

Minnesota Attorney General: Administrative Rules Proceedings

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Version 3
August 20, 2018

STATE OF MINNESOTA

DEPARTMENT OF ADMINISTRATION

IN THE MATTER OF THE PROPOSED ADOPTION OF RULES OF THE BUILDING CODE DIVISION GOVERNING STANDARDS OF PERFORMANCE FOR SOLAR ENERGY SYSTEMS AND SUBSYSTEMS APPLIED TO ENERGY NEEDS OF BUILDINGS.

ORDER ADOPTING RULES

The above entitled matter came on for hearing before Peter Erickson, Hearing Examiner, sitting on behalf of the Commissioner of Administration of the State of Minnesota on the 17th day of May, 1977, at 9:00 A.M. in Room CCI, Howard Johnson's Motor Lodge, 8401 Cedar Avenue South, Bloomington, Minnesota after proper notice required by Minn. Stat. 1974, Section 15.0412 was served upon all persons, associations and other interested groups registered with the Secretary of State for that purpose.

After affording interested persons an opportunity to present written and oral data, statements and arguments, having heard all of the testimony, having considered all of the evidence adduced and upon the records, files, and proceedings herein, and applicable statutory standards or criteria, and having confirmed the need for the above captioned rules and the reasonableness thereof.

NOW, THEREFORE, IT IS ORDERED that the Report of the Hearing Examiner including recommended amendments is adopted in its entirety concerning the above rules identified as Building Code Division standards of performance for solar energy systems and subsystems applied to energy needs of buildings on this 25 day of August, 1977, pursuant to authority vested in me by Minn. Stat. 16.86, subds. 1 through 7 (1976).

for Richard L. Brubacher
Commissioner

STATEMENT OF COMPLIANCE WITH

MANUAL OF RULE MAKING PROCEDURES

I, Special Assistant Attorney General Joan Volz, do hereby declare that I have examined the proposed rules and all related documents and that, based on them and my personal familiarity with the applicable procedures, the Manual of Rule Making Procedures has been followed. Any exceptions are noted below.

JOAN VOLZ
Special Assistant
Attorney General

DATE: MAY 31 1977

STATE OF MINNESOTA
OFFICE OF HEARING EXAMINERS

FOR THE DEPARTMENT OF ADMINISTRATION

IN THE MATTER OF THE PROPOSED ADOPTION)
OF RULES OF THE BUILDING CODE DIVISION)
GOVERNING STANDARDS OF PERFORMANCE FOR)
SOLAR ENERGY SYSTEMS AND SUBSYSTEMS)
APPLIED TO ENERGY NEEDS OF BUILDINGS.)

REPORT OF THE
CHIEF HEARING EXAMINER

WHEREAS, a hearing was held on May 17, 1977 before Peter C. Erickson, a Hearing Examiner of the State Office of Hearing Examiners, on the above-entitled matter in compliance with Minn. Stat. § 15.0412, Subd. 4; and

WHEREAS, the Report of Hearing Examiner made pursuant to Minn. Stat. § 15.052, Subd. 3, was issued to the Building Code Division on July 22, 1977; and

WHEREAS, the Building Code Division has now determined to adopt rules pursuant to Minn. Stat. § 15.0412, Subd. 4; and

WHEREAS, the Building Code Division has submitted said rules to the Chief Hearing Examiner for review pursuant to Minn. Stat. § 15.052, Subd. 4, and Rule HE 107; and

WHEREAS, the Chief Hearing Examiner finds that the final proposed rules are not substantially different from those proposed at the public hearing and that the Building Code Division has met all requirements of Minn. Stat. § 15.0412, Subd. 4.

NOW, THEREFORE, upon receipt of this Report, the Building Code Division has the responsibility of submitting the complete hearing record and the rules as adopted by the Division to the Attorney General and to publish in the State Register, all pursuant to Minn. Stat. § 15.0412, Subd. 4.

Dated this 26th day
of August, 1977.

Duane R. Harves

DUANE R. HARVES
Chief Hearing Examiner

STATE OF MINNESOTA
OFFICE OF HEARING EXAMINERS

FOR THE DEPARTMENT OF ADMINISTRATION

IN THE MATTER OF THE PROPOSED ADOPTION)
OF RULES OF THE BUILDING CODE DIVISION)
GOVERNING STANDARDS OF PERFORMANCE FOR)
SOLAR ENERGY SYSTEMS AND SUBSYSTEMS)
APPLIED TO ENERGY NEEDS OF BUILDINGS.)

REPORT OF HEARING EXAMINER

The above entitled matter came on for hearing before the Hearing Examiner, Peter C. Erickson, of the Minnesota Office of Hearing Examiners at 9:00 a.m. on Tuesday, May 17, 1977, in Room CCI, Howard Johnson's Motor Lodge, Bloomington, Minnesota.

Joan Volz, Special Assistant Attorney General, appeared as counsel on behalf of the Building Code Division. Bob Rogers, Assistant Director of the Division, and John White, Contract Consultant to the Division, testified in support of the proposed rules on behalf of the Building Code Division. The hearing continued until all interested groups or persons had an opportunity to be heard concerning the adoption of the proposed rules.

Pursuant to Minn. Stat. § 15.0412, subd. 4, this Report shall be available for review to all affected individuals upon request for at least five days.

The Building Code Division shall, if it proposes to adopt the rules as originally proposed or amended, submit the complete hearing record, including its Findings and Order, to the Chief Hearing Examiner no earlier than five days subsequent to the receipt of this Report. This submission shall also clearly indicate any changes made to the rules as originally proposed, preferably in the format that will be submitted to the State Register for publication. The Chief Hearing Examiner shall complete his review and submit his report to the Building Code Division on the issues of substantial changes in the rule and compliance with Minn. Stat. § 15.0412 within ten calendar days. Thereafter, the Division shall be responsible for filing the rules with the Attorney General.

Based upon all the records and proceedings herein, the Examiner makes the following:

FINDINGS OF FACT

1. On March 18, 1977 the Building Code Division filed the following documents with the Chief Hearing Examiner:

(a) A copy of the proposed rules;
(b) A proposed Order for Hearing;
(c) A proposed Notice of Hearing; and
(d) A Statement of the estimated length and number of people attending the hearing.

2. On April 11, 1977, a Notice of Hearing and a copy of the proposed rules were published at 1 State Register 1478.

3. On April 12, 1977, the Building Code Division mailed the Notice of Hearing to all persons and associations who had registered their names with the Secretary of State for the purpose of receiving such notice.

4. On April 22, 1977, the Building Code Division filed the following documents:

(a) The Order for Hearing;
(b) The Notice of Hearing as mailed;
(c) The Affidavit of Receipt of the Secretary of State's list;
(d) The Affidavit of Mailing;
(e) The Secretary of State's Certificate and list;
(f) The Statement of Need; and
(g) The Statement of Evidence, including the names of witnesses to be called;
(h) The names of Building Code Division personnel who will represent the agency.

The documents were available for inspection at the Office of Hearing Examiners from the date of filing tothe date of the hearing.

5. The record remained open through June 6, 1977 for the receipt of written comments and statements.

6. Statutory authority to promulgate the proposed rules is contained in Minn. Stat. § 116H.127. This section reads as follows:

> 116H.127 SOLAR ENERGY SYSTEM STANDARDS OF PERFORMANCE. The building code division of the department of administration in consultation with the agency shall promulgate rules by December 31, 1976, concerning quality and performance standards which are in reasonable conformance with the Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, National Bureau of Standards, January 1, 1975; and the Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities, National Aeronautics and Space Administration, February 28, 1975, to insure that within the existing state of development, solar energy systems as defined in section 116H.02, subdivision 11, which are sold or installed within this state, are effective and

represent a high standard of quality of material, workmanship, design, and performance. The department of administration in consultation with the energy agency shall modify existing standards and promulgate new standards subsequent to December 31, 1976, as new technology and materials become available, or as standards are revised by the federal government.

Manufacturers or retailers of solar energy systems shall disclose to each bona fide potential purchaser of a system the extent to which the system meets or exceeds each quality standard.

7. In response to public comment on the proposed rules, the Building Code Division (BCD) submitted a revised draft of the rules to the Examiner within the twenty day submission period.

8. Proposed SBC 6101, Authorization, recites the statutory authority for the proposed rules and enumerates two purposes of the rules, as mandated by statute.

9. Proposed SBC 6102, Purpose, further enumerates the intent of the application of the rules.

10. The BCD has proposed to combine the content of SBC 6101 and 6102 into a revised SBC 6101, Purpose, and make other clarifying amendments. The amended version reads as follows:

SECTION 6101

PURPOSE

A. These Rules are authorized by Minn. Stat. §§ 116H.127 and 16.85 (1976) and established through the rule making procedures set forth at Minn. Stat. § 15.0411, et seq.

B. These Rules shall apply to solar energy systems which are used to satisfy space heating and/or cooling and/or domestic or service hot water demands of buildings, and shall be used for all solar energy systems and subsystems as those terms are defined at Section 6105 herein.

C. The purpose of these Rules is twofold: first, to establish standards for the evaluation of the performance, durability, reliability and maintainability of solar energy systems and subsystems; and second, to require disclosure by the seller to each potential buyer of the extent to which the seller's solar energy system or subsystem meets or exceeds the Standards set forth at Sections 6106 and 6107 herein.

D. The Standards set forth herein are in reasonable conformance with Interim Performance Criteria for Commercial Solar Heating/Cooling Systems and Facilities (NASA), Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings (NBS), and Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (HUD).

E. The Standards set forth herein are intended to serve as a model for evaluating solar energy system or subsystem performance. These Rules require that the seller determine and disclose the extent to which its system or subsystem meets or exceeds these Standards. These Rules do not require the seller to comply with the Standards.

11. Proposed SBC 6103, Enforcement, provides that in all areas of the state where the building code is administered and enforced, the building official shall issue a permit for the installation of the solar energy system only after receiving a copy of the disclosure which is required by Minn. Stat. 116H.127. Since the State Building Code is not administered and enforced in all municipalities of the state this section further provides that where there is no authority regulating construction that a copy of the required disclosure be submitted to the State Building Inspector. Additionally this section brings to the attention of those who are affected by this standard, the penalties provided by Minn. Stat. 116H.15, subd.

a. Several local building officials commented that SBC 6103, as written, would be very difficult for them to implement. That they did not have the expertise to determine degrees of compliance with the disclosure statement provisions. Consequently, the BCD has proposed a revised "Enforcement" rule, SBC 6102, to read:

SECTION 6102

ENFORCEMENT

A. The building official in each municipality shall enforce the Rules set forth in Section 6103 herein. The building official shall not issue any permits required for installation of the electrical, mechanical or structural aspects of the solar energy system or subsystem until the seller has furnished the building official a copy of the completed Disclosure Statement Form required by these Rules. However, the building official shall not be required to determine the accuracy of the seller's solar energy system or subsystem meets or exceeds the Standards set forth in Sections 6106 and 6107 herein.

B. Any person who violates the provisions of these Rules or knowingly submits false information in the required Disclosure Statement Form shall be guilty of a misdemeanor and may be subject to a civil penalty of not more than $10,000 for each violation. See Minn. Stat. § 116H.15 (1976).

12. Proposed SBC 6104, Scope, generally identifies what solar energy systems will be regulated under this standard. This standard does not apply to all possible solar energy systems, but only those which are used to provide heating, cooling, or service hot water systems for buildings.

a. The BCD proposed a revised version of the "Scope" section as follows:

A. Every seller of a solar energy system or subsytem shall inform every bonafide prospective buyer of the extent to which the seller's system or subsystem meets or exceeds the Standards set forth at Sections 6106 and 6107 herein.

B. The information required by Section 6103.A above shall be provided on the Disclosure Statement Form set forth in Sections 6104.A and 6104.B herein.

C. A copy of the operation and maintenance manual described at Section 6106.6 herein shall be available for review by a bonafide prospective buyer, and shall be provided to each buyer upon sale of the solar energy system or subsystem.

D. The seller of a solar energy system or subsystem shall complete the Disclosure Statement Form, including Section 6104.C; and shall submit copies to the buyer at the time of sale and to the municipal building official prior to installation.

E. Where the solar energy system or subsystem includes flat plate collectors, or any other collectors whose thermal performance is capable of being rated in accordance with the National Bureau of Standards Interim Report 74-635, such collectors shall be tested in accordance with the methods set forth at NBSIR 74-635. No other tests are required by these Rules; however, the seller shall fully disclose on the Disclosure Statement Form the bases for its determinations as required on the Disclosure Statement Form, and where the determinations are not substantiated by testing, the seller shall so indicate.

This revision more clearly spells out the duties placed on the seller of a solar energy system or subsystem.

b. Mr. Orvel Lundberg suggested that a new subsection be added to read, "These rules shall apply only to solar systems and subsystems as defined herein when advertised, held out, or sold as a solar system."

13. Proposed SBC 6105, Definitions, provides definitions of the terms used in the rules to allow for a common understanding of what is required.

a. The BCD proposed to amend SBC 6105 by adding a definition for the term "facility", which is used throughout the rules. It reads as follows:

Facility. Means a building or structure including appliances, heating or cooling equipment, industrial or manufacturing processes to be served by the solar energy system.

b. Mr. Lundberg commented that the definition of "passive solar system" may include things which are not sold as a solar system per se. The BCD responded that the rules would only apply when something is sold as a solar system.

