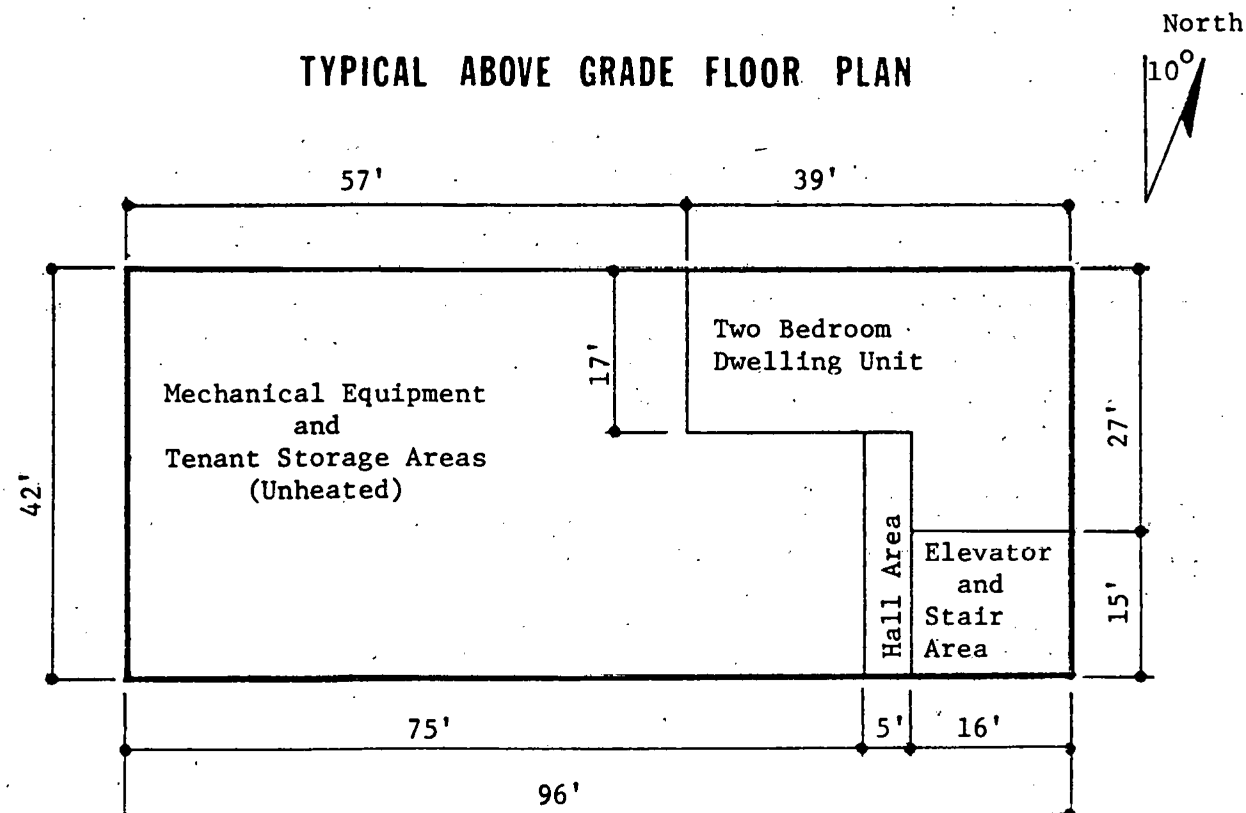
The exterior wall area for each floor above grade is:

$$10(96 + 96 + 42 + 42) = 2{,}760 \text{ sq ft/floor}$$

Figure 7-F



TYPICAL ABOVE GRADE FLOOR PLAN



BASEMENT FLOOR PLAN

The exterior wall area for the 4 floors above grade is:

4 x 2,760 = 11,040 sq ft

The total exterior wall area of the building is:

1212 + 11040 = 12,252 sq ft

1-B. Calculate 40% of the area determined in Step 1-A.

12,252 x 0.40 = 4901 sq ft

This is the basic glazing area for the entire building.

STEP 2. Determine the degree day zone for the building site. By reference to Chapter 6 - California Design Conditions - we find that Sacramento has 2782 heating degree days. The design of this building will, therefore, be governed by Section 1094(f)(1) rather than 1094(f)(2). Winter design temperature for Sacramento is 29°F and summer design temperature is 97°F.

STEP 3. By definition in this example, the building is both heated and cooled.

STEP 4. Determine compliance with 1094(f)(1).

4-A. The planned glazing area (assumed for this example) is as follows:

North elevation	- 1200 sq ft
East elevation	- 1000 sq ft
South elevation	- 3200 sq ft
West elevation	- 1000 sq ft
Total	- 6400 sq ft

4-B. The planned glazing area of 6400 sq ft is greater than the basic glazing area. Therefore, as specified in Section 1094(f)(1) "treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed."

Some of the various methods by which this may be accomplished are as follows:

a. Reduce the planned glazing area to the basic glazing area of 4901 sq ft.
b. Use insulating glass with an acceptable U factor for the entire planned glazing area.
c. Use a combination of single glass (U=1.13) and insulating glass with an acceptable U factor.
d. Use an acceptable combination of reduced planned glazing area and insulating glass.
e. Some other combination of materials in keeping with the provisions of Section 1094(c) of the regulations.

4-C. Calculate the allowable heat loss.

The heat loss (Q) through a particular section of a building is proportional to the U factor (U), the area (A) of the section and the temperature difference (ΔT) between the indoor and outdoor design temperatures; or:

$$Q = U \cdot A \cdot \Delta T$$

The planned glazing area exceeds the basic glazing area by:

$$6400 - 4901 = 1499 \text{ sq ft}$$

The allowable heat loss (the heat loss which would occur with the basic glazing area single glazed) for the 6400 sq ft would be equal to the allowable heat loss through 4901 sq ft basic glazing area plus the allowable heat loss through the 1499 sq ft of wall which was replaced by the excess planned glazing.

The allowable heat loss (Q) through the basic glazing area single glazed is:

$$Q = (\text{U factor of single glass})\ (\text{basic glazing area})\ (\Delta T)$$
$$Q = (1.13)\ (4901)\ (\Delta T) = 5538\ (\Delta T) \text{ Btu/hr}$$

Since the building is located in an area having less than 3500 degree days and the exterior wall construction weight exceeds 40 psf, the maximum allowable U factor of the wall is 0.16. (See Section 1094(e) of the regulations.) The allowable heat loss (Q) of the wall area replaced by the excess planned glass is:

$$Q = (\text{Allowable U factor of wall})\ (\text{wall area})\ (\Delta T)$$
$$Q = (0.16)\ (1499)\ (\Delta T) = 240\ (\Delta T) \text{ Btu/hr}$$

The total allowable heat loss for the 6400 sq ft of planned glazing area is:

$$5538\ (\Delta T) + 240\ (\Delta T) = 5778\ (\Delta T) \text{ Btu/hr}$$

Therefore, in order to be in compliance with Section 1094(f)(1), the actual design heat loss through the 6400 sq ft of planned glazing area cannot be greater than 5778 (ΔT) Btu/hr.

Note that ΔT (the difference between the indoor and outdoor design temperatures) is the same for both the actual and the allowable heat loss calculations and, therefore, is not required in the calculations.

4-D. One method of obtaining compliance is to use insulating glass for the entire planned glazing area. (Method b on page 7-16.) The U factor required for the insulating glass can be calculated by equating the actual design heat loss to the allowable heat loss as follows:

Actual Heat Loss = Allowable Heat Loss

(U factor of the insulating glass) (glass area) = 5778
(U) (6400) = 5778
U = 0.902

Check the actual heat loss through the 6400 sq ft of insulating glass with a maximum U factor of 0.902 as follows:

$Q = (0.902)(6400) = 5773$ Btu/hr F

This is less than the allowable heat loss, therefore, compliance with Section 1094(f)(1) could be obtained by using insulating glass with a U factor not greater than 0.902 for the entire 6400 sq ft of planned glazing area. Glazing with the appropriate U factor may be selected from either Table 7-1 or the manufacturer's technical data.

4-E. Another method of obtaining compliance is to use a combination of single glass and insulating glass. (Method c on Page 7-16.) For this example, the insulating glass will be double glass with a ¼ inch air space. (U = 0.65 from Table 7-1)

The area of insulating glass required could have been determined by estimating the area required, then calculating the actual design heat loss and comparing it to the allowable heat loss calculated in 4-C; or it can be calculated by equating the actual heat loss to the allowable heat loss as follows:

Actual Heat Loss = Allowable Heat Loss
Single Glass + Insulating Glass = Allowable
$1.13\ A_{SG} + U_{IG}\ A_{IG} = 5778$
Where:
A_{SG} = Area of single glass (sq ft)
A_{IG} = Area of insulating glass (sq ft)
U_{IG} = U factor of insulating glass

Since the total planned glass area is 6400,
then $A_{SG} = 6400 - A_{IG}$

$1.13\ (6400 - A_{IG}) + 0.65\ A_{IG} = 5778$
$7232 - 1.13\ A_{IG} + 0.65\ A_{IG} = 5778$
$0.48\ A_{IG} = 1454$
$A_{IG} = 3029$ sq ft = Area of insulating glass

The area of noninsulating or single glass would be:
6400 - 3029 = 3371 sq ft

The actual heat loss of the planned glazing area should be checked as follows:
$Q = 1.13\ (3371) + 0.65\ (3029)$
$= 5578$ Btu/hr F

Comparing the actual loss to the allowable heat loss shows that they are equal. Therefore, 3029 sq ft of insulating glass with a maximum U factor of 0.65 would be necessary to comply with Section 1094(f)(1).

STEP 5. Determine compliance with Section 1094(f)(2). Since this building is in Sacramento and there are less than 4500 degree days, these provisions do not apply.

STEP 6. Determine compliance with Section 1094(f)(3).

6-A. For cooled buildings, tinted glazing is required when the total glazing area exceeds the basic glazing area. However, the glazing area on walls oriented within 22½° of true North need not be included in the total glazing area.

Basic glazing area = 4901 sq ft (See 1-B)
Planned glazing area = 6400 sq ft (See 4-A)
Glazing area on North wall = 1200 sq ft (See 4-A)

The total glazing area as related to the tinted glazing requirement is calculated by subtracting the glazing area on the North wall from the planned glazing area.

Total glazing area = 6400 - 1200 = 5200 sq ft

Since this total glazing area exceeds the basic glazing area, some tinted glazing will be required for the building. The area of tinted glazing required shall not be less than the difference between the total glazing area and the basic glazing area.

Required tinted glazing area = 5200 - 4901 = 299 sq ft

Therefore, a total of 299 sq ft of tinted glazing must be provided on elevations not oriented within 22½° of true North (East, South or West). The required tinted glazing may be placed entirely on one of these elevations or it may be distributed among the three.

The tinted glazing shall have a maximum shading coefficient of 0.75 (0.55 after July 1, 1976). The clear window glass specified for the building is not in compliance, since clear window glass has a shading coefficient greater than 0.75. (See Table 7-2)

6-B. The regulations also offer the designer an option to tinted glazing. They state that permanent external shading which will allow no more than 50% direct solar exposure on the glazing at 9:00 a.m., noon, and 3:00 p.m. solar time August 21, may be utilized in lieu of tinted glass.

This can be accomplished in several ways. One method is the use of overhangs which will shade the glazing from the sun. The data given in Table 7-6 or the graphical shading method presented on Page 7-6 may be utilized to determine the shaded area produced.

Other options include permanent slat type sun shades and patented louvered sun screens. Values for these devices may be calculated from Tables 7-4 and 7-5 and the accompanying explanation.

Note: It is recommended that the glass manufacturer be consulted when unusual shading techniques are being considered. The introduction of various shadow patterns or glare-reducing films to certain types of glass may result in abnormal thermal stress concentrations within the glass, which may in turn increase the possibility of glass failure.

EXAMPLE II

Sample calculations for this example will be based upon:

A one-story, heated and air-conditioned single family dwelling located in Sacramento, California.

Figure 7-G details a highly simplified floor plan of the one-story single family dwelling. All finished ceiling heights are 8'-0". The construction weight of the exterior wall is less than 26 pounds per square foot and is of light frame construction. Clear window glass has been specified for this building.

STEP 1. Determine the basic glazing area. Pursuant to Section 1094(d)(14) the basic glazing area is 20% of the gross floor area.

1-A. Calculate the gross floor area.
(30 x 40) + (20 x 20) = 1600 sq ft

1-B. Calculate 20% of the gross floor area determined in Step 1-A. The basic glazing area is then:

.20 x 1600 = 320 sq ft

STEP 2. Determine the degree day zone for the building site. By reference to Chapter 6 - California Design Conditions - we find that Sacramento has 2782 heating degree days. The design of this building will, therefore, be governed by Section 1094(f)(1) rather than 1094(f)(2). The winter design temperature for Sacramento is 29°F and the summer design temperature is 97°F.

STEP 3. By definition in this example, the building is both heated and cooled.

STEP 4. Determine compliance with 1094(f)(1).

4-A. The planned glazing area (assumed for this example) is as follows:

North Elevation	-	40 sq ft
East Elevation	-	150 sq ft
South Elevation	-	140 sq ft
West Elevation	-	80 sq ft
Total		410 sq ft

4-B. The planned glazing area, 410 sq ft, is greater than the basic glazing area. Therefore, as specified in Section 1094(f)(1) "treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed."

Some of the various methods by which this may be accomplished are as follows:

a. Reduce the planned glazing area to the basic glazing area of 320 sq ft.
b. Use insulating glass with an acceptable U factor for the entire planned glazing area.
c. Use a combination of single glass (U = 1.13) and insulating glass with an acceptable U factor.
d. Use an acceptable combination of reduced planned glazing area and insulating glass.
e. Some other combination of materials in keeping with the provisions of Section 1094(c) of the regulations.

Examples of various methods of complying with the standards are discussed in detail in Example I of this chapter and the examples given in Chapter 11.

STEP 5. Determine compliance with Section 1094(f)(2). Since this building is in Sacramento and there are less than 4500 degree days, these provisions do not apply.

STEP 6. Determine compliance with Section 1094(f)(3).

6-A. For cooled buildings, tinted glazing is required when the total glazing area exceeds the basic glazing area. The glazing area on walls oriented within 22½° of true North need not be included in the total glazing area.

Basic Glazing Area	=	320 sq ft (see 1-B)
Planned Glazing Area	=	410 sq ft (see 4-A)
Glazing Area on North Wall	=	40 sq ft (see 4-A)

The building for this example is oriented as shown in Figure 7-G. The North wall is not oriented within 22½° of true North, therefore, the glazing area on the North wall must be included in the total glazing area as related to the tinted glazing requirements.

Since the building for this example has no wall oriented within 22½° of true North, the total glazing area as related to the tinted glazing requirement is the same as the planned glazing area, which is 410 sq ft.

This total glazing area exceeds the basic glazing area, therefore, tinted glazing will be required for the building. The area of tinted glazing required shall not be less than the difference between the total glazing area and the basic glazing area.

Required tinted glazing area = 410 - 320 = 90 sq ft

Therefore, a total of 90 sq ft of tinted glazing must be provided for the building. Since the building does not have a wall oriented within 22-1/2° of true North, the required 90 sq ft of tinted glazing may be placed entirely on any wall of the building or distributed on a combination of walls.

The tinted glazing shall have a maximum shading coefficient of 0.75 (0.55 after July 1, 1976). The clear window glass specified for the building is not in compliance, since clear window glass has a shading coefficient greater than 0.75. (See Table 7-2)

6-B. Note that if the North wall of the building was oriented within 22-1/2° of true North, the 40 sq ft of glazing on the North wall could be subtracted from the planned glazing area. The total glazing area as related to the tinted glazing requirement would be 410 - 40 or 370 sq ft. The required tinted glazing area would then be 370 - 320 or 50 sq ft, to be placed on elevations not oriented within 22-1/2° of true North.

6-C. The regulations also offer the designer an option to tinted glazing. They state that permanent external shading which will allow no more than 50% direct solar exposure on the glazing at 9:00 a.m., noon, and 3:00 p.m. solar time August 21, may be utilized in lieu of tinted glass.

For this example, the graphical shading method presented on Page 7-6 will be used. To comply with Section 1094(f)(3) of the regulations, the actual shaded glazing area at each of the three designated times must be at least 50% of the required tinted glazing area, which is 0.50 x 90 or 45 sq ft.

6-D. For this example, the building is in Sacramento, which is located at approximately 38° 30' North Latitude. The building has 1'-6" overhang on the North and South elevations only.

From Table 7-7c, determine the profile angle and solar azimuth on August 21 at 9:00 a.m., noon and 3:00 p.m. solar time. The Tables have been established for each degree of latitude. For simplicity, the nearest whole degree of latitude could be used to determine the profile angle and solar azimuth. However, for this example, interpolation between 38° and 39° will be used to determine the more exact profile angle and solar azimuth as follows:

South Elevation (S 30° W)

For 38°

9:00 a.m.	Profile angle	-
	Solar Azimuth	S 69.7 E
noon	Profile angle	67.4
	Solar Azimuth	0
3:00 p.m.	Profile angle	49.9
	Solar Azimuth	S 69.7 W

For 39°

9:00 a.m.	Profile angle	-
	Solar Azimuth	S 68.8 E
noon	Profile angle	66.5
	Solar Azimuth	0
3:00 p.m.	Profile angle	49.2
	Solar Azimuth	S 68.8 W

For 38° 30' (by interpolation)

9:00 a.m.	Profile angle	-
	Solar Azimuth	S 69.3 E
noon	Profile angle	67.0
	Solar Azimuth	0
3:00 p.m.	Profile angle	49.6
	Solar Azimuth	S 69.3 W

North Elevation (S 150° E)

For 38°

9:00 a.m.	Profile angle	79.5
	Solar Azimuth	S 69.7 E
noon	Profile angle	-
	Solar Azimuth	0
3:00 p.m.	Profile angle	-
	Solar Azimuth	S 69.7 W

For 39^{o}

9:00 a.m.	Profile angle	80.4
	Solar Azimuth	S 68.8 E
noon	Profile angle	-
	Solar Azimuth	0
3:00 p.m.	Profile angle	-
	Solar Azimuth	S 68.8 W

For 38^{o} 30' (by interpolation)

9:00 a.m.	Profile angle	80.0
	Solar Azimuth	S 69.3 E
noon	Profile angle	-
	Solar Azimuth	0
3:00 p.m.	Profile angle	-
	Solar Azimuth	S 69.3 W

From the above data and Figure 7-G, the elevations which are completely shaded, or completely unshaded, can be determined.

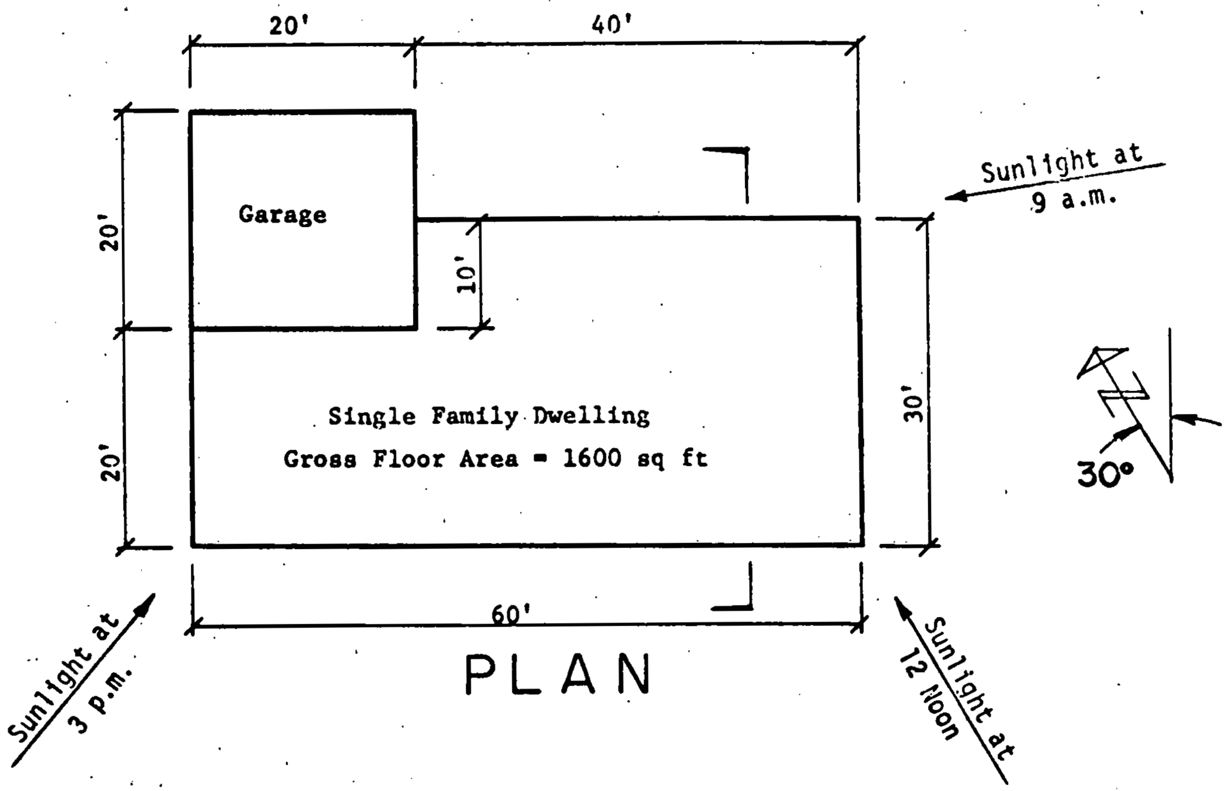
From the shading diagrams shown in Figures 7-H, 7-J, and 7-K, the area of glazing shaded on the North elevation at 9:00 a.m. and the South elevation at 12:00 noon and 3:00 p.m. can be determined.

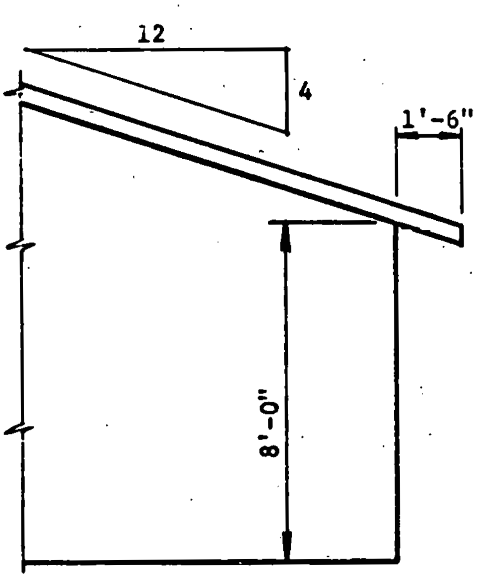
For this example, the area of glazing shaded on each elevation at 9:00 a.m., 12:00 noon, and 3:00 p.m. is summarized as follows:

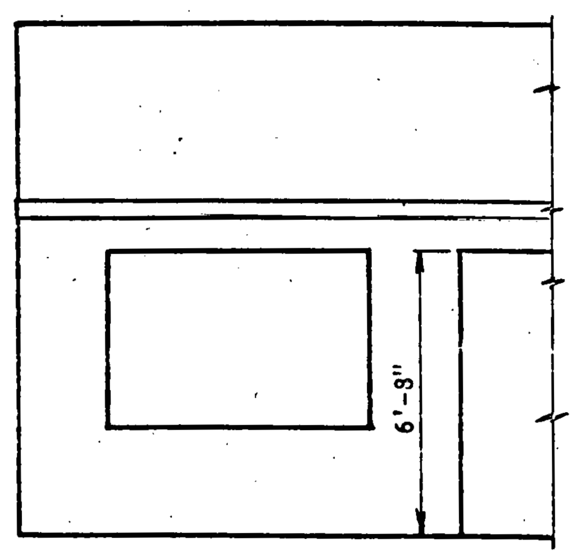
ELEVATION	NORTH	EAST	SOUTH	WEST	TOTAL
Area of Glazing (sq ft)	40	150	140	80	410
Area of Glazing Shaded (sq ft) at:					
9:00 a.m.	40	0	140	80	260
12:00 noon	40	0	77	80	197
3:00 p.m.	40	150	28	0	218

The most critical time for shading in this example is at 12:00 noon, when 197 sq ft of glazing is shaded. This exceeds the required shaded glazing area of 45 sq ft (see Step 6-C), therefore, the building complies with Section 1094(f)(3) of the regulations.

Note that for this example, the shading diagrams are not really needed, since, at each of the designated times, the area of glazing on the completely shaded elevations would be sufficient to comply with Section 1094(f)(3) of the regulations.







NOTE: Building has 1'-6" overhang on the North and South elevations. No overhang on the East or West elevations.

Figure 7-G

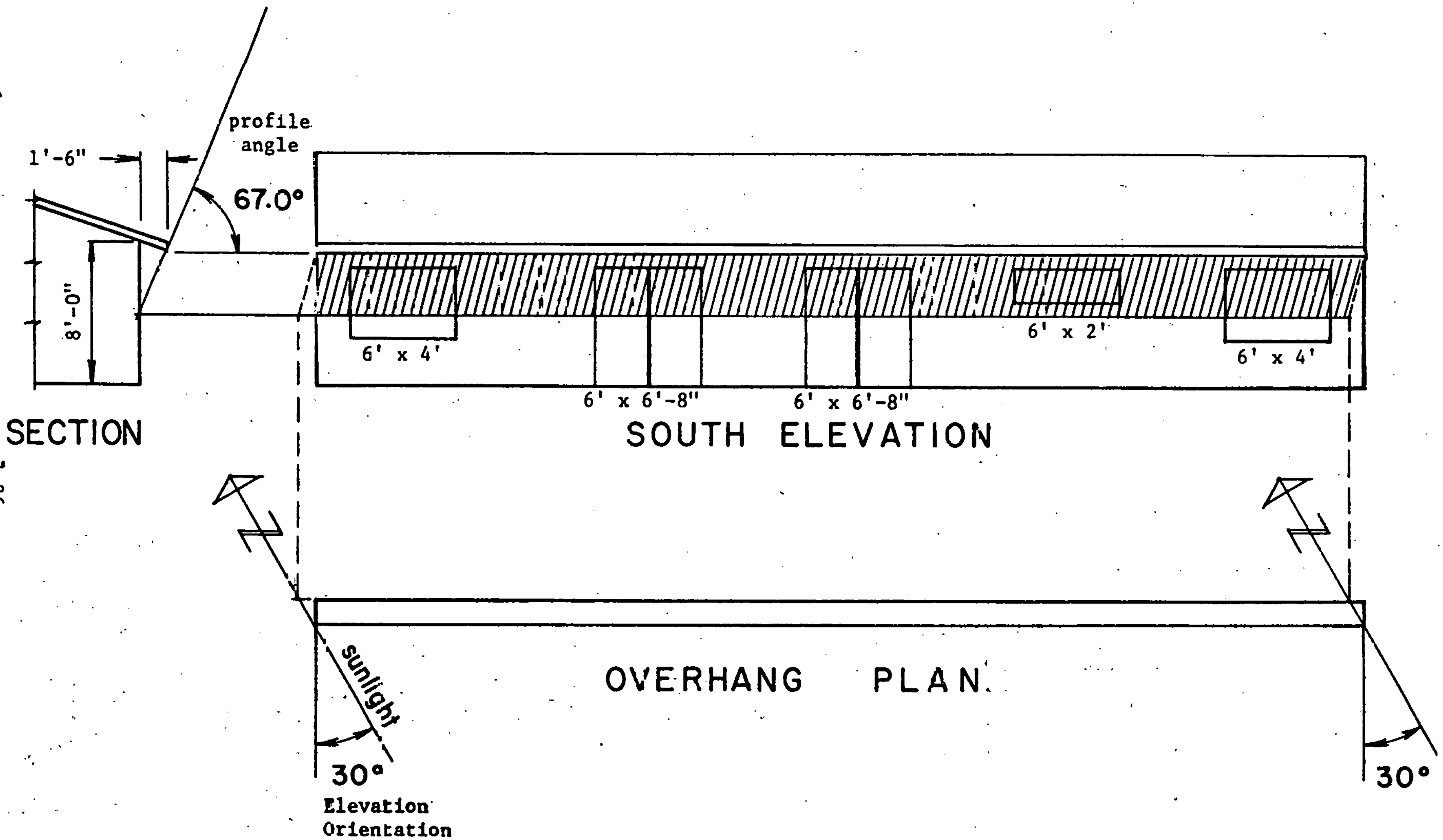


Figure 7-H . . . . Shading at 12:00 Noon (South Elevation)

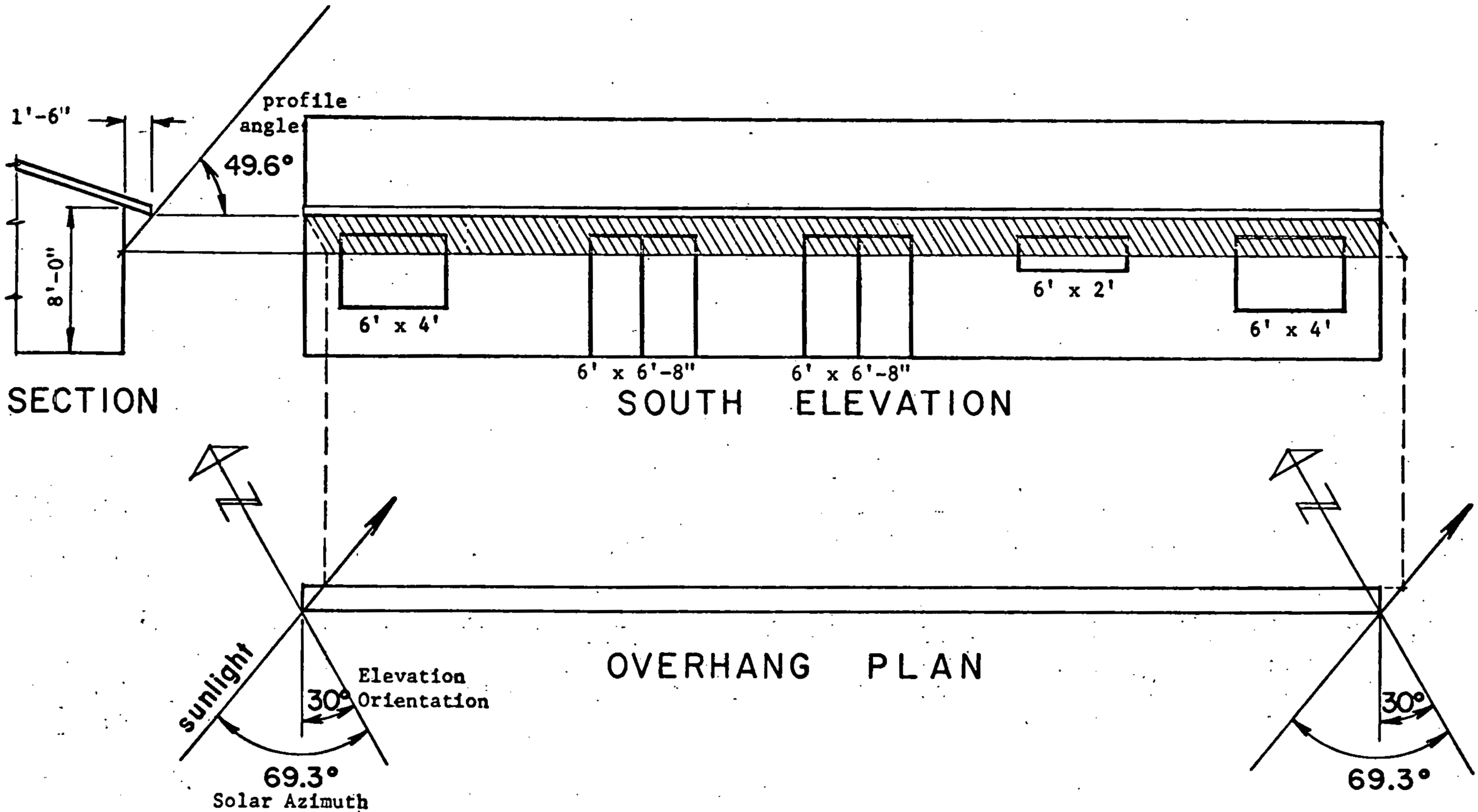


Figure 7-J . . . . Shading at 3:00 p.m. (South Elevation)

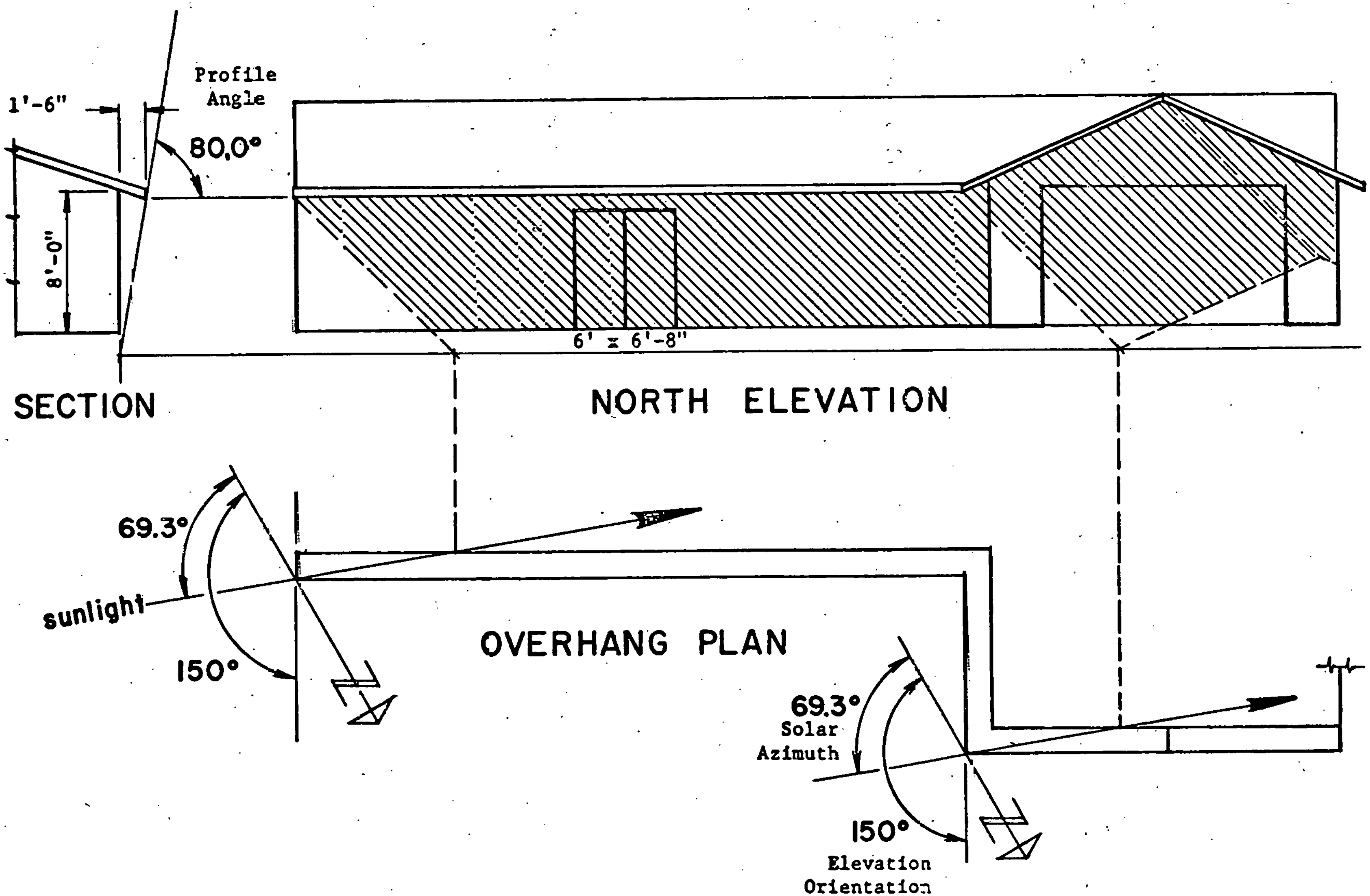


Figure 7-K . . . . Shading at 9:00 a.m. (North Elevation)

CHAPTER 8

INSTALLATION OF INSULATION

PURPOSE

To provide architects, designers, builders and building officials with a reliable guide to the proper installation of insulation. This chapter will include types of materials available, common application practices and suggested inspection procedures.