14. Proposed SBC 6106, Solar Energy Systems, relates to the total solar energy system and identifies solar system performance. Of particular importance is that the solar system shall supply more energy to the demand of the facility for which it is installed than is required for its operation. Further, this section relates to matters such as durability and reliability, as well as the maintainability of the solar energy system. The section further requires that both installation as well as maintenance and operation instructions be supplied. The owner of a solar energy system must be provided with information that will allow the periodic maintenance of such system that will insure that the system perform as it was designed.

a. The BCD proposed the following clarifying amendments to SBC 6106:

Section 6106

STANDARDS FOR EVALUATION OF SOLAR ENERGY SYSTEMS

A. Scope. This section contains design criteria for evaluation of performance and quality of solar systems.

B. Solar System Performance. The solar system shall be capable of collecting and converting solar energy into thermal energy. The thermal energy shall be used to meet the total energy needs for space heating, cooling and water heating alone or in combination with storage and auxiliary energy, as required. The solar system shall supply more energy to the demand of the facility for which it is installed than is required for the solar systems.

1. Solar energy system sizing. The solar system combination shall be based upon monthly average heat loads determined by a degree-day method using average monthly design temperature and conditions as the maximum analytical time interval. Building heat loss shall be determined by historical energy use data or calculation. Calculation of building heat loss for use in sizing solar energy systems shall be performed for the full heating and/or cooling season using the method described in Appendix B.

* * *

D. Maintainability

1. Accessibility for maintenance and servicing. The The Solar system shall be designed, constructed, and installed to provide adequate access for general maintenance and convenient servicing.

2. Service Personnel. The solar systems shall be capable of being serviced by a trained service technician using a maintenance manual.

* * *

6. Installation, operation and maintenance manual. A manual shall be provided to the purchaser for the operation and maintenance of the solar energy system/subsystem. An installation manual shall be provided to the trained service technician for installation and repair of the solar energy system/subsystem.

* * *

c. Maintenance Plan. The maintenance manual shall include a comprehensive plan for maintaining the specified performance of the solar system for its design life. The plan shall include all the necessary ordinary maintenance, preventive maintenance and minor repair work and projections for equipment replacement.

Additionally, all references to Appendix A were changed to Disclosure Statement and all references to Appendix C were changed to Appendix B. The word "allow" was replaced with the word promote in C. 8. d. The word "design" was replaced with Disclosure Statement in B.2. C. 6., "Function", was deleted because of its ambiguity.

b. Mr. Alan Baldwin suggested that SBC 6106 B. 2. be amended by adding the following language at the end of the paragraph:

> "(Calculations which have been substantiated by field testing of solar system/subsystems and components are an acceptable submission in lieu of Appendix C Calculation Procedures)"

He contends that this language is needed to spell out that other calculation procedures other than those set out in the Appendix may be appropriate.

c. Mr. Lundberg commented at length regarding the "absolute" nature of the standards and that many would be impossible to meet. He proposed the following amendments to SBC 6106:

> In ¶2 on page 11, I would recommend that the phrase "the system shall be designed to avoid" be inserted before the words "Mechanical stresses that arise", that the phrase "shall not cause" in the second line be deleted and the phrase "from causing" be substituted therefor. With respect to ¶2. a., I would recommend that the word "could" in the third line be deleted and the phrase "are likely to" be substituted in its place.
>
> With respect to sub 2. b. on page 11, I would recommend that the phrase "designed to be" be inserted on line two between the phrase "parts shall be" and "capable of performing".
>
> With respect to Sub. 2.c. on page 11, I would recommend that the phrase "be designed to" be inserted between the phrase "components shall" and "be capable of", and that the phrase "of the system" be inserted in the fifth line between the phrase "the performance" and "as declared".

With respect to ¶3. on page 11, I would recommend that the phrase "designed to be" be inserted between the phrases "Components shall be" and "capable of"; that the word "may" in the third line be deleted and the phrase "are likely to" be substituted therefor.

With respect to Sub. 3.a. on page 11, thermal cycling stresses, I would recommend that the phrase "designed to be" be inserted between the phrases "system shall be" and "capable" in the first line.

With respect to Sub. 3. b. on page 11, I would recommend that the word "may" be deleted and the phrase "is likely to" be substituted therefor on the second line.

On page 12, Sub. 3.c., thermal degradation, I would note to the examiner that the standard would be no thermal degradation to the extent that the function will be reduced to a degree that will "effect" the performance as declared in Appendix A. The word "effect" is obviously a typographical error as we want to "affect", not "effect". However, the standard becomes impossible, since all materials degrade thermally, and this standard does not even refer to the design life of the system, and it would seem to be a requirement that there be no thermal degradation forever. I would recommend substitution for this entire paragraph something substantially along the following lines: "There shall be disclosed to the purchaser by the declaration set forth in Appendix A the extent of thermal degradation of the system, or portions thereof, which can be reasonably expected during the design life of the system."

On Sub. 4., page 12, materials compatibility, as proposed, it would appear to have a standard of absolutely no deterioration, due to chemical interaction of materials. Again, this is a situation of impossibility. I would suggest that the first sentence of that paragraph be deleted, and that the following, or its substantial equivalent, be substituted: "There shall be disclosed to the purchaser, in the disclosure set forth in Appendix A, the extent of any deterioration which may be reasonably expected during the design life of the system due to chemical incompatibility of interaction which it may be reasonably expected to occur during the design lifetime under conditions reasonably to be expected."

With respect to Sub. 4. a., the standard seems to allow no corrosion of dissimilar materials whatever, and I would recommend deletion of that paragraph and substitution therefor of the following or its substantial equivalent: "There shall be disclosed to the purchaser in the disclosure set forth in Appendix A the extent to which materials may be reasonably expected to corrode and to result in impairment of function of the system, or part thereof, under conditions reasonably to be expected in use during their intended design lives."

On Sub. 4. b. on page 12, I would recommend deletion of the subparagraph and the substitution therefor of the following or its substantial equivalent: "There shall be disclosed to the purchaser by the disclosure in Appendix A of the extent to which corrosive deterioration of any components of the system is reasonably likely to impair the ability of those components to perform their intended function under conditions reasonably to be anticipated during their intended design lives."

Sub. 4. c. on page 13, I would recommend that the subparagraph be deleted and the following or its substantial equivalent be substituted: "There shall be disclosed to the purchaser by the disclosure in Appendix A of the extent to which degradation of components within the system can be reasonably expected to be caused by chemical decomposition products expelled from the components under reasonably expected in use conditions and the degree of any anticipated impairment of the

I would recommend with respect to ¶5., on page 13, that the paragraph be deleted and that the following or its substantial equivalent be substituted: "There shall be disclosed to the purchaser by the disclosure in Appendix A the extent to which the system and its components may be reasonably expected to be adversely affected by erosive wear, such as the flow of a liquid transfer medium, to an extent that will impair their functions during their intended design lives."

With respect to ¶8. on page 13, I would recommend that the phrase "not be affected" in the third line be deleted and the phrase "be designed to minimize impairment" be substituted therefor and that the phrase "to an extent that will impair their functions" in the third and fourth lines be deleted and the phrase "of their functions" be substituted therefor.

With respect to ¶8. a. on page 13 and 14, I would recommend that the subparagraph be deleted and the following or its substantial equivalent be inserted: "There shall be disclosed to the purchaser by the disclosure in Appendix A the extend to which the function of the system or its components are likely to be impaired during their design life under conditions reasonably to be expected in use by changes in properties of components or their materials when exposed to sunlight, when exposed to ultraviolet radiation alone or in combination with an intermittent water spray and their maximum "no flow" temperature, and the extent to which under such conditions there will be deteriorations such as cracking, crazing, embrittlement, etching, loss of adhesion, changes in permeability loss in flexural strength, or other changes that may affect the performance of the components in the system.

I would recommend with respect to ¶8. b. on page 14 that the phrase "not be degraded under" be deleted from the second line and that the phrase "be designed to avoid degradation under reasonably anticipated" be substituted in its place, and that the word "may" in the third line be deleted and that the phrase "is likely to significantly" be substituted in its place.

With respect to ¶8. c. on page 14, I would recommend that the phrase "which are reasonably anticipated to be" be inserted between the words "Materials" and "exposed under in-use conditions" in the first line and that the phrase "be so constructed as to not to be significantly and adversely" be inserted between the phrases "hydrogen chloride shall" and "not be affected" in the third line, and that the phrase "to an extent that may impair their functions" be deleted from the fourth line.

d. The BCD responded to Mr. Lundberg's comments by revising the proposed Disclosure Statement to allow the seller to more fully explain why the "impossibly high" standards are not met. The Statement has been proposed to be amended as follows:

SECTION 6104

DISCLOSURE STATEMENT

A. Compliance. The purpose of this Statement is to disclose to the buyer the extent to which this system meets the standards for solar systems set forth in the State Building Code.

1. This system/subsystem/compenent meets or exceeds the standards set forth at State Building Code Sections 6106 and 6107 except as noted in 3 below.

2. The seller's determination that these standards have or have not been met are based on the following tests, computations, and documentation which are available for review by the buyer:

SBC SECTION	TESTS, COMPUTATIONS, AND DOCUMENTATION

3. This system (subsystem/component) does not meet or exceed the standards set forth at State Building Code Sections 6106 and 6107 in the following respects:

4. The seller may explain below any reasons for the system (subsystem or component) not meeting the standards set forth at State Building Code Sections 6106 and 6107 and may indicate the extent to which the system does meet the standard.

B. Design Life. The manufacturer of solar energy systems shall outline herein the design life of systems and subsystems under anticipated design conditions. This is not a warranty or a guarantee of this life.

1. Design life of solar energy system, with normal maintenance as described by manufacturer _____

2. Design life of subsystems and components, with normal maintenance as described by manufacturer _____

   Collector subsystem _____

   Transport subsystem _____

   Storage subsystem _____

   Control subsystem _____

C. Solar Energy System Performance.

Sizing. Sizing of the previously identified solar energy system is outlined below. All load calculations are performed in accordance with Appendix A and/or B.

Calculated facility heating consumption _____

Calculated service hot water consumption _____

Calculated facility cooling consumption _____

Other calculated facility energy consumption as may be offset by solar energy system _____

TOTAL CALCULATED FACILITY CONSUMPTION _____

Solar Contribution. Solar contribution, as calculated in accordance with Appendix B, shall be provided as follows: (Calculations which have been substantiated by field testing of solar system/subsystems and components are an acceptable submission in lieu of Appendix B, Calculation Procedures.)

Calculated solar contribution to space heating consumption _____%

Calculated solar contribution to service hot water consumption _____%

Calculated solar contribution to facility cooling consumption _____%

Calculated solar contribution to other consumption _____%

CALCULATED SOLAR CONTRIBUTION TO TOTAL CONSUMPTION _____%

e. Mr. Lundberg also proposed the following amendments to SBC 6106:

1. In Section B., 1., a method is set forth for solar energy system sizing. However, in the Appendix C, more than one method is permissible. Accordingly, to avoid conflict as well as to contribute to conciseness, I would recommend that the text of Sub. B. 1. be deleted and the following or its substantial equivalent be substituted: "Computation of solar energy system size and contribution shall be based upon methods allowable under Appendix C to these rules."

2. With respect to Sub. B. 2. on page 9, I would note that it appears to require a total energy survey for every installation, however small. In view of the fact that such a survey of a particular home or building may be very laborious and expensive, it is entirely possible that the cost of doing that could exceed the other costs involved in a small system of, say, domestic hot water preheating only. I would recommend that the first sentence of sub. 2. be retained but that the balance of the subparagraph be deleted and the following or its substantial equivalent be substituted: "The solar energy contribution shall be determined by a method described in or allowed by Appendix C."

3. With respect to ¶C. 1. A. (3) on page 10 with respect to hail loads, I would like to support the information given to the Hearing Examiner by another witness to the effect that hail is not a significant risk to solar energy glazings. In particular the evidence that has come to me supports a conclusion that contrary to expectations there has been very little hail damage to solar energy glazings and accordingly a standard on this probably is superfluous. In addition, it would seem to me that this is the kind of risk that ought to be provided for by the normal fire and extended coverage policies carried by owners of property and that by this time insurance companies should be able to obtain enough information to be able to write those risks without excessive premiums. I would like to note in this connection that my own company, L.P.C., Incorporated uses a fiberglass type glazing on top, which would not be damaged by hail in any event, but I just don't believe this particular standard to be necessary.

4. With respect to sub. 2. d., Flexible joints, I would recommend that the word "fluids" in the first line be deleted and the word "liquids" be substituted therefore. The reason for this is that the word "fluids" is defined in the definition as including both gasses and liquids and it seems rather obvious that all solar energy systems known to date employ heat and transfer fluids of either gasses or liquid type. Accordingly the phrase "employing heat transfer fluids" becomes meaningless. If it is intended to apply to all systems whatsoever, that phrase could simply be deleted.

15. Proposed SBC 6107, Solar Subsystems, related to individual portions of a total solar energy system and makes certain requirements for collector subsystems, transport subsystems, sotrage subsystems, and control subsystems. Certain caution and possible problems with these various subsystems are outlined.

a. The BCD proposed to amend SBC 6107, as follows, for the purposes of clarification:

Section 6107

STANDARDS FOR EVALUATION OF SOLAR SUBSYSTEMS

* * *

3. Dirt retention. The cover plate(s) shall not, with normal maintenance, collect or retain dirt to an extent that would reduce its ability to transmit sunlight to a degree that would effect the performance as declared in the Disclosure Statement form.

Also, a reference to "Appendix A" was changed to <u>Disclosure Statement</u> in B. 2. and C. 2.

b. Mr. Baldwin and Mr. Meyer both proposed to amend C. 3. a. by replacing the word "flashpoint" with the word "firepoint". They contend that the rule as written would unnecessarily limit the types of fluids allowed for use in solar systems. The BCD concurred in this recommendation.

c. Mr. Lundberg proposed the following amendments to SBC 6107.

1. With respect to ¶C. 1. on page 17, I believe that entrapped air can only become a problem in a system using liquids, and as "fluids" is used to cover both liquids and gasses, I would recommend that the word "fluid" in the first line be deleted and the word "liquids" be substituted therefore.

2. With respect to ¶C. 2. on pages 17 and 18, I would recommend the addition of the following language or its substantial equivalent at the end of that paragraph: "Such protection may be made by any suitable means, including but not limited to periodic maintenance, and the maintenance required for such protection shall be disclosed to the purchaser in the disclosure required in Appendix A."

3. Subparagraph C. 3., on page 18 has the problem that, though the caption refers to flammable or combustible fluids, the text of the rule does not. Under the sometimes used rule of construction that the meaning is to be found in the text and not its title, I would recommend that the phrase "of flammable or combustible fluids" be inserted in the first line of the text between the phrase "the fluid transfer systems" and "shall include a pressure relief valve". I would further recommend for the same reasons the deletion of the word "fluid" in the second sentence and the insertion of the phrase "of flammable or combustible fluid" between the words "discharge" and "into". I would further recommend, for the same reason, the insertion in the fourth line of the text of the phrase "for such systems" following the phrase "The pressure relief valve".

4. With respect to ¶D. 1. on page 19, I would recommend that the phrase "be designed to" be inserted after the phrase "controls shall" and the phrase "prevent major damage". Basically the failure to do so would simply put the manufacturer in the position of having to say in our judgment our controls will prevent major damage to the system components in the event of power failure or other system malfunction, but no system controls can be absolutely dependent upon to do so, and accordingly, to that extent, any system will fail to conform to the state code. That seems to me to be a ridiculous result.

d. Dr. Harry Thomason proposed to amend 6107 B. 3. by adding the language "under normal weather conditions." He contends that this section could be too harshly applied if the weather conditions were abnormally dry.

e. It was mentioned that the word "suitable" in C. 5. should be changed to <u>suitably</u> to be grammatically correct.

f. The BCD proposed to amend the title to SBC 6107 to include the word <u>Evaluation</u>, however, that term was not added before "performance" in A. as was done in the amendments to SBC 6106. For the sake of clarity, the term <u>evaluation</u> should be added in 6107 A.

16. Proposed Appendix A, Disclosure Statement, is a form to be completed by the seller and is intended to allow a prospective purchaser certain information that will enable him to make a rational and informed decision as to what benefits may be expected from the proposed solar energy system. In addition, such a disclosure is intended to allow a prospective purchaser to make valid comparisons between competing solar energy systems.

a. As was set out in Finding 14 d., the BCD proposed to amend the Disclosure Statement and insert it as SBC 6104. The amended version makes provision for a seller to fully describe the characteristics of the solar system he is marketing.

b. There were many comments regarding the necessity for a registered professional architect or engineer to sign the Disclosure Statement. Mr. William C. George, PE, proposed to amend the Disclosure Statement to require the signature of a registered professional. The BCD contends that Minn. Stat. §326.03 provides for specific exceptions where the signature of a licensed professional is not required in certain types of building construction. Consequently, to require professional signatures on all Disclosure Statements would be in violation of that statute. However, signatures would be required for types of construction as set out in Minn. Stat. §326.02 et seq.

17. Proposed Appendix B, Reference Standards and Test Methodology, contains both reference standards as well as test methodology for manufacturers or retailers of solar energy systems. The standards and tests are national standards and tests in every case.

a. Because the BCD proposed to amend the rules by placing the Disclosure Statement (Appendix A) in the main body of the rules, they also propose to make the following amendments to Appendix B:

APPENDIX A

REFERENCE STANDARDS AND TEST METHODOLOGY

The following standards have been exerpted from the documents referenced below. Use of these standards and tests is recommended for evaluation of systems, subsystems and components.

ASTM American Society for Testing and Materials, 1916 Race St., Philadelphia, Penn. 19103

HUD NBSIR 76-1059 Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems April, 1976, 415 - 7th Street S.W., Washington, D.C. 20410

NASA 98M 10001 Interim Performance Criteria for Commercial Solar Heating and Combined Heating/ Cooling Systems and Facilities February 28, 1975 National Aeronautics & Space Admin., Solar Heating & Cooling Office, Marshall Space Flt. Cntr., Huntsville, Alabama 35812

NBS Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings January 1, 1975, U.S. Dept. of Commerce, Washington, D.C. 20234

NBSIR 74-635 National Bureau of Standards Method of Testing for Rating Solar Collectors Based on Thermal Performance, See above for address.

Of significance is the proposed replacement of the word "mandatory" with recommended in the second sentence. The BCD contends that mandatory use of the technical tests would be unfair if imposed on a small inventor or manufacturer. That only large manufacturers are really able to afford the complicated testing procedures.

18. Proposed Appendix C, Calculation Procedures - Solar Systems, contains a nomenclature section and the calculation procedures which are to be used by manufacturers or retailers which will insure that uniform calculations will be made by all persons who manufacture for retail solar energy systems to the public. It is intended that uniform calculation procedures will help to insure fair competition in the market place and will allow, through the required disclosure statement, that the prospective purchaser have the best information available to enable him to make a better informed decision as to the merits of the various solar energy systems offered for sale.

a. Because of the rearrangement of the Disclosure Statement, the BCD has proposed to make Appendix C, Appendix B. The following clarifying amendments have also been proposed:

1. Page 31:

DELETE: ~~P.F. x Q_s x 24 = BTU/DD~~
~~DD~~

ADD: $\frac{\text{P.F. } Q_s \times 24}{t_i - t_o} = \text{BTU/DD}$

2. Page 34: Delete the language "for use by architects and engineers" and add a new figure, 5-B, for air systems.

3. Page 45: ADD: $\bar{t}_a$ = average ambient air temperature for the particular month

CORRECTION: $\triangle$ time = Total number of hours in each month

ADDITION TO LAST PARAGRAPH, LINE TWO: Figure 5-E-1 or 5-E-2

4. Page 46: the addition of F-chart 5-E-2 for air systems.

19. Mr. Lundberg contends that proposed SBC 6106 D. 6. which requires that a manual be provided for the installation, operation and maintenance of the solar system is beyond the statutory authority given to the BCD. The BCD responded to this comment by revising the section. (See Finding 14 a.)

20. The Twin City Pipe Trades Council and the Minnesota Association of Plumbing, Heating and Cooling Contractors commented that to the extent that the proposed rules dictate actual construction and installation methods, there is great overlap with already existing mechanical codes. The BCD responded to these comments by revising the "Purpose" section, 6101, of the rules. (See Finding 10).

21. Dr. Harry Thomason gave a very lucid and informative presentation of his pioneer experience with solar energy systems and the political forces that are inhibiting and sponsoring the growth of solar energy. His major contention was that the test procedure used by the National Bureau of Standards to find the efficiency of solar collectors is incorrect. He stated that the error in the procedure becomes greater as the size of the collector increase, that is, approximately 5 per cent underrating for a 6 foot collector to 25 per cent underrating for a 24 foot collector. Dr. Thomason's assertion was not rebutted.

Based upon the foregoing Findings of Fact, the Hearing Examiner makes the following:

CONCLUSIONS

1. Due, timely and adequate legal notice of the hearing was properly served and filed by the Building Code Division. All other substantive and procedural requirements of statute or rule have been complied with.

2. Pursuant to Minn. Stat. § 15.052, subd. 3 (1976), it is the duty of the Hearing Examiner to: "...(4) make a report on each proposed agency action ... taking notice of the degree to which the agency has (i) documented its statutory authority to take the proposed action, (ii) fulfilled all relevant, substantive and procedural requirements of law or rule, and (iii) demonstrated the need for and reasonableness of its proposed action with an affirmative presentation of facts."

3. The Examiner agrees with Mr. Lundberg that the BCD does not have statutory authority to require that purchasers be given installation manuals. However, that requiring an operation and maintenance manual to be provided is within the statutory authority as those manuals are necessary for the purchaser to maintain his system at Disclosure Statement performance levels. The Examiner concludes that the BCD has documented its statutory authority to promulgate the proposed rules with the amendment to SBC 6106 D. 6. set out in Finding 14 a.

4. The Examiner concludes that the proposed rules be amended as set out in Findings 10, 11 a., 12 a., 13 a., 14 a., 15 a.b.d.e.f. and 18 a. for the reasons stated therein.

5. Mr. Lundberg's suggestion, see Finding 12 b., that a new subsection be added to the "Scope" section, revised section 6103, follows from the intent of the rules as stated by the BCD, see Finding 13 b. The Examiner concludes that Mr. Lundberg's proposal is reasonable should the BCD decide to adopt it.

6. The Disclosure Statement specifies that "Calculations which have been substantiated by field testing of solar system/subsystems and components are an acceptable submission in lieu of Appendix B Calculation Procedures" for solar contribution evaluation. See Finding 14 d. Mr. Baldwin suggested that this same language be inserted at the end of 6106 B. 2., Solar Energy System Contribution. See Finding 14 b. In order for the two sections to be in conformance, Mr. Baldwin's proposed amendment should be adopted.

7. Mr. Lundberg's comments, as set out in Finding 14 c., are well taken and should be examined by the BCD prior to final adoption of any rules. The Examiner concludes, however, that the revised Disclosure Statement will alleviate Mr. Lundberg's concerns to some extent and that the proposed rules be amended as set out in Finding 14 d. Mr. Lundberg's comments set out in Findings 14 e and 15 c should also be closely examined by the BCD prior to final adoption. The Examiner concludes that the proposed amendments set out in Findings 14 e. and 15 c. are reasonable should the BCD decide to adopt any or all of them.

8. Minn. Stat. § 116H.127 states that the BCD "shall promulgate rules ... concerning quality and performance standards ... to insure that ... solar energy systems ... which are sold or installed ... are effective and represent a high standard of quality of material, workmanship, design, and performance ... Manufacturers or retailers of solar energy systems shall disclose to each ... purchaser ... the extent to which the system meets or exceeds each quality standard." The BCD proposed amendments to the "Reference Standards and Test Methodology" section which make testing using the statutorily prescribed standards voluntary rather than mandatory. If a system is not tested, the manufacturer or retailer cannot disclose the "extent to which the system meets or exceeds each quality standard." The legislature did not intend for a retailer to disclose no performance capabilities or merely fabricate them. The Examiner concludes that the proposed rules be amended as set out in Finding 17 a., however, that the word mandatory be substituted for the word "recommended."

9. Dr. Thomason's comments regarding the inaccuracy in the solar collector efficiency calculation are well taken. This alleged inaccuracy would surface in the rating system for flat plate collectors. see Finding 17 a. paragraph E. The legislature, however, had mandated that the NBS rating procedure be one of the basis for the rules. see Minn. Stat § 116H.127. The Examiner gives great weight to Dr. Thomason's presentation, however, the statute dictates which standards are to be followed. For the sake of uniformity, any change in the testing methodology should be made at the national level. Hopefully, Dr. Thomason will be given the opportunity to make his presentation to the National Bureau of Standards.

10. The Examiner concludes that the BCD has demonstrated the need for and reasonableness of the proposed rules, as recommended to be amended in this report, by an affirmative presentation of facts.

11. The Examiner concludes that the amendments he is suggesting make the rules more reasonable and do not constitute a substantial change.

Based upon the foregoing Conclusions, the Examiner makes the following:

RECOMMENDATION

That the Building Code Division adopt the proposed rules as recommended to be amended in this report.

Dated: 7-22-77

Peter C. Erickson

PETER C. ERICKSON
Hearing Examiner

STATE OF MINNESOTA

DEPARTMENT OF ADMINISTRATION

In the Matter of the Proposed Adoption of Rules of the Building Code Division Governing Standards of Performance for Solar Energy Systems and Subsystems Applied to Energy Needs of Buildings.

CERTIFICATE OF DELIVERY OF THE SECRETARY OF STATE LIST

I hereby certify that the attached 503 labels and 8 1/2 sheets constitute the complete list of persons, associations, and other interested groups who as of 10:30 o'clock a.m., this 8th day of April, 1977, have requested pursuant to M.S. 1974, Section 15.0412 that their names be placed on file with the Secretary of State for the purpose of receiving notice of public hearing on proposed rules on the subject captioned above.

SECRETARY OF STATE

Joan Anderson Growe

By: Cecil Dixon

STATE OF MINNESOTA

DEPARTMENT OF ADMINISTRATION

In the Matter of the Proposed Adoption of Rules of the Building Code Division Governing Standards of Performance for Solar Energy Systems and Subsystems Applied to Energy Needs of Buildings.

AFFIDAVIT OF MAILING

DarlaMae Hormann, being first duly sworn, deposes and says:

That on the 12th day of April, 1977, at the City of St. Paul, County of Ramsey, State of Minnesota, she served the attached Notice of Hearing by depositing in the United States mail at said City of St. Paul, a true and correct copy thereof, properly enveloped, with postage prepaid, to all persons and associations at the addresses listed on the attached Certificate of the Secretary of State.

DarlaMae Hormann

DarlaMae Hormann
Building Code Division

Subscribed and sworn to before me
this 12th day of April, 1977.

Cynthia Claason

CYNTHIA L. CLAASON
NOTARY PUBLIC - MINNESOTA
RAMSEY COUNTY
My Commission Expires Feb. 23, 1982

State of Minnesota

Department of Administration

In the Matter of the Proposed Adoption of Rules of the Building Code Division Governing Standards of Performance for Solar Energy Systems and Subsystems Applied to Energy Needs of Buildings.

STATEMENT OF NEED

The above captioned standards are the Division's response to Minn. Stats. 1976 116H.127 which requires that the Building Code Division of the Department of Administration in consultation with the Minnesota Energy Agency shall develop solar energy system standards of performance concerning quality and performance which are in reasonable conformance with the "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems in Dwellings, National Bureau of Standards, January 1, 1975; and the Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities, National Aeronautics and Space Administration, February 28, 1975." The two references cited above were indeed used in the development of the proposed standards.

It is recognized by the Division that research and development in the solar energy field is moving rapidly and that the proposed standard must be written in such a fashion that new developments in solar energy systems can be recognized without amendment of the Standard, wherever possible.

SBC 6101 Authorization. This section merely recites the requirements of the Minnesota statute which requires that such standards be promulgated.