GENERAL

Insulation comes in many forms and many types of materials. We will discuss in this chapter, the most commonly used materials which you will encounter in residential construction. They are batts and blankets, rigid insulation, reflective insulation, loose fill, and sprayed insulation. For your information, we have compiled a list of all of the various types of materials and the Federal Specifications governing their characteristics.

Cork Board	FS HH-I-561E
Cellular Glass	FS HH-I-551E
Duct Insulation	FS HH-I-558B
Expanded Polystyrene Insulation Board	FS HH-I-524B
Fiberboard	FS LLL-I-535A or ASTM C-208 Class C
Insulation Board (Urethane)	FS HH-I-530A
Insulation, Thermal (Perlite)	FS HH-I-574B
Mineral Fiber, Pneumatic or Poured	FS HH-I-1030A
Mineral Fiber, Insulation Blanket	FS HH-I-521E
Perlite	FS HH-I-526A
Perimeter Insulation	FS HH-I-524A Type II FS HH-I-558B Form A, Class 1 or 2
Reflective, Thermal	FS HH-I-1252, Amend. 3
Structural Fiberboard Insulation Roof Deck	AIMA IB Spec. No. 1
Cellulose; Vegetable or Wood Fiber	FS HH-I-515B-25
Vermiculite	FS HH-I-585C
Vermiculite, Water Repellent Loose Fill	FHA UM-30
Mineral Fiber, Roof Insulation	HH-I-526C

BATTS AND BLANKETS

Batts and blankets are the most commonly used insulation materials in the residential market. They are generally made of mineral wool which includes both rock wool and glass fiber and are available in various widths to accommodate standard framing spacing. Batts and blankets are available either unfaced, kraft faced, foil faced, or foil enclosed.

These materials, which conform to Federal Specification HH-I-521E or HH-I-515B, are identified both on the package and on the vapor barrier facing with their "R" values. Under the Federal Specification, there are three standard products identified as R-7, R-11 and R-19. These values are based on the insulation value of the mass only and no credit is given for reflective facings. Some manufacturers offer other products such as R-8, R-13 and R-22. The specific thickness of insulation required for a specific "R" value may vary from one manufacturer to another due to differences in base materials and manufacturing processes. The key point for the field inspector is to identify the product by the "R" value on the package or on the facing material.

General Guidelines

1. Install insulation so the facing material, if present, faces the interior of the home - that is, the area that is heated in winter.

2. Asphalt coated kraft or foil facings should never be left as exposed finishes.

3. Insulate all spaces of the building section including small spaces over 1" wide.

4. Place insulation on the cold side (in winter) of pipes and ducts.

5. Apply blanket flanges snuggly against the sides of the framing members.

Ceilings

There are three methods of installing blanket insulation in ceilings:

1. Fastening from below (Fig. 1a and 1b).

2. Installing unfaced pressure-fit blankets (Fig. 2).

3. Laying the insulation in from above when the ceiling finish material is in place.

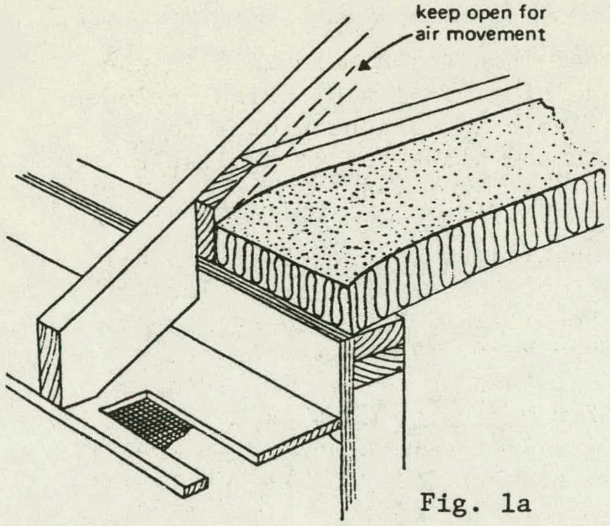


Fig. 1a

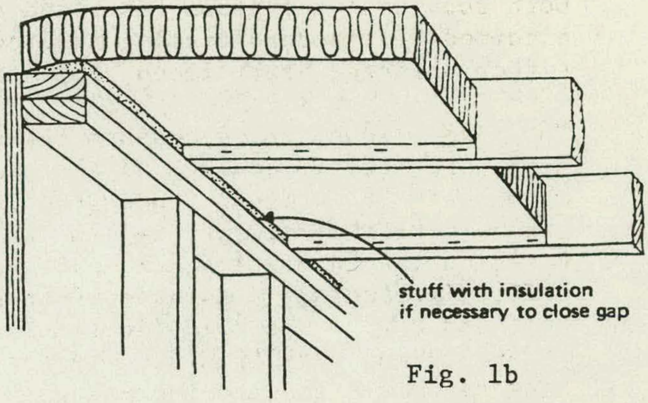


Fig. 1b

Fasten flanges to the ceiling joists as shown in Fig. 1b. Extend the insulation entirely across the top plate, keeping the blanket as close to the plate as possible. If necessary, stuff the gap between blanket and plate with loose insulation as shown in Fig. 1b. When eave vents are used, the insulation should not block air movement from eave to space above insulation.

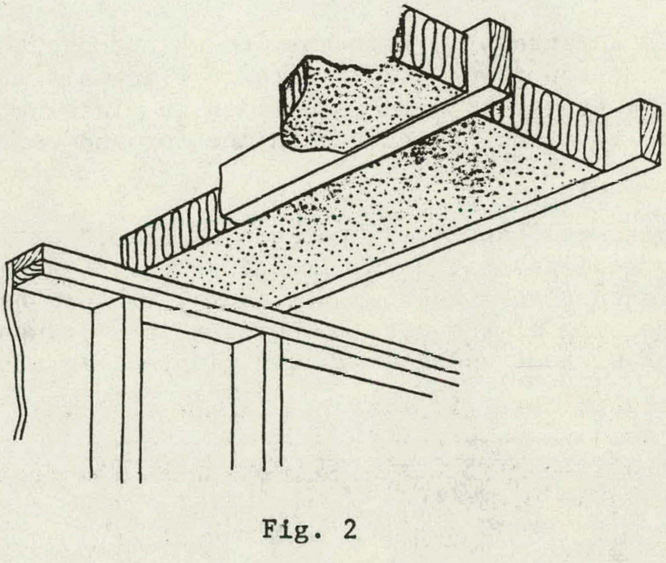


Fig. 2

Wedge unfaced, pressure-fit blankets between ceiling joists (Fig. 2). Allow insulation to overlap the top plate of thc exterior wall, but not enough to block eave ventilation. The insulation should touch the top of the plate to avoid heat loss and wind penetration beneath the insulation.

A separate vapor barrier is unnecessary under some conditions. For instance, no separate vapor barrier is necessary if the net free ventilating area is not less than 1/150 of the area of the space ventilated, except that the area may be 1/300 provided at least 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.

Walls

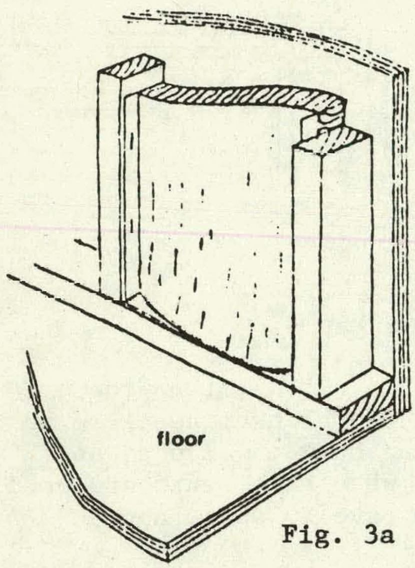


Fig. 3a

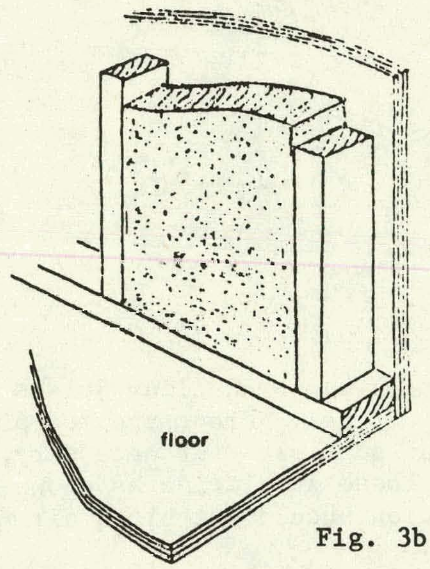


Fig. 3b

Push blankets into stud spaces so that they touch the sheathing or the siding. Working from the top down, staple through flanges of faced insulation into the sides of the studs, to hold insulation in place. Cut blankets slightly over length to assure contact with the top and bottom plates. (Fig 3a)

Type I insulation blankets conforming to Federal Specification HH-I-521E do not have membrane coverings, but have dimensions and physical properties to be self supporting when placed between structural members having standard spacings. The oversizing of the blanket results in a pressure fit which supports the blanket without additional fastening. (Fig. 3b)

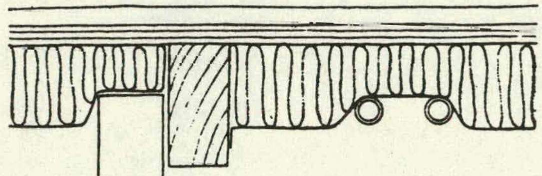


Fig. 4

Push insulation behind (cold side in winter) pipes, ducts, and electrical boxes (Fig. 4). As an alternate, the space may be packed with loose insulation or a piece of insulation of the proper size can be cut and fit into place.

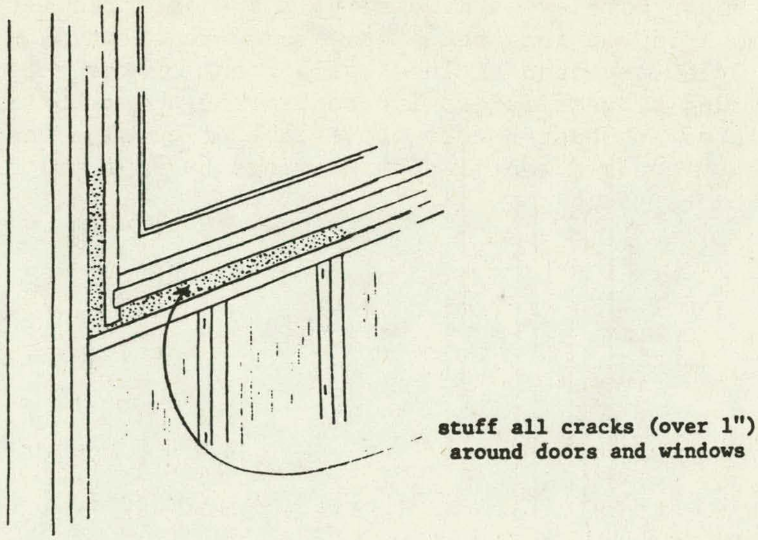


Fig. 5

Stuff small spaces between rough framing and door and window heads, jambs, and sills with pieces of insulation (Fig. 5).

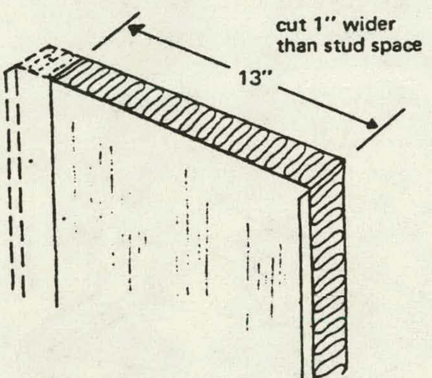


Fig. 6a

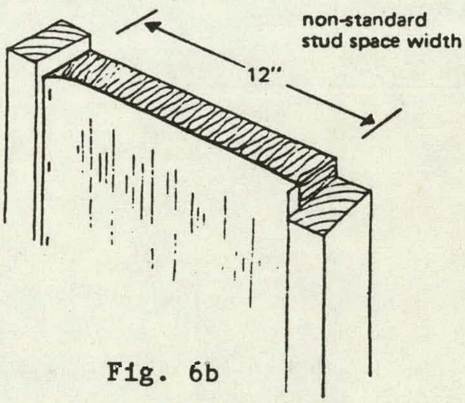


Fig. 6b

Insulate non-standard-width stud or joist spaces by cutting the insulation and vapor barrier an inch or so wider than the space to be filled (Fig. 6a). Fasten uncut flange as usual. Pull the vapor barrier on the cut side to the other stud, compressing the insulation behind it, and fasten through vapor barrier to stud (Fig. 6b). Unfaced blankets are cut slightly oversize and wedged into place.

Masonry Walls

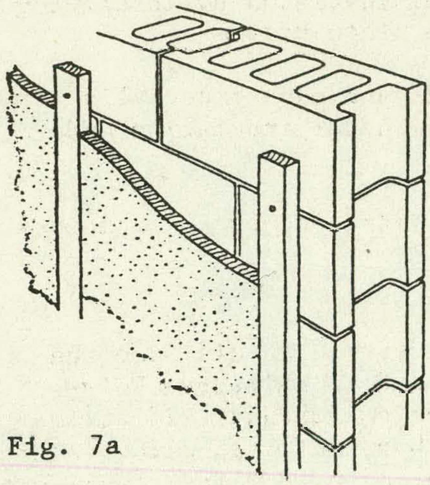


Fig. 7a

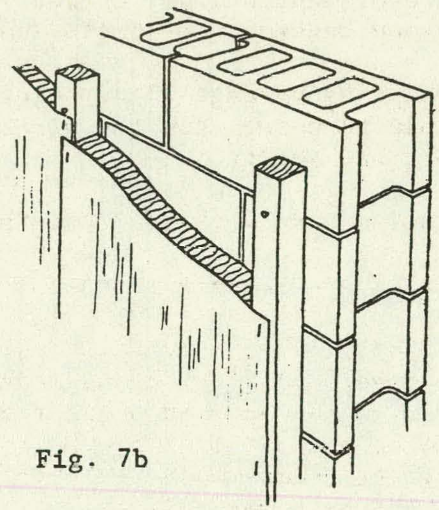


Fig. 7b

Masonry walls may be insulated using furring strips at 16 or 24 inches o.c. depending on thickness and type of wall finish (Fig. 7a and 7b). Insulation is placed between furring strips. Refer to typical drawings in Chapter 5.

Floors and Crawl Spaces

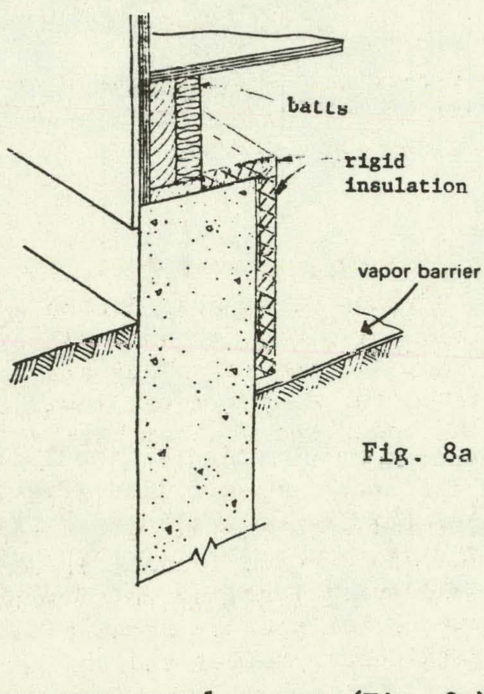


Fig. 8a

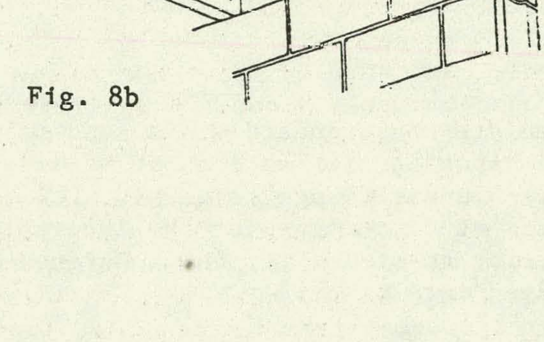


Fig. 8b

Floors over crawl spaces (Fig. 8a) may be insulated either by insulating the foundation walls if the crawl space is unvented, or if the crawl space is vented by placing insulation between the joists.

Floors over vented crawl spaces (Fig. 8b) can be insulated by installing insulation between the joists and holding it in place by:

1. Using heavy-gage wires pointed at both ends and made especially for this purpose. Bow the wires and wedge them under insulation and between joists.

2. Lacing wire back and forth between nails placed in bottom of joists.

3. Nailing chicken wire to bottom of joists.

In all cases, the vapor barrier side of the insulation should face the floor above - that is, be adjacent to the warm side in winter. Polyethylene may be used as a vapor barrier to cover the ground. If it is desired to protect the insulation from the weather, nail standard, interior grade softwood plywood, nail-base insulation board, or similar covering to the bottom of floor joists.

Dropped Soffits - Kitchen/Bath

Insulation of dropped soffits over kitchen cabinets, bathtubs, or showers may need special attention when they are exposed to the attic. If the dropped soffit is framed before ceiling finish material is applied, a "board" (plywood, hardboard, gypsumboard, etc.) needs to be installed over the cavity to support blown insulation. The dropped soffit area is no problem with blanket insulation or when blown attic insulation is used and the ceiling finish material extends over the cavity. When using blanket insulation, stuff it between trusses or rafters to extend over and span the dropped soffit cavity.

In apartments with back-to-back kitchens or baths, it is preferable to extend ceiling finish material over dropped soffits to the party wall to avoid acoustical short circuits.

RIGID INSULATION

Rigid insulation is available in boards of various sizes and thicknesses made of polystyrene, polyurethane, cork, cellular glass, mineral fiber (glass or rock wool), perlite and wood or cane fiberboard. They are commonly used as insulation for masonry construction, as perimeter insulations around concrete slabs, as exterior sheathing under the weather barrier, and as rigid insulations on top of roof decks.

Many of the board insulations are not identified with the "R" value information. To determine that the proper thickness is being installed, you should either refer to the approved plans and specifications which would show the type and thickness of board insulation, or you may request a certification from the supplier that the particular product and thickness supplied, provides the required "R" value.

Installation Procedures

Masonry Walls: Rigid insulations are applied to either face of a masonry wall (Fig. 9a and 9c) or are used as a cavity insulation between two courses of masonry (Fig. 9b). When applied to the face of masonry walls, they are generally installed with adhesive and/or mechanical fasteners. The manufacturer's recommendation should be followed.

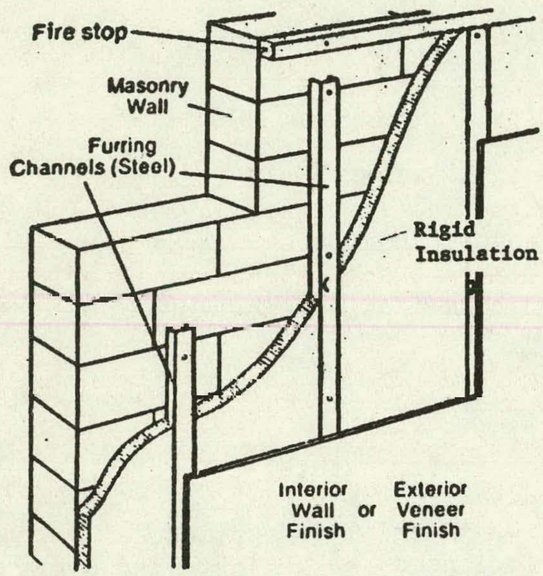


Fig. 9a

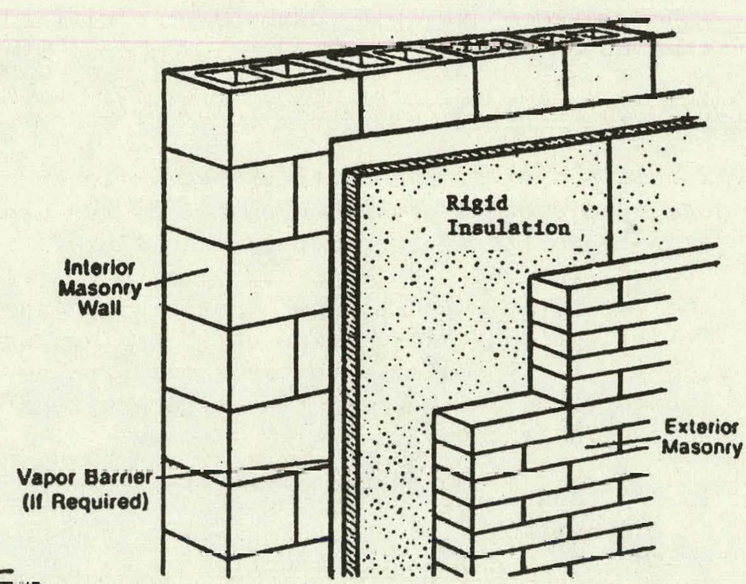


Fig. 9b

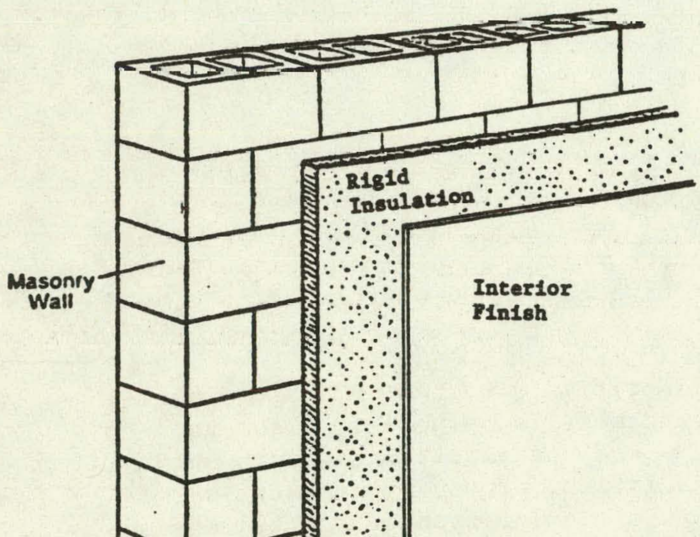


Fig. 9c

Frame Construction: When rigid insulation is used with frame construction (Fig. 10). It is normally applied as sheathing to the outside of the framing, and mechanically attached with nails to wood studs or to metal studs with screws or clips. Here again, the manufacturer's instructions should be followed.

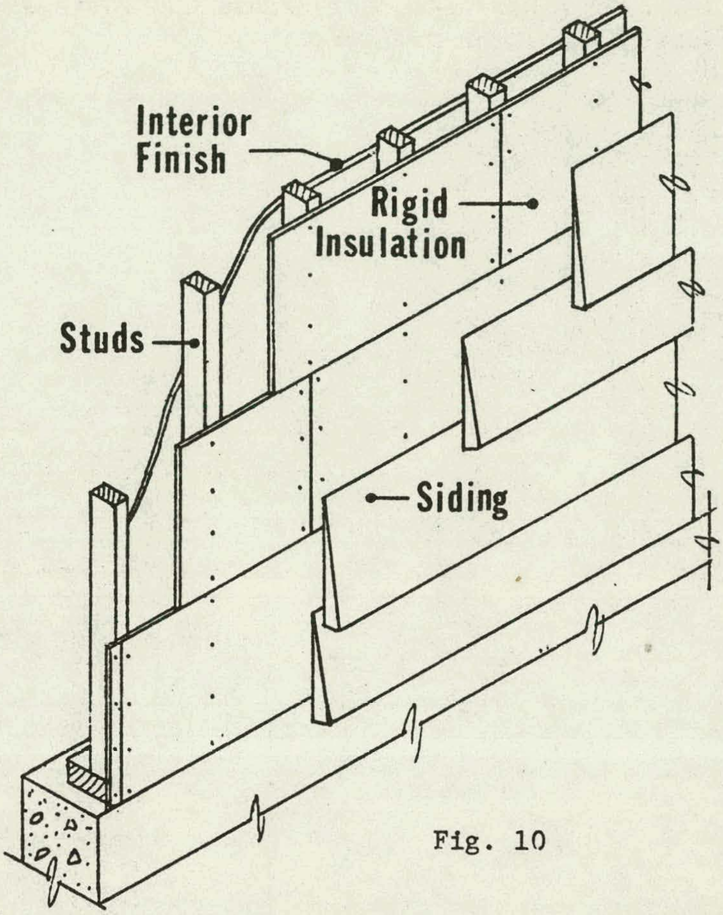


Fig. 10

Roof Insulation: Roof insulation boards are usually installed with a fire retardant adhesive, hot asphalt, or may be nailed to the roof sheathing. The manufacturer's instructions should be followed.

Slab-on-Grade: Rigid insulation is frequently utilized as insulation around the perimeter of concrete slabs on grade (Fig. 11b & 11c) and also may be used on the inside of foundation walls adjacent to heated crawl spaces or basements (Fig. 11a). Installation to crawl space or basement walls is normally accomplished with adhesive and/or mechanical fasteners. Perimeter insulation is usually installed against the footings and extended into the edge of the building at the time the concrete is poured. The manufacturer's recommended installation instructions should be followed.

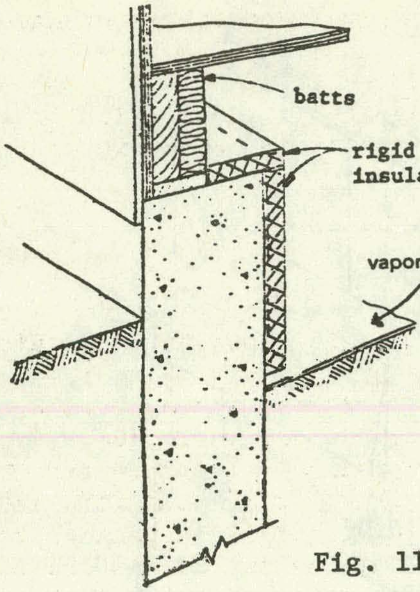


Fig. 11a

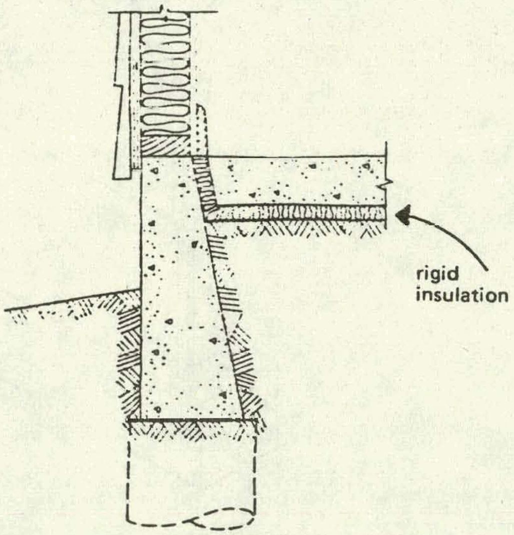


Fig. 11b

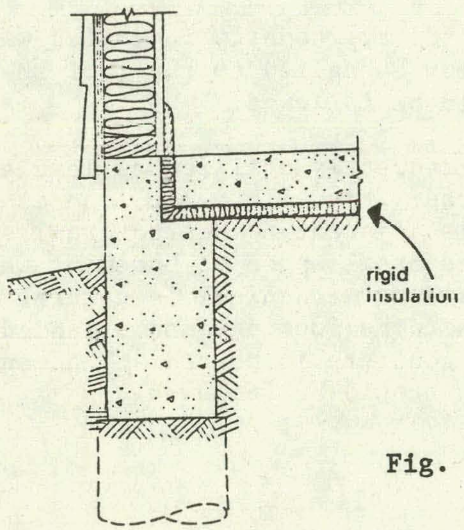


Fig. 11c

LOOSE FILL INSULATION

The most commonly used materials of this type are those made from mineral fibers (rock or glass), or cellulose materials (wood fibers or macerated paper).

The State regulations require that where loose fill insulation is to be used, that the "R" value of the installed insulation be shown on the building plans.

BLOWN ATTIC INSULATION

There are several variable factors pertaining to blown attic insulation that can cause differences in its installed resistance value (R). For a given manufacturer's insulation, the installed resistance depends on thickness and weight of insulating material applied per square foot. For that reason, Federal Specification HH-I-1030A for insulation requires that each bag of insulation be labeled to show the minimum thickness, the maximum net coverage, and the minimum weight of (that particular) insulation material required per square foot to produce resistance values of R-30, 22, 19 and 11. A specimen bag label for pneumatic insulation is shown in Fig. 12.

The number of bags of blown insulation required to insulate an attic of a given size may be calculated from data provided by the manufacturer.

If only the thickness of blown attic insulation is specified, and the density or number of bags is not, the desired or assumed thermal resistance value may not be achieved.

The important characteristic is weight per square foot. Thickness is the minimum thickness, not the average thickness experienced in the field.

When eave vents are installed, adequate baffling of the vent opening must be provided so as to deflect the incoming air above the surface of the installed blown or poured insulation. Baffles should be made of wood or other durable material and should be installed at the soffit on a 45 degree angle. Baffles must be in place at the time of framing inspection.

The regulations require a "U" factor of 0.05 for ceilings and when blown insulation is installed in a vented attic, it will be necessary that the insulation provides a minimum "R" = 19. For your information, three commonly used blown insulations to provide R-19 are:

Material	Minimum Thickness	Maximum Net Coverage/Bag	Bags/1000 Sq Ft	Minimum Wt./Sq Ft
Cellulose	5"	51.9 sq ft (40 lb bag)	19.3	0.77
Glass Fiber	8-3/4"	51 sq ft (24 lb bag)	20	0.489
Rock Wool	6-1/2"	26 sq ft (27 lb bag)	38	1.03

BLOWING WOOL

Manufactured By

The manufacturer recommends these maximum coverages at these minimum thicknesses to provide the levels of installed insulation resistance (R) values shown: (based on 25 lb. nominal weight bag).

R Value*	Minimum Thickness	Minimum Weight per sq. ft.	Bags per 1000 sq. ft.	Maximum Net Coverage per bag
To obtain an insulation resistance R of:	Installed insulation should not be less than:	The weight per sq. ft. of installed insulation should be not less than:	Number of bags per 1000 sq. ft. of net area shall not be less than:	Contents of this bag should not cover more than:
R-30	**13-3/4** in. thick	**0.768** lbs. per sq. ft.	**30**	**33** sq. ft.
R-22	**10** in. thick	**0.558** lbs. per sq. ft.	**22**	**45** sq. ft.
R-19	**8-3/4** in. thick	**0.489** lbs. per sq. ft.	**20**	**51** sq. ft.
R-11	**5** in. thick	**0.279** lbs. per sq. ft.	**11**	**90** sq. ft.

Weight contents: not less than 24 lbs.

*R values are determined in accordance with ASTM C-687 and C-236

Fig. 12

REFLECTIVE INSULATION

Reflective insulations are composed of aluminum foil in one or more layers either plain or laminated to one or both sides of kraft paper for structural strength. As a result of the requirements in the State regulations for floor insulation, reflective insulations will undoubtedly become more widely used.

The insulation value for reflective air spaces, which this type of insulation provides, varies widely depending on the direction of heat flow. They are much more efficient when the heat flow is <u>down</u>. For this reason, reflective insulations comply with the requirements when used in a floor, but may not be satisfactory in walls or ceilings, where the heat flow is horizontal and upward respectively.

Reflective insulations are only effective in controlling radiant heat energy and must be installed so that they face an air space. Note: Aluminum foil installed so that it is in contact with two building materials such as between a sub-floor and the finished floor will provide no insulation value. Values for reflective air spaces are found in Chapter 4 and for reflective insulation in Chapter 5.

Care must be taken that the insulation is installed in all cavities in such a manner that it is continuous, without tears or rips. The insulation must be installed in such a manner that it creates an air space.

SPRAYED INSULATION

There are several types of insulation which are sprayed against the surface of the building. Some of these are Cellulose with binder, mineral wool with binder and cellular foams such as polyurethane.

They may be sprayed directly on concrete, masonry or metal panels or may be sprayed between the framing members against the exterior sheathing. Manufacturer's recommended instructions should be followed exactly. In order to determine that the proper thickness is installed, you should either refer to the approved plans and specifications, or you may request a certification from the supplier that the insulation installed provides the required "R" value.

VAPOR BARRIERS

First of all, it should be clearly pointed out that vapor barriers are not required by these standards and the following are recommendations only.

Vapor barriers are used in conjunction with insulation to decrease the chance of moisture inside a building section in winter. Vapor barriers are placed on the side of the wall, ceiling or floor that is warm in winter.

Condensation occurs when the dewpoint is reached. For example, in a wall without insulation and without a vapor barrier, more moisture vapor reaches the inside surface of the siding or sheathing. However, with insulation, the temperature of the siding or sheathing surface is lower so a vapor barrier is used to reduce the amount of moisture vapor from reaching the siding or sheathing surface. Vapor barriers are not needed on the warm side of ceiling insulation where the attic is ventilated.

For equal vapor pressures, moisture vapor penetration through holes or tears in the insulation vapor barrier is proportional to the size of the opening. Rips or tears should be repaired by taping or stapling polyethylene or other vapor barrier over the tear or by taping the blanket vapor barrier back into place. Snug fit of blanket flanges against the framing is necessary to avoid bypassing the vapor barrier.

The importance of the vapor barrier increases as the winter design temperature becomes lower. In addition to the vapor barrier on the blanket, in cold climates consider using one of the following additional vapor barriers:

1. Two coats of a paint resistant to vapor penetration on the inside surface of exterior walls and insulated ceilings. Many interior vinyl latex paints have good vapor penetration-resistant properties, but it is suggested that advice be sought from the paint manufacturer.

2. Foil-backed gypsumboard on the inside surface of exterior walls or polyethylene applied across the inside face of the studs.

Some experts suggest a separate vapor barrier when the winter design temperature is -10°F. or lower. Local experience is the best guide to the need for a separate vapor barrier.

CERTIFICATIONS

As required by the State regulations, both the builder and the insulation applicator must sign a card certifying that the proper "R" values for all insulation locations have been installed. An example of a certification card, which is furnished by the builder or insulation applicator is shown in Fig. 13.

BN FORM 116
BIA FORM 1486

INSULATION CERTIFICATION

This is to certify that, in conformance with the current energy regulations (California Administrative Code, Title 25, State of California*) and approved plans, insulation has been installed in the building located at:

____________________ City ____________________ County

Street No. (If Available) ______ Street ______ Lot Number ______ Tract No. ______

DESCRIPTION OF INSTALLATION

ROOFS
Type of Material______ Manufacturer______ Thickness______ R Value**______

EXTERIOR WALLS
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ R Value**______

CEILINGS
BATTS:
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ R Value**______
Sq. Ft. Covered______

BLOWN:
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ No. Bags______
Wt./Bag______ Sq. Ft. Covered______ R Value**______

FLOORS
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ R Value**______

SLAB ON GRADE
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ R Value**______
Width of Insulation ______ Inches

FOUNDATION WALLS (if required)
Type of Material______ Manufacturer (Or Trade Name)______ Thickness______ R Value**______

REMARKS (if desired)______

General Contractor (Builder)______ License Number______

By______ Title______ Date______

Sub-Contractor (Insulation Applicator)______ License Number______
(Insulation, Masonry, Etc.) (State "SAME" if same as General Contractor)

By______ Title______ Date______

(*California Administrative Code, Energy Insulation Standards, declares: "Compliance. Upon completion of the installation of insulation, a card certifying that the insulation has been installed in conformance with the requirements of these regulations shall be completed and executed by the insulation applicator and by the builder. This insulation compliance card shall be posted at a conspicuous location within the dwelling.")

(**R Value is the measure of the resistance of a material or building component to the passage of heat. The resistance value (R) of mass-type insulations shall not include any value for reflective facing.)