SBC 6102 Purpose. While the purpose of the Standard is to provide reasonable requirements for performance durability, reliability, and maintainability of solar energy systems and subsystems, such standard must be balanced to the extent that new methods, materials, and system designs not be excluded from the market place to the detriment of any person who may consider the purchase and installation of solar energy systems. For that reason these proposed standards will permit the use of any system, subsystem and components making up a solar energy system which provides a net energy gain to the building for which it is installed. It is, however, the purpose of these rules to exclude any solar energy system which consumes more energy than it provides to the buiding or space which it is to serve.

SBC 6103 Enforcement. This section provides that in all areas of the state where the building code is administered and enforced, the building official shall issue a permit for the installation of the solar energy system only after receiving a copy of the disclosure which is required by Minn. Stat. 116H.127.

Since the State Building Code is not administered and enforced in all municipalities of the state this section further provides that where there is no authority regulating construction that a copy of the required disclosure be submitted to the State Building Inspector. Additionally this section brings to the attention of those who are affected by this standard, the penalties provided by Minn. Stat. 116H.15, subd. 1.

SBC 6104 Scope. This section generally identifies what solar energy systems will be regulated under this standard. It should be noted that this standard does not apply to all possible solar energy systems, but only those which are used to provide heating, cooling, or service hot water systems for buildings.

SBC 6105 Definitions. Definitions are provided so that there can be a common understanding of both the language used as well as certain technical terms commonly used by persons working with solar energy systems.

SBC 6106 Solar Energy Systems. This section relates to the total solar energy system and it should be noted that a requirement in this section identifies solar system performance. Of particular importance is that the solar system shall supply more energy to the demand of the facility for which it is installed than is required for its operation. Further this section relates to matters such as durability and reliability, as well as the maintainability of the solar energy system. The section further requires that both installation as well as maintenance and operation instructions be supplied. It is particularly important that the owner of a solar energy system be provided with information that will allow the periodic maintenance of such system that will insure that the system perform as it was designed.

SBC 6107 Solar Sub-systems. This section generally relates to individual portions of a total solar energy system and makes certain requirements for collector sub-systems, transport sub-systems, storage sub-systems, and control sub-systems. Certain caution and possible problems with these various sub-systems are outlined. Appendix A contains the disclosure statement which is intended to allow a prospective purchaser certain information that will enable him to make a rational and informed decision as to what benefits may be expected from the proposed solar energy system. In addition, such a disclosure is intended to allow a prospective purchaser to make valid comparisons between competing solar energy systems.

The disclosure statement is really the heart of the proposed standards.

Very few prospective purchasers are knowledgeable in the area of solar energy systems and that basic information be uniformly provided to all prospective purchasers. Appendix B contains both reference standards as well as test methodology for manufacturers or retailers of solar energy systems. The standards and tests are in every case national standards and tests. Appendix C contains the calculation procedures which are to be used by manufacturers or retailers which will insure that uniform calculations will be made by all person who manufacture for retail solar energy systems to the public.

It is intended that uniform calculation procedures will help to insure fair competition in the market place and will allow, through the required disclosure statement, that the prospective purchaser have the best information available to enable him to make a better informed decision as to the merits of the various solar energy systems offered for sale.

Richard L. Brubacher
Commissioner of Administration

Date: 4-21-77

State of Minnesota

Department of Administration

In the Matter of the Proposed Adoption of Rules of the Building Code Division Governing Standards of Performance for Solar Energy Systems and Subsystems Applied to Energy Needs of Buildings.

STATEMENT OF EVIDENCE

Robert F. Rogers, Assistant Director of the Building Code Division, will appear on behalf of the Building Code Division at the hearing to be held on May 17, 1977. He will testify regarding the need for and reasonableness of the proposed rules. The substance of his testimony is set forth in the Statement of Need submitted herewith.

DATE: April 21, 1977

Don Pates

Don Pates, Director
Building Code Division

STATE OF MINNESOTA

DEPARTMENT OF ADMINISTRATION

IN THE MATTER OF THE PROPOSED ADOPTION OF RULES OF THE BUILDING CODE DIVISION GOVERNING STANDARDS OF PERFORMANCE FOR SOLAR ENERGY SYSTEMS AND SUBSYSTEMS APPLIED TO ENERGY NEEDS OF BUILDINGS.

ORDER FOR HEARING

IT IS HEREBY ORDERED that a public hearing on the above-captioned rules be held in Room CCI, Howard Johnson's Motor Lodge, 8401 Cedar Avenue South, Bloomington, Minnesota, 55420 on May 17, 1977 commencing at 9:00 a.m. and continuing until all persons have had an opportunity to be heard.

IT IS FURTHER ORDERED that a Notice of Hearing be mailed to all persons or representatives of associations or other interested groups who have registered their names with the Secretary of State for that purpose.

IT IS FURTHER ORDERED that the Notice of Hearing be published in the State Register.

Date: 3/23/77

Richard J Brubacher

Richard L. Brubacher
Commissioner of Administration

STATE OF MINNESOTA

DEPARTMENT OF ADMINISTRATION

IN THE MATTER OF THE PROPOSED ADOPTION OF RULES OF THE BUILDING CODE DIVISION GOVERNING STANDARDS OF PERFORMANCE FOR SOLAR ENERGY SYSTEMS AND SUBSYSTEMS APPLIED TO ENERGY NEEDS OF BUILDINGS.

NOTICE OF HEARING

NOTICE IS HEREBY GIVEN that a public hearing in the above-entitled matter will be held in Room CCI, Howard Johnson's Motor Lodge, 8401 Cedar Avenue South, Bloomington, Minnesota, 55420 on May 17, 1977 commencing at 9:00 a.m. and continuing until all persons have had an opportunity to be heard.

All interested or affected persons will have an opportunity to participate. Statements may be made orally and written materials may be submitted at the hearing. In addition, written materials may be submitted by mail to Peter Erickson, State Hearing Examiners Office, Room 300, 1745 University Avenue, St. Paul, Minnesota, 55104, 612/296-8118, either before the hearing or within 20 days after the close of the hearing.

The proposed rules, if adopted, would insure that the required disclosure would enable prospective purchasers to evaluate the quality and calculated performance of solar energy systems sold or installed within the State of Minnesota. Copies of the proposed rules are now available and one free copy may be obtained by writing to the Building Code Division, 408 Metro Square Building, 7th and Robert Streets, St. Paul,Minnesota, 55101. Additional copies will be available at the door on the date of the hearing. The agency's authority to promulgate the proposed rules is contained in Minn. Stat. 16.86 (1974). A "statement of need" explaining why the agency feels the proposed rules are necessary and a "statement of evidence" outlining the testimony they will be introducing will be filed with the Hearing Examiners Office at least 25 days prior to the hearing and will be available there for public inspection.

Please be advised that pursuant to Minn. Stat. 10A.01, subd. 11 (1974) any individual engaged for pay or other consideration for the purpose of representing persons or associations attempting to influence administrative action, such as the promulgation of these rules, must register with the State Ethics Commission as a lobbyist within five days of the commencement of such activity by the individual.

Date: 3/23/77

Richard L. Brubacher
Commissioner of Administration

Standards of Performance

For Solar Energy Systems and Subsystems

Applied to Energy Needs of Buildings

Public Hearing
May 17, 1977

State of Minnesota
Department of Administration
Building Code Division
408 Metro Square Building
St. Paul 55101

INDEX

SBC 6101.....Purpose

SBC 6102.....Enforcement

SBC 6103.....Rules

SBC 6104.....Disclosure Statement

SBC 6105.....Definitions

SBC 6106.....Solar Systems

SBC 6107.....Solar Subsystems

SBC 6108.....Appendices

Appendix A Reference Standards and Test Methodology

Appendix B Calculation Procedures - Solar Systems

SBC 6109 through SBC 7099.....Reserved for future Use

SECTION 6101

PURPOSE

A. These Rules are authorized by Minn. Stat. §§ 116H.127 and 16.85 (1976) and established through the rule making procedures set forth at Minn. Stat. § 15.0411, et seq.

B. These Rules shall apply to solar energy systems which are used to satisfy space heating and/or space cooling and/or domestic or service hot water demands of buildings, and shall be used for all solar energy systems and subsystems as those terms are defined at Section 6105 herein. These Rules are to be used in conjunction with existing Building Codes and Standards and do not replace existing Building Codes.

C. The purpose of these Rules is twofold: first, to establish standards for the evaluation of the performance, durability, reliability and maintainability of solar energy systems and subsystems; and second, to require disclosure by the seller to each potential buyer of the extent to which the seller's solar energy system or subsystem meets or exceeds the Standards set forth at Sections 6106 and 6107 herein.

D. The Standards set forth herein are in reasonable conformance with Interim Performance Criteria for Commercial Solar Heating/Cooling Systems and Facilities (NASA), Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings (NBS), and Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (HUD).

E. The Standards set forth herein are intended to serve as a model for evaluating solar energy system or subsystem performance. These Rules require that the seller determine and disclose the extent to which its system or subsystem meets or exceeds these Standards. These Rules do not require the seller to comply with the Standards.

SECTION 6102

ENFORCEMENT

A. The building official in each municipality shall enforce the Rules set forth in Section 6103 herein. The building official shall not issue any permits required for installation of the electrical, mechanical or structural aspects of the solar energy system or subsystem until the seller has furnished the building official a copy of the completed Disclosure Statement Form required by these Rules. However, the building official shall not be required to determine the accuracy of the seller's disclosures or to otherwise determine the extent to which the seller's solar energy system or subsystem meets or exceeds the Standards set forth in Sections 6106 and 6107 herein.

B. Any person who violates the provisions of these Rules or knowingly submits false information in the required Disclosure Statement Form shall be guilty of a misdemeanor and may be subject to a civil penalty of not more than $10,000 for each violation. See Minn. Stat. § 116H.15 (1976).

SECTION 6103

RULES

A. Every seller of a solar energy system or subsystem shall inform every bonafide prospective buyer of the extent to which the seller's system or subsystem meets or exceeds the Standards set forth at Sections 6106 and 6107 herein.

B. The information required by Section 6103.A above shall be provided on the Disclosure Statement Form set forth at Sections 6104.A and 6104.B herein.

C. A copy of the operation and maintenance manual described at Section 6106.6 herein shall be available for review by a bonafide prospective buyer, and shall be provided to each buyer upon sale of the solar energy system or subsystem.

D. The seller of a solar energy system or subsystem shall complete the Disclosure Statement Form, including Section 6104.C; and shall submit copies to the buyer at the time of sale and to the municipal building official prior to installation.

E. Where the solar energy system or subsystem includes flat plate collectors, or any other collectors whose thermal performance is capable of being rated in accordance with ASHRAE Standard 93-77 "Methods of Testing to Determine the Thermal Performance of Solar Collectors", such collectors shall be tested in accordance with the methods set forth at ASHRAE Standard 93-77. No other tests are required by these Rules; however, the seller shall fully disclose on the Disclosure Statement Form the bases for its determinations as required on the Disclosure Statement Form, and where the determinations are not substantiated by testing, the seller shall so indicate.

SECTION 6104

DISCLOSURE STATEMENT

A. Compliance. The purpose of this Statement is to disclose to the buyer the extent to which this system meets the standards for solar systems set forth in the State Building Code.

1. This system/subsystem/component meets or exceeds the standards set forth at State Building Code Sections 6106 and 6107 except as noted in 3 below.

2. The seller's determination that these standards have or have not been met are based on the following tests, computations, and documentation, which are available for review by the buyer:

SBC SECTION	TESTS, COMPUTATIONS, AND DOCUMENTATION

3. This system (subsystem/component) does not meet or exceed the standards set forth at State Building Code Sections 6106 and 6107 in the following respects:

4. The seller may explain below any reasons for the system (subsystem or component) not meeting the standards set forth at State Building Code Sections 6106 and 6107 and may indicate the extent to which the system does meet the standard.

B. Design Life. The manufacturer of solar energy systems shall outline herein the design life of systems and subsystems under anticipated design conditions. This is not a warranty or a guarantee of this life.

1. Design life of solar energy system, with normal maintenance as described by manufacturer _____

2. Design life of subsystems and components, with normal maintenance as described by manufacturer

   Collector subsystem _____

   Transport subsystem _____

   Storage subsystem _____

   Control subsystem _____

C. Solar Energy System Performance.

Sizing. Sizing of the previously identified solar energy system is outlined below. All load calculations are performed in accordance with Appendix A and/or B.

Calculated facility heating consumption _____

Calculated service hot water consumption _____

Calculated facility cooling consumption _____

Other calculated facility energy consumption as may be offset by solar energy system. _____

TOTAL CALCULATED FACILITY CONSUMPTION _____

Solar Contribution. Solar contribution, as calculated in accordance with Appendix B, shall be provided as follows: (Calculations which have been substantiated by field testing of solar system/subsystems and components are an acceptable submission in lieu of Appendix B Calculation Procedures.)

Calculated solar contribution to space heating consumption ____%

Calculated solar contribution to service hot water consumption ____%

Calculated solar contribution to facility cooling consumption ____%

Calculated solar contribution to other consumption ____%

CALCULATED SOLAR CONTRIBUTION TO TOTAL CONSUMPTION ____%

Section 6105

DEFINITIONS

Abbreviations. DHW Domestic Hot Water

H Heating

HC Heating/Cooling

UV Ultra violet

Absorptance. The ration of the amount of radiation absorbed by a surface to the amount of radiation incident upon it.

Absorptivity. The capacity of a material to absorb radiant energy.

Active solar system (Flat plate or concentrating collector based). A system characterized by the use of powered mechanical equipment to move the heat transfer fluid (liquid or gas) through a collector and from a collector to load or storage.

Auxiliary energy subsystem. Equipment utilizing conventional energy sources both to supplement the output provided by the solar energy system and to provide full energy backup during periods when the solar H or DHW systems are inoperable.

Cathodic protection - Corrosion protection against electrolytic reactions.

Chemical compatibility - The ability of materials and components in contact with each other to resist mutual chemical degradation, such as the chemical degradation caused by electrolytic action or plasticizer migration.

Collector efficiency (instantaneous). The ratio of the amount of energy removed by the transfer fluid per unit of aperture (entrance window area) over a 15 minute period to the total incident solar radiation onto the same collector area for the same 15 minute period (as defined by NBSIR 74-635).

Collector subsystem. The assembly for absorbing solar radiation, converting it into thermal energy, and transferring the thermal energy to a heat transfer fluid.

Combined system (combined collectors and storage devices). A combined component system characterized by system with integral construction and operation of the components such that the solar radiation collection and storage phenomena cannot be measured separately in terms of flow rate and temperature changes.

Control subsystem. An assembly of devices and its electrical, pneumatic or hydraulic auxiliaries used to regulate the processes of collecting, transporting, storing and utilizing energy.

Design life. The period of time during which a solar energy system or component is expected to perform without major maintenance or replacement.

Dielectric fitting. An insulating or nonconducting fitting used to isolate electrochemically dissimilar materials.

Emittance. The ratio of the radiant energy emitted by a body to the radiant energy emitted by a black body at the same temperature.

Facility. Means a building or structure including appliances, heating or cooling equipment, industrial or manufacturing processes to be served by the solar energy system.

Flow condition. The condition existing in the solar energy system when the heat transfer fluid is flowing through the collector under normal operating conditions.

Fluid requiring special handling. Fluid which is a "highly toxic substance" or a "toxic substance" as defined by paragraphs 191.1(e) and (f) of the Federal Hazardous Substances Labeling Act, Regulations, Part 191, Chapter I, Title 21(A); or fluid having a degree of flammability such that it is a "flammable substance" or an "extremely flammable substance" as defined by application of the Tagliabue Open-Cup Flash Point Test (stated in the Hazardous Substances Act, Public Law 86-613, July 12, 1960).

Heat generated cooling. The use of thermal energy to operate an absorption refrigerating unit.

Heating degree days. The number of degrees that the daily mean temperature is below 18.3°C. (65°F.).

Maximum "flow" temperature - The maximum temperature obtained in a component when the heat transfer fluid is flowing through the system.

Maximum "no-flow" temperature - The maximum temperature obtained in a component when the heat transfer fluid is not flowing through the system.

Maximum service temperature - The maximum temperature to which a component will be exposed in actual service, either with or without the flow of heat transfer fluid.

Operating energy - The conventional energy required to operate the H, HC and HW systems, excluding any auxiliary energy which supplements the solar energy collected by the systems (e.g., the electrical energy required to operate the energy transport and control subsystems).

Outgassing. The emission of gases by component materials usually during exposure to elevated temperature or reduced pressure.

Passive solar system (Integral collector, storage and building). A passive system characterized by collector and storage components which are an integral part of the building. Auxiliary energy may be used for control purposes but heating is achieved by natural heat transfer phenomena. Roof ponds, modified walls, roof sections with skylights, or similar applications where solar energy is used to supply a measurable fraction of the building heating requirements are examples of passive systems.

Solar energy system. An assembly of subsystems and components which is designed to convert solar energy into thermal energy.

Transmittance. The ratio of the radiant flux transmitted through and emerging from a body to the total flux incident on it.

Section 6106

STANDARDS FOR EVALUATION OF SOLAR ENERGY SYSTEMS

A. Scope. This section contains design criteria for evaluation of performance and quality of solar systems.

B. Solar System Performance. The solar system shall be capable of collecting and converting solar energy into thermal energy. The thermal energy shall be used to meet the total energy needs for space heating, cooling and water heating alone or in combination with storage and auxiliary energy, as required. The solar system shall supply more energy to the demand of the facility for which it is installed than is required for the solar systems.

1. Solar energy system sizing. The solar system combination shall be based upon monthly average heat loads determined by a degree-day method using average monthly design temperature and conditions as the maximum analytical time interval. Building heat loss shall be determined by historical energy use data or calculation. Calculation of building heat loss for use in sizing solar energy systems shall be performed for the full heating and/or cooling season using the method described in Appendix B.

2. Solar Energy System Contribution. The average yearly contribution of solar energy to the operation of the solar systems shall be specified in the Disclosure Statement and shall result in a reduction in the annual consumption of conventional energy. The solar energy contribution shall be determined as a percentage of the average annual space conditioning and water heating energy requirements less solar system operating energy demand. Analytical simulations or correlations based upon simulations combining the building heating and cooling loads, solar system performance and climatic conditions shall be utilized to predict the average monthly and annual energy contribution to be provided by solar energy, auxiliary energy and electrical operating energy as illustrated in Appendix B.

(Calculations which have been substantiated by field testing of solar system/subsystems and components are an acceptable submission in lieu of Appendix B Calculation Procedures.)

C. Durability and Reliability.

1. Structural. The structural design of the solar system including connections and supporting structural elements shall be based on loads anticipated during the design life of the systems.

a. Service loads. The following additional loads shall be used in the structural design of conventional and non-conventional elements and connections of H, HC and DHW systems:

(1) Constraint loads caused by the environment, normal functioning of the system and time-dependent changes within the materials of the system shall be taken as the most severe likely to be encountered during the design life.

(2) Ice loads (I) shall be taken as those produced by the accumulation of ice on surfaces exposed to the natural environment. The thickness of ice shall be taken as a radial thickness of ½ inch.

(3) Hail loads. System components and supporting structural elements that will be exposed to the natural environment in service shall be designed to resist, without excessive damage or major impairment of the functioning of the system, the perpendicular impact of falling hail having a particle diameter of 3/4 inch. "Excessive damage or major impairment" shall not include punching or local cracking of nonstructural elements such as glass cover plates of collector panels under hail impact, but shall include damage which creates a major curtailment in the functioning of the system, premature failure or hazards created by excessive shattering of glazed elements.

2. Mechanical stresses. Mechanical stresses that arise within the system shall not cause damage or malfunction of the system or its components.

   a. Vibration stress levels. Vibrations in collectors, piping, ducts, instrumentation lines, and control devices shall be controlled to reduce stress levels below those that could cause fatigue and subsequent component damage.

   b. Components involving moving parts. Components that involve moving parts shall be capable of performing their intended function without excessive wear or deterioration for their design lives with normal maintenance.

   c. Wear and fatigue. Check valves, pressure regulators, pumps, electrical switches, and similar components shall be capable of operating under in-use conditions for their design lifespans without exhibiting wear or fatigue to a degree that would effect the performance as declared in Disclosure Statement form.

   d. Flexible joints. All systems employing heat transfer fluids shall be designed to accommodate flexing of subsystems and components.

3. Temperature and pressure resistance. Components shall be capable of performing their functions for their design lives when exposed to the temperatures and pressures that may develop in the system under both flow and no-flow conditions.

   a. Thermal cycling stresses. The solar energy system shall be capable of withstanding the stresses induced by thermal cycling for their respective design lives.

   b. Thermal changes. The solar energy system shall be designed to allow for the thermal contraction and expansion that may occur over the service temperature range.

c. Thermal degradation. Solar energy systems shall not thermally degrade to the extent that their function will be reduced to a degree that will effect the performance as declared in Appendix A.

d. Relief valves and vents. As required for protection of a particular system design, combination temperature and pressure relief valves, vacuum relief valves, separate pressure relief valves, pressure reducing valves, and/or atmospheric vents shall be provided.

4. Materials Compatibility. All materials which are joined to or in contact with other materials shall have sufficient chemical compatibility with those materials to prevent deterioration that may impair their functions to a degree that would effect the performance as declared in Disclosure Statement form. Allowances shall be made for differences in the expansion of jointed materials.

a. Corrosion of dissimilar materials. Non-isolated dissimilar materials with or without corrosion resistant finishes, where used either in contact with a transfer fluid, or without such contact, shall not be corroded to the extent that their function is or may be impaired under in-use conditions during their intended design lives. Dissimilar materials joined to form the transport system shall be electrically isolated from each other unless documentation is provided to demonstrate that the joints are sufficiently compatible to prevent corrosive wear and deterioration to the extent that their function would be impaired to a degree that would effect the performance as declared in Disclosure Statement form.

b. Corrosion by leachable substances. Chemical substances that can be leached by moisture from any of the materials within the system shall not cause corrosive deterioration of any other components that may impair the ability of these components to perform their intended function as declared in Disclosure Statement form.

c. Effects of decomposition products. Chemical decomposition products that are expelled from components under in-use conditions shall not cause the degradation of other components within the system to the extent that it would impair their ability to perform their intended functions to a degree that would effect the performance as declared in Disclosure Statement.

5. Erosion/Corrosion. The solar system and components shall not be adversely affected by erosive wear (such as by the flow of a liquid transfer medium) to an extent that will impair their functions during their intended design lives.

6. Heat or humidity transfer effects. Heat or humidity transfer from the collector, thermal storage, piping or other components of the solar system or subsystem shall not interfere with the efficient operation of the solar system or cause loss of control of temperature, humidity or other controlled conditions.

7. Effects of external environment. The solar systems for heating (H) and combined heating and cooling (HC) and the hot water (HW) system/subsystem and their components shall not be affected by external environmental factors to an extent that will impair their performance as declared in Disclosure Statement form.

a. Solar Degradation. Components or materials that are exposed to sunlight shall not undergo changes in their properties during their design lives that would impair the function of the system to a degree that would effect the performance as declared in Disclosure Statement form. When components or materials are exposed to UV radiation in combination with an intermittent water spray at their maximum "no-flow" temperature, there

shall be no excessive deterioration such as cracking, crazing, embrittlement, etching, loss of adhesion, changes in permeability, loss in flexural strength or any other changes that may affect the performance of the components in the system.

b. Soil Corrosion. Materials that are intended to be buried in soils shall not be degraded under in-use conditions to an extent that may impair their functions during their intended design lives.

c. Airborne Pollutants. Materials exposed under in-use conditions to airborne pollutants such as ozone, salt spray, sulfur dioxide, oxides of nitrogen and/or hydrogen chloride shall not be affected by those pollutants to an extent that may impair their functions during their intended design lives.

d. Growth of fungi. Components and materials used in the solar systems shall not promote the growth of fungi, mold or mildew.

D. Maintainability.

1. Accessibility for maintenance and servicing. The solar system shall be designed, constructed, and installed to provide adequate access for general maintenance and convenient servicing.

2. Service Personnel. The solar systems shall be capable of being serviced by a trained service technician using a maintenance manual.

3. Replacement Parts. Parts, components, and equipment required for service, repair or replacment shall be commercially available or available from the system or subsystem manufacturer or supplier.

4. Draining and filling of liquids. To facilitate system or subsystem maintenance and repair, subsystems employing liquids shall be capable of being filled and drained.

5. Flushing of liquid subsystems. Suitable connections shall be provided for the flushing (cleaning) of liquid energy systems and subsystems.

6. Installation, operation and maintenance manual. A manual shall be provided to the purchaser for the operation and maintenance of the solar energy system/subsystem. An installation manual shall be provided to the trained service technician for installation and repair of the solar energy system/subsystem.

   a. Installation instructions. The manual shall include physical, functional and procedural instructions describing how the components of the solar energy system are to be installed. These instructions shall include descriptions of both interconnections among the system components and their connections with the facility and site.

   b. Maintenance and operation instructions. The manual shall completely describe the H, HC and DHW systems, their breakdown into subsystems, their relationship to external systems and elements, their performanc characteristics, and their required parts and procedures for meeting specified capabilities. The manual shall list all parts of the system, by subsystem, describing as necessary for clear understanding of operation, maintenance, repair and replacement such characteristics as shapes, dimensions, materials, weights, functions and performance characterisitics. The manual shall include a tabulation of those specific performance requirements which are dependent upon specific maintenance procedures. The maintenance procedures, including ordinary, preventive and minor repairs, shall be cross-referenced for all subsystems and organized into a maintenance cycle. The manual shall fully describe operation procedures for all parts of the system including those required for implementation of specifed planned changes in mode of operation. The manual shall include instructions for the inspection, treatment, and disposal of transfer fluids used in the system.

c. Maintenance Plan. The maintenance manual shall include a comprehensive plan for maintaining the specified performance of the solar system for its design life. The plan shall include all the necessary ordinary maintenance, preventive maintenance and minor repair work and projections for equipment replacement.

d. Manual adjustment. If manual control adjustments are required during normal operation of the system/subsystem, the operating instructions shall enumerate the time period over which these adjustments must be made and the environmental conditions requiring such adjustments.

Duct and fan systems shall be protected against accumulations of deposits of dust, dirt or fungi that reduce flow and efficiency.

3. Automatic pressure and temperature relief valves for flammable or combustible fluids. The fluid transfer systems shall include a pressure relief valve. The valve and its discharge system shall not permit fluid discharge into occupied space. A holding tank shall be included in the system for collection of discharge expected from the relief valve. The pressure relief valve shall be designed based on maximum temperature criteria for abnormal operating conditions. (ΔP must be limited to comply with temperature criteria.) It shall prevent further increase in temperature and provide discharge in the same manner as the pressure relief valve. Maximum fluid temperature at which temperature relief valve shall operate:
   a. 37.8°C. (100°F.) below firepoint of fluid.