EXCERPT from Sec. 19875 of the Health and Safety Code of the State of California:

"No certificate of occupancy or similar certification that a newly constructed hotel, motel, apartment house, home or other residential dwelling is habitable shall be issued by such a building department unless the structure at least satisfies the minimum energy insulation standards established pursuant to this chapter."

Fig. 13

CHAPTER 9

PIPE AND DUCT INSULATION

PIPE INSULATION

Pursuant to Section 1094(k), typical circulating systems which would require insulation when located in vented attics, vented crawl spaces, the ceilings of garages which are not enclosed and not heated, or on the roofs or outside walls of a building are:

1) Steam and condensate return piping
2) Heating hot water circulating piping
3) Domestic (plumbing) hot water circulating piping

Systems which would not require insulation are:

1) Any of the above three (3) systems located between floors, in shafts, in walls, or chases in the building
2) Piping (non-circulating) from a boiler or water heater to a fixture
3) Branch run-outs (non-circulating) from a circulating main to a fixture

Insulation, when required, shall be continuous including all pipes, valves and fittings except unions and flanges. Insulation for piping may be molded (pre-formed cylinders) insulation made to fit the various pipe sizes or flexible insulation wrapped around the pipe. If flexible insulation is used, it must be at least twice the nominal thickness of molded insulation specified in Table 9-B.

Fittings shall be insulated with mitered sections of molded pipe insulation, insulating cement or flexible insulation.

Insulation shall be finished with a jacket or facing with the laps sealed with adhesive or staples so as to secure the insulation on the pipe. In lieu of jackets, insulation may be secured with 16 ga. galvanized wire ties at not more than 9" on center.

Section 1094(k) requires that the insulation be of a thickness to limit the heat loss to 50 Btu/hr. per lineal foot for pipe sizes up to and including 2"; and 100 Btu/hr. per lineal foot for larger sizes.

Plans and specifications submitted for approval shall indicate the type and thickness of insulation to be used for compliance with the regulations.

Thickness (molded insulations) of calcium silicate, fibrous glass, or flexible cellular rubber tubing insulations may be selected from Tables 9-A and 9-B in conjunction with design temperature data from Chapter 6; <u>or</u> thickness of any insulation may be calculated from the formula:

$$Q = \frac{(t_p - t_o)\cdot(\pi \cdot \frac{r_2}{6})}{\frac{r_2 \cdot \ln\frac{r_2}{r_1}}{K} + \frac{1}{f}}$$ Equation 9-1

where Q = Btu/hr, lineal foot
t_p = Pipe Temp, °F
t_o = Winter Design Air Temp, °F (from Chap. 6)
r_1 = Inside radius of insulation, inches
r_2 = Outside radius of insulation, inches
K = K factor of insulation, Btu/hr, °F, sq. ft./inch (Table 9-D)
f = Outside air film coefficient (usually 1.65)

TABLE 9-A

TEMPERATURE DIFFERENCES (ΔT)

Pipe System	Temp. Range	Winter Design Temp. °F (from Chap. 6)			
		below 10°F	10-20°F	20-30°F	30°F & above
Domestic Hot Water	120-150	150	140	130	120
Heating Hot water	170-180	180	170	160	150
Low Pressure Steam	225-230	230	220	210	200

T = Thickness
H.L. = Heat Loss, BTU/Hr., L.F.

TABLE 9-B

TEMP. DIFF. (ΔT)	INSULATION		PIPE SIZE: IRON PIPE SIZE 1/2	3/4	1	1¼	1½	2	2½	3	4	6	COPPER TUBING SIZE (Nominal) 3/8	1/2	3/4	1	1¼	1½	2	2½	3	3½	4	5	6
230	Calcium Silicate	T	1	1	1	1½	1½	1½	1	1	1	2	1	1	1	1	1	1	1½	1	1	1	1	1	1½
		H.L.	32	39	41	37	42	48	70	83	99	85	26	27	33	36	42	44	43	61	68	75	83	98	90
	Fibrous Glass	T	½	½	½	½	3/4	1	½	½	3/4	3/4	½	½	½	½	½	½	3/4	½	½	½	½	3/4	3/4
		H.L.	32	32	43	47	44	43	76	98	71	100	23	24	27	35	36	46	43	63	71	80	87	70	82
220	Calcium Silicate	T	1	1	1	1	1½	1½	1	1	1	2	1	1	1	1	1	1	1½	1	1	1	1	1	1½
		H.L.	30	37	39	50	41	46	67	80	95	82	25	26	32	34	41	43	41	50	66	73	80	94	86
	Fibrous Glass	T	½	½	½	½	3/4	3/4	½	½	3/4	3/4	½	½	½	½	½	½	½	½	½	½	½	½	3/4
		H.L.	31	31	42	45	42	50	74	94	68	98	22	23	26	34	35	44	50	60	68	77	83	97	79
210	Calcium Silicate	T	1	1	1	1	1	1½	1	1	1	1½	1	1	1	1	1	1	1	1	1	1	1	1	1½
		H.L.	30	36	37	48	48	44	64	76	91	93	24	24	31	33	39	41	49	56	63	69	76	90	82
	Fibrous Glass	T	½	½	½	½	3/4	3/4	½	½	3/4	3/4	½	½	½	½	½	½	½	½	½	½	½	½	3/4
		H.L.	29	30	40	44	41	48	71	91	66	95	21	22	25	33	33	42	49	57	66	74	80	94	75
200	Calcium Silicate	T	1	1	1	1	1	1	1	1	1	1½	1	1	1	1	1	1	1	1	1	1	1	1	1
		H.L.	28	34	36	46	46	42	62	73	87	94	23	23	29	31	37	39	46	54	60	66	73	86	100
	Fibrous Glass	T	½	½	½	½	3/4	3/4	½	½	3/4	3/4	½	½	½	½	½	½	½	½	½	½	½	½	3/4
		H.L.	28	29	38	42	39	46	68	87	63	91	20	21	24	31	32	40	47	55	63	71	77	90	72
180	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	3/4	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	24	24	33	36	45	49	58	74	88	79	17	18	20	27	28	34	40	47	54	61	65	76	89
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	3/4	3/8	½	½	3/4	3/8	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	3/8	½	½	½
		H.L.	29	34	35	42	49	42	90	80	96	85	24	26	27	29	37	45	43	68	79	89	72	84	98
170	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	3/4	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	22	23	30	33	42	46	54	69	82	74	16	17	19	25	26	32	37	44	50	57	61	71	83
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	½	½	3/4	3/8	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	3/8	3/8	½	½
		H.L.	27	31	33	39	46	50	84	70	89	79	23	24	25	27	35	43	40	64	74	84	94	79	92

T = Thickness
H.L. = Heat Loss,BTU/Hr.,L.F.

TABLE 9-B

TEMP. DIFF. (ΔT)	INSULATION		PIPE SIZE: IRON PIPE SIZE 1/2	3/4	1	1¼	1½	2	2½	3	4	6	COPPER TUBING SIZE (Nominal) 3/8	1/2	3/4	1	1¼	1½	2	2½	3	3½	4	5	6
160	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	3/4	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	21	22	29	32	40	4[illegible]	51	65	78	60	15	16	18	23	24	30	35	41	48	54	58	68	79
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	½	½	3/4	3/8	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	3/8	3/8	½	½
		H.L.	26	30	31	37	43	47	80	67	85	75	22	23	24	25	33	41	38	60	70	79	89	76	87
150	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	3/4	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	19	20	25	29	37	40	46	59	71	64	14	15	16	21	22	28	32	38	43	49	53	62	72
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	½	3/4	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	½	½
		H.L.	24	27	23	34	40	43	73	99	78	69	20	21	22	23	30	38	50	55	64	73	82	62	80
140	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	16	18	24	26	34	37	43	55	65	96	12	13	15	20	20	26	29	35	40	45	49	57	66
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	½	3/4	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	½	½
		H.L.	22	25	25	32	37	40	68	92	72	64	18	19	20	21	28	36	47	51	59	67	76	63	74
130	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	17	17	23	25	32	34	40	51	61	90	11	12	14	18	19	24	28	33	37	42	46	53	62
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	½	½	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	½	½
		H.L.	20	23	25	30	34	37	63	86	67	99	17	18	19	20	26	33	44	48	55	63	71	59	69
120	Fibrous Glass	T	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½	½
		H.L.	15	16	21	23	29	32	37	48	57	84	10	11	13	17	18	22	26	30	35	39	42	50	58
	Flexible Tubing	T	3/8	3/8	3/8	3/8	3/8	½	3/8	3/8	3/8	½	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	½	½
		H.L.	19	22	23	29	32	35	58	79	100	92	16	17	17	19	24	30	40	46	51	58	66	55	64

TABLE 9-C

IPS	Pipe Diam.	Ins. Inner rad. r	1/2" Thick			3/4" Thick			1" Thick			1-1/2" Thick			2" Thick		
			$r_2 \cdot \ln\frac{r_2}{r_1}$	A	r_2	$r_2 \cdot \ln\frac{r_2}{r_1}$	A	r_2	$r_2 \cdot \ln\frac{r_2}{r_1}$	A	r_2	$r_2 \cdot \ln\frac{r_2}{r_1}$	A	r_2	$r_2 \cdot \ln\frac{r_2}{r_1}$	A	r_2
1/2	0.840	0.420	0.72	.48	.92	1.21	.62	1.18	1.77	.75	1.44	3.12	1.05	2.00	4.46	1.31	2.50
3/4	1.050	0.525	0.69	.54	1.03	0.96	.62	1.18	1.44	.75	1.44	2.67	1.05	2.00	3.90	1.31	2.50
1	1.315	0.657	0.65	.61	1.16	1.11	.75	1.44	1.71	.92	1.75	2.77	1.18	2.25	4.01	1.46	2.78
1-1/4	1.660	0.830	0.63	.70	1.33	1.29	.86	1.64	1.31	.92	1.75	2.76	1.31	2.50	3.36	1.46	2.78
1-1/2	1.990	0.950	0.53	.63	1.39	1.06	.92	1.75	1.49	1.05	2.00	2.42	1.31	2.50	2.98	1.46	2.78
2	2.375	1.187	0.62	.90	1.71	1.02	1.04	1.99	1.43	1.18	2.25	2.37	1.46	2.78	3.39	1.73	3.31
2-1/2	2.875	1.437	0.58	1.02	1.94	0.99	1.17	2.24	1.38	1.31	2.50	1.84	1.46	2.78	2.76	1.73	3.31
3	3.500	1.750	0.56	1.18	2.25	0.87	1.29	2.48	1.29	1.46	2.78	2.11	1.73	3.31	2.96	2.00	3.81
3-1/2	4.000	2.000	0.52	1.29	2.48	0.89	1.46	2.78	1.67	1.73	3.31	1.67	1.73	3.31	2.46	2.00	3.81
4	4.500	2.250	0.59	1.46	2.78	1.25	1.72	3.29	1.28	1.73	3.31	2.01	2.00	3.81	2.80	2.26	4.31
6	6.625	3.312	0.64	2.05	3.90	0.83	2.13	4.06	1.13	2.26	4.31	1.79	2.52	4.81	2.60	2.82	5.38

Table 9-D . . . . Thermal Conductivity (*k*) of Industrial Insulation (Design Values)[a] (For Mean Temperatures Indicated)

Expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference per in.)

Form	Material (Composition)	Accepted Max Temp for Use,[*] F	Typical Density (lb/cu ft)	Typical Conductivity k at Mean Temp F: −100	−75	−50	−25	0	25	50	75	100	200	300	500	700	900
BLANKETS & FELTS	MINERAL FIBER																
	(Rock, Slag, or Glass)																
	Blanket, Metal Reinforced	1200	6–12									0.26	0.32	0.39	0.54		
		1000	2.5–6									0.24	0.31	0.40	0.61		
	Mineral Fiber, Glass																
	Blanket, Flexible, Fine-Fiber Organic Bonded	350	0.65				0.25	0.26	0.28	0.30	0.33	0.36	0.53				
			0.75				0.24	0.25	0.27	0.29	0.32	0.34	0.48				
			1.0				0.23	0.24	0.25	0.27	0.29	0.32	0.43				
			1.5				0.21	0.22	0.23	0.25	0.27	0.28	0.37				
			2.0				0.20	0.21	0.22	0.23	0.25	0.26	0.33				
			3.0				0.10	0.20	0.21	0.22	0.23	0.24	0.31				
	Blanket, Flexible, Textile-Fiber Organic Bonded	350	0.65				0.27	0.28	0.29	0.30	0.31	0.32	0.50	0.68			
			0.75				0.26	0.27	0.28	0.29	0.31	0.32	0.48	0.66			
			1.0				0.21	0.25	0.26	0.27	0.20	0.21	0.45	0.60			
			1.5				0.22	0.23	0.24	0.25	0.27	0.29	0.39	0.51			
			3.0				0.20	0.21	0.22	0.23	0.24	0.25	0.32	0.41			
	Felt, Semi-Rigid Organic Bonded	400	3–8						0.24	0.25	0.26	0.27	0.35	0.44			
		850	3	0.16	0.17	0.15	0.10	0.20	0.21	0.22	0.23	0.24	0.25	0.55			
	Laminated & Felted Without Binder	1200	7.5											0.35	0.45	0.60	
	VEGETABLE & ANIMAL FIBER																
	Hair Felt or Hair Felt plus Jute	180	10						0.26	0.28	0.29	0.30					
BLOCKS, BOARDS & PIPE INSULATION	ASBESTOS																
	Laminated Asbestos Paper	700	30									0.40	0.45	0.50	0.60		
	Corrugated & Laminated Asbestos Paper																
	4-ply	300	11–13								0.54	0.57	0.68				
	6-ply	300	15–17								0.49	0.51	0.59				
	8-ply	300	18–20								0.47	0.49	0.57				
	MOLDED AMOSITE & BINDER	1500	15–18									0.32	0.37	0.42	0.52	0.62	0.72
	85% MAGNESIA	600	11–12									0.35	0.38	0.42			
	CALCIUM SILICATE	1200	11–13									0.38	0.41	0.44	0.52	0.62	0.72
		1800	12–15												0.63	0.74	0.95
	CELLULAR GLASS	800	9			0.32	0.33	0.35	0.36	0.38	0.40	0.42	0.48	0.55			
	DIATOMACEOUS SILICA	1600	21–22												0.64	0.68	0.72
		1900	23–25												0.70	0.75	0.80
	MINERAL FIBER																
	Glass,																
	Organic Bonded, Block and Boards	400	3–10	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.25	0.26	0.33	0.40			
	Non-Punking Binder	1000	3–10									0.26	0.31	0.38	0.52		
	Pipe Insulation, slag or glass	360	3–4					0.20	0.21	0.22	0.22	0.21	0.29				
		500	3–10					0.20	0.22	0.24	0.25	0.26	0.33	0.40			
	Inorganic Bonded-Block	1000	10–15									0.33	0.38	0.45	0.55		
		1800	15–24									0.32	0.37	0.42	0.52	0.62	0.74
	Pipe Insulation slag or glass	1000	10–15									0.33	0.38	0.45	0.55		
	MINERAL FIBER																
	Resin Binder		15			0.23	0.24	0.25	0.26	0.28	0.29						
	Rigid Polystyrene																
	Extruded, R-12 exp	170	3.5	0.16	0.16	0.15	0.16	0.16	0.17	0.18	0.19	0.20					
	Extruded, R-12 exp	170	2.2	0.16	0.16	0.17	0.16	0.17	0.18	0.19	0.20						
	Extruded	170	1.8	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.23	0.27					
	Molded Beads	170	1	0.18	0.20	0.21	0.23	0.24	0.25	0.26	0.28						
	Polyurethane[**]																
	R-11 exp	210	1.5–2.5	0.16	0.17	0.13	0.18	0.18	0.17	0.16	0.16	0.17					
	RUBBER, Rigid Foamed	150	4.5						0.20	0.21	0.22	0.23					
	VEGETABLE & ANIMAL FIBER																
	Wool Felt (Pipe Insulation)	180	20						0.28	0.30	0.31	0.33					
INSULATING CEMENTS	MINERAL FIBER																
	(Rock, Slag, or Glass)																
	With Colloidal Clay Binder	1800	24–30									0.49	0.55	0.61	0.73	0.85	
	With Hydraulic Setting Binder	1200	30–40									0.75	0.80	0.85	0.95		
LOOSE FILL	Cellulose insulation (Milled pulverized paper or wood pulp)		2.5–3							0.26	0.27	0.29					
	Mineral fiber, slag, rock or glass		2–5			0.19	0.21	0.23	0.25	0.26	0.28	0.31					
	Perlite (expanded)		5–8	0.25	0.27	0.29	0.30	0.32	0.34	0.35	0.37	0.39					
	Silica aerogel		7.6			0.13	0.14	0.15	0.15	0.10	0.17	0.18					
	Vermiculite (expanded)		7–8.2			0.39	0.40	0.42	0.44	0.45	0.47	0.49					
			4–6			0.34	0.35	0.38	0.40	0.42	0.44	0.46					

[a] Representative values for dry materials as selected by the ASHRAE Technical Committee 2.4 on Insulation. They are intended as design (not specification) values for materials of building construction for normal use. For the thermal resistance of a particular product, the user may obtain the value supplied by the manufacturer or secure the results of unbiased tests.

[*] These temperatures are generally accepted as maximum. When operating temperature approaches these limits the manufacturer's recommendations should be followed.

[**] These are values for aged board stock. For discussion on the change in conductivity with age of Refrigerant 11 expanded urethane see section on Factors Affecting Thermal Conductivity, Chapter 17.

UNDERGROUND RECIRCULATING HOT WATER PIPING

In many multifamily projects, recirculating hot water systems are used to supply domestic hot water instead of individual water heaters. In those cases where these systems are used, the recirculating hot water loops may require insulation depending on the following factors:

(1) Buried depth of the pipe or tube.
(2) Design temperature of the area.
(3) Size of pipe or tube.
(4) Water temperature of the system.

Table 9-E and Figure 9-G list heat losses of various tube sizes buried 18 inches for several temperature differences between the water in the tube and the ambient air.

Table 9-F and Figure 9-H list heat losses of various tube sizes buried 30 inches for several temperature differences between the water in the tube and the ambient air.

Section 1094(k) requires that insulation be of a thickness to limit the heat loss to 50 Btu/hr per lineal foot for pipe or tube sizes up to and including 2" and 100 Btu/hr per lineal foot for larger sizes.

When insulation is required due to heat losses in excess of those listed in Section 1094(k), the following can be used to calculate the thermal conductivity of the insulation required to reduce the heat loss to meet the requirements of Section 1094(k).

TABLE 9-E

HEAT LOSS OF TUBE BURIED 18 INCHES (Btu/hr ft)

TUBE DIAMETER (nominal)	TEMPERATURE DIFFERENCE BETWEEN WATER IN TUBE & AMBIENT AIR, F			
	50°	110°	150°	200°
1-1/4"	22.6	50.2	68.8	92.1
1-1/2"	23.5	52.3	71.6	95.9
2"	25.2	56.1	76.8	102.7
2-1/2"	26.7	59.6	81.4	109.2
3"	28.1	62.6	85.6	114.9
3-1/2"	29.4	66.0	89.7	120.4
4"	30.6	68.3	93.6	125.6

TABLE 9-F

HEAT LOSS OF TUBE BURIED 30 INCHES (Btu/hr ft)

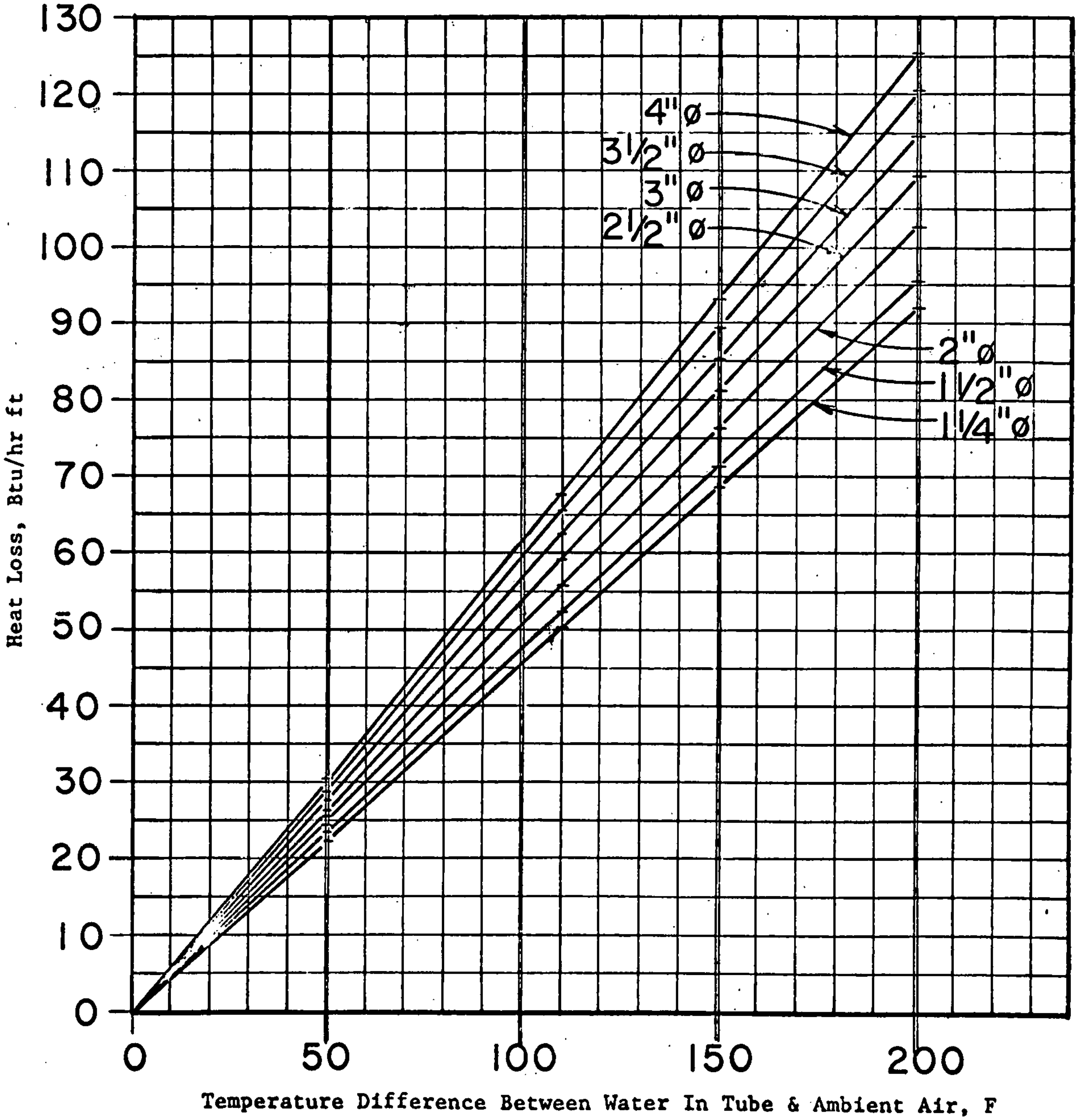
TUBE DIAMETER (nominal)	TEMPERATURE DIFFERENCE BETWEEN WATER IN TUBE & AMBIENT AIR, F			
	50°	110°	150°	200°
1-1/4"	20.5	45.4	62.0	82.8
1-1/2"	21.2	47.0	64.2	85.8
2"	22.6	50.0	68.4	91.5
2-1/2"	23.8	52.7	72.1	96.4
3"	24.9	55.1	75.4	100.7
3-1/2"	25.9	57.4	78.5	105.0
4"	26.8	59.6	81.4	108.9

TUBING BURIED BENEATH CONCRETE SLABS ADJACENT TO HEATED SPACES

Where tubing is buried beneath concrete slabs adjacent to heated spaces in the building, the tubing would not need to be insulated when the space over the buried pipe is maintained at approximately 70 degrees. Under these conditions, a heat loss of less than 50 Btu/hr per lineal foot of tube for tube sizes up to and including 2" and 100 Btu/hr per lineal foot for larger sizes is obtained when using Equation 9-2.

FIGURE 9-G

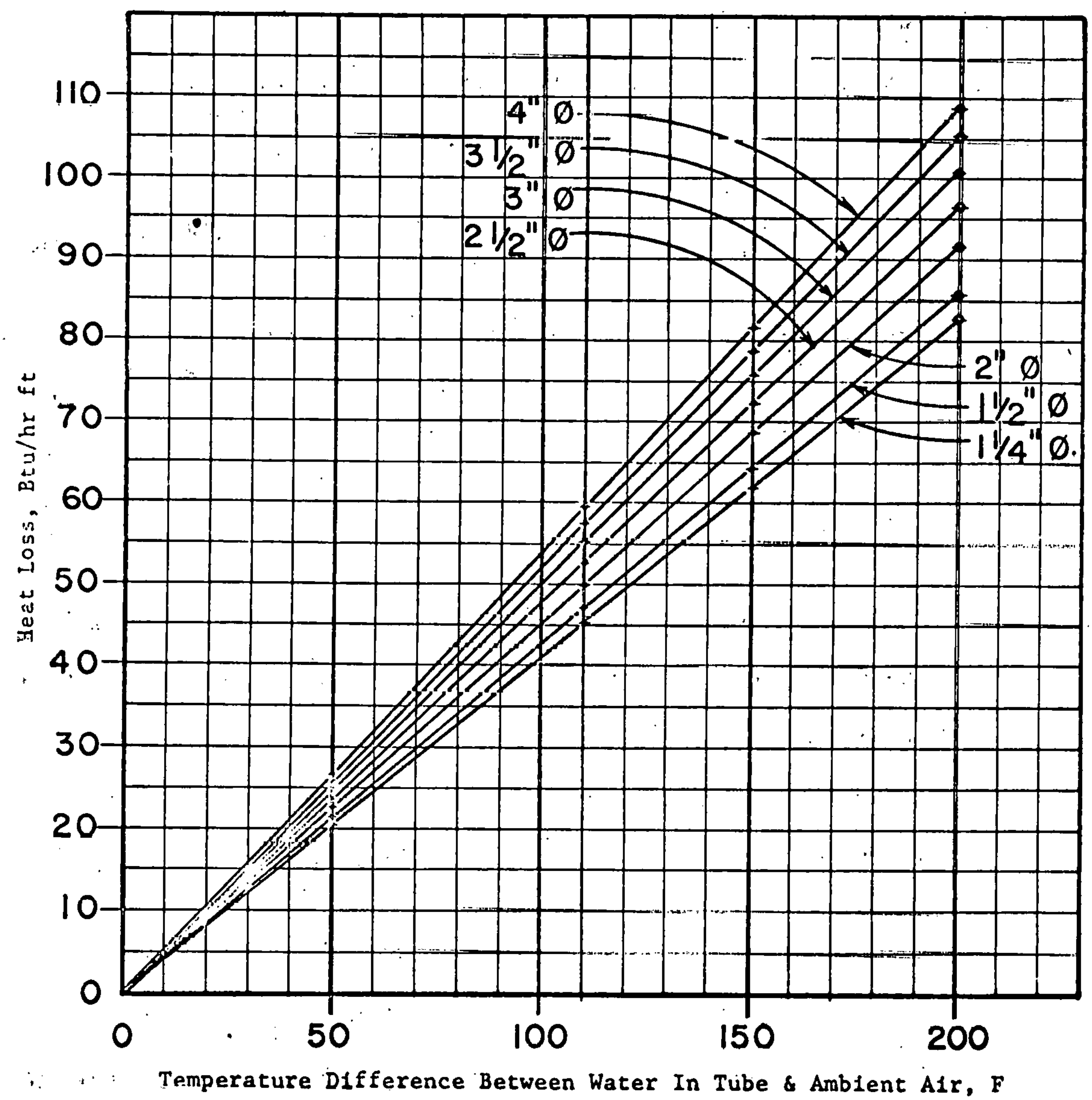
HEAT LOSS OF TUBE BURIED 18 INCHES BELOW THE SOIL SURFACE



NOTE: Nominal tube diameters are shown.

FIGURE 9-H

HEAT LOSS OF TUBE BURIED 30 INCHES BELOW THE SOIL SURFACE



NOTE: Nominal tube diameters are shown.

Tables 9-E and 9-F and Figures 9-G and 9-H were based on a soil conductivity of 0.3 Btu/hr ft^2 F/ft and the following equations, which are applicable to pipes or tubes.

(1) Heat loss from a horizontal pipe buried in the ground is:

$$q = \frac{k\ (t_i - t_w)\ 2\pi}{\ln\ (4x'/D)} \qquad \text{Equation 9-2}$$

Where

- k = the thermal conductivity of the soil (Btu/hr ft^2 F/ft)
- t_i = the temperature of the pipe (F)
- t_w = the winter design temperature (F)
- x' = the effective depth of pipe (ft)
- D = outside pipe diameter (ft)

(2) The effective depth of the pipe is obtained from:

$$x' = x + \frac{k}{.22\ (t_i - t_w)^{1/3}} \qquad \text{Equation 9-3}$$

x = The distance from the surface of the soil to the center of the pipe (ft)

The addition of a layer of thermal insulation on the outside of the pipe will: 1) increase the effective pipe radius used in Equation 9-2, and 2) make invalid the assumption that the outer surface of the pipe-insulation combination is close to the fluid temperature. The temperature of the outer wall of the insulation may be obtained from the following equation:

$$q = \frac{2\pi K_i L (t_i - t_o)}{\ln\ (r_o/r_i)}$$

Where

q	=	the heat flow through the insulation	(Btu/hr)
K_i	=	the thermal conductivity of the insulation	(Btu/hr ft^2 F/ft)
L	=	the length of the pipe	(ft)
t_i	=	the temperature of the pipe surface	(F)
t_o	=	the temperature of the outer insulation surface	(F)
r_o	=	the outside radius of the insulation	(ft)
r_i	=	the inside radius of the insulation	(ft)

Assuming that the inside surface of the insulation is at the same temperature as the pipe and selecting a unit length of one foot yields:

$$q = \frac{2\pi K_i\ (t_i - t_o)}{\ln\ (r_o/r_i)} \qquad \text{Equation 9-4}$$

Equation 9-2 is restated using the temperature of the outside of the insulation as the surface temperature of the buried cylinder:

$$q = \frac{K\ (t_o - t_w)\ 2\pi}{\ln\ (4\ x'/2r_o)} \qquad \text{Equation 9-5}$$

Equations 9-4 and 9-5 form a set of two simultaneous equations with two unknowns, t_o and q. They may be solved by standard algebraic techniques to yield the anticipated heat loss, q.

DUCT INSULATION

The Energy Insulation Standards are incorporated into Subchapter 1, Chapter 1, Title 25, California Administrative Code or more simply stated, "The State Housing Law." The State Housing Law in California adopts by reference current model building codes such as the Uniform Building Code, Uniform Mechanical Code, Uniform Plumbing Code and National Electrical Code. Duct insulation is included in the Uniform Mechanical Code and is part of the Energy Insulation Standards. Every conditioned air supply duct and plenum except for ducts and plenums used exclusively for evaporative cooling systems shall be insulated pursuant to Section 1005 of the 1973 Uniform Mechanical Code, which states the following:

> Insulation of Ducts
>
> Section 1005. Every conditioned air supply duct and plenum shall be insulated with not less than the amount of insulation set forth in Table 9-J, except for ducts and plenums used exclusively for evaporative cooling systems. Nonmetallic ducts shall have not less than the insulating value required in Table 9-J.
>
> Only approved materials shall be used within the ducts and plenums for insulating, sound deadening or other purposes. All such materials shall have a mold, humidity and erosion resistant face that has met the requirements of U.M.C. Standard No. 10-1. Such materials shall be allowed in occupancies as for Class 1 and Class 2 air ducts based upon their flame-spread and smoke developed ratings. Duct systems operating at velocities in excess of 2000 feet per minute shall be fastened with both adhesive and mechanical fasteners, and all exposed edges shall have adequate treatment to withstand the operating velocity.
>
> Insulations applied to the exterior surface of metal ducts located in buildings of Types I and II construction shall have a flame spread of not more than 25 and a smoke development rating of not more than 50 when tested as a composite installation, including insulation, facing materials, tapes and adhesives as normally applied.

Section 25999 of the Health and Safety Code related to air duct systems and the use of asbestos fibers states the following:

Section 25999. If asbestos-containing materials are used in an air duct system which is installed in any building in the state, such material shall be overcoated with a sealant adequate to preclude erosion of asbestos fibers.

TABLE 9-J--INSULATION OF DUCTS

DUCT LOCATION	DUCT LENGTH (IN FEET)		
	0 Through 70 Feet	71 Feet Through 150 Feet	151 Feet and Longer
Roof or Exposed to Outside Air	C and W	C and W	C and W
Attics	A	B	C
Between Floor Spaces, Underfloor Spaces, and Basements	A	B	C
Within the Conditioned Space[1]	NONE REQUIRED		
Cement Slab or Within Ground	NONE REQUIRED		

[1]Insulation may be omitted on that portion of a duct which is located within a vertical wall space if the wall space is directly adjacent to the occupied portion of the building.

Insulation Types

A. One-half inch of fiber glass or rock-wool insulation with a minimum density of 0.65 pound per cubic foot or ¼-inch air cell asbestos or ¼-inch air cell foil.

B. One inch of fiber glass or rock-wool insulation with a minimum density of 0.65 pound per cubic foot or two layers of ¼-inch air cell asbestos or air cell foil.

C. Two inches of fiber glass or rock-wool insulation with a minimum density of 0.75 pound per cubic foot or four layers of ¼-inch air cell asbestos or ¼-inch air cell foil, or 1-inch fiber glass insulation with a minimum density of one and one-half pounds per cubic foot.

W. Approved weatherproof vapor barrier.

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CHAPTER 10

WEATHERSTRIPPING

PURPOSE

The purpose of this chapter is to provide architects, builders, designers, and building officials with additional information to help implement Section 1094(h) which calls for the weatherstripping of windows and doors on all residential construction.

The purpose of weatherstripping is to minimize the amount of infiltration, which is the leakage of cold air into the dwelling and a leakage of an equal amount of warm air out of the dwelling. Heat must be supplied to warm the cold air which leaks into the building. Air infiltration in a well insulated house may account for as much as 35% of the total heating load, whereas infiltration in the same house, with weatherstripped doors and windows, may be reduced to 15% of the total heat load with a corresponding saving in energy consumption.

DOORS LEADING TO UNCONDITIONED AREAS

There are three basic types of weatherstripping most commonly used for doors on residential type construction.

1. Interlocking weatherstrip where the head and jambs are grooved out and metal is inserted so as to interlock with similar metal on the door itself when closed. (See Fig. 10-1.) In inspection of this type of weatherstripping, care should be taken to see that the weatherstripping is nailed and affixed to the door jambs, head and the door itself. (Nailing no more than 6" on center.)

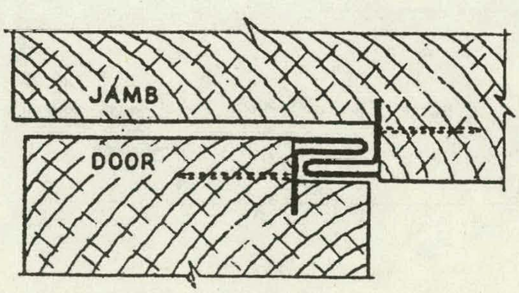


Fig. 10-1

This type weatherstripping for head and jambs is often used in conjunction with an interlocking type threshold. (See Fig. 10-2A and 10-2B.) Another type threshold is commonly known as a combo sill; a complete door assembly installed with a neoprene gasket that meets the bottom of the door.

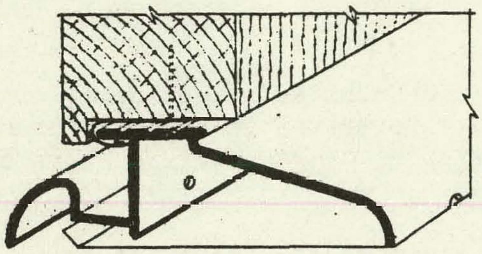


Fig. 10-2A

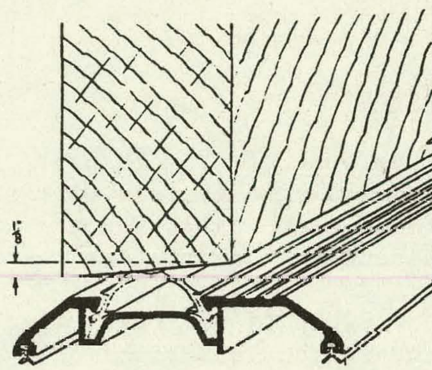


Fig. 10-2B

2. Gasket weatherstripping. This type of weatherstripping is placed on the head and jambs and consists of an extruded or rolled piece of metal with a neoprene gasket that is screwed or nailed to the head and jamb and is visible when the door is closed. (See Fig. 10-3A through 10-3E.) The extruded metal has slotted nail or screw holes so that should the door warp, the screws may be loosened and readjusted to maintain the proper seal.

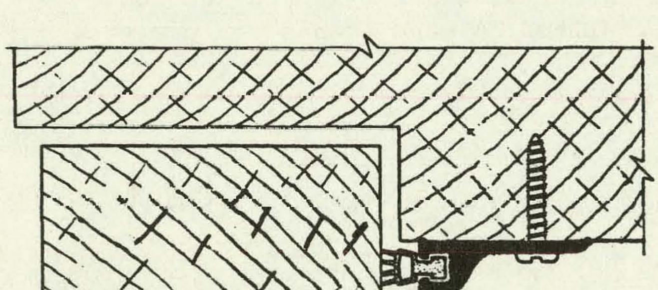


Fig. 10-3A

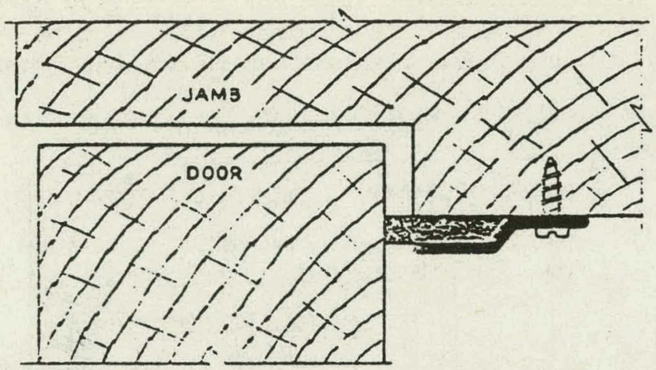


Fig. 10-3B

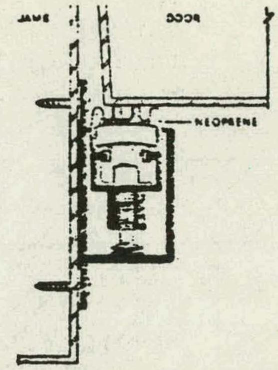


Fig. 10-3C

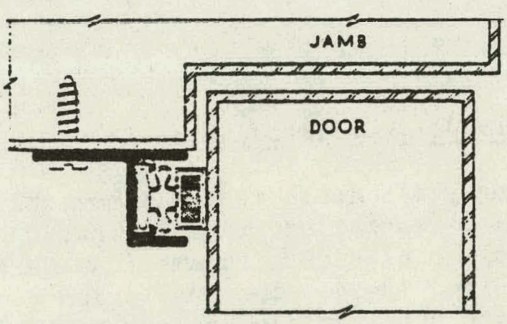


Fig. 10-3D

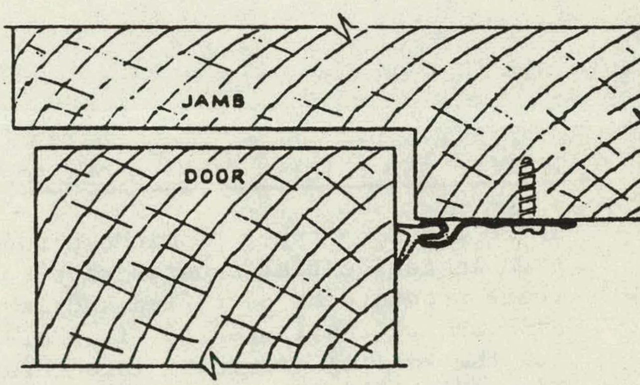


Fig. 10-3E

3. Pressure weatherstripping. This type of weatherstripping although not commonly used today, utilizes a piece of spring metal nailed in the jamb and the head of the door that provides a seal as the door is closed. (See Fig. 10-4A and 10-4B.)

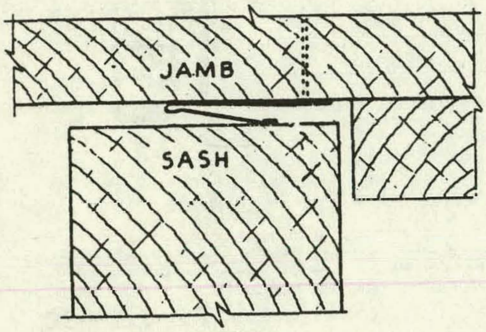


Fig. 10-4A

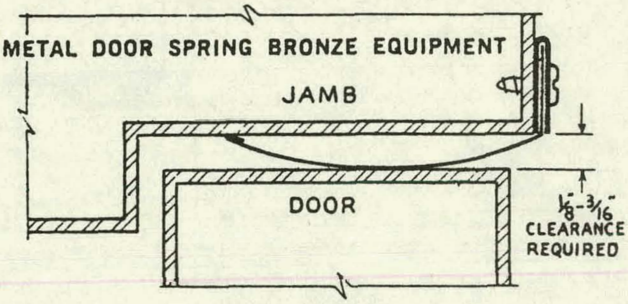


Fig. 10-4B

WINDOWS AND SLIDING GLASS DOORS FOR RESIDENTIAL CONSTRUCTION

There are many types of windows and sliding glass doors that are commonly used in residential construction today. The regulations require that these products be certified and labeled for compliance with American National Standard Institute A134.1, 134.2, 134.3 and 134.4. The regulations call for the testing procedure in accordance with the American Society of Testing Materials E283-63.

CHAPTER 11

ALTERNATE DESIGN EXAMPLES

PURPOSE

The California Energy Insulation Standards recognizes the importance of allowing the designer flexibility and innovation in the design of the structure, provided that the material, method of construction, design or insulating system is at least equivalent in the conservation of depletable energy as the specific requirement of the standards and is approved by the Building Official.

REGULATIONS

The regulations relative to alternatives are:

> 1094(c). Alternate Materials, Method of Construction, Design or Insulating System. The provisions of this article are not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein provided that any such alternate has been approved.
>
> The U value of any component of ceiling, floor, roof deck or wall, including glazing, may be increased, and the U value for other components decreased until the overall heat gain or heat loss of the building does not exceed the total resulting from conformance to the stated U values.
>
> The Building Official may approve any alternative design including designs utilizing nondepleting energy systems such as solar or wind provided he finds that the proposed design complies with the provisions of this Article in that the material, method of construction, design or insulating system does not use more depletable energy than the requirements of this Article.
>
> The Building Official shall require that suffucient evidence or documentation be submitted to substantiate any claims made regarding the installation and use of any such alternate and may require testing of the final installation.
>
> NOTE: Basic glazing area may be adjusted if in compliance with Subsection (c) above.

The following examples are typical of the types of alternatives that may be considered when confronted with a design which will not meet the specific requirements of the standards.

It is emphasized that the following are only examples and not to be construed to be the only method that can be used.

EXAMPLE I

Sample calculations for this example will be based upon:

(A) (1) A one-story heated and air-conditioned single family dwelling located in Red Bluff, California. (see Chapter 6 for design conditions).

Annual Heating Degree Days	-	2688
Winter Design Temperature	-	$31^{o}F$
Summer Design Temperature	-	$101^{o}F$

(2) The simplified floor plan of the house is shown on Figure 11-1.

(3) Exterior wall construction will be as shown on Page 5-2, Wall Section 1 using 3/8" exterior plywood siding, R=1.77 (without insulation); with R-11 insulation, R=12.77, U=0.078.

(4) Garage wall construction between the house and the garage is similar to the other exterior wall construction except 5/8" Type X gypsum wallboard is used in place of the plywood siding and still air may be considered for the exterior air film.

$$R = 0.68 + 0.45 + 11.00 + 0.56 + 0.68 = 13.37$$
$$U = 0.075$$

(5) Floor construction will be as shown on Page 5-6, Floor Section 3, R=3.29 without insulation, U=0.304.

(6) Clear window glass has been specified, U=1.13.

(7) The ceiling construction will be as shown on Page 5-9, Roof/Ceiling Section 1, R=1.67 (without insulation); with R-19 insulation, R=20.67, U=0.048.

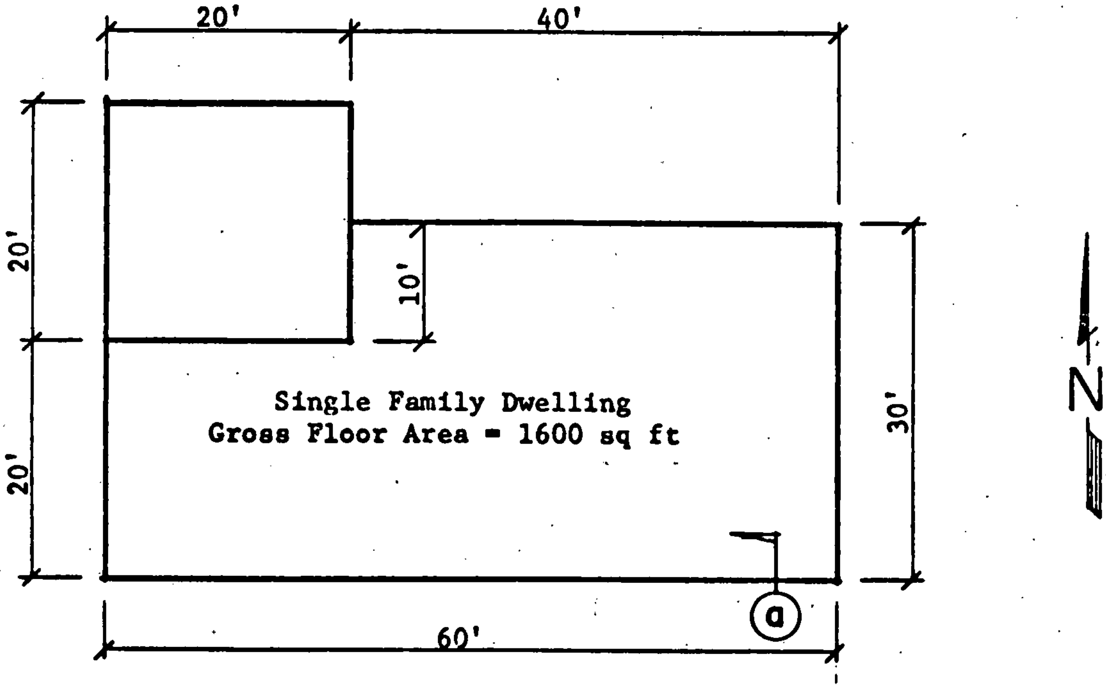
(8) The finished ceiling heights for this example are 8'-0".

(B) Since this house is air-conditioned, compliance with Section 1094(f)(3) must also be verified, however, it is not considered in this example. See Chapter 7 for examples of the procedure to determine compliance with Section 1094(f)(3).

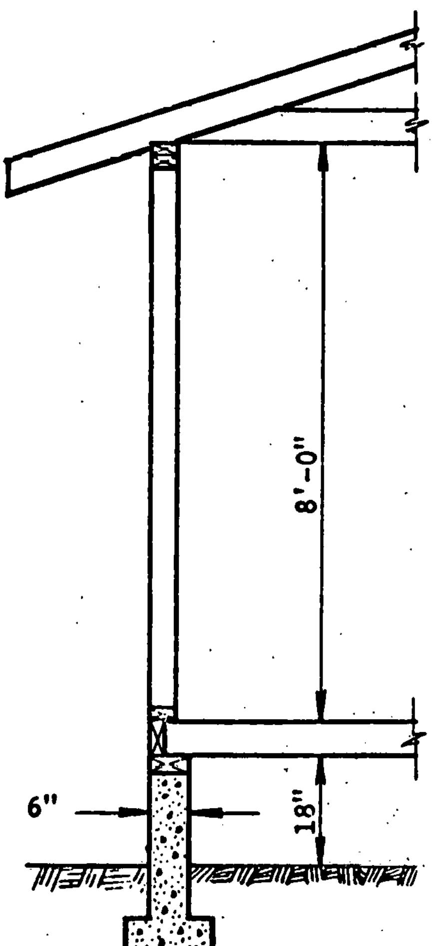
(C) For this example the planned glazing areas are as follows:

North Elevation	-	80 sq ft
South Elevation	-	200 sq ft
East Elevation	-	80 sq ft
West Elevation	-	50 sq ft
Total Glazing	-	410 sq ft

Figure 11-1



PLAN



Foundation Wall

Area = 1.5(60 + 20 + 20 + 10 + 40 + 30) = 270 sq ft

	R
Interior Air Film	0.68
6" Concrete	0.48
Exterior Air Film	0.17
Total R =	1.33

$$U = \frac{1}{1.33} = 0.752$$

SECTION ⓐ

STEP 1. Determine the basic glazing area. Since this building is less than four stories, it is a low rise building pursuant to Section 1094(d)(5) and the basic glazing area is 20% of the gross floor area.

1-A. From Figure 11-1, the gross floor area of the dwelling unit is 1600 sq ft.

1-B. Calculate 20% of the area from Step 1-A.
1600 x 0.20 = 320 sq ft
This is the basic glazing area for the entire building.

STEP 2. Determine compliance with 1094(f)(1).

2-A. The planned glazing area of 410 sq ft is greater than the basic glazing area. Therefore, as specified in Section 1094(f)(1) "treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed."

Some of the various methods by which this may be accomplished are as follows:

a. Reduce the planned glazing area to the basic glazing area of 320 sq ft.
b. Use insulating glass with an acceptable U factor for the entire planned glazing area.
c. Use a combination of single glass (U = 1.13) and insulating glass with an acceptable U factor.
d. Use an acceptable combination of reduced planned glazing area and insulating glass.
e. Some other combination of materials in keeping with the provisions of Section 1094(c) of the standards. For instance, Section 1094(c) allows that when approved by the Building Official, the allowable amount of glazing in excess of the basic glazing area may be adjusted if the proposed design, construction or insulating system does not use more depletable energy than the specific requirements of the standards. This may be accomplished by insulating other elements of the building (such as floor, wall or roof) in excess of specific requirements of the standards, thereby increasing the allowable glazing area by an amount such that equivalency in energy conservation is obtained.

STEP 3. The approach that will be used for this example will be based on Section 1094(c) - Alternate Materials, Method of Construction, Design or Insulating System.

STEP 4. Calculate the exterior wall area of the building. (Assume 8' wall height.) The area of the garage wall construction could be calculated separate from the other exterior wall construction, however, in this example it is not necessary to do so, since the U factor of the garage wall construction is lower than the other exterior wall construction. The benefit of calculating these areas separately would be minimal since the garage wall area is only about 3% of the total exterior wall area. Therefore, in this example, the areas will not be considered separately and the U factor of the garage wall construction between the house and the garage will be considered to be the same as the U factor of the other exterior wall construction.

Wall Area = 8 (60 + 20 + 20 + 10 + 40 + 30) = 1440 sq ft

Less Planned Glazing Area = 1440 - 410 = 1030 sq ft

Note: The exterior wall area of the garage is not included, however, the garage wall between the house and the garage is included.

STEP 5. Calculate the heat loss of the basic house which will exactly meet the specific requirements of the standards. The heat loss (Q) through a particular section of a building is proportional to the U factor (U), the area (A) of the section and the temperature difference (ΔT) between the indoor and outdoor design temperatures; or:

$$Q = U \cdot A \cdot \Delta T \qquad \text{Equation 11-1}$$

Since T (the difference between the indoor and outdoor design temperatures) is the same for the basic house and the house we want to construct, it can be dropped from the equation; or:

$$Q = U \cdot A \qquad \text{Equation 11-2}$$

5-A. A basic house which exactly meets the specific requirements of the standard is:

Ceiling	U = 0.05
Walls	U = 0.08
Glazing	U = 1.13
Floor (used)	U = 0.304

Note: The calculation for the floor can be dropped from the calculations since the same floor system must be used for both the basic house and the proposed house.

STEP 6. Calculate the heat loss for the basic house using Equation 11-2.

HEAT LOSS - BASIC HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.05	80.0 Btu/hr F
Wall	1120	.08	89.6
Glazing	320	1.13	361.6
		Total	531.2 Btu/hr F

STEP 7. Calculate the heat loss for the proposed house using Equation 11-2.

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.048	76.8 Btu/hr F
Wall	1030	.078	80.3
Glazing	410	1.13	463.3
		Total	620.4 Btu/hr F

The heat loss for the proposed house exceeds the heat loss for the basic house by 89.2 Btu/hr F, therefore, some alternatives will have to be explored to obtain equivalency in energy conservation.

ALTERNATIVES

Alternative 1. The easiest alternative to obtain equivalency in heat loss would be to reduce the amount of glazing. Some additional glazing over the basic glazing area (320 sq ft) could be used since the ceiling and walls have U values lower than those required by the standard.

The area of glass that could be used can be determined by using a trial-and-error procedure or it can be calculated by equating the actual heat loss through the ceiling, glazing and wall to the total allowable heat loss for the basic house as follows:

$$\text{Ceiling} + \text{Glazing} + \text{Wall} = \text{Allowable}$$
$$.048\,(1600) + 1.13\,A_G + 0.078\,(1440 - A_G) = 531.2$$
$$76.8 + 1.13\,A_G + 112.3 - 0.078\,A_G = 531.2$$

$$1.052\,A_G = 342.1$$
$$A_G = 325.2 \text{ sq ft} \qquad \text{Use } 325 \text{ sq ft}$$

The additional glazing over the basic glazing area that would be acceptable is, therefore, 5 sq ft. The heat loss for the proposed house can be checked as follows:

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.048	76.8 Btu/hr F
Wall	1115	.078	87.0
Glazing	325	1.13	367.3
		Total	531.1 Btu/hr F

The heat loss of 531.1 Btu/hr F is less than the 531.2 Btu/hr F obtained for the basic house. The amount of glazing acceptable, therefore, is 325 sq ft instead of the 320 sq ft allowed for the basic house.

Alternative 2. The next alternative which will be explored is to increase the ceiling insulation from R-19 to R-24 and to add 1/2" of fiberboard under the 3/8" exterior plywood.

WALL

R = 1.77 + 1.25 + 11 = 14.02   U = 1/14.02 = 0.071

CEILING

R = 1.67 + 24 = 25.67   U = 1/25.67 = 0.039

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.039	62.4 Btu/hr F
Wall	1030	.071	73.1
Glazing	410	1.13	463.3
		Total	598.8 Btu/hr F

This alternative still exceeds the heat loss for the basic house by 67.6 Btu/hr F. Some additional glazing over the basic glazing limit could be used but not the full 410 sq ft which was planned. By trial and error or using the technique shown in Alternative 1, it can be determined that the glazing area can be increased from 320 sq ft (basic glazing area) to 346 sq ft. The heat loss for the proposed house with 346 sq ft of glazing would be checked as follows:

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.039	62.4 Btu/hr F
Wall	1094	.071	77.7
Glazing	346	1.13	391.0
		Total	531.1 Btu/hr F

The heat loss of 531.1 Btu/hr F is less than the 531.2 Btu/hr F obtained for the basic house.

The amount of glazing acceptable, therefore, is 346 sq ft instead of the 320 sq ft allowed for the basic house.

Alternative 3. Another possibility to consider would be to use some insulating glass in order to comply with the standards.

For this example, the following heat losses are applicable:

(a) The allowable heat loss for the basic house is 531.2 Btu/hr F (see Step 6, Page 11-5.)
(b) The heat loss for the proposed house with 410 sq ft of glazing is 620.4 Btu/hr F (see Step 7, Page 11-6).
(c) The heat loss difference = 620.4 - 531.2 = 89.2 Btu/hr F.

The next step is to calculate the amount of insulating glass necessary to reduce the heat loss of the proposed house to 531.2 Btu/hr F and obtain equivalency in depletable energy conservation. This is done by equating the heat loss through the ceiling, glazing and walls of the proposed house to the total allowable heat loss for the basic house as follows:

Ceiling	+ Single Glass	+ Insulating Glass	+ Wall	= Allowable
.048 (1600)	+ 1.13 A_{SG}	+ U_{IG} A_{IG}	+ .078 (1030)	= 531.2

Where:

A_{SG} = Area of single glass (sq ft)
A_{IG} = Area of insulating glass (sq ft)
U_{IG} = U factors of the insulating glass

$$1.13\ A_{SG} + U_{IG}\ A_{IG} = 374.1$$

Since the total glass area is 410 sq ft, then $A_{SG} = (410 - A_{IG})$, therefore,

$$1.13\ (410 - A_{IG}) + U_{IG}\ A_{IG} = 374.1$$
$$1.13\ A_{IG} - U_{IG}\ A_{IG} = 89.2$$

The value on the right side of the equation turns out to be the heat loss difference as calculated in (c) above. Therefore, the general equation to calculate the amount of insulating glass required, knowing the heat loss difference is:

$$A_{IG}\ (1.13 - U_{IG}) = \text{Heat Loss Difference} \qquad \text{Equation 11-3}$$

For this example, insulating glass with a U factor of 0.65 (1/4 in. air space from Table 4-3c) is used.

Using Equation 11-3, we have:

$$A_{IG}\ (1.13 - U_{IG}) = \text{Heat Loss Difference}$$
$$A_{IG}\ (1.13 - 0.65) = 89.2$$
$$0.48\ A_{IG} = 89.2$$
$$A_{IG} = 185.8 \text{ sq ft}$$

The amount of insulating glass with a U factor of 0.65 needed to reduce the heat loss of the proposed house to equal the heat loss in the basic house would be 185.8 sq ft. The amount of single or non-insulating glass would be:

$$410 - 185.8 = 224.2 \text{ sq ft}$$

The heat loss for the proposed house should then be checked as follows:

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.048	76.8 Btu/hr F
Wall	1030	.078	80.3
Glazing	(410)		
Single	224.2	1.13	253.3
Insulated	185.8	0.65	120.8
		Total	531.2 Btu/hr F

The above heat loss of 531.2 Btu/hr F for the proposed house will match the heat loss of the basic house and comply with the alternative provisions of the standards.

Alternative 4. Another alternative which may be considered is to insulate the underfloor area in order to obtain the desired glazing in the proposed house. Since the proposed house is to be located in an area (Red Bluff) which has less than 3000 degree days, no specific insulation requirement exists for floor sections over unheated crawl spaces and the amount of reduced heat loss by insulating the floor section can be credited.

The heat loss from heated rooms to unheated spaces must be based on the estimated or assumed temperature in such unheated spaces. This temperature will lie in the range between the indoor and outdoor design temperatures, depending on the relative areas of the surfaces adjacent to the heated room and those exposed to the outside. In addition to the U factor and area of the floor, such items as the area of the ground, temperature of the ground, area of foundation wall, U factor of the foundation wall, and amount of ventilation should be considered.

One document which provides a method of estimating the crawl space temperature is a National Bureau of Standards document "Retrofitting Existing Housing for Energy Conservation." The 1972 ASHRAE Handbook of Fundamentals also provides a method to calculate the crawl space temperature, except this method does not consider the ground temperature or ventilation.

However, for simplicity, when all factors including ventilation and ground temperature are considered, the following methods of estimating the crawl space temperature may be used.

1. The temperature in an unheated crawl space with an insulated floor may be estimated to be the mean of the indoor and outdoor design temperatures.

2. The temperature in an unheated crawl space with an uninsulated floor may be estimated to be the mean of the indoor and outdoor design temperatures plus 5 degrees.

If, for instance in this example, the mean of the indoor and outdoor design temperatures were used, the following estimated crawl space temperatures would be obtained:

1. Uninsulated Floor $\frac{31+70}{2} + 5 = 55.5^{o}F$

2. Insulated Floor $\frac{31+70}{2} = 50.5^{o}F$

For this example, however, the method provided in the National Bureau of Standards Document "Retrofitting Existing Housing for Energy Conservation," will be used for calculating the crawl space temperature (t_c) with an uninsulated and insulated floor as follows:

$$t_c = \frac{70\ A_f\ U_f + t_o\ (A_w\ U_w + 1.08\ A_f\ V) + 0.3\ A_g\ t_g}{A_f\ U_f + A_w\ U_w + 1.08\ A_f\ V + 0.3\ A_g} \quad \text{Equation 11-4}$$

$$Q_f = A_f\ U_f\ \frac{70 - t_c}{70 - t_o} \quad \text{Equation 11-5}$$

Where:

A_f = Area of floor
U_f = U factor of floor
A_g = Area of ground
t_o = Winter design temperature
t_g = Temperature of ground
A_w = Area of foundation wall
U_w = U factor of foundation wall
t_c = Crawl space temperature
Q_f = Heat loss through the floor
V = Ventilation rate

TABLE 11-1
Temperature of Ground

Degree Days	Temperature of Ground
2000 and below	65.0°F
3000	60.0°F
4000	55.0°F
5000	52.5°F
6000	50.0°F
7000	47.5°F
8000	45.0°F
9000	42.5°F

For this example the floor over the unheated crawl space will be insulated with R-11 insulation giving a total R value for the floor section of R = 3.29 + 11 = 14.29, U = 0.070.

For this example:

A_f = 1600 sq ft
U_f = 0.304 (uninsulated)
U_f = 0.070 (insulated with R-11)
A_g = 1600 sq ft
t_o = 31^oF (Winter design temperature, from Page 6-3)
t_g = 61.6^oF (From Table 11-1, for 2688 degree days by interpolation)
A_w = 270 sq ft (From Page 11-3)
U_w = 0.752 (From Page 11-3)
V = 0.1 cfm/sq ft

Calculate the crawl space temperature and heat loss through the floor using Equations 11-4 and 11-5 as follows:

Before insulating the floor

$$t_c = \frac{70 \times 1600 \times .304 + 31\ (270 \times .752 + 1.08 \times 1600 \times .1) + .3 \times 1600 \times 61.6}{1600 \times .304 + 270 \times .752 + 1.08 \times 1600 \times .1 + .3 \times 1600}$$

t_c = 56.0 F

$$Q_f = 1600 \times 0.304 \times \frac{70 - 56.0}{70 - 31} = 174.6 \text{ Btu/hr F}$$

After insulating the floor with R-11 insulation

$$t_c = \frac{70 \times 1600 \times .070 + 31\ (270 \times .752 + 1.08 \times 1600 \times .1) + .3 \times 1600 \times 61.6}{1600 \times .070 + 270 \times .752 + 1.08 \times 1600\ .1 + .3 \times 1600}$$

t_c = 50.6 F

$$Q_f = 1600 \times 0.070 \times \frac{70 - 50.6}{70 - 31} = 55.7 \text{ Btu/hr F}$$

Calculate the heat loss for the basic house without underfloor insulation using Equation 11-2.

HEAT LOSS - BASIC HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.05	80.0 Btu/hr F
Wall	1120	.08	89.6
Glazing	320	1.13	361.6
Floor	1600	(Page 11-11)	174.5
		Total	705.8 Btu/hr F

Calculate the heat loss for the proposed house with underfloor insulation using Equation 11-2.

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling	1600	.048	76.8 Btu/hr F
Wall	1030	.078	80.3
Glazing	410	1.13	463.3
Floor	1600	(Page 11-11)	55.7
		Total	676.1 Btu/hr F

The heat loss in the proposed house with underfloor insulation is less than the heat loss in the basic house. Therefore, the proposed house with underfloor insulation is an acceptable alternative, which is at least equivalent in the conservation of depletable energy.

EXAMPLE II

Sample calculations for this example will be based upon:

(A) (1) A one-story heated and air-conditioned single family dwelling located in Sacramento, California (See Chapter 6 for design conditions).

Annual Heating Degree Days	-	2782
Winter Design Temperature	-	$29^{o}F$
Summer Design Temperature	-	$97^{o}F$

(2) The simplified floor plan of the house is shown on Figure 11-2.

(3) Exterior wall construction will be as shown on Page 5-2, Wall Section 1, using 3/8" exterior plywood siding, R=1.77 (without insulation); with R-11 insulation, R=12.77 and U=0.078.

(4) Garage wall construction between the house and the garage is similar to the other exterior wall construction except 5/8" Type X gypsum wallboard is used in place of the plywood siding and still air may be considered for the exterior air film.

$$R = 0.68 + 0.45 + 11.00 + 0.56 + 0.68 = 13.37$$
$$U = 1/13.37 = 0.075$$

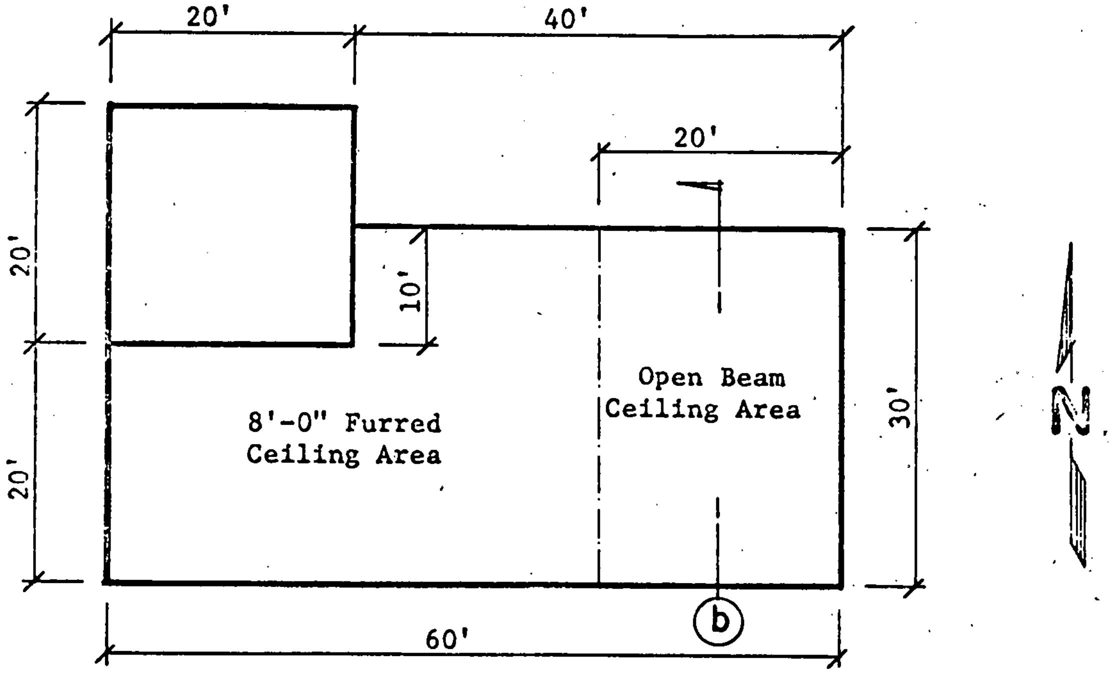
(5) The knee wall construction between the open beam ceiling area and the attic is similar to the exterior wall construction, except the exterior sheathing is not used and still air may be considered for the exterior air film.

$$R = 0.68 + 0.45 + 11.00 + 0.68 = 12.81$$
$$U = 1/12.81 = 0.078$$

(6) Floor construction will be as shown on Page 5-6, Floor Section 3, R = 3.29 without insulation, U = 0.304.

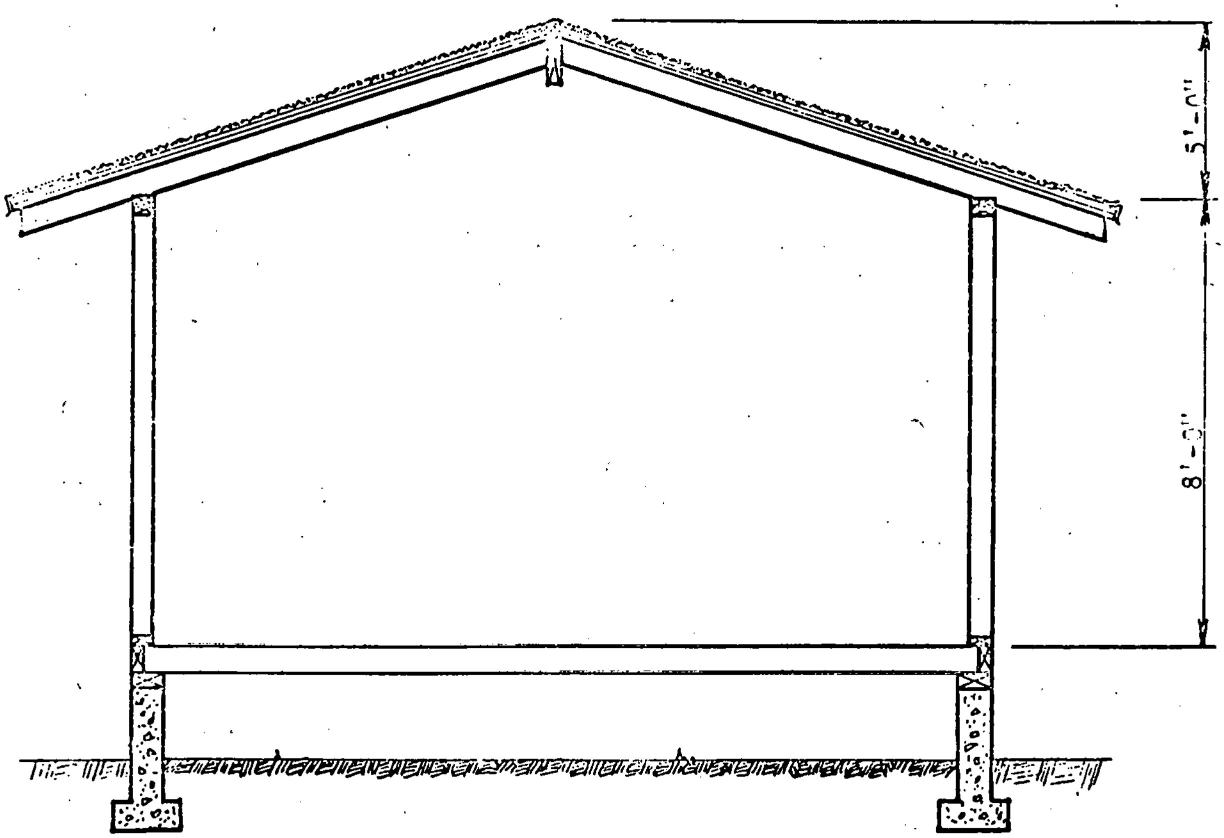
(7) Clear window glass has been specified, U = 1.13.

Figure 11-2



PLAN

Gross Floor Area = 1600 sq ft



SECTION (b)

(8) The ceiling construction will consist of two types:

1. Roof/Ceiling Section 1, Page 5-9, R=1.67 (without insulation); with R-19 insulation, R=20.67, U=0.048 (1000 sq ft). The finished ceiling height for this area is 8.0 ft.

2. Roof/Ceiling Section 3, Page 5-10, R=3.0 (without insulation), U=0.333 (632.5 sq ft); with R-6 insulation not penetrated by framing members, R=9.0, U=0.111. See Figure 11-2.

(B) Since this house is air-conditioned, compliance with Section 1094(f)(3) must also be verified, however, it is not considered in this example. See Chapter 7 for examples of the procedure to determine compliance with Section 1094(f)(3).

(C) For this example the planned glazing area is as follows:

North Elevation	-	80 sq ft
South Elevation	-	110 sq ft
East Elevation	-	80 sq ft
West Elevation	-	50 sq ft
Total Glazing	-	320 sq ft

STEP 1. Determine the basic glazing area. Since this building is less than four stories, it is a low rise building pursuant to Section 1094(d)(5) and the basic glazing area is 20% of the gross floor area.

1-A. From Figure 11-2, the gross floor area of the dwelling unit is 1600 sq ft.