4. Detection of highly toxic and flammable fluids. If heat transfer fluids that are highly toxic and/or flammable are used, means shall be provided for the detection of leaks and the warning of occupants when leaks occur.
5. System Drainage. System designs incorporating automatic drainage of heat transfer fluid or storage to prevent freezing of the fluid in solar collectors shall not be constructed of materials which corrode in the presence of air or shall be suitably protected against such corrosion. Liquid systems, system components, piping or storage tanks shall be designed for complete isolation and drainage for maintenance purposes.
6. Heat Transfer Fluids. The heat transfer fluid shall not cause deleterious effects to those parts of the solar energy system with which it comes into contact. Except when such changes are allowed by the design of the system,

Section 6107

STANDARDS FOR EVALUATION OF SOLAR SUBSYSTEMS

A. Scope. This section contains design criteria for evaluation of performance and quality of solar subsystems. Solar subsystems shall include but not be limited to the following:

1. Collector subsystems.
2. Energy transport subsystems.
3. Storage subsystems.
4. Control subsystems.

B. Collector Subsystems.

1. Transmission losses due to outgassing. Outgassing of volatiles that will reduce collector performance below specified design values shall not occur when the collector is exposed to the temperature and pressure that will occur in actual service.
2. Condensation. Condensation formed on the underside of the cover plate(s) shall not reduce its transmittance during its design life to a degree that would effect the performance as declared in Disclosure Statement form.
3. Dirt retention. The cover plate(s) under normal weather conditions shall not, with normal maintenance, collect or retain dirt to an extent that would reduce its ability to transmit sunlight to a degree that would effect the performance as declared in the Disclosure Statement Form.
4. Damage by hail. Refer to SBC 6106C.1.a.(3).

C. Transport and Storage Subsystems.

1. Entrapped air. When liquid heat transfer fluids are used, the system shall provide suitable means for air removal.
2. Protection against blockage of fluid flow. The entire heat transport system shall be protected to prevent contamination by foreign substances that may impair the flow and quality of the heat transfer fluid to a degree that would effect the performance as declared in Disclosure Statement form.

the heat transfer fluid shall not freeze, give rise to excessive precipitation, otherwise lose its homogeneity, boil, change pH or undergo large changes in viscosity when exposed to its intended service temperature and pressure range.

7. Contamination. Thermal transfer system and storage materials, including any interior protective coatings and the heat storage medium used, shall not contaminate potable water nor ventilation air.

D. Control Subsystems. The control subsystem shall provide for the safe and efficient operation of the solar systems/subsystems.

1. The solar energy system controls shall prevent major damage to system components in the event of power failure or other system malfunction.
2. Identification and location of controls. Main shutoff valves and switches shall be conspicuously marked and placed in readily accessible locations.
3. Bypass. The control subsystem shall include such provision for manual bypass, adjustment, or over-ride of automatic controls as is required to facilitate installation, startup, shutdown and maintenance.

APPENDIX

Reference Standards and Test Methodology

The following standards have been exerpted from the documents referenced below. Use of these standards and tests is mandatory for evaluation of systems, subsystems, and components.

ASTM American Society for Testing and Materials, 1916 Race St., Philadelphia, Penn. 19103

HUD NBSIR 76-1059 Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems April, 1976, 415 7th Street S.W., Washington D.C. 20410

NASA 98M 10001 Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities February 28, 1975 National Aeronautics & Space Admin., Solar Heating & Cooling Office, Marshall Space Flt. Cntr., Huntsville, Alabama 35812

NBS Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings January 1, 1975, U.S. Dept of Commerce, Washington, D.C. 20234

ASHRAE 93-77 "Methods of Testing to Determine the Thermal Performance of Solar Collectors", ASHRAE Circulation Sales Dept., 345 E. 47th Street, New York, NY 10017

SOLAR SYSTEM - Durability/Reliability

A. Materials Compatability

1. Effects of decomposition products - NASA Chapter 5, Section 15
2. Material compatability test - NASA Chapter 5, Section 13
3. Absorbtive coatings, compatibility with heat transfer medium - ASTM D-1308-57, 1973
4. Transport subsystem, materials used for transporting fluids - HUD Appendix Table B-2

   Materials/transfer fluid compatibility - ASTM D 2570-73

   NBS Appendix Section 12
5. Gaskets and sealants

   Chemical and physical compatibility - ASTM F82-67, 1973

   Deterioration of gaskets and sealants - NASA Chapter 5, Section 10

B. Effects of the external environment

1. Growth of fungi, mold or mildew

   Section 10, UL 181-74

   Method 508 MIL-STD-810

2. Solar degradation - NASA Chapter 5, Sections 01, 02, 03

3. Soil corrosion - NASA Chapter 5, Section 04

4. Airborne pollutants - NASA Chapter 5, Section 5

5. Collector subsystem

   Cover plate, UV stability - ASTM E-424-71

   Absorber plate, UV stability - ASTM D822-60, 1973

   (modification of above) HUD 515 2.4.3

   Moisture stability - ASTM D2247-68, 1973

6. Organic coupling hoses

   UV stability - ASTM D750-68, 1974

   Compatibility with heat transfer fluid - ASTM F82-67, 1973

   Ozone degradation - ASTM D1149-64, 1970

C. Temperature and pressure resistance

1. Thermal cycling stresses - NBS Appendix, Section 08

2. Thermal degradation test - NASA Chapter 5, Appendix, Section 06

3. Leakage - NBS Appendix, Section 09

4. Absorptive coatings, thermal stability

   ASTM D660-44, 1970; D661-44, 1975; D714-56, 1974; D772-47, 1975

5. Gaskets and sealing pressurized systems test - ASTM D1081-60, 1974

COLLECTOR SUBSYSTEMS

A. Collector performance. Collector thermal performance test - NBSIR 74-635

B. Durability and reliability of collector subsystems. Outgassing, transmission losses due to - NASA Chapter 5, Section 11

C. Durability/reliability of transport subsystems. Deterioration of heat transfer fluids - NBS Appendix, Section 07.

APPENDIX B

Calculation Procedures - Solar Systems

NOMENCLATURE

A_c	Collector aperture area (ft^2) (M^2)
$(\dot{m}c_p)$	Min fluid capacitance [Btu/(h^oF)] (Watts/^oC)
c_p	Fluid capacitance [Btu/(lb^oF)] (Joules/Kg - ^oC)
D_1, D_2	Dimensionless parameters
Δt_d	Temperature difference for building design temperature conditions (^oF)
Δt	Total number of hours in a particular month (h)
ε_c	Effectiveness of the collector-storage heat exchanger
ε_L	Effectiveness of the load heat exchanger
θ	Collector tilt (^{o})
E	Solar energy supplied for a particular month (Btu/month)(Joule/month)
E_{total}	Solar energy supplied for an entire year (Btu/year) (Joules/year)
f	Monthly fraction of total heating load supplied by solar energy
F_{annual}	Yearly fraction of the total heating load supplied by solar energy
F_R	Collector heat removal factor
F_R'	Combined form of the collector heat exchanger effectiveness and the collector heat removal factor (F_R)
γ	Solar collector azimuth angle (for due south = 180^o)
$\bar{I}_H$	Monthly average of the daily radiation incident on a horizontal surface [Btu/($day \cdot ft^2$)] (Joule/Day - M^2)
$\bar{I}_T$	Monthly average of the daily radiation incident on a tilted surface [Btu/($day \cdot ft^2$)] (Joul /Day - M^2)
$\bar{K}_t$	Ratio of the monthly averages of the daily radiation on a horizontal surface to the extraterrestrial radiation on a horizontal surface
K_1	Correction factor to correct f for various storage capacities other than 15 Btu/($^oF \cdot ft^2$) (306,620 Joule/^oC - M^2)

K_2	Correction factor to correct for $_L(\dot{m}c_p)$min/UA other than 2
L	Total heating and hot water load for a particular month (Btu/month) (Joules/month)
L_{Total}	Total heating and hot water load for an entire year (Btu/year) (Joules/year)
m	Mass of domestic hot water used for a particular month (lb)(kg)
$\dot{m}$	Flow rate of the working fluid either air or liquid (lb/hr) (kg/hr)
M	Mass of thermal storage (lb) (kg)
N	Number of days in a particular month
ϕ	Latitude
Q_s	Space heating load for a particular month (Btu/month) (Joules/month)
Q_w	Domestic hot water heating load for a particular month (Btu/month)
q_d	Building design rate of sensible heat loss (Btu/h) (Watts)
$\bar{R}$	Ratio of the monthly average daily radiation on a tilted surface to that on a horizontal surface
S	Monthly incident solar radiation on a tilted surface Btu/(month·ft^2) (Joules/month·M^2)
$\bar{t}_a$	Average ambient air temperature for the particular month
t_s	Temperature of domestic hot water supply (^oF) (^oC)
t_m	Temperature of water main supply (^oF) (^oC)
t_{ref}	Reference temperature, 212^oF (100^oC)
Δ time	Total number of hours in each month
$\overline{\tau\alpha}$	Average transmissivity-absorptivity product for design purposes
$(\tau\alpha)_n$	Transmissivity-absorptivity product at normal incidence
U_L	Collector heat loss factor Btu/(h·^oF·ft^2) (Watt/^oC - M^2)
UA	Building heat loss factor Btu/(h·^oF) (Watt/^oC)
f_n	Monthly fraction of heating load supplied by solar energy
f_c	Monthly fraction of cooling load supplied by solar energy
f_o	Monthly fraction of other load supplied by solar energy
P.F.	Proportionality factor used to refine heat load calculations based on the 65^o degree-day method.

References Cited

1. Klein, S. A., Beckman, W. A., and J. A. Duffie, "Design Procedure for Solar Heating Systems," presented at the 1975 International Solar Energy Congress, UCLA, Los Angeles, California, July, 1975.

2. B. Y. H. Liu, R. C. Jordan, "Availability of Solar Energy for Flat-Plate Solar Heat Collectors," Low Temperature Engineering Application of Solar Energy, ASHRAE, New York, 1967.

APPENDIX B

Calculation Procedures[1] - Solar Systems

A. Performance measurements for a solar system shall be made using the following outline:

1. Calculate the monthly energy load (heating, cooling).
2. Calculate the monthly incident solar radiation on the collector array.
3. Determine the component parameters, i.e. subsystem efficiencies, capacities, required operating energies, etc.
4. Calculate the monthly fraction of load supplied by solar system.
5. With the monthly loads and monthly fractions supplied by solar, calculate the annual fraction of load supplied by solar energy less solar system operating energy.

B. Specifically, performance measurements for different solar systems shall be made as follows:

1. Combined collector and storage devices. The system thermal performance is determined by the short term (1 to 3 days) collection and storage of thermal energy obtained from solar radiation and the amount of useful energy delivered to the load from storage for part and full load conditions. Experimental performance data, in terms of heat collected and stored or delivered to load, shall be provided for the design conditions including solar power density, heat transfer fluid temperature, ambient temperature, wind, solar radiation incident angle, and flow rates. The daily and average test period electrical operating requirements shall be reported with system performance.
2. Passive (integral) solar systems. The thermal performance of an integral solar system shall be obtained from a detailed simulation analysis of the climate, building thermal properties and occupancy thermal influence.

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1. Klein, S. A., Beckman, W. A., and J. A. Duffie, "Design Procedure for Solar Heating Systems," presented at the 1975 International Solar Energy Congress, UCLA, Los Angeles, California, July, 1975.

3. Active solar systems. Where applicable, collector based solar systems shall use the calculation procedures outlined in paragraph C. below. When different procedures are used due to an incompatability between the system (or subsystem) under study and the outlined procedures, the elected calculation procedure shall be representative of realistic demand, solar radiation, component capacities, efficiencies, required operating energies, etc.

C. Determining monthly load. The monthly load is comprised of heating, cooling, and other service loads that might be offset by the solar system.

1. Total heating load. The total heating load is determined on a monthly basis for both space and hot water heating. The space and hot water heating loads are calculated separately and for combined systems, the monthly individual loads are added to get a monthly total load.

a. Hot water load. Determine the required volume of domestic hot water (gal) required on a monthly basis. Then, knowing the volume, calculate the mass (m) using a value of 8.33 lb/gal (119.8 kg/M^3). Determine the water main temperature (t_m) or assume $t_m = 55^oF.$ (12.8^oC). Calculate the monthly domestic hot water heating load using the following equation:

$$Q_W = \left[\frac{(\text{lb or kg})\ \text{DHW consumed}}{\text{Month}}\right] \left[\text{Specific Heat of Water } \left(\frac{\text{Joule}}{\text{kg-}^oC}\right)\right] \left[\text{Temp. Supply} - \text{Temp. Water Main}\right]$$

For situations where the domestic hot water requirements cannot be reasonably estimated, a load of 1.6×10^6 Btu/month may be assumed for a typical residence. This is equivalent to approximately 90 gallons of hot water use per day.

b. Space heating load. The space heating load for each month shall be calculated using the degree-day method. A P.F. value of 0.75 shall be used unless practical experience in the locality dictates the use of a different value.

(1) To calculate space heating load. Building heat loss shall be calculated according to methods described in the ASHRAE Handbook of Fundamentals or other recognized means. The loss calculations shall include:

Heat loss by transmission:

$Q_{st} = U\ A\ (t_i - t_o)$

Heat loss by infiltration - use (a) or (b):

(a) Air change method

(b) Crack method

In either case, $Q_{si} = .018\ V(t_i - t_o)$

(2) Obtain the monthly total degree days from the ASHRAE Systems Handbook for the particular location for each month.

(3) Add infiltration and transmission losses to obtain design total instantaneous loss. $Q_s = Q_{st} + Q_{si}$

(4) Obtain BTU's per degree day for month.

$$\frac{P.F. \times Q_s \times 24}{t_i - t_o} = Btu/DD$$

Q_s = Heat flow rate, BTU/Hr.

U = Heat transfer coefficient, $BTU/(hr)(ft^2)(F^o)$

A = Area of transfer surface, ft^2

t_i = Design indoor temperature, ^oF

t_o = Design outdoor temperature,

P.F. = Proportionality factor

V = Volume of air (c.f. per hour)

D.D. = Degree day

2. Calculation of cooling and other loads. Calculations of cooling loads and/or other loads that might be offset by the solar system shall be according to the ASHRAE Handbook of Fundamentals or other recognized means.