1-B. Calculate 20% of the area from Step 1-A.
1600 x 0.20 = 320 sq ft
This is the basic glazing area of the entire building.

STEP 2. Determine compliance with Section 1094(f)(1).

2-A. The planned glazing area of 320 sq ft is equal to the basic glazing area, therefore, it is in compliance with Section 1094(f)(1).

STEP 3. Since the open beam ceiling area does not comply with the specific requirements of the Energy Insulation Standards (U=0.06), the alternative approach showing equivalency of energy conservation will be used.

STEP 4. Calculate the exterior wall and ceiling area of the building. (Assume 8' wall height.) The area of the garage wall construction could be calculated separate from the other exterior wall construction, however, in this example it is not necessary to do so, since the U factor of the garage wall construction is lower than the other exterior wall construction. The benefit of calculating these areas separately would be minimal since the garage wall area is only about 3% of the total exterior wall area. Therefore, in this example, the areas will not be considered separately and the U factor of the garage wall construction between the house and the garage will be considered to be the same as the U factor of the other exterior wall construction.

Since the knee wall construction has a U factor identical to that of the exterior wall construction, its area will not be considered separately.

Wall Area = 8 (60 + 20 + 20 + 10 + 40 + 30) = 1440 sq ft plus end and knee wall area where open beam ceiling occurs.

End or Knee Wall = 5 x 15 x 1/2 x 2 = 75 sq ft

Total Wall Area = 1440 + 75 x 2 = 1590 sq ft

Less Planned Glazing Area = 1590 - 320 = 1270 sq ft

Ceiling Area: Open Beam = $(15^2 + 5^2)^{1/2}$ x 2 x 20 = 632.5 sq ft
Furred = (40 x 30) - (20 x 10) = 1000 sq ft

STEP 5. Calculate the heat loss of the basic house which will exactly meet the specific requirements of the standards, using Equation 11-2.

$Q = U \cdot A$

5-A. A basic house which exactly meets the specific requirements of the standard is:

Ceiling		
Open beam	U =	0.06
Furred	U =	0.05
Walls	U =	0.08
Glazing	U =	1.13
Floor (used)	U =	0.304

Note: The calculation for the floor can be omitted since the same floor system must be used for both the basic house and the proposed house.

STEP 6. Calculate the heat loss for the basic house using Equation 11-2.

HEAT LOSS - BASIC HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling			
Open beam	632.5	.06	38.0 Btu/hr F
Furred	1000	.05	50.0
Wall	1270	.08	101.6
Glazing	320	1.13	361.6
		Total	551.2 Btu/hr F

STEP 7. Calculate the heat loss for the proposed house using Equation 11-2.

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling			
Open beam	632.5	0.111	70.2 Btu/hr F
Furred	1000	0.048	48.0
Wall	1270	0.078	99.1
Glazing	320	1.13	361.6
		Total	578.8 Btu/hr F

The heat loss for the proposed house exceeds the heat loss for the basic house by 27.6 Btu/hr F, therefore, some change will have to be made to obtain equivalency in energy conservation.

The alternative which will be used to obtain equivalency in heat loss is the use of insulating glass with a U factor of 0.65 for a portion of the house.

The amount of heat loss which must be made up by the insulating glass is equal to the difference between the heat loss of the proposed house and the heat loss of the basic house.

Heat Loss Difference = 578.8 - 551.2 = 27.6 Btu/hr F

Using Equation 11-3 with $U_{IG} = 0.65$

$$
\begin{aligned}
A_{IG}\ (1.13-U_{IG}) &= \text{Heat Loss Difference} \\
A_{IG}\ (1.13-0.65) &= 27.6 \\
0.48\ A_{IG} &= 27.6 \\
A_{IG} &= 57.5 \text{ sq ft} = \text{Area of insulating glass required}
\end{aligned}
$$

Check heat loss for the proposed house as follows:

HEAT LOSS - PROPOSED HOUSE

COMPONENT	AREA	U	HEAT LOSS
Ceiling			
Open beam	632.5	0.111	70.2 Btu/hr F
Furred	1000	0.048	48.0
Wall	1270	0.078	99.1
Glazing			
Insulated	57.5	0.65	37.4
Single	262.5	1.13	296.6
			551.3 Btu/hr F

The heat loss for the proposed house now compares with the heat loss for the basic house and meets the requirement of equivalency in energy conservation.

APPENDIX B

THE CALIFORNIA RESIDENTIAL ENERGY REGULATIONS
Their Impact on the Building Process

Prepared for the Division of Codes and Standards
Department of Housing and Community Development
State of California February 1977

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THE CALIFORNIA RESIDENTIAL ENERGY REGULATIONS

THEIR IMPACT ON THE BUILDING PROCESS

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ABSTRACT

In support of the energy conservation efforts of the United States Energy Research and Development Administration and the California Department of Housing and Community Development, a study of various building sectors impacted by statewide energy regulations has been conducted.

More than eighty interviews were conducted with local building code enforcement officers, architects and engineers, builders and developers, building material suppliers and manufacturers, and homeowners. The various groups identified problems encountered with energy regulations and their response.

The report contains recommendations for action by all levels of government and the building sector. Recommendations are directed towards current administrative practices; the technical aspects of the regulations, including product approval and certification, and educational needs.

Key words: building regulations, building standards, codes, energy conservation.

EXECUTIVE SUMMARY

In support of the ongoing efforts to implement energy conserving regulations by the State of California and the Energy Research and Development Administration, a survey of the various sectors of the building industry was conducted to determine problems and recommendations relating to the implementation, design, and enforcement aspects of the California Residential Insulation Standards.

Interviews were conducted with more than eighty local enforcement officials, architects, contractors and developers, material suppliers and product manufacturers, and homeowners. These interviews were conducted using a structured interview guide. Interviews were conducted in all geographic regions of the State, including south coastal, north coastal, mountain, desert, and central valley. Included were the major metropolitan areas, San Francisco Bay Area, and Los Angeles.

Each sector interviewed identified problem areas relative to the regulations. Building officials were concerned with increased workloads, inability to add personnel, inadequate educational opportunities, and poor product certification and approval. There was significant variation in the degree of enforcement and the understanding of the regulations across the State.

Architects were concerned with the prescriptive nature of the regulations and the lack of flexibility in the regulations.

Builders and contractors identified the communication problem as the primary obstacle to implementing the regulations, but once an understanding of the regulations was achieved, implementation followed with little difficulty. Window manufacturers and suppliers were concerned with market pressures and adjustments resulting from the regulations, while the insulation sector experienced few problems in this area. Homeowners were usually not aware of the energy conserving features of their homes.

The report concludes with recommendations for all levels of government and building sectors. Principal recommendations are directed towards revisions in current administrative practice, the technical aspects of the regulations, including product approval and certification, and the educational needs of enforcement personnel and members of the building industry.

INTRODUCTION

Under contract to the State of California, Department of Housing and Community Development (HCD), a study has been conducted relative to the problems encountered in the implementation, enforcement, and design aspects of the California Energy Insulation Standards for Residential Buildings. This study is part of a large project, "The California Residential Energy Insulation Standard: Problems and Recommendations Relating to Implementation, Design, and Cost Impact", funded by The United States Energy Research and Development Agency. This research will assist other states which are in the early stages of implementing energy conservation regulations. Feedback from the study will also provide guidance for revisions to the California Residential Regulations as well as give direction to the implementation of the State's non-residential energy conservation regulations.

The California residential energy insulation regulations are a product of State enabling legislation, passed in 1972, which mandated the development of such regulations by the Department of Housing and Community Development. The regulations were adopted on February 22, 1974, and were implemented one year later, on February 22, 1975. Since that time, they have been revised on four occasions to introduce new concepts and to provide clarification of problem areas. The last change in the regulations occurred in January 1976.

The regulations set forth the minimum requirement for the insulation of a residential building's exterior envelope, as well as thermal design standards for glazing, weatherstripping, ducts, and piping. To assist in the dissemination of these regulations, the Department of Housing and Community Development issued a Residential Energy Design Manual and conducted seminars for building enforcement officials at various locations throughout the State.

These regulations affected, in different ways, the various sectors of the building process -- a process encompassing diverse elements which are vulnerable to change and constraint. Each sector of the building process felt immediate effects as a result of the implementation of the regulations.

It is towards a description and evaluation of the effects of the regulations on these sectors -- and the people that comprise them -- that this study is directed. Through structured interviews, experiences of individuals throughout the State who have been affected by the regulations -- enforcement officials, builders and developers, architects and engineers, manufacturers and suppliers, and consumers -- have been documented (see appendix for interview guide).

The following report details and evaluates the findings generated by the interviews and conclude with recommendations.

METHODOLOGY

The methodology used to accomplish the project goals involved a series of field interviews relative to the impact of the adopted laws and regulations. Interviews were conducted on a statewide basis with individuals and agencies. The findings were evaluated by the project team, and the report was prepared, utilizing feedback by the team members at various stages in the report's development.

Interview Guide: An interview guide, developed in consultation with HCD staff, was utilized in conducting the field research. It contained both general and role-specific questions designed to elicit responses concerning the effect of the regulations on the various sectors of the building process.

The general questions were divided into the following categories:

a. Plan Review and Inspections
b. Functional Aspects
c. Product Standards
d. Education and Training

Role-specific questions were designed for the following groups:

a. Building Official
b. Architect and Engineer
c. Builder/contractor
d. Manufacturer/supplier
e. Homeowner/consumer

The general category questions were asked of interviewees when appropriate to their work and experience. Generally, the interview guide was utilized as just that: a flexible guide for interviewer and interviewee, which often led to valuable input in areas not covered explicitly by the guide but nonetheless relevant to the inquiry.

Sector and Geographical Distribution: In excess of eighty interviews of individuals involved in various sectors of the building process were conducted by the project team. In each sector category, the break-down, by number of interviews, was as follows:

a.	Local Enforcement Agency	37
b.	Builder/developer	22
c.	Architect and Engineer	12
d.	Manufacturer/supplier	7
e.	Homeowner/consumer	6

Region was a factor in selecting individuals for interviews. A geographical cross-section was sought, utilizing as guidelines the State's four major climatic zones: coastal, central, mountain, and desert. In this way, problems particular to a region were pinpointed.

Wherever possible, all sectors relating to a specific project or development were interviewed in order to obtain depth by analyzing the process in toto rather than piecemeal.

I. LOCAL ENFORCEMENT AGENCIES

The role of the local enforcement agency is to assure compliance with health and safety regulations. The degree to which this is accomplished in the field is influenced by a number of factors, including:

a. Understanding of the regulations.

b. The techniques by which the goals may be implemented.

c. Understanding the need for the regulations.

The manner in which the regulations were implemented on the local level are discussed below. Data collection findings are discussed first with a statewide overview followed by any unique geographic findings.

A. ADMINISTRATIVE

The two principal regulatory functions to assure implementation of the regulations are the plan review and the inspectional functions of the local enforcement agencies.

1. Plan Review: The overwhelming majority of agencies interviewed stated the plans were checked for compliance with the regulations. Upon closer examination, this meant that the "R" value for insulation materials required within the various building elements; i.e., walls, floors, and roof/ceiling, were specified on the building department approved plans. Few agencies required a statement on the plans that aluminum windows be labeled to show compliance with ANSI 134.1, or any statement relative to weatherstripping of openings. In addition, drawings were

seldom required to show the exact elements to be insulated such as walls between garage and dwellings, dormers, etc. It was assumed that the field inspector would check the installation of insultaion.

The California regulations require low-rise buildings exceeding twenty percent of the gross floor area in glazing (basic glazing area) to be designed by heat loss analysis. The local enforcement agencies reported few buildings exceed twenty percent glazing. Most reported from one percent to five percent exceeded twenty percent glazing. Only those geographical areas with significant views (ocean, hillside, etc.) had a number of "designed" buildings. Many agencies reported never planchecking a designed building. There were a few agencies that responded that "they had no trouble getting compliance with the twenty percent glazing limitation"; identifying a significant misunderstanding of the regulations. Some local agencies located in rural areas reported poorly performed heat loss analysis and upon thorough checking, significant design deficiencies were uncovered.

2. Inspection: Approximately one-third of the agencies contacted are not inspecting for compliance with the regulations, but are accepting the Certificate of Installation signed by the contractor and installer. The reasons given by these agencies vary, but frequently relate to budget staff, and workload. Hostility towards state-mandated regulations was also mentioned.

Agencies that did inspect frequently reported that they required a copy of the signed certificate prior to final inspection of the building. Others reported they feel the fact that the certificate is signed by the installer and contractor encourages the contractor to be more responsible. Local enforcement agencies in Southern California were significantly more active in inspection for energy conservation with only one local agency interviewed reported acceptance of the certificates in lieu of inspection. One city in Northern California reported initially inspection for compliance, but now is accepting the certificates after finding the workload excessive and being unable to increase staff.

The inspection requirements varied somewhat across the State. Where inspections were conducted, approximately one-half of the agencies interviewed required an additional called insulation inspection. After the rough-in inspections (framing, electrical, plumbing and mechanical), the building is wrapped for stucco, siding, etc.; then the insulation installation inspection was generally conducted. It is made from within the building and is of short duration compared to the rough-in inspection. Inspection of wall insulation is easily accomplished, but deficiencies in ceiling insulation installation were not readily detected. Specifically noted was whether the insulation lapped the top plates, and whether the insulation blocked the eave vents. A significant number of departments required blocking to be installed to assure functioning of the eave vents. This blocking was usually checked at the rough framing stage. Ventura County reported that changing the conventional framing methods to add blocking was a difficult process, and as a result they simply required the total attic ventilation to be provided at the gable ends of the roof.

Inspection procedures for multi-family buildings did not have the same impact on workload since these buildings are inspected at different stages and phases; thus, an additional called inspection was not required.

Specific inspection problems for wood frame buildings included insulation frequently overlooked behind prefabricated showers as well as conventional showers and tubs; behind and under stairways, and in plywood shear walls. Insulation was frequently not fastened (stapled). Attic eave vent blocking was required but may not be installed at the framing stage.

Another inspection problem occurred with floor insulation. In this case, the insulation is exposed to the weather since it is installed before the floor sheathing is in place and is unprotected from rain and dampness. It is difficult to inspect the supports (wires or staples) for the floor insulation without crawling under the building.

All agencies reported no problem with insulation and labeling. Field inspectors were instructed to check the bags and wrappings to verify the "R" value of the material.

The whole issue of windows and weatherstripping requirements was apparently not clearly understood by many building departments. Approximately two-thirds of those interviewed were not aware of the fact that aluminum windows were to be labeled as complying with ANSI 134.1, and thus were not inspecting for them. Even those enforcement agencies that inspected reported it was frequently difficult to find the label. As a result, these agencies requested independent certification or a letter stating compliance from supplier or manufacturer. This problem occurs because the windows are checked for labels at the final inspection. Often the contractor is in the process of final clean-up which includes washing the windows, thereby removing labels. Weatherstripping, duct and pipe insulation requirements were usually not known to the great majority of agencies.

3. Agency Operations: Fee increases to offset the increased plan check and inspection tasks required varied widely. Frequently the agency relied on the increased valuation provided by the insulation for additional income to cover the required services. Other cities increased their fees as follows:

a. .02/sq.ft.

b. Lump sum fee - $20.00

c. Ten percent increase in fees (this included other State mandated regulations such as noise transmission).

Few agencies reported authority to increase personnel, and most stated that the increased workload simply "added to the burden"; and the new work was performed at the expense of other work.

B. TECHNICAL

1. Adequacy of Regulations: Enforcement agency personnel interviewed generally felt the regulations adequate. Most admitted that they had nothing to compare with and that these regulations were the law, so they enforced it. The few interviewees with extensive understanding of energy conservation principles felt the standards did not go far enough since they did not cover HVAC systems, water heating and other energy-consuming elements within the building. A couple of agencies felt additions to existing buildings should be regulated, and some including Los Angeles County had extended their authority to effect this.

2. Prior Insulation Practice: Insulation practices prior to the enactment of the regulations varied statewide. The mountain areas, such as the Lake Tahoe area, had insulated walls and roofs prior to the standards, but at generally lower "R" values than present regulations require. Floors generally were not insulated, nor were windows double glazed. In other areas of the State, insulation was generally installed in custom homes and "some of the better tract homes". In these cases the insulation was usually limited to R-11 insulation in the ceiling. No conflicts were noted between energy and other standards although concern over the potential flammability of some types of insulation was expressed by a number of agencies.

3. Implementation: An area of significance is the manner in which the local agencies implemented the regulations. The building department seemed to be the principal vehicle for educa

ting the contractors about the regulations. Some contractors' associations have sponsored seminars, but most contractors learned of the regulations through the building department. Several building departments met with the local contractors, to develop an inspection sequence to have the minimum construction cost and time impact for the contractor, while assuring compliance with the regulations. The most significant general comment received was that the energy conservation regulations were the easiest to implement of all recent State mandated regulations since the contractors and homeowners could see the return on their investment. Some agencies responded that the initial six months of the program was a difficult period for implementation. Much of this related to the changing of glazing limitations occuring during that period. Local enforcement agencies responded that they act as the front man for the State, and that the State should take responsibility for the education of architects, designers and contractors.

C. PRODUCT STANDARDS

Few building officials interviewed had studied the manner in which insulation and windows are tested and labeled. Few were aware that insulation is labeled and tested under a voluntary standard as compared to the independent laboratory and inspection process for traditionally regulated building products. Each agency was queried regarding who should approve energy conserving products. Most responded that ICBO would be the agency looked to for approval with Underwriters Laboratory next. Others felt the State Energy Commission or HCD might be appropriate in certain situations.

No communities reported any local standards for products or solar components, although Los Angeles County has some solar product standards under consideration.

D. EDUCATIONAL

Virtually all local enforcement agencies interviewed received some sort of training relative to the regulations.

Usually this training was received at a state-conducted seminar, or less formally, at a building officials' chapter meeting. Some reported joint meetings with contractors' associations or architectural groups. The training was related to the regulations and their content. None received specific training related to the concepts of energy conservation. It appears that some course material should be developed to acquaint all sectors of the building community with good design principles in addition to the methodology of implementation of the regulations.

The information received at seminars or classes was used for training of other personnel within the agency. The one-man enforcement agencies were frequently unable to attend any class or seminar since they reported they were unable to get away from the office, and had no one to relieve them. Many that have attended seminars stated that the technical content of the class materials was not at the level they would have preferred. Only the College of the Redwoods was reported to have offered a semester-long evening course in the residential energy regulations.

E. FIELD PROBLEMS

The data collection findings of field problems encountered by building officials fell within three general areas. These include:

1. Administrative problems
2. Technical problems
3. Product acceptance, approvals and standards

1. Administration: The significant findings relative to the building regulatory agencies is that most consider the regulations an insulation standard only. Thus, when they plan check and/or inspect for insulation, the requirements of the regulations are believed to have been met. Only about one-third of the local agencies interviewed reported inspecting for complying windows. One reason for this could be the required Certificate of Compliance. The form of certificate contained in the Energy Design Manual relates only to insulation, and is signed by the insulation installer. As a result, upon receipt of the certificate and inspection of insulation, most enforcement agencies feel they have performed their job in a proper manner and are not aware of the other requirements.

Other administrative problems noted were:

a. Staffing was frequently inadequate. Many local agencies report they are unable to add personnel to accomplish the mandated State regulations.

b. Agencies questioned the need for posting the Certificate of Compliance within the building. Several required a signed copy of the certificate to be submitted to the enforcement agency prior to final inspection. This copy is maintained with the office copy of the permit.

c. Acceptance of Certificate of Compliance in lieu of inspection is a common practice. Many local agencies that accept the certificate report they still inspect to varying degrees for compliance, which would include labeled windows. But the majority feel the signing of the certificate was the total job, whereas in reality, no one certifies compliance with glazing, weatherstripping, piping and ducts requirement.

d. Continuity of requirements is difficult to assure. Los Angeles City found it necessary to develop a new tracing system to assure ongoing compliance for additions and alterations to buildings constructed after the implementation of the regulation. This particularly applies to buildings to which air conditioning is being added, and a permit applied for. Few other agencies reported they were prepared for such events, but it could develop into significant future enforcement problems.

e. Verification of the regulations is sometimes difficult to obtain. Local enforcement agencies reported being given information by insulation contractors, and being told by them that, "that's the way the State says to do it". The local agency reports being unable to verify and frequently going along with the contractor.

f. The Energy Design Manual was sometimes confused with the letter of the law. One local official commented that the

Energy Design Manual is treated as the law, and if a material, method, or assembly is not contained in the manual, it is not permitted.

g. Some local agencies were not permitting glazing to exceed twenty percent of the floor area, and not accepting design by heat loss analysis.

h. Some rural areas reported poorly done heat loss analysis, and only through rigorous checking were significant deficiencies uncovered.

i. Increased time for plan check and inspection was noted. Ventura County reported an additional 15-20 minute average increased plan check time. This figure was developed by averaging time over an extended period; it includes both tract and custom homes, requiring a heat loss analysis. Inspection time increases usually amounted to the one additional called inspection but areas exceeding 4500° days reported as many as three additional required inspections. Those included the under-floor insulation, the inspection after rough-in, and a rigid roof insulation inspection in open beam ceiling situations.

j. Several agencies reported poorly trained workmen. They also noted the workers were "paid by the piece", and only speed counted.

k. Areas in which air conditioning is the principal energy consuming system had many problems with the regulations. Palm Springs is proposing different and more restrictive requirements locally. Most felt that glazing requirements were too loose and that the standards were based on "degree days heating" which was not appropriate. They feel that the requirements have virtually eliminated the use of masonry wall buildings in the desert regions, previously the principal type of construction.

1. In areas where two zonal requirements are adjacent to each other, the significant construction requirements of the standard are questioned. An example is along the Eel River in Humboldt County. One side of the river is less than 4500° days, while the other is slightly over 4500° days. The local agencies expressed the opinion that there is a significant increase in requirements in a short geographical distance and perhaps a sliding scale of requirements would be more appropriate.

2. Technical Problems: The technical problems might best be divided in the following manner:

a. Insulation

b. Window certification roquirements

c. Weatherstripping

a. Insulation: The insulation requirements have resulted in several difficulties:

1) Workmanship: Many field reports involved poor installation of insulation. This usually involved the fact that the insulation was not stapled, but simply a "friction fit". Local agencies reported that the insulation frequently sagged, or came down or out of the stud space.

Under floor insulation creates still another problem. It must be supported or adequately stapled in place and be protected from the weather (rain or fog). The City of South Lake Tahoe has required wire support for the insulation with specific requirements for the supports for the wires. Foil type insulation creates another series of problems. The foil must be properly expanded, and each layer separated from the others. Poor workmanship here, or mishandling by other trades (repairs or changes to electrical, plumbing, etc.) may significantly reduce the effectiveness of the insulation.

2) Product Standards: Another difficulty relates to the products themselves, many of them new on the market. These products fall into two groups. The first respond to the need to cut costs. Since standards do not require a vapor barrier, products meeting the minimum requirements of the regulations are appearing in the field. These products are "conventional" insulation, but without a vapor barrier. Inspectors accustomed to seeing batts or blankets with the "R" value printed on the vapor barrier were confused by these products.

The second group includes innovative insulation materials and the specific products designed to meet special field problems. Enforcement officials report the need for products which meet the special construction requirements for slab-on-grade construction, as well as wood floors, insulated under-floor space, masonry and concrete walls, and open beam roof/ceilings. New materials being sold and utilized include paper products, expansive foams and similar products. Enforcement officials, accustomed to ICBO Research Recommendations, Underwriters Laboratory labels and similar approvals, are not familiar with the voluntary industry standard in effect for insulation. As a result, some agencies have accepted and others rejected new products.

b. Window Certification Requirements: Windows also have several problems. The fact the standards call for a limited glazing area leads many enforcement agencies to believe that is all they are required to check. Most agencies appear not to be aware of the window infiltration requirements. The fact that aluminum frame windows are covered by the regulations (in accordance with ANSI 134.1), and wood sash windows are not, has caused confusion among those that have been inspecting windows for certification.

Where certified windows were installed, the labeling was not often clear. Some labels include all rough-in dimensions and assembly instructions, as well as a statement certifying compliance with ANSI 134.1. Other recent installations have had a separate label affixed to the slider. Concern has been expressed over the durability of the additional material within the window frame to limit infiltration.

A couple cases of double glazed assemblies cracking because of the pressure differential at high altitudes were reported. Replacement glazing for broken windows has been difficult to obtain, and some departments have given final approval to dwellings with single glazed temporary windows before the replacement glass arrives.

c. Weatherstripping: Few agencies responded to questions relative to weatherstripping, and it appears that compliance is minimal at best. No comments were received about pipe or duct insulation.

3) Product Acceptance and Approvals and Standards: The last area of field problems involves the product acceptance system. Traditionally, regulated building materials are inspected, labeled, certified, tested, etc. at various points in their assembly by independent agencies. New building products may be approved by the model code groups, State regulatory agencies, or major city ongoing product approval process. Energy conservation products are labeled under voluntary standards. Local enforcement officials are concerned over the lack of independent testing and certification of insulation. They are concerned about other standards, such as flammability, that affect insulation. Thus, potentially acceptable products may be kept off the market because of lack of acceptance by local officials; and poor products may be inadvertently accepted by local officials.

F. CONCLUSION

The California Residential Energy Insulation Standards are enforced with varying degrees of success by local enforcement agencies. In general, of all the regulations, the wall and ceiling insulation requirements are best understood by the agencies, and no major enforcement problems are perceived although inspection procedures vary. The whole issue of windows and weatherstripping, pipe and duct insulation, is apparently not clearly understood by many local enforcement agencies. Most notable is the widespread ignorance of the required labeling of aluminum windows.

Building officials are most often concerned with the increased workload generated by the regulations, the inability to add personnel, inadequate educational opportunities, and poor product certification and approval standards. Thorough implementation of the regulations awaits solutions in these areas.

II. ARCHITECTS AND ENGINEERS

As a key participant in the building process, the architect is charged with translating written regulations and codes into working plans for a structure. In theory, he or she interprets these legal requirements. But, most often, in practice, the architect simply (and mechanically) incorporates these regulations into a final design.

The architectural profession is marked by a wide range of attitudes and practices regarding the California Residential Energy Insulation Regulations. For the most part, architects are now well acquainted with the regulations and have made the appropriate adjustments in their practice. Some feel comfortable working with the regulations while others feel that the regulations restrict the range of potential solutions to design and energy problems. A small number of architects, seeking new solutions through solar energy and other unconventional systems, deal with very sophisticated calculations. Their designs, which operate independently of conventional heating and cooling systems, usually far exceed the energy conservation levels achieved by those designs which conform to the minimum requirements of the regulations.

A. . TECHNICAL

1. Adequacy of Regulations: Most of the architects interviewed agreed that the regulations are generally adequate. In specific categories, everyone felt the insulation requirements for ceiling and walls are adequate. Some felt that under floor

and slab-on-grade insulation should be required in areas below 3,000 degree-days/year because of significant potential energy savings. A majority agreed that that square footage allotment of glazing areas for both the heating and cooling seasons is adequate, despite the fact that elsewhere in the interview, most architects indicated that they generally increased window area over the standard design maximums. This apparent contradiction might be explained by the difference between the architects' professional judgment vs. their clients' demands. Some architects felt that energy savings resulting from infiltration provisions are negated by inefficient building operations (i.e. opening doors and windows). Exfiltration provisions were suggested as a possible addition to the regulations. Fans, perhaps, could be required to use positive closer devices; flue combustion air requirements could be incorportatd, etc. Piping insulation standards were felt to be adequate. Several architects expressed the opinion that additions to residences should be covered by the regulations.

Several architects who work frequently with heat loss analyses feel a performance standard would be more desirable than the prescriptive regulations now in force. If the State is trying to promote energy conservation, a performance approach would yield a clearer picture as to which structures are energy efficient and which are not. A performance approach would also allow designers to take advantage of many environmental design constraints currently ignored - siting, orientation, window placement, building massing, micro climate, etc. The regulations as now written do not recognize the fact that windows are the greatest friend as well as the greatest foe of internal thermal stability. When window area and orientation are thoughtfully designed, greater energy savings can be realized. One interviewee described a situation where the same floor plan used throughout a tract was turned 180 degrees, causing the addition of one extra ton of air conditioning. As now written, the regulations seem to say "the less glass the better", and have spawned such "no-think" solutions as using single pane up to the allotted twenty percent and double pane for the glass areas exceeding the limit. Or, more commonly, designers assume an energy-conscious design will result from limited glass area regardless of window orientation. The prescriptive nature of the regulations has caused design decisions which are not cost beneficial.

2. Standard Design vs. Heat Loss Analysis: Most of the architects interviewed make use of heat loss analysis, particularly those involved in single family residential design. It was found consistently that the reason for utilizing alternative design provisions was to provide more glass area -- for view, feelings of openness, and natural light. Some designers have developed consistent approaches to design trade-offs when glass areas exceed twenty percent of the floor area. Some go to double glazing, while others find it more economical to insulate under floors to compensate for increased window area.

3. Design Problems: The most frequently mentioned design problem imposed by the regulations involves the detailing of an open-beamed (vaulted, cathedral) ceiling. It was also observed

that concrete block is rarely used now because of the difficulty in achieving wall insulation requirements. In the mountain areas, it was reported that under-floor insulation posed significant problems due to moisture accumulation; alternative design details were called for. The architect of the high-rise hotel noted difficulty in developing a system to satisfy the roof insulation requirement.

4. Energy Design Manual: Most architects contacted were familiar with the Energy Design Manual and found it useful. However, they frequently complained that the manual was not circulated within the profession and many did not know where to obtain a copy. Suggested changes to the Energy Design Manual were:

a. Expansion of the materials list.
b. Expansion of the listing of California cities to include all cities, preventing errors in assigning degree-day values to small communities.
c. Replacement of current shade angle calculations with page 442 of ASHRAE Handbook of Fundamentals (1972).
d. Development of alternative high-rise roof insulation systems.
e. Development of alternative under-floor insulation systems for moisture-prone climates.

5. Prior Insulation Practices: Prior to the effective date of the regulations, architects report they frequently used insulation in ceilings and walls, but rarely under floors. Few architects used either heat-absorbing tinted glass or double glazing.

Acoustical insulation requirements in multi-residential structures often coincided with thermal insulation considerations.

6. Impact on HVAC Unit Size: Despite the reported energy savings under the regulations, few of the architects interviewed are using smaller mechanical system units. A decrease in unit size seems appropriate only in larger structures covered by the regulations. Unit sizing for single family dwellings seems to be done by rule of thumb. One architect suggested that the regulations be changed to include a clearer tie between heating load and mechanical unit size. In this way, the regulations would relate to the system, not just to the building envelope. For a single family dwelling the cost of a larger unit is insignificant. This results in mechanical unit sizes often being twice what they could be for meeting the heating requirements.

7. Economic Impact: According to the architects interviewed, the cost impact of the regulations for buyers of new homes involves an increase of $100.00 to $300.00 per home (more in areas of severe climate). At the same time, the majority felt the resulting energy savings were substantial. Most architects are not aware of an increased burden on building departments as a result of the regulations. Few architects have raised their fees or specifically identified a fee for designing a structure to comply with the regulations. Those operating on an hourly fee are not always able to itemize costs for separate services. According to the director of technical services of the Sheet Metal and Air Conditioning Contractors National Association

(Oakland office), the fee charged by the association for a complete heat load calculation is currently \$3.00/100ft.^{2} for a custom house; \$2.00/ft.^{2} for a tract house. The actual costs of doing the calculation is reportedly in excess of these figures but the industry subsidizes the costs.

B. PRODUCT STANDARDS

Apart from an occasional insulation shortage, architects report that products required to meet the regulations are generally available. Batts and rigid insulation are usually labeled, while blown-in insulation often is not. Some of the architects interviewed were not familiar with window labeling practices. Some report that blown-in insulation is subject to careless application and consequent reduced "R" values. One respondent noted that rigid insulation degrades with age. Other problems mentioned included the difficulty of operating double-paned (glazed) sliding glass doors, and deterioration of aluminum-framed window seals which result in increased air infiltration. Most architects report that data relative to the thermal properties of insulating material has been readily available. They generally rely on the data and figures furnished by manufacturers as no alternative test data are available. Only the Tahoe area architect reported any difficulty in locating relevant and reliable data. Few respondents had investigated the manner in which energy products are tested or labeled; one architect observed a lack of consistency in testing standards for windows and insulation.

No major conflicts have been found between the Residential Energy Regulations and any other standards such as flammability. ICBO, UL, and the State Fire Marshal were most frequently mentioned as possible acceptable sources of energy product approvals.

C. EDUCATION

Many architects stated that they learned about the Residential Energy Insulation Regulations when applying for a building permit; one architect was told by his developer-client. As a result of such patterns, many designs had to be re-worked to adjust glass areas when the regulations first went into effect. The AIA is looked to by many architects to provide notification of relevant new laws as well as seminars and training, if necessary. The AIA has stated that its membership was notified of the regulations in advance and was offered seminars on the topic. However, with one exception, none of the architects interviewed received any training directly related to the regulations. Most read either the Design Manual or the regulations in order to become acquainted with the new law. Some had received relevant training at various points in their academic careers. Others have attended seminars on general energy conservation topics given by various building trade organizations and the AIA. Architects doing solar design rely on ASHRAE publications and mechanical engineers as their primary sources of information.

Only the Tahoe area architect reported receiving training directly related to the regulations -- from the City of South Lake Tahoe.

Few of the architects interviewed reported a need to contact the Department of Housing and Community Devleopment for technical information, or help of any kind. However, there exists a sentiment among architects that notification of enactment of the regulations should have come directly from the State, along with full explanation as to what would be required for compliance. Most complaints about the problems caused by the State's actions in the implementation of the regulations were in reference to the initial lack of information and notification, the speed with which the law took effect, and the unavailability of the Design Manual. Almost all architects interviewed felt training is now needed to provide technical information pertaining to the regulations in particular, and energy conservation in general. Several architects strongly recommended the need for better training of building enforcement officials. Plan checkers, for example, are not always able to evaluate the technical information contained in non-standard residential design.

The upcoming non-residential regulations have created a great deal of apprehension and confusion in the profession. Most architects realize they are in danger of being denied a permit after these new regulations become effective, in much the same way as they were when the residential regulations were enacted two years ago. There exist many questions regarding time table, content of the regulations, availability of a Design Manual, and legal ramifications.

D. CONCLUSION

For most architectural offices the regulations are seen as another constraint to which a finished design must conform. After the design is completed, glass areas are adjusted and walls insulated with proper thicknesses of insulation to comply with the Residential regulations. The regulations do not force consideration of energy efficiency during the early stages of design development. As one architect described, there is a lack of discipline among architects to recognize and address the very real problem of dwindling energy supplies. More often, stylistic solutions take precedence over important functional, and in this case, energy concerns. In the past, architects had no need to consider natural environmental controls to achieve thermal stability. If it took an extra two tons of air conditioning for a design to retain an unshaded south facing glass facade, it was of no concern to the architect. Mechanical systems could bail out any environmentally poor design.

Currently, there is generally a lack of basic information about environmental controls within the profession. Simple considerations such as window orientation, shading of summer sun while allowing penetration of winter sun, natural ventilation, etc., are not recognized in the regulations as potential energy savers. This coupled with a lack of consumer awareness and consumer demand for energy efficient design has provided the architecture profession with no impetus to achieve energy efficient design.

III. BUILDER-DEVELOPERS

The builder is the individual in the design/construction process who must ultimately execute the work required by the law and represented in the drawings and specifications. Builders must understand both the requirements and the intent of the law in order to put it into effective practice. This presents difficulties, since the State has no channels of communication with the building industry as such; nor is it practicable to develop such channels, since builders are generally independent, diverse, and competitive with one another, and therefore difficult to organize or reach.

Nevertheless, resentment has occurred among builders, who often feel that they are not receiving enough from the State. Many feel that insufficient efforts are made to communicate with them.

In general, it is the builder who also acts as developer who expresses need for help with design information. Builders who perform only general contracting services are likely to follow the drawings only and not participate in decisions regarding their contents.

A. TECHNICAL

1. Adequacy of Regulations: The regulations are generally felt to be adequate although typical complaints recur within environmental zones, showing patterns which point to deficiencies in regional applicability of the regulations. In the coastal area, one builder said that the regulations are too

restrictive in the immediate vicinity of the ocean and too lax inland; and another that they are generally too lax. Another who feels that regulations are inadequate stated that insulation regulations would be difficult to upgrade for retroactive enforcement since retrofit of walls for increased insulation is technically difficult. In the central area, glazing limitations are felt to be too restrictive, but the rest of the regulations are well accepted. More complaints occurred in the severe-climate zones; the general consensus in mountain areas is that insulation requirements are inadequate, and in desert areas, that the glazing and orientation provisions do not really address the problem; and that the insulation requirements are designed to save on heating energy rather than air conditioning.

Most builders were not quite satisfied with the regulations but few had suggestions for changes. The suggestions which were received show no pattern or consensus; in fact, no two builders wanted the same thing. Opinions ranged from advocacy of a laissez-faire policy on the part of the government to a belief that the regulations should be made more restrictive in selected areas. One builder who advocates tightening the regulations believes that they should still not be promulgated by government. One favors the elimination of the standard design and the requirement of heat loss analysis for all buildings.

Whether or not the regulations have resulted in energy savings is considered debatable by many contractors. Responses concerning the efficacy of the regulations ran the gamut from completely favorable to completely unfavorable, with numerous intermediate shades of doubt, assumption, or indecision. One builder commented that no true comparisons have been made, since no two buildings would have the same energy consumption characteristics anyway. Most contractors believe that the existing regulations are accepted by the public -- insofar as the public thinks about them at all.

2. Design: Builders reported that almost all houses complied with the standard design requirements. Where compliance problems arise, the design is generally changed to meet the standard requirements. Builders of higher quality tracts and houses use heat loss calculations more frequently, especially if their developments are in areas where the view is a saleable commodity. For example, in mountain areas builders often make a practice of compliance with standard design requirements, but the view in such areas is likely to warrant the trouble of deviating from the standard design, and a significant number of heat loss calculations are performed. One builder used the heat loss calculation method on all his houses.

3. Technical and Design Problems: None of the builders was having overwhelming problems in dealing with the regulations, but most were having some. Design practice has been affected, and various minor problems and complaints were voiced with respect to this. Some problem has been encountered in satisfying the requirements where open beam ceilings are used, especially in mountain areas. Several builders complained that the regula-

tions do not give proper consideration to siting and shading. This problem is particularly acute in desert areas. Conflicting calculations for heat loss have been provided by different mechanical engineers, and this results in trouble and confusion for builders. Design problems are also occurring in areas of high humidity; the specified details may result in significant moisture problems.

4. Energy Design Manual: In almost all cases, builders were not familiar with the Energy Design manual, or did not use it because it was not needed. Some builders in the mountain area felt it is too confusing. In general, builders do not refer their questions to the State, but work through the local building department. Some rely on subcontractors, or VA, or FHA standards.

5. Prior Practices: As compared to previous practices almost all contractors agreed that insulation has been upgraded and glazing brought under control. The majority had been using insulation prior to the regulations, but they were not using as much insulation, and some were using none at all. For most, the regulations introduced the first sense of a need for glazing control.

Few new relationships appear to be developing between mechanical engineers and contractors. Some contractors do not work directly with mechanical engineers; others always have, but among those who did not previously do so, impetus for development of this relationship has only rarely been provided by the energy standards.

6. Field Problems: Most contractors had no trouble with implementation of the regulations. One complained that confusion of interpretation among various jurisdictions in which he works had made his job difficult. For most, compliance with regulations did not cause any scheduling problems. One coastal zone contractor said that some delays in inspection had been experienced.

In general, product availability appears to be good, although some complaints of shortages and accusations of profiteering were made. Some of the window manufacturers had not been able to expedite deliveries properly. Some insulating materials have been in short supply, specifically fiberglass and rockwool.

With respect to labor availability, there were no complaints about insufficient numbers of subcontractors, although there was some grumbling about "sloppy work". Predictably, areas with a limited construction season have more problems with delays and scheduling than do those where construction is possible year-round.

7. Economic Impact: Even though contractors generally agree that the regulations are not too restrictive, many feel that they are not cost-effective for the consumer. All builders agreed that costs to consumers have increased, but none mentioned a substantial figure in terms of percentage of building cost. Estimates of cost impact for conformance varied from one-half of one percent of building cost to ten percent of building cost, with most contractors approximately in agreement with the lower

figure. One builder stated that industry had opportunistically raised prices for materials required to meet the regulations. Another believed that no impact had been felt, because he had been designing buildings equivalent to those specified in the standard design all along. The anticipation that initial costs for insulation would be partially offset by reduced HVAC system costs has not proved to be realistic. Builders are not typically installing smaller HVAC systems, and at least one is under the impression that the Uniform Building Code does not permit reduction of size of HVAC units below that appropriate for a house not conforming with the regulations.

In the mountain area, it was stated that windows complying with the regulations were twice as expensive as those formerly used, and that insulation costs had increased by about twenty percent. In this area, smaller size HVAC equipment is being used due to the additional insulation required by the energy regulations; however, the initial savings effected by this size reduction is not substantial. Estimated overall additional materials costs for compliance varied considerably with a figure of about $500.00 frequently mentioned. One builder estimated the total additional cost for meeting the regulations at $800.00 to $1,000.00 for a $40,000.00 house. Most contractors felt that the additional cost was small and quickly paid back by decreases in winter heating bills.

B. PRODUCT STANDARDS

Product labeling is considered satisfactory, and builders generally consider the performance of labeled products to be consistent with manufacturers' claims. Some variability in quality windows was noted.

At high altitudes, some double-glazed windows have disintegrated or exploded due to pressure differences. Other problems have been encountered statewide with deterioration of urethane insulation, inadequate performance of blown-in insulation and unrealiability of solar products. This last problem is so severe that most builders would not consider installing solar energy devices until independent and reliable testing for such products is initiated. Many builders would like to see independent testing and certification of all energy conservation products.

In general, builders have not pursued development of their own products or product standards. A few exceptions were found: one builder is investigating the use of solar panels as roofing, and another is engaged in a five year research project to develop a minimum energy dwelling. One mountain area contractor is heavily involved in research and testing of solar installations.

C. EDUCATION

Builders and contractors reported receiving various degrees of training relative to the regulations.

One builder in the coastal area attended training sessions run by the Building Industry Association, and it is reasonable to assume that training was made available to builders in the area. No builder in the coastal area expressed a desire for further training. However, central California builders expressed desire for formal training programs in addition to the information already distributed by trade associations and manufacturers. The severe-climate zones were characterized by need for considerable training and education. In the mountain area, this has been provided. The building department and the contractors' association both conducted seminars for contractors, and various manufacturers' also provided training. In the desert area, no comprehensive local efforts of this type have been made, and builders complain that the small amount of training which has been offered is not convenient or accessible.

D. CONCLUSION

Where concerted attempts have been made to communicate with the builder, regulations have been realized in the field with a minimum of technical difficulty. This has typically occurred in areas subject to more severe climatic conditions, where the need for close cooperation at all levels of the building process is most obvious.

Results of a lag between implementation of energy standards and response of market forces have been disadvantageous to many builders, resulting in inflation and lost time. These problems may not be preventable and are temporary in nature; nevertheless, they are not conducive to positive attitudes towards building regulatory processes on the part of contractors.

IV. MANUFACTURERS AND SUPPLIERS

The California Residential Energy Insulation Standards regulate manufacturing and labeling requirements for most glazing products (aluminum frame windows and sliding doors) utilized in residential construction. And although the standards do not regulate insulation manufacture and labeling, they do regulate its installation. The manufacturers, suppliers, and subcontractors of glazing and insulation materials are therefore two sectors of the building industry which are most directly affected by these regulations.

When looking at the insulation and glazing industries separately, the effects of the regulations were found to have been very different. The window manufacturers, in most cases, were required to re-think their individual products in order to bring them into compliance with the various performance standards in the law. The amount of revamping necessary depended on the level of product quality maintained before the law became effective; but in all cases, those contacted indicated that at least some changes were necessary. The insulation manufacturers and subcontractors, on the other hand, were not required to change their products -- they only had to certify that their products were capable of certain levels of resistance and label them accordingly. Glazing and insulation manufacturers do not make products for specific geographical areas, but rather manufacture fairly uniform products which are adapted to various regions. Certain specifications, particularly on glazing products, may be more common in certain areas; i.e., solar bronze glass in a hot summer area requiring air conditioning. But for the most part, regional differences in product utilization is determined more by architect and contractors than by the glazing and insulation industries per se. Any unique geographical findings will, however, be noted.

A. INSULATION SUBCONTRACTORS

All the insulation subcontractors interviewed expressed a high degree of acceptance of the regulations. It should be noted that the industry was well prepared for the implementation of the regulations. The various insulation industry associations to which the subcontractors belong were a significant force behind the regulations -- both in formulating the content and scope of the regulations, and in its final passage.

1. Adequacy of Regulations: There was general agreement as to the adequacy of the regulations. Suggestions for changes include requiring new additions to conform to the minimum standards, as well as a requirement for under-floor insulation in areas of low degree-day ratings.

2. Energy Design Manual: Insulation subcontractors reported familiarity with the Energy Design Manual. It was commended as a good first effort, and does not seem to present any major difficulties to the subcontractors themselves. However, some respondents expressed the wish for some clarification to facilitate the Manual's use by less sophisticated personnel.

3. Economic Impact: Insulation subcontractors report that the regulations have resulted in stiffer competition. Accustomed as they were to ordering as much insulation as they wanted, insulation subcontractors found that with the implementation of the regulations, demand outstripped supply, and manu-

facturers were forced to establish quotas for areas and individual subcontractors. Capital margins shrank drastically, and the smaller subcontractors, unable to endure the squeeze of less materials in stock and more competition in the marketplace, foundered. Insulation subcontractors agree that the cost impact of additional insulation for the final housing product is borne by the consumer; but the consensus of opinion in the insulation industry seems to be that monies spent for insulation are the best spent energy conservation dollars. Actual figures were hard to quote, but a general amount of one-half of one percent of the total cost of structure was commonly heard as the actual cost increase to the homeowner.

4. Product Standards: All testing, assigning "R" values, and labeling of insulation products is done at the factory level, and the subcontractors merely apply appropriate amounts and types of the product as required by individual jobs. The industry as a whole has not experienced any unusual shortages of materials since the law's creation, but increased demand has caused an allocation system to be set up in order to distribute the products statewide. Prior to the law's creation, use of insulation by general contractors and builders was erratic enough to allow individual subcontractors to order as much as they thought they needed. However, some insulation subcontractors in the southern part of the State mentioned that they were expecting further shortages in the near future for a couple of reasons:

a. A shortage of energy supplies which could cause reduction in the gross output of fiberglass insulation (making glass fiber is an industry which required large amounts of heat); and,

b. The increase in the number of housing starts which would strain supplies which are already being allocated.

One major area of complaint centered around subcontractors who are taking liberties in applying "R" values to rigid insulation. The rigid insulation installers are using a 'foamed in place' "R" value although the sheets of insulation are actually factory produced. During storage, the "R" value is much reduced due to natural deterioration, especially when exposed to the ultra-violet radiation of the sun. This deterioration factor (up to 50% of original "R" value loss) is not considered in calculations, resulting in less than adequate insulation being installed. It is significant that none of the subcontractors contacted handled rigid insulation. Rigid insulation seems to have been left to the roofing subcontractors. This problem could become significant as architects and engineers learn more about these products and their convenience in applications to vaulted or cathedral ceilings.

Another problem concerns blown-in insulation -- in particular, that some small companies make exaggerated claims for the capabilities of blown-in cellulose. Inferior quality materials, little better than shredded newspaper, are used in such cases, and they may create a very real fire hazard. The insulation people contacted almost unanimously requested more stringent inspection and certification methods to help eliminate these fly-by-night operations, which reflect poorly on the industry as a whole.

5. Education: The insulation sector noted the need for more uniform education for building inspectors concerning insulation because of the wide variation of opinion among building officials as to what methods constitute a proper installation of insulation on the site. More education was also requested for the building industry as a whole, again, because of general confusion concerning heat loss calculations and air conditioning requirements.

B. WINDOW MANUFACTURERS

Window manufacturers as a group were generally characterized by a low degree of acceptance of the regulations and were opposed to the imposition of any new restrictions. The loudest complaints were in the area of conformance; i.e., "how much of what they were doing to comply was their competition doing". Inspection practices regarding windows and their labels are very inconsistent -- many local enforcement agencies were not inspecting for labels, and the window manufacturers noted that "unequal inspection creates an unfair market".

1. Adequacy of Regulations: Window manufacturers consistently regarded the regulations as too restrictive with respect to glazing requirements. They observed that building an air conditioned house with windows which eliminated heat gain, while helping to reduce cooling loads, worked to the detriment of the heating system in the winter. One suggestion to remedy this situation, also heard from some builders, was to eliminate the original cooling restrictions, leaving only heating requirements, and instead place a performance specification on the cooling unit itself.

2. Energy Design Manual: Window manufacturers reported a significant time lag between the effective date of the regulations and distribution of the Manual. Most said they consulted it only to obtain "U" values for dual glazed windows and the various spacings of the panes of glass. Otherwise, not too much comment, and no real suggestions for changes were made.

3. Economic Impact: All window manufacturers reported increases in costs, both R & D and final wholesale and retail costs, and this, in turn, has resulted in stiffer competition. They observed that the small window manufacturer, unable to develop financial capital in amounts necessary to research and develop new lines of windows which meet specifications or improve existing lines, is forced out of the market.

Despite the rising cost of making windows conform, no manufacturer contacted felt that there had been a marketplace invasion by wood window manufacturers, whose products are exempt from the regulations but still comply. The primary reason for this is the initial wood window cost, which is still substantially higher than the cost of aluminum windows. Another factor may be the spectre of high maintenance attached to wood windows, which would tend to deter many buyers.

Most window manufacturers indicated that they had raised prices -- costs they felt were immediately passed on to the consumer. These increased costs were felt to be non-recoverable by the average original owner through heating bill reductions. However, all agreed that over the average life-span of a house, the increased efficiency would eventually pay its way.

4. Product Standards: Despite their resistance to the regulations, all window manufacturers said they already had windows which met the performance criteria before the effective date of regulations. The problems arose in the lower quality models, which were dropped or re-engineered to upgrade them. This is where all the money is being spent: trying to maintain a series of model lines of various quality. One engineer for a quality brand of windows indicated that in upgrading certain models, new stresses were created which caused new leaks and made the re-engineering more complicated than first expected.

All manufacturers indicated that they already had, or would be initiating a new line of windows utilizing dual glazing.

All manufacturers contacted indicated that they did supply labels specifying conformance with the basic requirement of the law. Most of those contacted said they thought that some manufacturers were getting away with non-conforming products, but would not, or could not identify these manufacturers. There was a general consensus regarding the desire for standardization in the testing and labeling procedures. It was noted that label placement was not standardized -- some were in jambs, some on the glass, and others slipped between sash and frame. Inspectors who do inspect for the labels are not always able to find them -- labels are often removed (or fall off) during the building process.

5. Education: Window manufacturers received most of their education and information concerning the regulations from the

various window associations to which they belong. All manufacturers wanted more education and information -- they also indicated they were very unprepared for the law (with some minor exceptions), which caused some corporate heartaches in the beginning. None reported receiving assistance from the Department of Housing and Community Development.

C. CONCLUSION

When asked for a general opinion on the overall effectiveness of the regulations, the insulation and glazing industries are diametrically opposed. Window manufacturers are characterized by their lack of enthusiasm for the regulations and point to higher energy use on the manufacturing end of spectrum. The insulation people praise the law, not only because it is good for business, but because the cost of the law to the consumer is small and a valid savings will be realized in a short time.

V. <u>HOMEOWNER-CONSUMERS</u>

The California Residential Energy Insulation Regulations were designed to reduce energy consumption in the heating and cooling of residential buildings -- and to benefit, ultimately, the consumer as well as the nation as a whole. Therefore, in this study, it was thought important to conduct several representative interviews with occupants of residential buildings constructed after the effective date of the regulations, recognizing that the information thus gathered might be limited by the average consumer's lack of technical sophistication in the field of energy conservation, as well as his late entry into (and lack of control in) the building process. Exceptions to these patterns would most likely occur in cases of custom-home building, where an early and often more active collaboration exists between builder and homeowner. The decision was made to interview owner-occupants of single-family and multi-family residences -- rather than renter-occupants on the assumption that home-ownership creates a more aware consumer.

With the exception of one homeowner (who worked as a plan checker in South Lake Tahoe), none of the homeowners interviewed had a clear cut awareness of the Residential Energy Insulation Regulations <u>per se</u>. Most of them, however, did have observations on the energy-conserving (or, more often, consuming) characteristics of their homes and therefore, by implication, on the Insulation Regulations as implemented in their new homes.

A. TECHNICAL

1. <u>Insulation</u>: In general, the tract home and condominium buyers reported that they had to inquire of the builder as to

the type of ceiling and/or wall insulation that was installed in the building. This information was not routinely part of the sales pitch, perhaps due to the fact that the housing market in California today is largely a sellers' market. None of the homeowners indicated their intention to upgrade the value of the ceiling and/or wall insulation at the present time. The Clovis homeowner, however, complained that the inspection procedures had failed to force the correction of inadequate wall insulation in the first three houses of the tract in which he had purchased his home (his home was one of these three). The insulation in question was a reflective foil-type, with layers which had been poorly installed thereby eliminating air pockets. Also, he expressed dissatisfaction with the unevenness of the blown-in ceiling insulation in his house -- as did the San Jose homeowner. The Walnut Creek homeowner told of plans to install an attic vent fan to relieve overheating in the summertime.

2. Windows, Doors, Weatherstripping: Windows and doors presented different problems. In general, they were not initially perceived (at the time of purchase) as part of the total insulation picture. Yet, problems with air infiltration, excessive heat transfer, and window placement were frequently reported. The Palm Springs homeowner was forced to add shade screens to clerestory windows to reduce summer heating of the house. She also remarked on the inadequacy of tinted windows in the summertime. "They feel hot all over unless you keep the air conditioning on." The Walnut Creek homeowner has added weatherstripping around a door leading to the garage and underneath an exterior garage entry door to reduce cold air infiltration.

She also remarked that her south-facing sliding doors and windows resulted in additional needed warmth in the winter, but these same windows and doors had to be heavily shaded (with venetian-type blinds) in the summer to reduce excessive heat. The San Jose homeowners had to ask their builder to install weatherstripping around the double front doors -- and they complain of continued air leakage where the double doors meet. Both the San Jose and Irvine homeowners reported cold spots at their single glazed window and door openings. It is unclear whether this is a transfer of cold through the thin glass, air leakage, or simply a greater awareness of cold spots in a house with insulated walls vs. a house with non-insulated walls. A Tahoe contractor reported a homeowner's observation of fewer cold spots in his new home which was not only insulated, but double-glazed throughout.

3. Heating/Air Conditioning: Several interesting comments emerged on the subject of heating and air conditioning. The Palm Springs homeowner keeps the air conditioning at 88 degrees in the summertime when the house is unoccupied, and she estimates that the cooling operates constantly at this setting. Oddly enough, she remarked that the coolest place in the house in the summer is outdoors -- the north-facing covered entryway. The Walnut Creek homeowner has installed dampers on the heating vents leading to the second floor as ample heat rises from the first floor. According to this homeowner, her heating bills are less than in similar neighboring homes. The San Jose family also commented on the lack of need for second-floor heating.

4. Impact on HVAC Operating Cost: It was difficult for most of the homeowners to assess whether the Insulation Standards had resulted in reduced HVAC costs. This was due, primarily, to the non-comparability of their current homes and the homes previously occupied. The Tahoe homeowner, however, had lived in a similar but less insulated home previously, and he reported substantial energy savings. The Palm Springs homeowner felt that the Regulations resulted in no HVAC savings.

5. Adequacy of Regulations: All of the homeowners interviewed felt that the regulations could be strengthened. Windows, doors, and weatherstripping -- the most visible features of the insulating package -- were most often mentioned as problem areas.

B. CONCLUSION

The California Energy Insulation Standards are passive and obscure with regard to their ultimate beneficiaries, the consumer/homeowner. Enforcement of the regulations is often weak. Furthermore, the regulations appear inadequate for special heating and cooling needs. They often result in oversized heating units in relation to the insulating potential of many new homes. And the regulations seem not to address the special cooling need of homes in very hot summer areas. There appears to be a consumer readiness for home energy conservation, but this is tempered by the consumer's lack of sophistication in energy conservation matters.

RECOMMENDATIONS

This series of recommendations are derived from an analysis of the data collection, coupled with the project team's experience in energy regulations and implementation, and knowledge of the building design and regulatory process. The result is a series of recommendations covering all levels of government and several portions of the building industry. Most recommendations are directed towards the State since it promulgates the regulations and has constitutional responsibility for public health and safety.

I. FEDERAL LEVEL

A. EDUCATIONAL MATERIAL DEVELOPMENT

The Federal government should undertake to sponsor the development of educational material that may be deployed through both the public and private sectors. Such courses should be developed for all sectors of the building industry including building regulatory personnel at all levels, architects, engineers and building designers, and contractors and sub-contractors.

Courses should be developed at the Federal level because energy conservation is a national need and must be rapidly implemented. In addition, it is more economical for one agency to do this than fifty States each developing courses individually. Further, certain elements of energy conservation regulations have a negative impact upon some industry groups, thereby, eliminating any incentive for the private sector to develop such courses. This may be verified by the number of seminars, and publications efforts, presented by insulation manufacturers and the lack of broad based information relative to labeling of windows and glazing limitations.

Course material should cover not only the technical enforcement of the regulations, but an understanding of design principles that create an energy-conserving building.

B. IMPLEMENTATION AIDS

The Federal Government might also develop certain of the implementation aids recommended for the State in this report since the basic principles and concepts of energy conservation are appropriate for all of the States.

C. DEMONSTRATION PROJECTS

The Federal Government might consider the following demonstration projects:

1. Inspection Personnel: Fund additional local inspection and plan check personnel to determine if more inspection results in proper implementation of the energy conservation regulations.

2. Homeowner Information: Provide guidance to the consumer regarding the proper use and maintenance of the building.

II. STATE LEVEL

A. ADMINISTRATIVE

Improve dissemination of regulations, design, and technical aid to all sectors of the building industry. A number of comments were received from architects and contractors relative to the fact that the first they heard of the regulations was when they went to the building department for a permit.

The State should work with other State regulatory agencies that can communicate to the broad building sector. This would include the Boards of Registration for Architects and Professional Engineers, and the Contractors' State License Board. Each of these boards' newsletters reaches all licensed individuals, rather than the limited number who may belong to a professional society or contractors' organization. Concurrent with the above, continuing liason should be maintained with the professional societies and contractors' organizations.

B. SUPPORT IMPLEMENTATION

Develop supporting implementation information for local agencies. There is a total lack of information for local enforcement agencies relative to the costs of implementing the regulations. The State should study, identify, and make available for the information and use by local agencies, information concerning:

1. Cost Impact of the regulations: How much will the additional inspection and plan review cost the city or county?

2. Plan check and inspection aids: Inspection and plan checking aids for the several geographic regions of the State would assist local agencies in implementation of the regulations.

3. Two-way communication: Establish two way communication channels between State and local enforcement agencies. A toll free phone number, staffed by individuals competent to answer technical questions should be established. Local agencies, now reluctant to call long distance, could obtain assistance from a centralized information source.

4. Encourage dissemination of the California Energy Design Manual to other States: This document should serve as an important guide to other States in the process of developing their own residential energy regulations.

C. TECHNICAL

Augment prescriptive provisions of the regulations with standards giving great flexibility of design. The regulations should have performance-type language to permit a total envelope design. This could be accomplished in a manner similar to ASHRAE 90-75, based on the current level of knowledge, or similar envelope energy budget concepts as they are developed. Based on comments received during the interviews, the current regulations should be re-evaluated for adequacy in the following areas:

1. Desert Regions: Glazing and insulation requirements may be inadequate to meet special cooling needs of desert regions. Window placement and orientation, siting, and sun angles need to be considered.

2. Sliding Scale of Requirements: Rather than group insulation requirements in three distinctive degree-day categories, a practice which creates potentially arbitrary discontinuities in the regulations, a system for instituting insulation requirements in smaller gradations should be considered.

3. Additions: New additions to residential buildings should be covered by the regulations (insulation as a minimum).

4. HVAC Requirements: Sizing of HVAC units should be tied to a given residential building. Most buildings have oversized heating units installed. The proper size unit operates most efficiently for energy utilization.

5. Requirement for Certificate of Compliance: The Certificate of Compliance should be modified to certify compliance with glazing, labeling, and weatherstripping requirements, or eliminated altogether

as a requirement. It has only confused field enforcement personnel and focused attention on insulation only.

6. Conform to ASHRAE 90-75: The level of required insulation should be equal to those proposed in ASHRAE 90-75.

7. User Information: So that buyers and owners of new homes be made aware of the regulations and their energy-conserving implications, the regulations should require a transmittal of this information, perhaps within the context of a general energy conservation information packet, to the consumer. Information concerning devices and equipment requiring maintenance to assure energy conserving efficiency should be included. For example, this would explain closable underfloor vents and why they must be opened during certain times of the year.

8. Degree days: Technical advice should be available to local enforcement agencies, particularily counties, to enable them to develop their own degree day zone for different areas of the county.

D. PRODUCT APPROVAL AND STANDARDS

The entire area of product approvals must be strengthened to provide acceptance of energy conservation products. To accomplish this, consensus standards must be developed and existing standards strengthened to include traditional aspects of building code acceptance such as durability, fire resistance, etc. A system of labeling conforming products through independent testing and certification should be instituted. This should be accomplished in close coordination with the model code group's National Research Board, and regional approval system of the model code groups. The system currently used in Oregon wherein there is a State approval system, including product testing, should be studied for applicability to the needs of other States including California. This system permits a manufacturer to secure statewide approval if this is his market area but to use the more regional approval mechanism where it is appropriate. Such a system would solve the problem of labeling of the windows which are generally marketed within a small geographic region.

E. EDUCATIONAL

An ongoing educational program for all levels of personnel within local enforcement agencies should be established. NCSBCS currently has such courses under development. There should be a statewide deployment plan which would include seminars on a regional level; such a plan could involve the State university system, State college system, and the junior colleges. Courses should be directed at the major city building departments, smaller and one-man agencies, and the field inspector. Course material should result in understanding of the regulations and the fundamental concept of energy conservation including siting, orientation, shading and similar passive factors.

III. LOCAL LEVEL

A. ADMINISTRATIVE

1. Staffing: Local government officials, elected and managerial, should understand the need for energy conservation and that its effective implementation will rely on the efforts of local government. The lack of adequate staff to inspect construction was cited by a number of cities (large and small) as the reason they accepted a Certificate of Compliance in lieu of field inspection of energy conserving building elements.

2. Communications: Local enforcement agencies should be en-

couraged to develop better lines of communication with contractors and designers in their area to ease implementation of energy regulations. Some communities developed their inspection procedures in concert with contractors groups, others keep contractors informed of pending regulations. This should help in securing compliance.

3. Relations with the State: Local enforcement agencies should be encouraged to provide input, both formally and informally, to the State regarding regulations, implementation problems and technical problems (see State suggestions).

4. Equal enforcement needed: There is a need for local enforcement agencies to understand and equally enforce the regulations. Material manufacturers complained of complying with the standards only to see their competitors, who know that a specific city may not be inspecting for complying windows, underbid them by not supplying complying windows.

B. TECHNICAL

1. Inspection sequence: All local enforcement agencies should be encouraged to require a minimum of one additional called inspection: after rough-in, to inspect for insulation. Additional called inspections for floor and rigid roof insulation should be specified when appropriate.

2. Types of Energy Conservation Materials: Local enforcement agencies should be encouraged to develop reference libraries of available products. This would provide a ready source of information for plan reviewers and inspectors as well as provide information to contractors and homeowners.

C. EDUCATIONAL

Staff personnel at all levels should be encouraged to take educational offerings relative to energy conservation. Local officials should be encouraged to provide time off, tuition reinbursement, etc., as required for personnel to attend such classes. Staff should understand not only the regulations, but the basic software concepts of energy conservation such as siting, orientation, shading, etc. A number of local agencies have been limiting glazing to 20% and not accepting any other design options.

IV. PRIVATE SECTOR

A. ADMINISTRATIVE

Architects and contractors need channels for structured input into State development of building regulations and into the process of maintaining currency of regulations.

Both in the initial development phase and in the transmission of feedback from the field, architects and contractors could contribute significant information concerning design and technical aspects of regulations. This could include ongoing information relative to product performance and identification of research needs for development of new products.

B. TECHNICAL

Manufacturers should develop communication with architects and contractors to derive information with respect to research and development needs for new products. A number of new product needs have been identified in this study.

C. EDUCATIONAL

Ongoing professional education should be made available through architects' and contractors' associations.

Both of these groups felt that significant difficulties had been encountered due to initial unfamiliarity with the regulations. Without good understanding of energy conservation during design and execution of the work, regulations lose much of their effect. The existing professional associations are probably the best vehicle for communication and education reltive to State enacted regulations because they already have good lines of communication with their memberships. Attendance at enforcement personnel courses is another option that should be made available.

Manufacturers should be providing technical information concerning their products to all sectors in the building process.

Such information should be comprehensible, accurate, and readily available.

Utility companies should provide technically accurate information to consumers, contractors, and professionals.

This information should not be provided through public relations representatives of the company, but through individuals with specific technical training in energy conservation.

Homebuyers should receive user information relative to energy conservation characteristics of their new homes.

Such information, analogous to the owner's manual which is provided when an automobile is purchased, would explain the practical meaning of the regulations from the consumer's point of view.

General information relative to energy conservation regulations and their impact should be available to the public.

D. PRODUCT APPROVAL AND STANDARDS

Energy product approvals and certification should be developed.

Most of the California contractors, building officials, and design professionals stated that a product approval and certification system should be developed.

Manufacturers should cooperate in an industry-wide consensus with respect to standards and certification.

Independent recognized testing laboratories using nationally accepted test methods and standards are necessary for product credibility.

APPENDIX A

LIST OF INDIVIDUALS INTERVIEWED

ENFORCEMENT OFFICIAL LIST

Douglas E. Harris
City of Arcata
Arcata, CA.

Louie H. Tan, P.E.
City of Anaheim
204 E. Lincoln Ave.
Anaheim, CA 92805

Mr. Robinson
Chief Inspector
City Bldg. Dept.
533 Pollasky Ave.
Clovis, CA

Mac Dalgleish
Director of Building & Safety
City of El Segundo
350 Main St.
El Segundo, CA 90245

George W. Keating
Plan Checker
Humboldt County Bldg. Dept.
520 East St.
Eureka, CA

Clint Swanson
Building Official
City of Eureka
6th and K St.
Eureka, CA

Marvin May
Chief Bldg. Inspector
City of Folson
50 Natoma St.
Folson, CA

W. Wang & Linchoni
Chief Inspector & Inspector
Fresno City Bldg. Dept.

Fresno, CA

Mr. Weaver
Chief Inspector
Fresno County Bldg. Dept.
Fresno, CA

John B. Vogelsang
Asst. Director of Bldg.
City of Huntington Beach
2000 Main Street
Huntington Beach, CA 92648

Ed Wachter Jr.
Mechanical Engineer
L.A. County, Bldg. Dept.
108 W. 2nd St.
Los Angeles, CA 90012

Walt Bruggen, Asst. Director;
Al Ashman, Chief of Res. P.C.
Los Angeles City
Los Angeles, CA 90012

Mr. McConnel
Mechanical Plan Checker
Contra Costa County Bldg. Dept.
Martinez, CA

Fred N. Odgaard
Plan Checker
City of Orange
300 E. Champan Ave.
Orange, CA 92666

Richard Miyahira
Adm. of Building & Safety
City of Oxnard
Oxnard, CA

Jim Hill
Director of Bldg. & Safety
Bldg. Dept., Palm Desert
45-275 Prickly Pear Lane
Palm Desert, CA 92260

S. E. Summers
Chief Bldg. Inspector
Bldg. Dept.
3200 E. Tahquitz McCallum
Palm Springs, CA 92262

R. C. Smith
Building Director
Riverside County
4080 Lemon St.
Riverside, CA

Hrista Stamenkovic
Plan Check Engineer
Riverside City
3870 Mulberry
Riverside, CA 92502

Enforcement Official (cont.)

Clarence Johnson
Chief Inspector
Sacramento County Bldg. Dept.
7th St.
Sacramento, CA

Mr. Sullivan
Chief Inspector
Sacramento City Bldg. Dept.
915 I St.
Sacramento, CA

J. C. Rosebraugh, San Bern. County
Chief Building Inspector
1111 East Mill St.
San Bernardino, CA 92415

Corinsky & Choy
Chief Inspectors
San Francisco Bldg. Dept.
450 McAllister St.
San Francisco, CA

Frank Brown
Chief Inspector
San Jose Bldg. Dept.
130 Park Center Plaza
San Jose, CA

William Parissenti
Asst. Manager
Santa Clara County Bldg. Dept.
West Hedding 70
San Jose, CA

Floyd G. McLellan, Sr.
Chief Inspector
County of Orange
Civic Center
Santa Ana, CA

Ray Nokes
Director of Building & Safety
Santa Barbara, CA

William Rome
Building Officer
City of Santa Monica
1685 Main St.
Santa Monica, CA 90405

Harry Ross
Chief Building Inspector
City of Santa Paula
Santa Paula, CA

Richard Jon
Chief Inspector
Sausalito Bldg. Dept.
Sausalito, CA

Wm. Martin, Plan Checker
Wm. Niles, Bldg. Inspector
City of South Lake Tahoe
P.O. Box 1210
South Lake Tahoe, CA 95705

Ralph Grippo
Building Regulations Administration
City of Torrance
3031 Torrance Blvd.
Torrance, CA

Lee Leerhumor, Director
County of Ventura
Ventura, CA

Mr. Lassel
Bldg. Inspector
County Bldg. Dept.
Tulare County
Visalia, CA

Mr. McLeod
Chief Inspector
Walnut Creek Building Dept.
Walnut Creek, CA

Alex Craighton, Chief Bldg. Insp.
Edward Lee, Plan Checker
Yolo County Bldg. Dept.
292 W. Beamer
Woodland, CA

Robert Murdock
Bldg. Inspector/Plan Checker
City of Woodland
200 1st St.
Woodland, CA 95695

ARCHITECT AND ENGINEER LIST

Hashim Al-yassin
316 Broadway Avenue
Millbrae, CA.

J. Bulkley
Bulkley & Associates
1154 Clement Street
San Francisco, CA.

Jim Bevers
Interactive Resources
Richmond, CA.

Jim Boulware
Mission Viejo Corporation
Mission Viejo, CA.

John Boyd
Boyd & Associates
454 Forest Street
Palo Alto, CA.

Carl Groch
1939 Addison
Berkeley, CA.

David Kaech
Morris-Lohrback & Associates
17848 Sky Park Boulevard
Irvine, CA.

Robert Mason
976 Edgwood Circle
South Lake Tahoe, CA.

Rains
Saroyan & Associates
West Shaw Avenue
Fresno, CA.

Phil Trafton
Donald Dickerson Engineers
Van Nuys, CA.

I. Kurt Weber
233 Wilshire Boulevard
Santa Monica, CA.

Allen Wicks
Sheet Metal & Air Conditioning
8301 Edgewater Drive
Oakland, CA.

BUILDER/DEVELOPER LIST

Mr. Armbrust
Armbrust Construction Co.
6701 Mission Street
Daly City, CA.

Bayfield Enterprises Ltd.
3834 Telegraph Avenue
Oakland, CA.

Jim Boulware
Mission Veijo Corporation
Mission Veijo, CA.

Andrew Cresci
Bay Area Contractors
San Francisco, CA.

Dan Doyle
General Contractor
South Lake Tahoe, CA.