3. Table A is included for tabulating loads.

D. Determining the monthly incident solar radiation. Table B is included for tabulating the incident solar radiation calculation.

1. Monthly average of the daily radiation incident on a horizontal surface, I_H. For locations near St. Cloud, I_H shall be taken from Table 4A. For other locations, alternate means of determining I_H, such as interpolation from radiation maps, may be used.

2. Ratio of the monthly averages of the daily radiation on a horizontal surface to the extraterrestrial radiation, (K_t). For locations near St. Cloud, K_t shall be taken from Table 4A. For other locations, alternate means may be used.[1] [2]

3. Ratio of the monthly average daily radiation on a tilted surface to that on a horizontal surface for collectors facing due south (R). Using Table 4B and knowing collector tilt (Θ), latitude $(\varnothing)$, and $\overline{K}_t$, determine $\overline{R}$ for each month. K_t may be interpolated.

4. Monthly average daily radiation on a tilted surface, $(\overline{I}_T)$. Knowing $\overline{I}_H$ and $\overline{R}$ for each month, calculate $\overline{I}_T$ on a monthly basis using the equation:
$\overline{I}_T = (\overline{I}_H)(\overline{R})$

5. Total monthly radiation on a tilted surface, (S). $\overline{I}_T$, the monthly average daily radiation on a tilted surface, must be multiplied by the total days in each month, (N) to obtain total insolation for each month.
$S = (\overline{I}_T)(N)$

6. Shading. Shading should not be neglected in calculating the incident solar radiation on a particular collector array. The amount of shading is strongly dependent on the collector site and orientation; thus, each case must be analyzed separately.

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[1] Donald G. Baker and John C. Klink, Solar Radiation Reception, Probabilities and Areal Distribution in the North-Central Region, Agricultural Experiment Station, University of Minnesota, Technical Bulletin 300 (1975).

[2] Donald G. Baker, Climate of Minnesota Part VI Solar Radiation at St. Paul, Agricultural Experiment Station, University of Minnesota, Technical Bulletin 280 (1971).

TABLE 4-A

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
St. Cloud, Minn.	$\bar{I}_H$	632.8	976.7	1383	1598.1	1859.4	2003.3	2087.8	1828.4	1369.4	890.4	545.4	483.1
Lat. 45°35'N	$\bar{K}_t$	0.595	0.629	0.614	0.534	0.530	0.533	0.573	0.570	0.539	0.490	0.435	0.504
El. 1034 ft.	$\bar{t}_q$	13.6	16.9	29.8	46.2	58.8	68.5	74.4	71.9	62.5	50.2	32.1	18.3

Values from "A Rational Procedure for Predicting a Long Term Average Performance of Flat Plate Collectors." Solar Energy, 17, No. 2, 1963. B.Y.H. Liu, R. C. Jordan.

E. Predicting system performance. This procedure does not apply to passive systems or to active systems that do not generally conform to the configuration of Figure 5A or 5B as appropriate. The procedure cannot be used for systems in latitudes farther north than sixty degrees. The procedure is intended to evaluate long-term performance of most solar heating systems using a simple desk calculator or slide rule. Since in most instances flat plate collectors are utilized for heating buildings, the collector component parameters are only valid for modeling flat plate collectors. Concentrating collectors or evacuated tubular collectors cannot be incorporated into the solar heating system evaluation as it is presently written in this Appendix. The system evaluation procedure as outlined in this Appendix can only accurately predict system performance for systems using south facing collector arrays. Cases of different collector orientations must be analyzed using a different procedure.

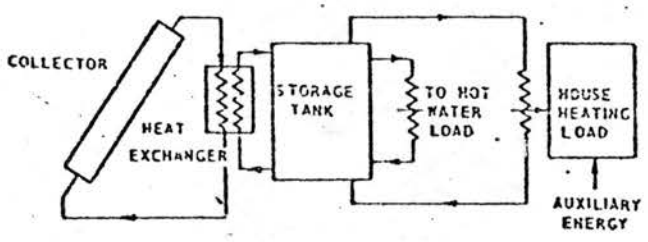


Figure 5-A Liquid System

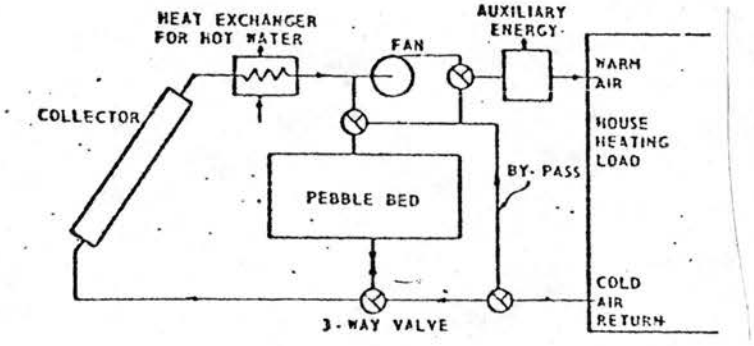


Figure 5-B Air System

TABLE 4B

$\overline{R}$ for $\overline{K}_T$ = .40

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt)= 15.0							
40	1.44	1.35	1.17	1.06	.99	.97	.98	1.03	1.12	1.27	1.39	1.51
45	1.68	1.40	1.24	1.09	1.00	.97	.98	1.05	1.17	1.39	1.58	1.85
50	1.90	1.58	1.32	1.12	1.01	.97	.99	1.06	1.23	1.46	1.92	2.11
					(Latitude - Tilt)= .0							
40	1.61	1.45	1.19	1.03	.93	.89	.91	.98	1.12	1.34	1.53	1.70
45	1.88	1.49	1.26	1.05	.93	.89	.91	.99	1.16	1.47	1.75	2.12
50	2.13	1.69	1.35	1.08	.94	.88	.90	1.01	1.22	1.54	2.14	2.40
					(Latitude - Tilt)=-15.0							
40	1.68	1.48	1.15	.95	.83	.78	.80	.89	1.06	1.34	1.58	1.80
45	1.98	1.51	1.22	.96	.83	.77	.80	.90	1.10	1.47	1.82	2.27
50	2.24	1.72	1.30	.99	.83	.76	.79	.91	1.16	1.53	2.24	2.56
					Vertical							
40	1.51	1.25	.86	.61	.48	.44	.46	.55	.75	1.08	1.39	1.65
45	1.84	1.30	.96	.67	.53	.48	.50	.60	.83	1.25	1.66	2.17
50	2.13	1.54	1.08	.74	.58	.52	.54	.66	.93	1.34	2.12	2.47

TABLE 4B

$\overline{R}$ for $\overline{K}_T$ = .50

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt) = 15.0							
40	1.52	1.40	1.20	1.08	1.00	.97	.98	1.04	1.14	1.32	1.46	1.60
45	1.80	1.47	1.28	1.11	1.08	.97	.98	1.06	1.20	1.45	1.69	1.99
50	2.06	1.68	1.38	1.14	1.02	.97	.99	1.08	1.27	1.54	2.08	2.30
					(Latitude - Tilt) = .0							
40	1.72	1.53	1.24	1.04	.93	.88	.90	.99	1.15	1.41	1.63	1.83
45	2.05	1.59	1.32	1.07	.93	.88	.90	1.01	1.20	1.56	1.89	2.31
50	2.34	1.83	1.42	1.10	.94	.88	.91	1.03	1.28	1.64	2.35	2.65
					(Latitude - Tilt) = -15.0							
40	1.82	1.58	1.20	.96	.82	.77	.79	.90	1.10	1.42	1.71	1.96
45	2.18	1.62	1.28	.98	.83	.76	.79	.91	1.15	1.57	1.99	2.50
50	2.48	1.87	1.38	1.01	.83	.76	.79	.93	1.21	1.65	2.48	2.84
					Vertical							
40	1.66	1.35	.90	.61	.46	.41	.43	.54	.77	1.16	1.51	1.83
45	2.05	1.42	1.01	.68	.52	.45	.48	.60	.86	1.35	1.83	2.42
50	2.37	1.70	1.16	.76	.57	.50	.53	.67	.97	1.46	2.37	2.77

TABLE 4B

$\overline{R}$ for $\overline{K}_T$ = .60

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						(Latitude - Tilt) = 15.0						
40	1.60	1.46	1.23	1.09	1.00	.96	.98	1.05	1.17	1.37	1.53	1.68
45	1.92	1.54	1.32	1.12	1.01	.97	.99	1.07	1.23	1.52	1.79	2.13
50	2.22	1.79	1.44	1.17	1.03	.97	.99	1.10	1.32	1.63	2.24	2.49
						(Latitude - Tilt) = 0						
40	1.84	1.61	1.28	1.06	.93	.88	.90	1.00	1.18	1.47	1.73	1.96
45	2.21	1.69	1.37	1.09	.94	.88	.90	1.02	1.25	1.65	2.03	2.50
50	2.54	1.96	1.50	1.13	.95	.88	.91	1.05	1.33	1.75	2.55	2.90
						(Latitude - Tilt) = -15.0						
40	1.96	1.68	1.25	.98	.82	.76	.78	.90	1.13	1.50	1.83	2.12
45	2.37	1.73	1.34	1.01	.83	.75	.78	.92	1.19	1.68	2.16	2.73
50	2.71	2.07	1.46	1.04	.83	.75	.79	.94	1.27	1.77	2.72	3.13
						Vertical						
40	1.81	1.45	.94	.61	.44	.38	.40	.53	.79	1.23	1.64	2.00
45	2.26	1.53	1.07	.69	.50	.43	.46	.60	.90	1.45	2.01	2.66
50	2.62	1.85	1.23	.78	.56		.52	.67	1.02	1.58	2.61	3.07

TABLE 4B

$\overline{R}$ for $\overline{K}_T$ = .70

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt) = 15.0							
40	1.66	1.50	1.26	1.10	1.00	.96	.98	1.05	1.19	1.40	1.58	1.75
45	2.01	1.60	1.36	1.14	1.02	.97	.99	1.08	1.26	1.57	1.87	2.23
50	2.34	1.87	1.49	1.19	1.03	.97	1.00	1.11	1.35	1.69	2.36	2.63
					(Latitude - Tilt) = .0							
40	1.92	1.68	1.31	1.07	.93	.57	.89	1.00	1.21	1.52	1.80	2.06
45	2.34	1.76	1.42	1.11	.94	.67	.90	1.03	1.28	1.71	2.14	2.65
50	2.70	2.07	1.55	1.16	.95	.68	.91	1.06	1.37	1.83	2.71	3.09
					(Latitude - Tilt) = -15.0							
40	2.07	1.75	1.29	.99	.81	.75	.78	.91	1.16	1.56	1.92	2.25
45	2.52	1.82	1.39	1.02	.83	.75	.78	.93	1.23	1.75	2.28	2.90
50	2.89	2.14	1.53	1.07	.84	.75	.79	.96	1.32	1.87	2.90	3.35
					Vertical							
40	1.92	1.52	.97	.61	.42	.36	.39	.52	.81	1.29	1.74	2.13
45	2.42	1.61	1.11	.70	.49	.41	.45	.59	.93	1.53	2.14	2.85
50	2.81	1.96	1.29	.79	.55	.47	.51	.68	1.06	1.47	2.80	3.30

Component Parameters. The component parameters characterize the various components that make up the system. In cases of design where several different solar heating systems may be considered for the same location and collector tilt, incident radiation on a tilted surface ($\overline{I}_T$) need only be calculated once. In such a case, only the values of the component parameters need to be adjusted for the different systems.

Solar collector. Using collector thermal performance efficiency curves provided by the manufacturer (as determined by test in accordance with NBSIR 74-635) range of operational temperature, insolation, tilt angles and flow rates determine the collector parameters $F_R U_L$ and $F_R(\tau\alpha)$. The thermal efficiency collector curve must be plotted such that the y-axis is the thermal efficiency (η) and the x axis, the temperature difference between the collector fluid inlet and the ambient air divided by the incident solar radiation ($t_i - t_a/I_T$). The thermal efficiency is the ratio of useful output thermal energy to the incident solar energy on the collector aperture area. To determine $F_R U_L$ calculate the slope of a linear curve fit for the efficiency curve. The y-axis intercept is equal to $F_R(\tau\alpha)$.

Collector-Storage Heat Exchanger. To simplify the number of input parameters, the collector-storage heat exchanger effectiveness ε_c, and the collector heat removal factor, F_R, can be combined in a single parameter F_R'. Determine F_R'/F_R by the following equation, or the graphical representation in Figure 5-D .

$$\frac{F_R'}{F_R} = \frac{1}{1 + \left(\frac{F_R U_L A_C}{(\dot{m}\, c_p)_c}\right)\left(\frac{(\dot{m}\, c_p)_c}{\varepsilon_c (\dot{m}\, c_p)_{min}} - 1\right)}$$

where A_c = aperture area of the collector array

$(\dot{m}\, c_p)_{min}$ = minimum fluid capacitance rate of the working fluids across the collector-storage heat exchanger.

$(m\, c_p)_c$ = fluid capacitance rate of the collector working fluid.

ε_c = effectiveness of the collector heat exchanger

$$= \frac{\text{actual heat transfer}}{\text{maximum possible heat transfer}}$$

The water-to-water collector storage heat exchanger effectiveness (ε_c) is easily calculated from methods given in the ASHRAE Handbook of Fundamentals or from data supplied by the manufacturer.