Robert Fey
Fey's Canyon Estates, Inc.
2499 S. Palm Canyon Drive
Palm Springs, CA. 92262

Gordon French
French Construction
5758 Broadway
Oakland, CA.

Sherman B. Given/Bert Levitt
Morley Construction
7700 Sunset Boulevard
Los Angeles, CA. 90046

George Hayes
Hayes Construction Inc.
759 Sheldon Street
El Segundo, CA. 90245

Ken Hoffman
Ken Hoffman Masonry
Box 11556
Tahoe-Paradise, CA. 95705

Michael B. Jager
Frank H. Ayres & Son
Construction Co.
20951 Brookhurst Street
Huntington Beach, CA. 92648

Vurn Kimble
Builders Fore Inc.
800 Jones Street
Berkeley, CA.

Ray Kope
K & I Homes
P. O. Box 11968
Tahoe-Paradise, CA. 95705

Jim Lange
Contractor
Tahoe City, CA.

Lawrence Lapham
Lawrence Lapham & Associates
Alan Ladd Bldg., Suite 207
500 S. Palm Canyon Drive
Palm Springs, CA. 92262

E. V. Levitch
Levco Builders
Berkeley, CA.

B. Mayta
Mayta & Jensen
Wilson Street
San Francisco, CA.

Richard W. Shay
Bren & Company
N. California Street
Walnut Creek, CA.

R. Rives Cal Construction
833 Williams Street
San Leandro, CA.

Bob Volmer/Dave McAllister
Broadmoor Construction
17802 Irvine Boulevard
Tustin, CA.

Builder/Developer (cont.)

Donald Tate
Donald Tate & Associates
480 N. First Street
San Jose, CA.

Mr. Wilson
Wilson & Shahl Homes
West Shaw Avenue
Fresno, CA.

MANUFACTURER AND SUPPLIER LIST

Ador Hilite Windows/Doors (714) 694-5602
2401 W. Commonwealth
Fullerton, California

Advanced Installations (213) 998-0411
21029 Itasza
Chatsworth, California 91311

Arcadia (213) 964-6511
Northrop Architectural Systems
999 S. Hatcher Avenue
City of Industry, California 91749

Cel Spray (714) 549-2967
3619 Pendleton Avenue
Santa Ana, California

International Window
San Antonio Road
Hayward, California

Premiere Aluminum Products (213) 321-4040
18233 S. Hoover
Gardena, California

Wipple Building Supply
McKinleyville, California

HOMEOWNER LIST

City	Developer/ Builder	Approx. Price	Type of Dwelling
Irvine	Broadmoor	$ 50,000	"Patio home" Single-family detached two-story zero lot line
Palm Springs	Fey	$110,000	Condominium, single-story attached
S. Lake Tahoe	Custom	N.A.	Single-family detached
San Jose	McKeon	$ 50,000	Condominium, Townhouse two-story attached
Walnut Creek	Bren	$ 60,000	Single-family detached two-story
Clovis	N.A.	N.A.	Single-family

For State of California
Department of Housing
and Community Development

**MELVYN GREEN
& Associates, Inc.**
Consulting Structural
and Civil Engineers

690 NORTH SEPULVEDA BOULEVARD
SUITE 120
EL SEGUNDO, CALIFORNIA 90245
(213) 322-8491

APPENDIX B

INTERVIEW GUIDE

RESIDENTIAL ENERGY INSULATION STANDARDS
INTERVIEW QUESTIONNAIRE

Date: ______________________ Interviewer: ______________________

Name: ____

Title: ____

Organization: ______________________________________

Street Address: ____________________________________

City: ______________________________ Zip Code: ______________

Telephone: (   ) ___________________________________

Enforcement Official________ Consumer________

Builder or Developer________ Manufacturer or Supplier___

Architect or Engineer_______

County: ______________________ Annual Degree Day Range: _________

PLAN REVIEW AND INSPECTIONS

1(a). What % of the buildings comply with the standard design vs. those that are designed by heat loss analysis?

(b). For what reason are the alternative design provisions generally utilized?

(c) Have you increased fees to cover PC and inspections for energy? If so, how much?

(d) Do you charge an extra plan check fee for designed buildings?

(e) Do you plan check (1) designed buildings?

(2) special requirements for:

(a) single-family detached
(b) multi-family
(c) high-rise

(f) Do you have any design, plan check, or inspection aids, etc.? (obtain 2 copies)

2(a). What type of field inspections do you conduct relative to energy insulation?

(1) Inspected w/rough-in?
(2) Additional inspection required?

(b). How many inspections are needed per building to assure conformance with the Standards?

(c). How many of these are extra inspections made specifically for the Standards?

(d). Is certificate of installation accepted in lieu of any inspections?

(e). Are different procedures required for multi-family and high rise vs. single family detached? If so, explain.

3. What has been the cost impact on your functions as a result of the residential energy standards? (discuss)

(a) any extra personnel required?
(b) Have you increased fees to cover the additional work?

4(a). Do you have any special requirements for seasonally used residences? (vacation houses)

Summer?
Winter?

(b). What is your policy relative to building alterations and additions?

(1) Voluntary or public information?
(2) Mandatory?

(c). Any change of procedure in the period since standards have been adopted? How have your procedures changed since February 1975?

(d). Do you inspect for baffles in attics of buildings with blown-in insulation?

FUNCTIONAL

1. What has been the cost impact of residential energy standards as you see it:

(a) to consumers
(b) to A & E
(c) to building department

2. In the following areas, are the Standards:

	Adequate	Too Restrictive	Too Lax	Comments
Ceilings				
Walls				
Glazing (heating)				
Glazing (cooling)				
Floors				
Slabs-on grade				
Infiltration				
Piping				
Additions				
Compliance				

3. Prior to the Standards becoming effective, what were the common practices used relative to:

	single-family dwellings	multi-family	high-rise
Ceilings			
Walls			
Floors			
Glazing			

4. Are you acquainted with the State's Energy Design Manual?

(a) has it been useful?
(b) any recommended changes, new sections, etc.

5. What problems have you encountered in the implementation, enforcement and design aspects of the Standard?

6. How have your procedures changed since the Standard was first implemented? (develop chronology)

7(a). Are there any specific provisions in the standard that cannot be met? (i.e., slab insulation, labeled windows?)

(b). Any specific design provisions caused problems or complaints?

8. Are you able to obtain adequate technical assistance from Department of HCD?

9(a). What change would you like to see in the residential energy standards?

(b) in the design manual?
(c) in the educational program?

10. How do you handle questions from A & E and the public, as well as technical questions and problems in the field?

(a) answer by department?
(b) have consultant?
(c) refer to state?
(d) ask other building departments?
(e) professional organization?

11. How do you plan to enforce the non-residential standards?

PRODUCT STANDARDS

1(a). Are the products required to meet the residential energy standards readily available?

(b). Have these products been labeled or otherwise identified?

(c). Do you inspect for labels on products?

(1) windows
(2) insulation - rigid
- batt
- blown-in

2. Is data relative to the thermal properties of insulating materials readily available?

3(a). Do you accept manufacturer certification of thermal properties of insulating materials?

(b). Is the available data reliable?

4(a). What problems have you had with the products currently available?

(1) windows
(2) insulation

(b). Have you investigated the way energy products are tested or labeled?

(c). Have you developed any energy standards or acceptance criteria of your own (including solar)?

5. Have you found any conflict between the energy standard and any other standards, i.e., flammability, etc.?

6. Who would you look to for energy product approvals?

UL?
State Fire Marshal?
ICBO?
State HCD?
Energy Commission?

EDUCATIONAL

1. Did you or your organization receive any training relative to the Energy Insulation Standards?

2. If yes, from whom?

3. What did the training consist of?

4. What educational efforts have you made, conducted, or attended regarding energy conservation in building construction?

   (a) for technical personnel
   (b) for staff (such as with City Hall)
   (c) public awareness (service clubs, etc.)

5. Have there been adequate educational offerings for you relative to energy conservation (i.e., with the technical content you would like)?

6. Is training needed now? What type?

7. If major changes are made to the Standards, should training be provided?

1. In your opinion, has this standard resulted in any energy savings?

2. Has the installation of insulation and labeled windows resulted in reduced HVAC construction costs (smaller size units installed)?

3. Are there sufficient qualified sub-contractors and mechanics to perform the required work?

4. What are the additional material costs for energy conservation in this area?

    (a) insulation?
    (b) windows?
    (c) caulking?

5. Are the existing Energy Insulation Standards generally accepted?

6. In general, are the Standards adequate, too restrictive, or too lax?

7. What problems were encountered in the implementation of this Standard by the States actions?

    (a) Standards______
    (b) Manual________
    (c) Training_______
    (d) Other__________

8. Building Official:

    (a) Are you conducting any energy research or collecting any data?

    (b) Have you adopted standards more restrictive than the States relative to residential energy conservation? (explain)

    (c) Do you have any requirements for solar energy utilization?

    (d) Do you have any solar easement requirements? (under consideration?)

    (e) Anyone else in city hall involved in energy conservation?

    (f) Has your energy experience assisted any other department in your governmental agency?

9. Architect and Engineer:

(a) Have you designed any buildings using the design options for energy conservation?

(b) Is there now earlier collaboration between the architect and mechanical engineer in the design process?

(c) What has been the impact on fee structure for A & E's for residential energy standards (try to discuss separately single-family detached, multi-family, and high rise)?

(d) What is the additional design fee for single-family detached?

10. Contractor:

(a) Do energy standards add to the construction time or costs in any of the following:

(1) insulation installation
(2) delivery of materials (windows, etc.)
(3) delays in inspection
(4) material shortage and delays
(5) other cost and time factors

(b) Do you now work directly with the mechanical engineer?

11. Supplier:

(a) Where do the windows, insulation, etc., come from? How far are they transported? What means of transportation is used?

(b) Have shortages in energy conservation products been experienced since the standards became effective?

(c) Have the energy standards resulted in significant cost impacts for energy conservation products?

12. Homeowner/Consumer: (note type of residential building)

(a) Has adequate information concerning energy conservation standards been available to you?

(b) Does heat-conserving insulation result in heat retention in the building when this is undesirable? (i.e., does A/C have to be used at night to remove heat accumulated during the day?)

(c) Do you think the residential energy standards result in energy and/or money savings? If so, do such savings offset the cost of installation?

(d) What changes, if any, do you think are needed?

(e) When you purchased this house were you aware that it was an energy conserving building?

(f) How were the features presented to you?

(g) Has the implementation of this standard reduced building operating costs in your opinion?

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS
Bureau of Building Inspection

February 11, 1975

CODE RULING NO. 73-14 SUBJECT: Energy Insulation Regulations - Mandatory State Requirements - New Residential Buildings

REFERENCES: 1. State Administrative Code; Title 25, Chap. 1, Subchapter 1 (commencing with Section 1094). Printed in California Administrative Code, Register 74, No. 12
2. Regulations adopted by Commission on Housing and Community Development on February 22, 1974, and amended in August 1974 (copy attached)

DISCUSSION: The State regulations requiring energy insulation become effective for all plans for residential buildings filed for permits after February 22, 1975. A copy of the regulations as adopted on February 22, 1974 and amended in August 1974 are attached hereto.

San Francisco, by the State evaluations, is in a 3000+ degree day area insofar as the application of the energy insulation provisions are concerned.

RULING: PLAN CHECKERS shall require that all plans filed after the February 22, 1975 effective date shall contain at least the following information in conformance with attached regulations:

1. Calculations of the area of glazing and the percent glazing for each face of the building and the overall area of each building face.

2. Type of exterior insulation to be used, typical wall, roof and foundation details, "U" factors of materials and assemblies.

3. Plan view of all heated and unheated areas shown in relation to the several wall segments.

4. Calculations of equivalent wall system effectiveness where glazing areas exceed stated percentages or where "U" factor of wall system is more than the stated permissible values.

PROCEDURE: The State Department of Housing and Community Development is charged by its Commission to prepare a manual to accompany the regulations enacted. Said manual is to be used by this Bureau in checking compliance with these requirements for insulation. In the absence of the manual from the State, attached herewith (to Distribution A only) are Chapters 4 and 5 of the proposed manual which are the draft versions of these provisions which are the key elements with regard to "U" factor and typical design and analyses of design. These should be used until such time as the State manual is available.

Until such time as this Bureau has a mechanical engineer on its staff, alternate systems of conserving energy will not be accepted in lieu of complying with these regulations. If submitted, this Bureau will not process such presentations but will require the design professional to appeal to the Board of Examiners as an alternate method of construction.

Alfred Goldberg, Superintendent
Bureau of Building Inspection

AG:WK:cg

Attachments: Chapters 4 & 5 of proposed manual
CAC, Title 25, Chapter 1, Subchapter 1, Article 5

Distribution A (with attachments):

PAD (4)
AIA
Daily Pacific Builder
ASHRAE
Homebuilders

Distribution B (without attachments):

Counter (50)
PAD (50)

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS
Bureau of Building Inspection

February 23, 1976

ADMINISTRATIVE BULLETIN No. A-39

SUBJECT: Energy Insulation Certificate of Compliance

REFERENCES: 1. State Administrative Code; Title 25, Chap. 1, Subchapter 1 (commencing with Section 1094). Printed in California Administrative Code, Register 74, No. 12

2. Regulations adopted by Commission on Housing and Community Development on February 22, 1974, and amended in August, 1974.

DISCUSSION: The State regulations for energy insulation of new residential buildings require that the contractor provide a Certification of Compliance as evidence that he has complied with the insulation regulations. This card is required to be posted in the building.

RULING: BUILDING INSPECTORS shall, prior to issuing a Certificate of Final Completion (CFC), verify that a fully executed "Certification of Compliance" has been permanently attached within the building adjacent to the main electrical switch location. A sample of such Certification of Compliance is attached. It shall be filled in completely so as to cover all areas required to be insulated as shown on the approved plans.

The BUILDING INSPECTOR shall print his name and sign on the bottom of the Certification of Compliance on the job with his full name and the date and shall indicate same as having been done on the job card and the CFC, using the following text: INSULATION CERTIFICATE POSTED AND VERIFIED ____________.
date

This procedure has been legally mandatory in California since February 22, 1975, and all permit applications filed after that date are required to comply with the energy conservation regulations and the certification provisions.

Alfred Goldberg, Superintendent
Bureau of Building Inspection

AG:WK:jp
Attachment = Sample Certificate of Compliance

Distribution:
Counter (40)
Bldg. Insp. (25)
PCD (30)
PAD (20)
DPB: AIA; SEA; Port

356

BUILDING CODE MANUAL

Residential Addition - Energy Conservation (Section 80.01)

Building Code Section 80.01 sets forth energy conservation regulations for additions to residential type buildings.

This section allows approved alternate methods of energy conservation based upon the State regulations for addition to hotels, motels, apartment houses, homes and other residential dwellings constructed prior to State energy conservation regulations. The following shall be considered an approved alternate method for additions 600 sq. ft. or less:

1. Insulate the walls and ceilings of the addition to the required U value per T25-1094e.

2. Weather strip all swinging windows and door openings of the addition per T25-1904h.

The following shall be considered an approved alternate method for additions over 600 sq. ft.:

1. Insulate the walls and ceilings of the addition to the required U value per T25-1094e.

2. Weather strip all windows and door openings of the addition and all manufactured windows to be labeled per T25-1094h.

If this addition is over 50% of the value of the existing structure, the accessible attic of the existing dwelling shall be insulated to the required U value per T25-1094e and all swinging windows and doors to the exterior shall be weather stripped per T25-1094h.

Plans for additions to regulated residential buildings constructed pursuant to State energy Conservation regulations shall show that the addition complies in total to the State regulations.

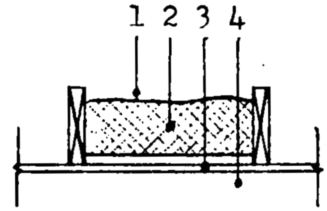
EEW:TVS-vk 4

* MOUNTAIN ENERGY INSULATION REQUIREMENTS

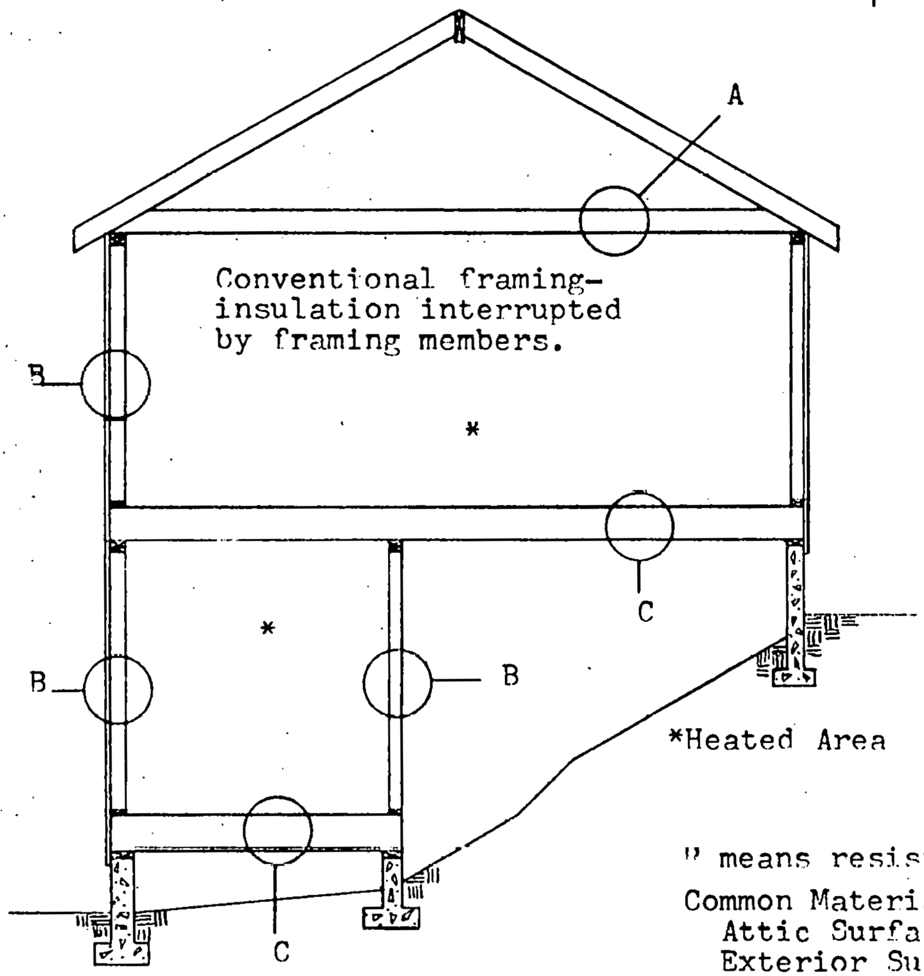
San Bernardino County

Vapor barriers must be installed on warm side.

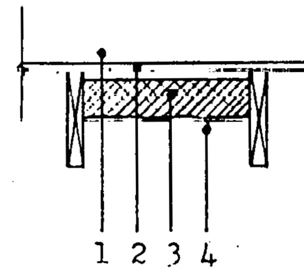
1. Surface attic
2. Insulation req.
3. 1/2" Sheetrock
4. Interior Surface



Detail A
Ceiling R req. = 20

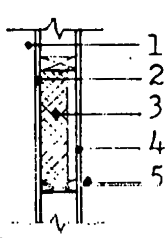


Detail C
Floor R req. = 12.5



1. Interior Surface
2. 5/8" Subfloor
3. Insulation
4. Exterior Surface

Detail B
Wall R req. = 12.5



1. Exterior Surface
2. Plywood 3/8"
3. Insulation
4. Sheetrock 1/2"
5. Interior Surface

R means resistance to heat loss

Common Material R Values

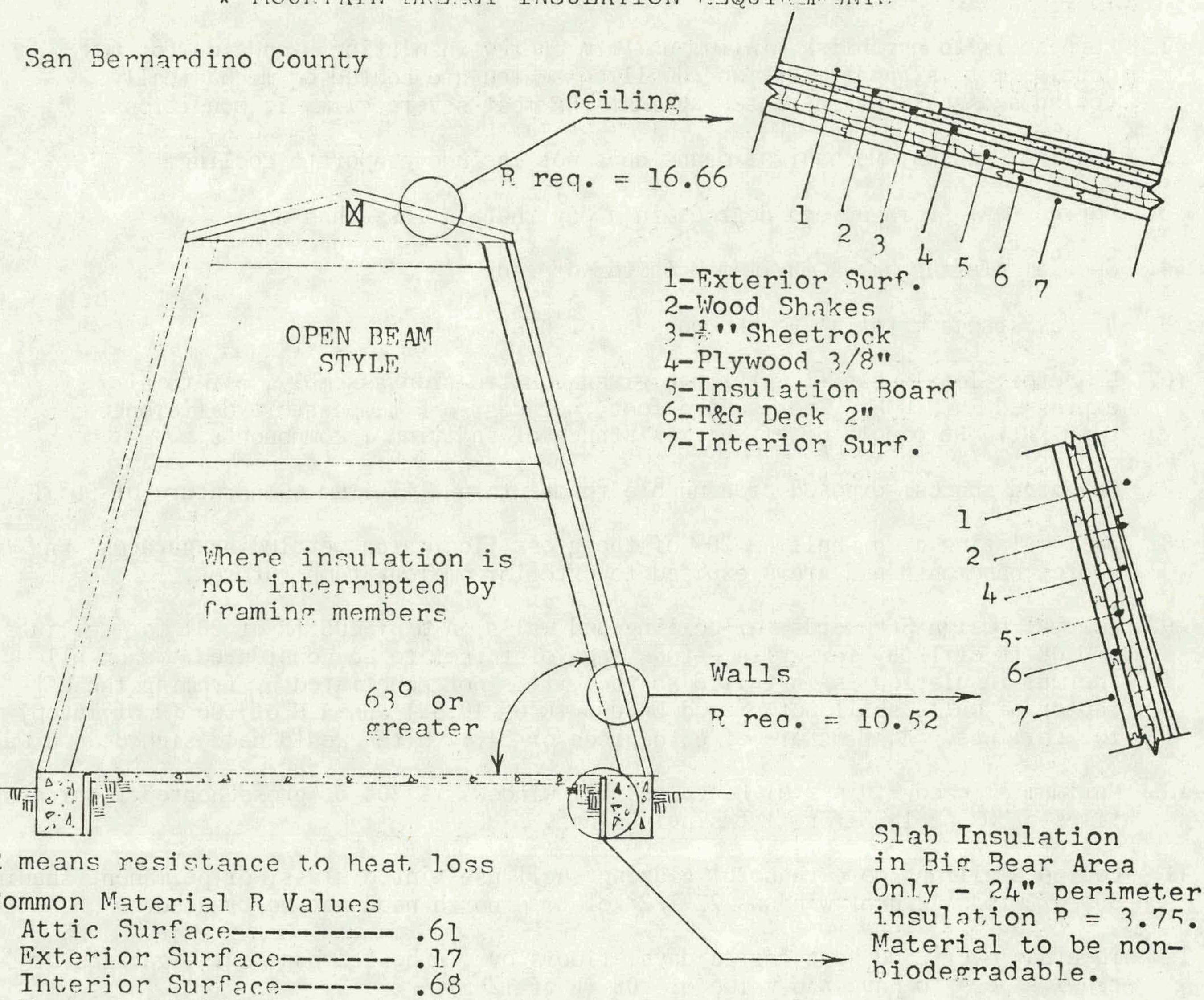
Attic Surface	.61
Exterior Surface	.17
Interior Surface	.68
Nominal 2" T&G Decking	1.89
3/8" Plywood	.47
5/8" Plywood	.78
Asphalt Shingles	.44
Wood Shakes	.87
1/2" Sheetrock	.45
Insulation Board	Per Manuf. Spec

Notes:
1. Weather strip all doors and windows between heated and unheated areas.
2. Window area shall not exceed 20% of gross floor area unless special requirements are met. (See local inspector)
3. A certificate stating that the insulation has been installed must be signed by the installer and builder, and posted in the building.
4. Insulation must be inspected before covering.
5. Unheated areas with walls and/or floors common to heated areas require the same insulation as exterior walls and floors.

*PRELIMINARY DRAWING

* MOUNTAIN ENERGY INSULATION REQUIREMENTS

San Bernardino County



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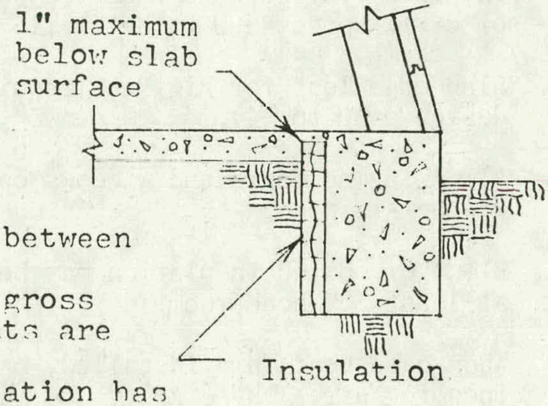
Asphalt Shingles--------	.44
Wood Shakes-------------	.87
1/2" Sheetrock----------	.45
Insulation Board---Per Manufacturer's Specification	



Notes:

1. Weather strip all doors and windows between heated and unheated areas.
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5. Unheated areas with walls and/or floors common to heated areas require the same insulation as exterior walls and floors.

*PRELIMINARY DRAWING

ENERGY INSULATION STANDARDS

1. Purpose is to establish minimum uniform energy insulation standards for new hotels, motels, apartments and dwellings which are heated or mechanically cooled and shall be insulated against the most severe climatic conditions.

2. Cooling systems: Mechanical means does not include evaporate cooling.

3. Degree Day: Average mean degrees in a day that is less than 65°.

4. Special glazing has a maximum U factor of .70.

5. R: Resistance material to the passage of heat.

6. U factor: Total heat flow through given construction assembly, air to air, expressed in BTU/hr., per square foot, per degr-e F temperature difference. U = 1/Rt. Rt equal sum of the resistance of individual components.

7. Unheated spaces: exposed area unable to maintain a minimum temperature of 50° F.

8. Basic glazing area shall be 20% of the gross floor area, excluding garages, unheated basements and areas exposed to exterior ambient temperatures.

9. Thermal Design Standards for ceiling and walls. A U of .05 (R of 20) for ceilings-a U.08 (R of 12.5) for walls, studs and joists not to be considered. When all thermal insulation is installed so that it is not penetrated by framing the U factor of walls shall not exceed U=.095 (R of 10.52) and a U of .06 (R of 16.66) for ceilings. A structure of 63 degrees or 24.12 pitch would be designed as a wall.

10. Maximum allowed BTU per hr heat loss for windows is 20% of gross heated floor area times a "U" of 1.13 for flat single glass.

11. Cooled dwellings more than 20% glazing shall use tinted glass, or permanent shading 50% of window except windows 22-1/2° of true north need not be treated.

12. In areas over 2500 heat degree days, floors over unheated basements, garages or crawl spaces to have a U value of .08 (R of 12.5).

13. In areas over 2500 heat degree days foundation wall section of heated basements or crawl spaces a U value of .15 (R of 6.66).

14. Slab edge loss for Big Bear requires 24" wide insulation with a R of 3.75 (winter design of 0 to -4).

15. All swinging doors and windows opening to the exterior or garages shall be fully weatherstripped.

16. Blown or poured insulation may be used in attics of 2-1/2 :12 or more pitch with at least 30" head room.

17. When eave vents are installed, baffles are to be installed @ 45° angle to deflect incoming air. These are to be in place at time of frame inspection.

18. The insulation applicator and builder shall post within the dwelling, in a conspicuous location a card certifying insulation has been installed per requirements of these regulations.

19. Design Temperatures: Inside winter design temperature shall be not less than 70°F and summer design temperature not greater than 78°F.

Area single glazing =

$$.20\ (\text{floor area})\ \frac{U \text{ of single glazing} - U \text{ of insulating glass (total glazing)}}{U \text{ of single glass} \quad U \text{ of insulating glass with a U of .69}}$$

Using example 1. $\frac{.20(1375)\ 1.13 - .69(325) = 197}{1.13 - .69}$

Percent of Glazed Floor Area
Min. Double Glazed % of Total Window Area.

20.0	23.0 - .34	26.0 - .59	29.0 - .78
.1 - .01	1 - .34	.1 - .59	.1 - .79
.2 - .02	2 - .35	.2 - .60	.2 - .80
.3 - .04	3 - .36	.3 - .60	.3 - .81
.4 - .05	4 - .37	.4 - .61	.4 - .82
.5 - .06	5 - .38	.5 - .62	.5 - .82
.6 - .07	6 - .39	.6 - .63	.6 - .83
.7 - .87	7 - .40	.7 - .64	.7 - .84
.8 - .10	8 - .41	.8 - .65	.8 - .84
.9 - .11	9 - .42	.9 - .66	.9 - .85
21.0 - .12	24.0 - .43	27.0 - .67	30.0 - .85
.1 - .13	.1 - .43	.1 - .67	.1 - .85
.2 - .14	.2 - .44	.2 - .68	.2 - .86
.3 - .15	.3 - .45	.3 - .69	.3 - .87
.4 - .16	.4 - .46	.4 - .70	.4 - .88
.5 - .18	.5 - .47	.5 - .70	.5 - .88
.6 - .19	.6 - .48	.6 - .71	.6 - .88
.7 - .20	.7 - .49	.7 - .71	.7 - .89
.8 - .21	.8 - .50	.8 - .72	.8 - .89
.9 - .22	.9 - .51	.9 - .73	.9 - .89
22.0 - .23	25.0 - .51	28.0 - .73	31.0 - .90
.1 - .24	.1 - .51	.1 - .73	.1 - .91
.2 - .25	.2 - .52	.2 - .74	.2 - .92
.3 - .26	.3 - .53	.3 - .75	.3 - .92
.4 - .27	.4 - .54	.4 - .76	.4 - .93
.5 - .28	.5 - .55	.5 - .77	.5 - .94
.6 - .29	.6 - .56	.6 - .77	.6 - .94
.7 - .30	.7 - .57	.7 - .78	.7 - .95
.8 - .31	.8 - .58	.8 - .78	.8 - .95
.9 - .32	.9 - .59	.9 - .78	.9 - .96

GLAZED AREA INCLUDES: WINDOWS, GLASS DOORS & SKY LIGHTS

1. Example: 1375 Sq. Ft. house with 325 Sq. ft. windows.
   1375 x 20% = 270 sq. ft window permitted, glass 1.13
   325 = .236   .39 x 325 = 127 sq. ft. of .69 glass
   1375   325 - 127 = 198 sq. ft of 1.13 glass

2. Example: 1920 sq. ft. house,,548 sq. ft. windows
   1920 x 20% = 384 sq. ft. window permitted, glass 1.13
   548 = .285   .77 x 548 = 422 sq. ft. of .69 glass
   1920   548 - 422 = 126 sq. ft. of 1.13 glass

3. Example: 2325 sq. ft. house with 485 sq. ft. glass
   min. 465 sq. ft. windows permitted of 1.13 glass
   485 = .208   .10 x 485 = 49 sq. ft. of .69 glass
   2325   485 - 49 = 436 sq. ft of 1.13 glass

COUNTY OF SAN BERNARDINO
ENVIRONMENTAL IMPROVEMENT AGENCY
DEPARTMENT BUILDING AND SAFETY

GLAZING NOMOGRAPH

(To determine the maximum permissable area of single glazed windows)

Thermal Design Standards for Glazing

For heated buildings located in areas of 4500 degree days or less, where the total glazing area exceeds the basic glazing area, treatment shall be required to limit the conducted design heat loss to that which would occur with the basic glazing area single glazed.

EXAMPLE 1: In a 1747 sq.ft. house with 400 sq. ft. of windows how much single glazing is permitted in combination with special glazing that has a U-factor of 0.60?

SOLUTION: (1) $\frac{1747}{1000} = 1.747$, (2) $\frac{400}{1.747} = 229$,

(3) Enter nomograph ordinate at 229 and go to the right until you intersect the U = 0.60 line. Then go down and read 82.

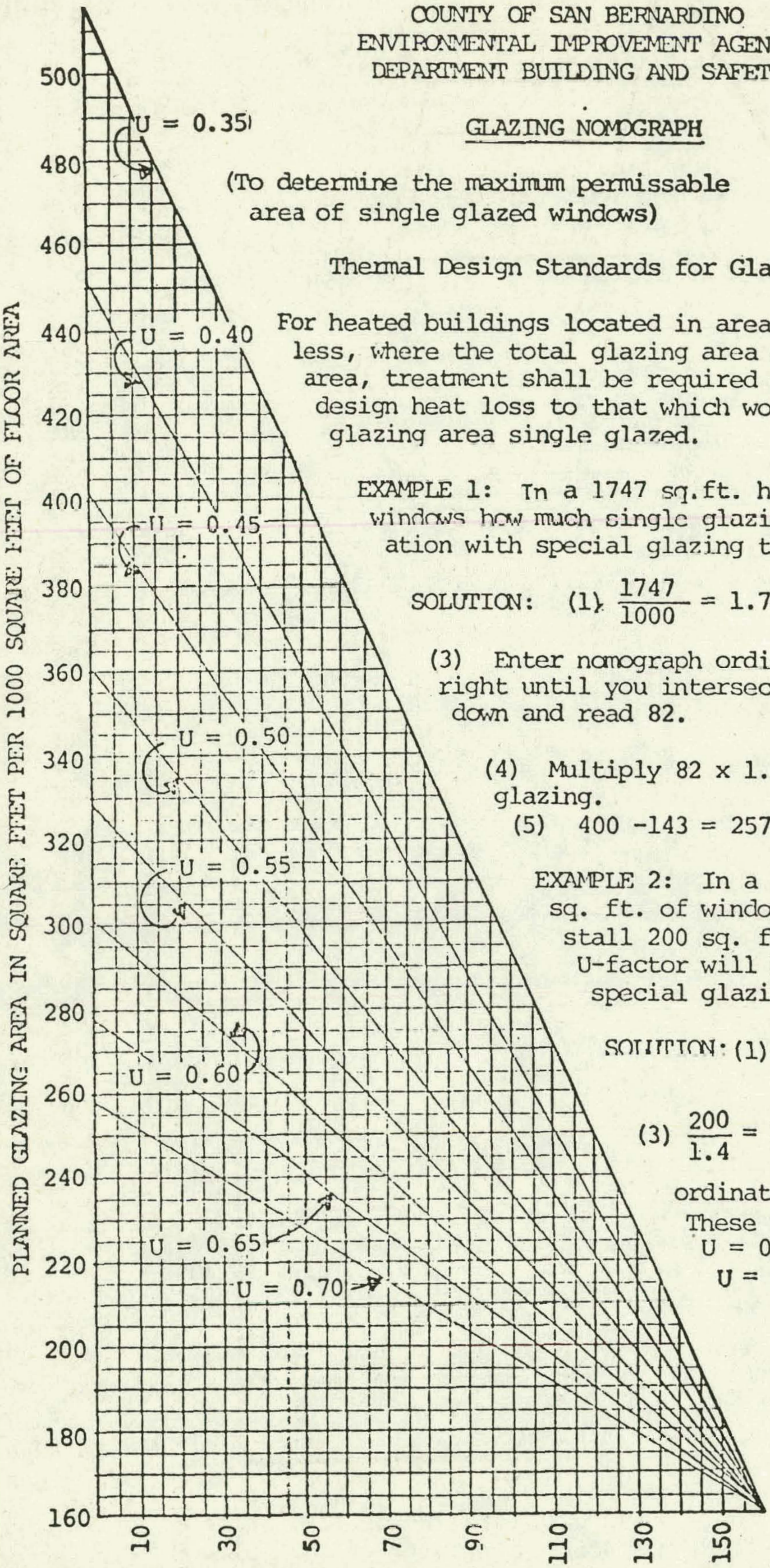
(4) Multiply 82 x 1.747 = 143 sq. ft. single glazing.

(5) 400 -143 = 257 sq. ft. of U= 0.60 glazing.

EXAMPLE 2: In a 1400 sq. ft. house with 250 sq. ft. of windows the owner proposes to install 200 sq. ft. of single glazing. What U-factor will he need for the 50 sq. ft. of special glazing?

SOLUTION: (1) $\frac{1400}{1000} = 1.4$, (2) $\frac{250}{1.4} = 178$,

(3) $\frac{200}{1.4} = 143$, (4) Enter nomograph ordinate at 178 and abscissa at 143. These two lines intersect above the U = 0.55 line. Therefore use U = 0.50.

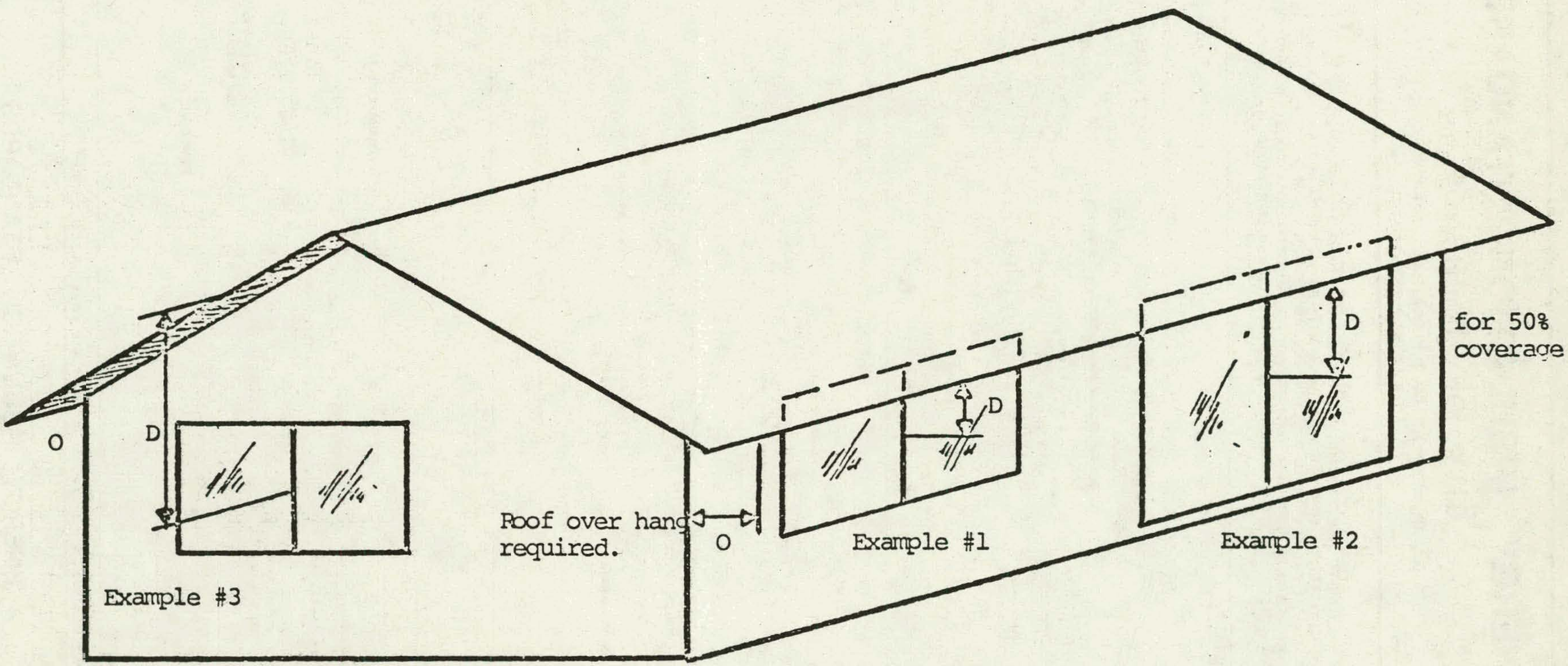


Max. single glazed area in sq. ft. per 1000 sq. ft. of floor area.

NW/NE	.46 x D = O
W/E	1.03
SE	1.00
SW	.30
S	.42

D = Distance from roof overhang to center of window.

O = Required roof overhang to cover 50% of window.



EXAMPLE 1. 6° x 5° window, the vertical distance from roof overhang to center of window 24". South elevation 24" x .42 = 10.08" roof overhang required. If east or west elevation 24" x 1.03 = 24.72" required.

EXAMPLE 2. 6° x 6'-6" slider, the vertical distance from roof overhang to center of slider 36". South elevation 36" x .42 = 15.12" roof overhang required. If east or west elevation 36" x 1.03 = 37.08" overhang required.

EXAMPLE 3. 6° x 4° window, the vertical distance from roof overhang to center of window 60". South elevation 60 x .42 = 25.2" roof overhang required. If east or west elevation 60 x 1.03 = 61.8" overhang required.

ENERGY INSULATION STANDARDS

CITY OF TORRANCE

DEPARTMENT OF BUILDING AND SAFETY

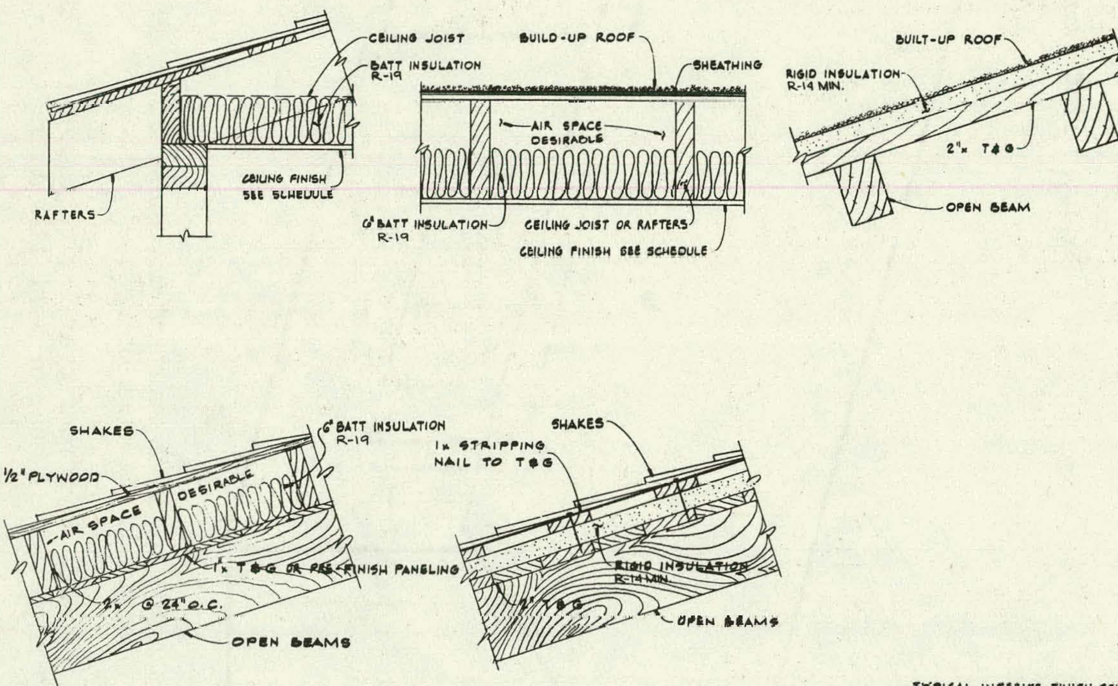
LIMITATIONS:

TO UTILIZE THESE CONVENTIONAL CONSTRUCTION ASSEMBLIES THE FOLLOWING LIMITATIONS APPLY:

1. BUILDING SHALL NOT EXCEED THE BASIC GLAZING AREA OF 20% OF THE GROSS FLOOR AREA.
2. BUILDING SHALL CONSIST ENTIRELY OF CONSTRUCTION ASSEMBLIES SHOWN HEREON.

NOTE. ALTERNATE CONSTRUCTION METHODS ARE PERMITTED AS ARE GREATER GLAZING AREAS PROVIDED A HEAT LOSS ANALYSIS SHOWING CONFORMANCE TO STATE STANDARDS IS SUBMITTED AND APPROVED BY THIS DEPARTMENT.

ROOF/CEILING ASSEMBLIES



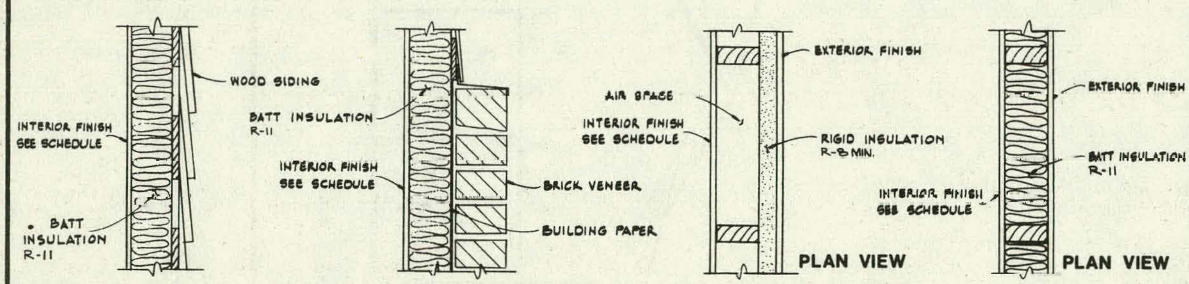
TYPICAL INTERIOR FINISH SCHEDULE

1. GYPSUM WALLBOARD
2. LATH AND PLASTER

WALL ASSEMBLIES

TYPICAL INTERIOR FINISH SCHEDULE

1. GYPSUM WALLBOARD
2. LATH AND PLASTER
3. 3/8" MIN. WOOD PANELING

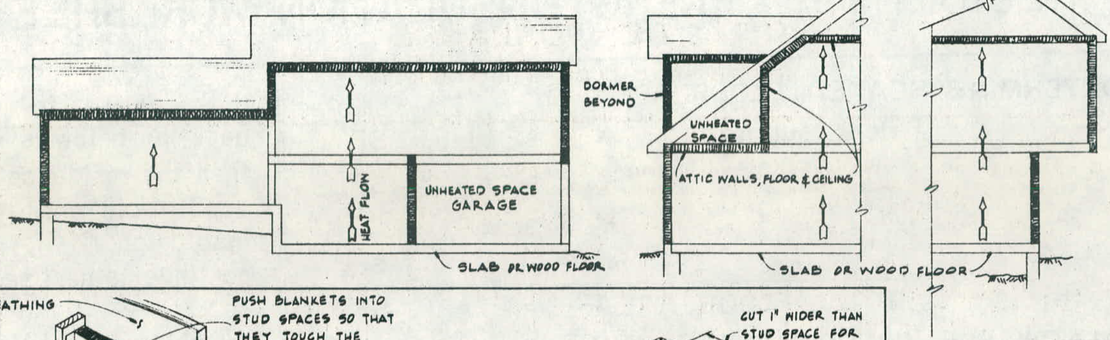


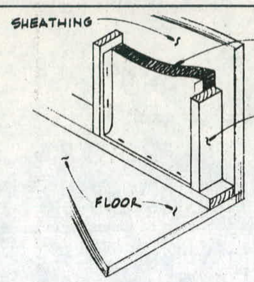
NOTE:

DETAILS SHOWN ARE FOR INSULATION METHODS AND ARE NOT COMPLETE CONSTRUCTION DETAILS.

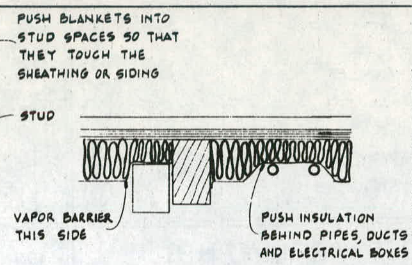
STANDARD DETAIL: EIS 9-75	ENERGY INSULATION STANDARDS	APPROVED BY John J. McKinnon DIRECTOR OF BUILDING AND SAFETY

AREAS REQUIRING INSULATION

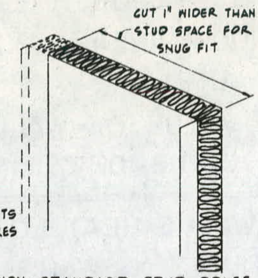




TYPICAL STUD SPACE



PLAN DETAIL AT PIPES IN WALL

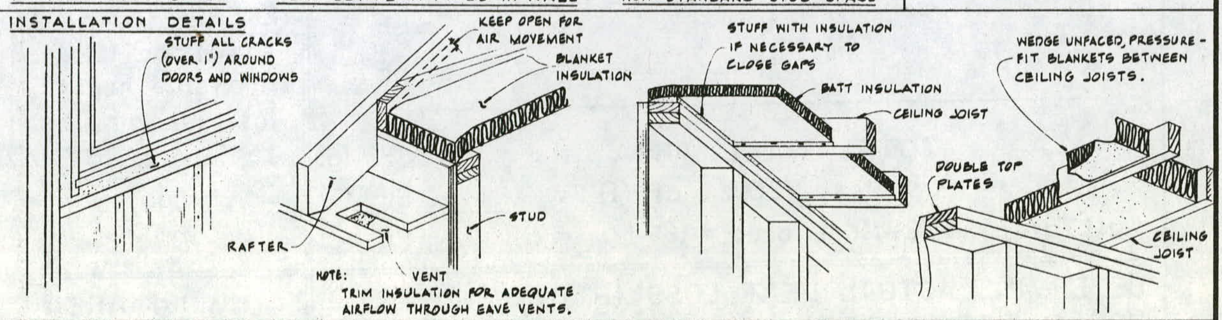


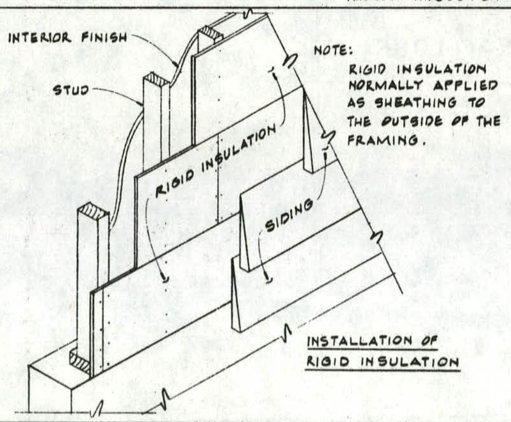
NON-STANDARD STUD SPACE

NOTES:

1. IF LOOSE FILL INSULATION IS USED THE "R" VALUE OF THE INSTALLED INSULATION IS TO BE SHOWN ON THE BUILDING PLANS.
2. BOX AROUND RECESSED LIGHT FIXTURES TO PROVIDE VENTILATION.

INSTALLATION DETAILS





INSTALLATION OF RIGID INSULATION

KEEP IN MIND:

VAPOR BARRIERS ARE PLACED ON THE SIDE OF THE WALL AND CEILING THAT IS WARM IN WINTER, BUT THEY ARE NOT NEEDED ON THE WARM SIDE OF CEILING INSULATION WHERE THE ATTIC IS VENTILATED.

ALL SWINGING DOORS AND WINDOWS OPENING TO THE EXTERIOR OR UNCONDITIONED AREAS (GARAGES) MUST BE WEATHER STRIPPED, GASKETED, OR OTHERWISE TREATED TO LIMIT INFILTRATION OF COLD AIR.

ATTIC VENTILATION IS NECESSARY FOR TWO REASONS: THE REDUCTION OF SUMMER HEAT BUILD-UP AND PREVENTION OF WINTER MOISTURE CONDENSATION.

WHERE BATTS ARE SHOWN BLANKET TYPE INSULATION MAY BE USED.

THE ENERGY INSULATION STANDARDS HAVE BEEN ADOPTED IN THE CALIFORNIA ADMINISTRATIVE CODE, TITLE 25, CHAPTER I, SUBCHAPTER I (STATE HOUSING LAW REGULATIONS), ARTICLE 5, SECTION 1094, AND IN THE CALIFORNIA ADMINISTRATIVE CODE, TITLE 24, PART 6, DIVISION T 25, CHAPTER I, SUBCHAPTER I (STATE HOUSING LAW REGULATIONS), ARTICLE 5, SECTION T 25-1094 THROUGH THE AUTHORITY OF SENATE BILL 277 AUTHORED BY SENATOR ALQUIST. THESE REGULATIONS WERE ADOPTED BY THE COMMISSION OF HOUSING AND COMMUNITY DEVELOPMENT ON FEBRUARY 22, 1974 AND BECAME EFFECTIVE FEBRUARY 22, 1975. THE REGULATIONS SHALL APPLY TO ALL APPLICATIONS FOR RESIDENTIAL BUILDING PERMITS MADE SUBSEQUENT TO THE EFFECTIVE DATA OF REGULATIONS.

CERTIFICATION OF COMPLIANCE WITH THESE STANDARDS IS REQUIRED BY THE INSULATION APPLICATOR AND BY THE BUILDER. THIS INSULATION COMPLIANCE CARD SHALL BE POSTED AT A CONSPICIOUS LOCATION WITHIN THE DWELLING.

ALL SWINGING DOORS AND WINDOWS OPENING TO THE EXTERIOR OR TO UNCONDITIONED AREAS SUCH AS GARAGES SHALL BE FULLY WEATHERSTRIPPED, GASKETED OR OTHERWISE TREATED TO LIMIT INFILTRATION. ALL MANUFACTURED WINDOWS AND SLIDING GLASS DOORS SHALL MEET THE AIR INFILTRATION STANDARDS OF THE 1972 AMERICAN NATIONAL STANDARDS INSTITUTE (A134.1, .2, .3, .4) WHEN TESTED IN ACCORDANCE WITH THE ASTM E 283-73 WITH A PRESSURE DIFFERENTIAL OF 1.67 LBS/FT.^{2} AND SHALL BE CERTIFIED AND LABELED.

RESIDENTIAL ENERGY INSULATION WORKSHEET

DETERMINE HEATED FLOOR AREA:

floor subarea # 1 = SF
" " # 2 = SF
" " # 3 = SF
" " # 4 = SF

TOTAL FLOOR AREA = SF ①

ALLOWABLE WINDOW AREA = .2 X ① = SF ②
ACTUAL WINDOW AREA = SF ③
ACTUAL MIN. "R" VALUE OF WALL = ④
ACTUAL MIN. "R" VALUE OF CEILING = ⑤

If the answer to each question below is yes, then the residence has acceptable energy insulation. If not, continue to next section

Is ② ⩾ ③?
Is ④ ⩾ 12.5?
Is ⑤ ⩾ 20.0?
USE 16.67 FOR OPEN BEAM CEILINGS INSTEAD OF 20.0

DETERMINE ALLOWABLE HEAT LOSS (BTU/°/HR):

Wall Perimeter (Ft) X Wall Height (Ft)
X = SF
X = SF

TOTAL WALL AREA = SF ⑥
less 20% of ① = ______ SF ⑦
wall area − .2 floor area = ⑥−⑦ = SF ⑧

Using values of ① and ⑧, B-51- ENERGY CHART I shows the total allowable heat loss is equal to ________ BTU/°/HR

DETERMINE ACTUAL HEAT LOSS (BTU/°/HR):
USE B-52, ENERGY CHART II.

ITEM			AREA	U OR $\frac{1}{R}$		HEAT LOSS (BTU/°/HR):
ceiling	subarea	#1=		X	=	
"	"	#2=		X	=	
"	"	#3=		X	=	
wall	"	#1=		X	=	
"	"	#2=		X	=	
"	"	#3=		X	=	
window	"	#1=		X	=	
"	"	#2=		X	=	
"	"	#3=		X	=	

WORK AREA

TOTAL ACTUAL HEAT LOSS = BTU/°/HR

THE ACTUAL HEAT LOSS SHALL NOT EXCEED TOTAL ALLOWABLE HEAT LOSS.

WORK AREA

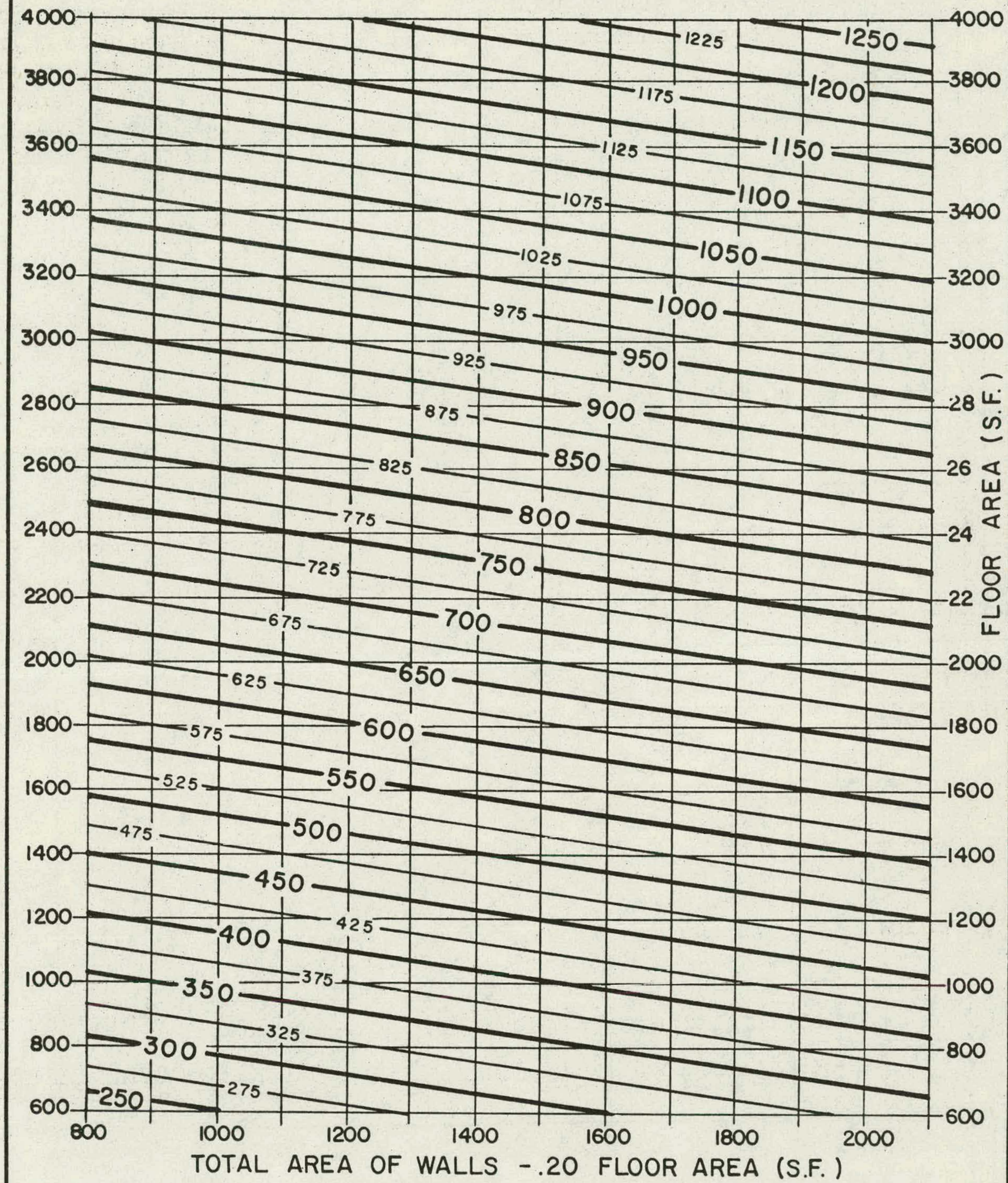
BUILDING and SAFETY
COUNTY of VENTURA

APPROVED BY ________

B&S STD B-50
DATE: 4-75
REVISED:

366

ENERGY CHART 1 - ALLOWABLE HEAT LOSS (BTU)



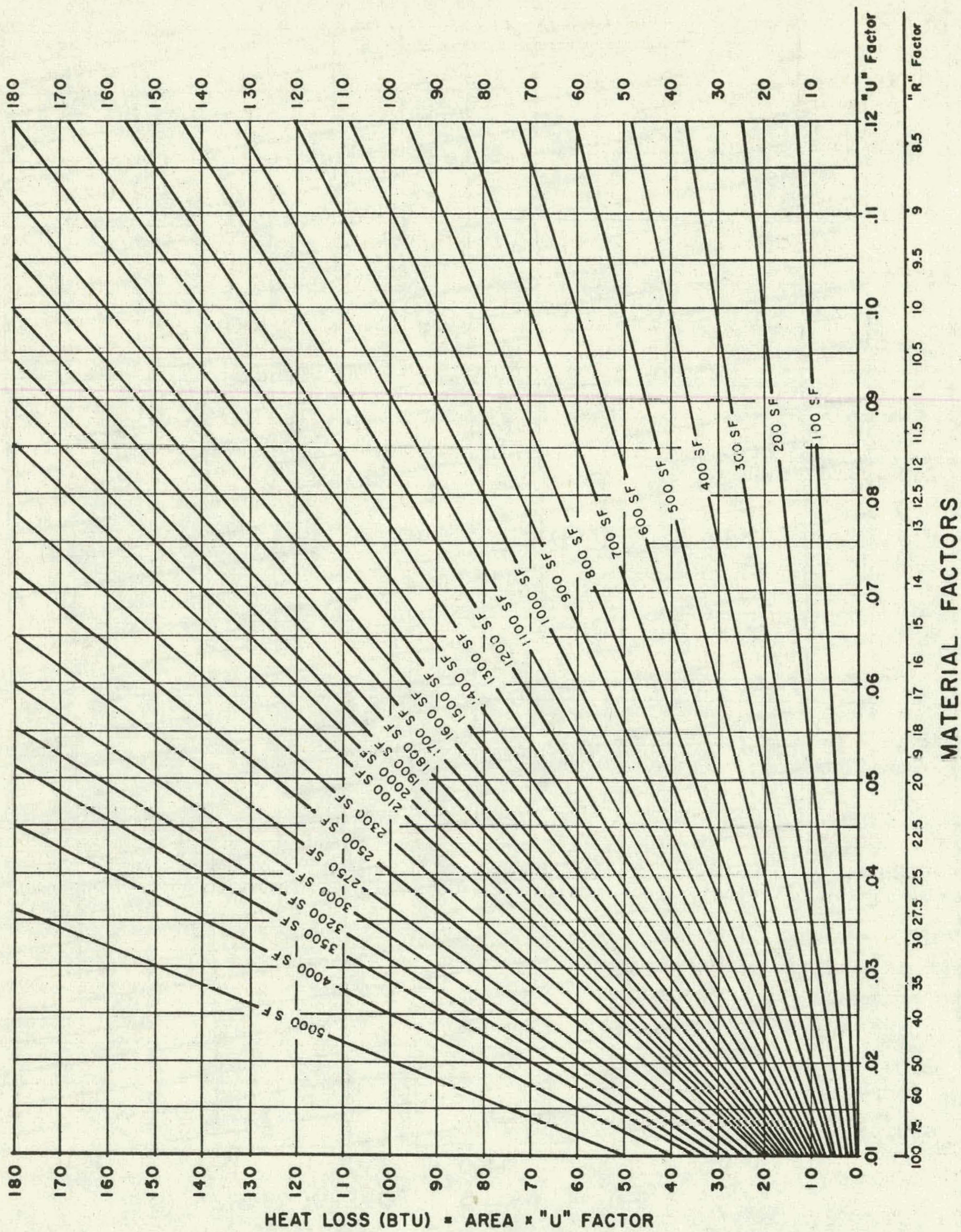
BUILDING and SAFETY
COUNTY of VENTURA

APPROVED BY [signature]

B&S STD B-51

DATE: 4-75
REVISED:

ENERGY CHART 2 – MATERIAL vs. AREA

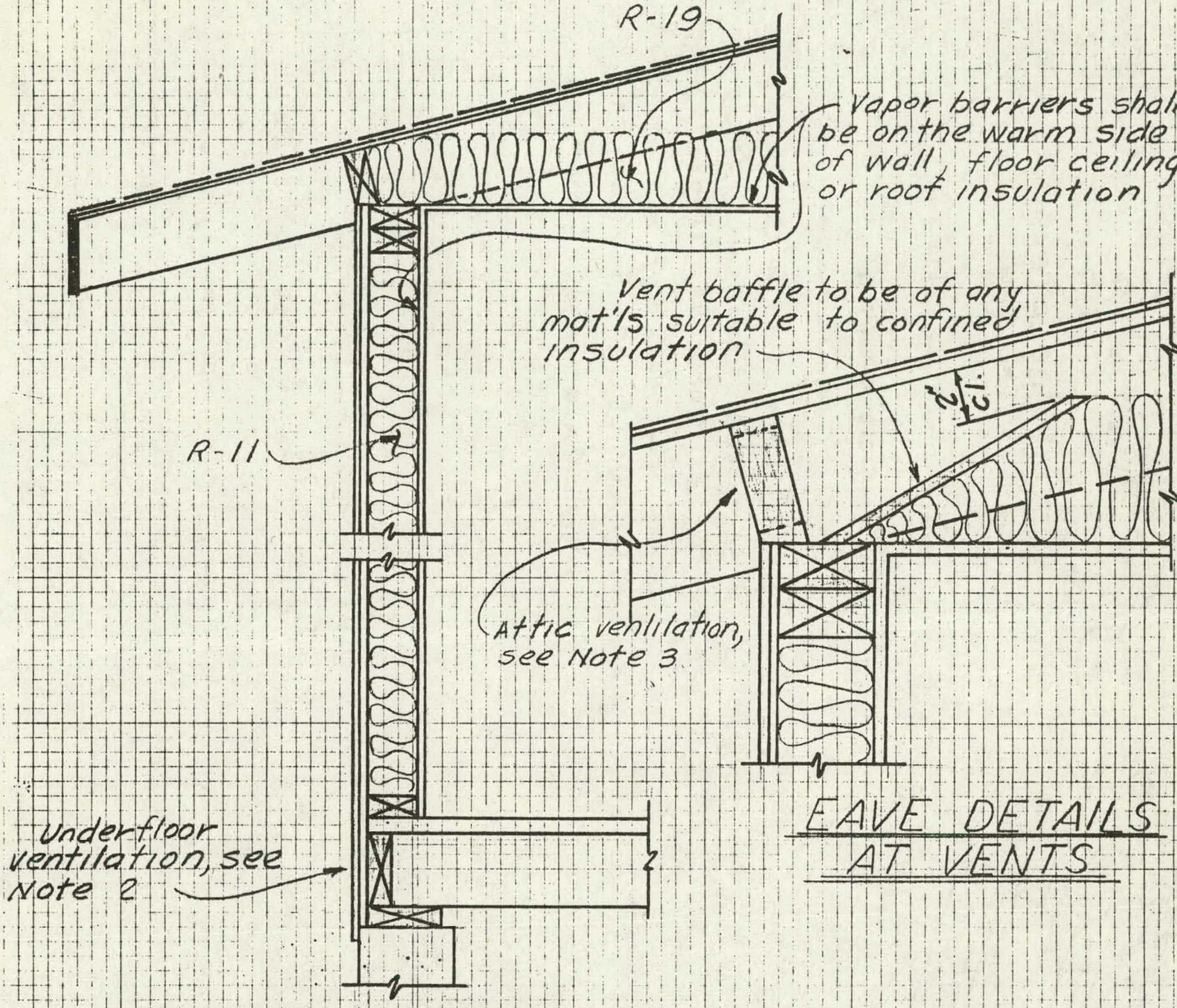


BUILDING and SAFETY
COUNTY of VENTURA

APPROVED BY ____________

B&S STD	B-52
DATE:	4-75
REVISED:	

INSULATION



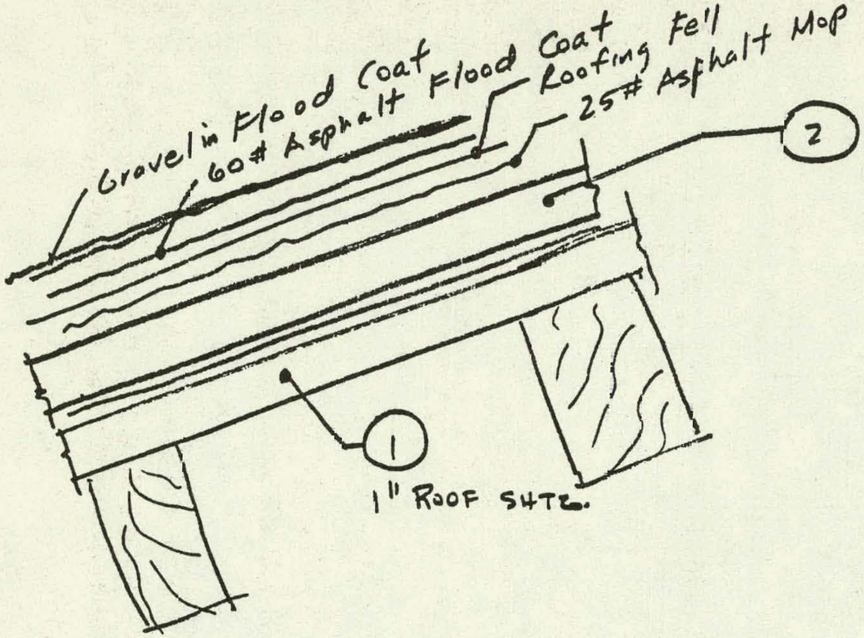
STUD WALL PART SECTION

EAVE DETAILS AT VENTS

NOTES:

1. Provide a Certificate of Certification for insulation materials used.
2. Underfloor ventilation, provide 1½ sq. ft. of ventilation per 25 L.F. of exterior wall under floors.
3. Attic ventilation, provide a total area not less than 1/150 the area ventilated

YOLO COUNTY



(2) MIN. 1 7/8" U.S.G. URETHANE ROOF INSULATION
MIN 2" CELOTEX URETHANE TEMPCHEK INSULATION

ROOF INSTALLATION

IN ACCORDANCE WITH MFG. RECOMMENDATIONS WITH SIMPLEX NAILS OR SUITABLE ROOFING NAILS DRIVEN THROUGH METAL DISCS AT 12" O/C AND 2" FROM EDGES ALL NAILS OF SUFFICIENT LENGTH TO PENETRATE ROOF SHTG.

APPROVED ALTERNATE
ROOF INSULATION SYSTEM

CITY OF TORRANCE
DEPT. OF BUILDING & SAFETY
6-4-75

BN FORM 116
BIA FORM 1486

INSULATION CERTIFICATION

This is to certify that, in conformance with the current energy regulations (California Administrative Code, Title 25, State of California*) and approved plans, insulation has been installed in the building located at:

City ____________________ County ____________________

Street No. (If Available) ________ Street ____________________ Lot Number ________ Tract No. ________

DESCRIPTION OF INSTALLATION

ROOFS
Type of Material __________ Manufacturer __________ Thickness ______ R Value** ______

EXTERIOR WALLS
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ R Value** ______

CEILINGS
BATTS:
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ R Value** ______
Sq. Ft. Covered ______

BLOWN:
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ No. Bags ______
Wt./Bag ______ Sq. Ft. Covered ______ R Value** ______

FLOORS
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ R Value** ______

SLAB ON GRADE
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ R Value** ______
Width of Insulation ______ Inches

FOUNDATION WALLS (If required)
Type of Material __________ Manufacturer (Or Trade Name) __________ Thickness ______ R Value** ______

REMARKS (If desired) ______________________________

General Contractor (Builder) ____________________ License Number ______________

By ____________________ Title ____________________ Date ______________

Sub-Contractor (Insulation Applicator) ____________________ License Number ______________
(Insulation, Masonry, Etc.) (State "SAME" if same as General Contractor)

By ____________________ Title ____________________ Date ______________

(*California Administrative Code, Energy Insulation Standards, declares: "Compliance. Upon completion of the installation of insulation, a card certifying that the insulation has been installed in conformance with the requirements of these regulations shall be completed and executed by the insulation applicator and by the builder. This insulation compliance card shall be posted at a conspicuous location within the dwelling.")

(**R Value is the measure of the resistance of a material or building component to the passage of heat. The resistance value (R) of mass-type insulations shall not include any value for reflective facing.)

EXCERPT from Sec. 19875 of the Health and Safety Code of the State of California:

"No certificate of occupancy or similar certification that a newly constructed hotel, motel, apartment house, home or other residential dwelling is habitable shall be issued by such a building department unless the structure at least satisfies the minimum energy insulation standards established pursuant to this chapter."

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Fig. 13