Note: In systems that do not use a collector to storage heat exchanger, the ratio of F_R' to F_R is equal to 1.

$$\frac{F_R'}{F_R} = 1$$

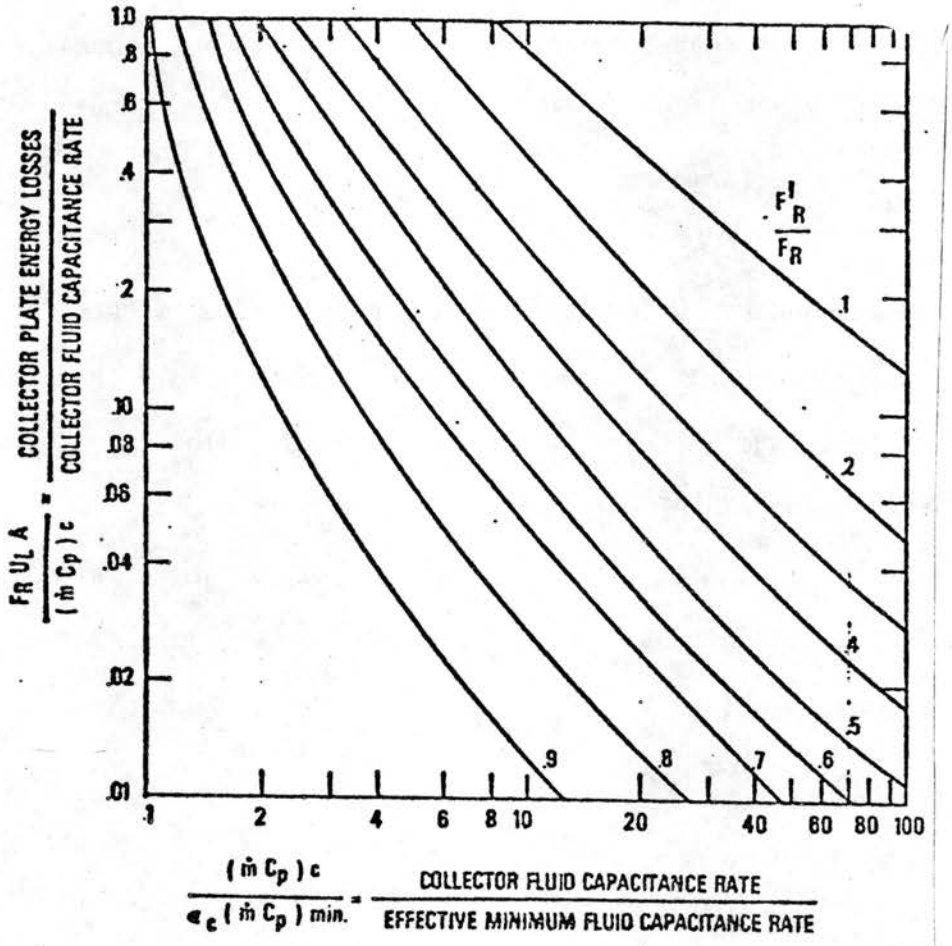


FIGURE 5-D. F_R'/F_R as a function of $F_R U_L A/(\dot{m} C_p)_c$ and $(\dot{m} C_p)_c/\epsilon_L (\dot{m} E_p)_{min}$

Storage. In general for solar heating systems utilizing water or air as heat transfer fluids an average storage capacity of 15 Btu/^{o}F per square foot of collector has been determined as near economic optimum. For storage capacities other than 15 a correction factor will be introduced later to correct the value of the predicted system thermal performance.

Load Heat Exchanger. Determing from the manufacturer's specifications the load heat exchanger effectiveness (ε_L) and calculate minimum fluid capacitance $(\dot{m}c_p)_{min}$ rate across the exchanger. Where ε_L is not provided, values can be determined using procedures in the ASHRAE Handbook of Fundamentals.

Note: Since a load heat exchanger is not usually incorporated into a system using air collectors and air as the transport medium, the load heat exchanger effectiveness may be assumed equal to 1.

Dimensionless Parameters (D_1, D_2). The dimensionless parameters D_1 and D_2 characterize the entire solar heating system thermal effectiveness. Calculate the two dimensionless parameters for each month using the factors defined previously on a monthly basis according to the following equations:

$$D_1 = \frac{\text{energy absorbed by collector plate}}{\text{total heating load}}$$

$$= [A_c]\left[F_R(\tau\alpha)_n\right]\left[\frac{(\overline{\tau\alpha})}{(\tau\alpha)_n}\right]\left[\frac{F_R'}{F_R}\right]\frac{S}{L}$$

$$D_2 = \frac{\text{ref. collector plate energy losses}}{\text{total heating load}}$$

$$= \left[A_c\right]\left[F_R U_L\right]\left[\frac{F_R'}{F_R}\right]\left[t_{ref} - \bar{t}_a\right]\frac{\Delta \text{ time}}{L}$$

t_{ref} = 212°F (arbitrarily chosen reference temperature)

$\bar{t}_a$ = average ambient air temperature for the particular month.

Δ time = total number of hours in each month

$\left[\frac{\overline{\tau\alpha}}{(\tau\alpha)_n}\right]$ = 0.90 to account for the change in the value of the effective transmission-absorption product with incident angle throughout a day.

Monthly Fraction of Total Heating Load Supplied by Solar Energy (f_n). The fraction of the heating load supplied by solar energy (f_n) can be determined from Figure as a function of the dimensionless parameters, D_1 and D_2. Locate the two dimensionless parameters on Figures 5-D and 5-E and determine the fraction of total heating load supplied by solar energy (f_n) on a monthly basis.

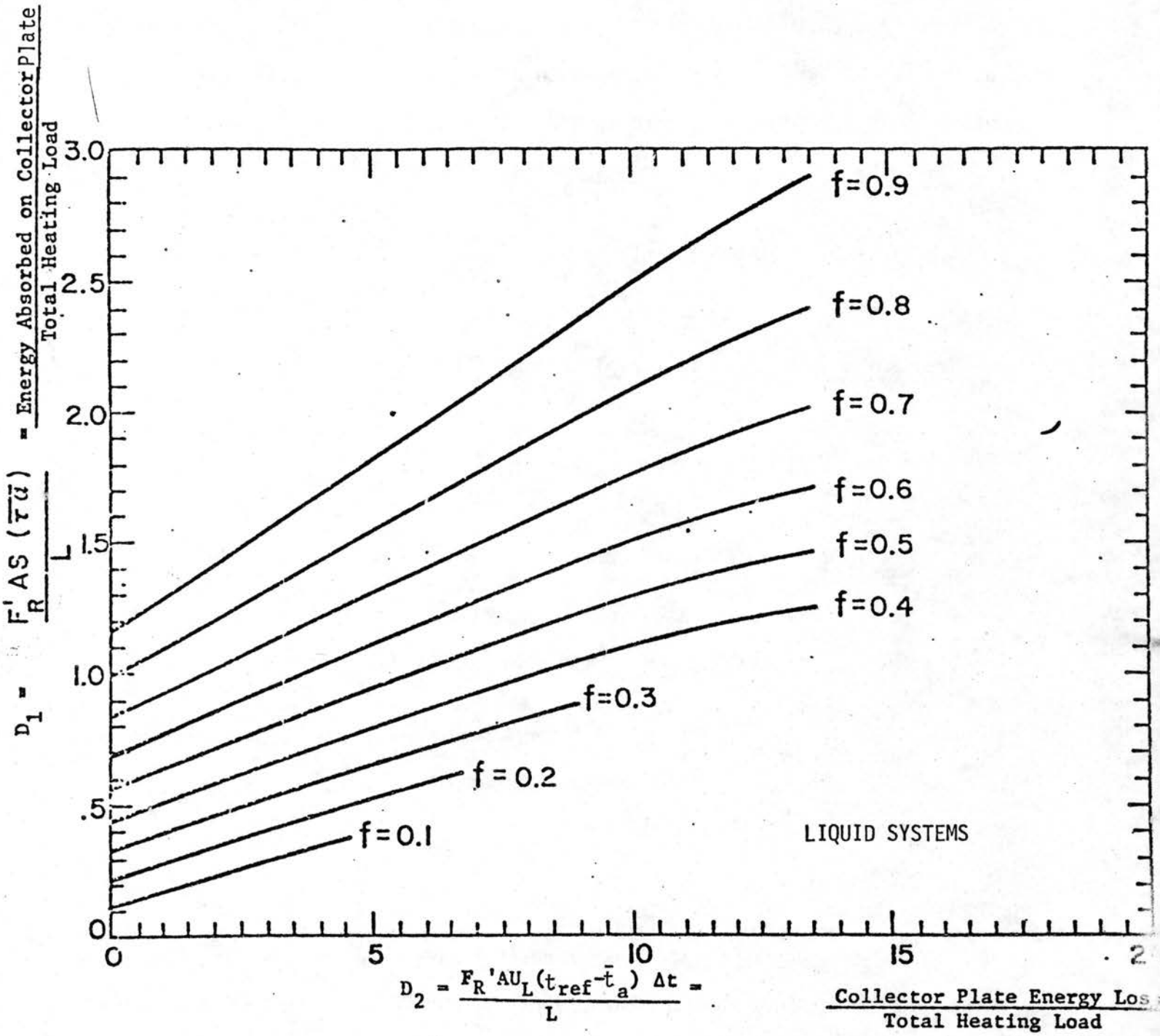


FIGURE 5-D (Liquid systems) Relationship between solar fraction and dimensionless parameters D_1 and D_2.

$$D_1 = \frac{F'_R \, AS \, (\overline{\tau u})}{L} = \frac{\text{Energy Absorbed on Collector Plat}}{\text{Total Heating Load}}$$

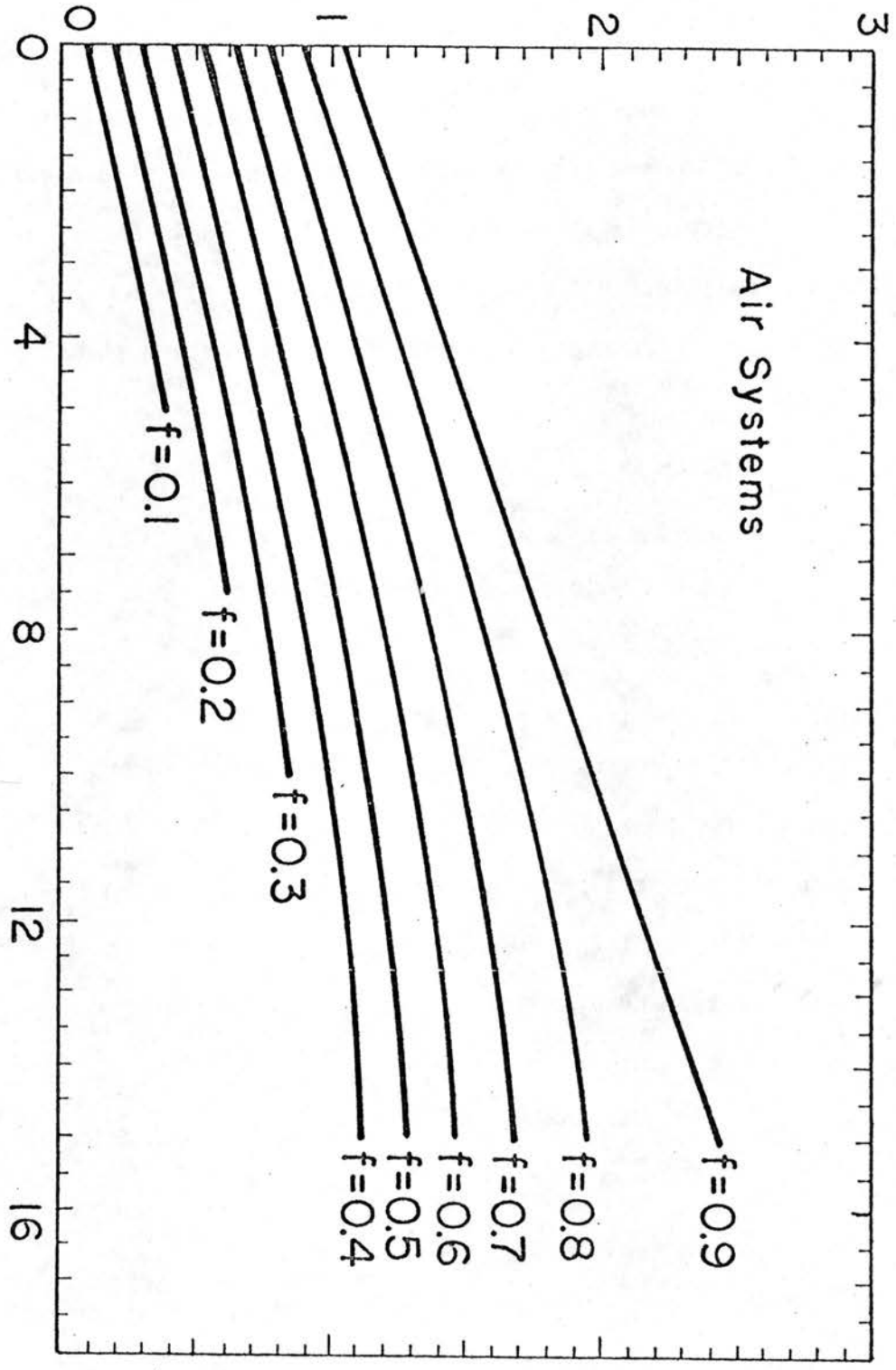


FIGURE 5-E (Air Systems) Relationship between solar fraction and dimensionless parameters D_1 and D_2.

Annual fraction of the total heating load supplied by solar energy (F_{annual}).

It was mentioned earlier that the procedure was intended to only provide an estimate of system performance for a particular month but a relatively good estimate for long-term performance (yearly basis). In order to calculate f on a yearly basis, the following calculations must be performed. Table C has been included for tabulating and calculating f on a yearly basis.

A. The actual solar energy supplied for each month must be calculated as follows:

$E_{Jan} = f_{Jan} L_{Jan}$

$E_{Feb} = f_{Feb} L_{Feb}$

$E_{Dec} = f_{Dec} L_{Dec}$

Total the solar energy supplied for the entire year by summing the contributions from each month.

$E_{Total} = E_{Jan} + E_{Feb} \cdot \cdot \cdot E_{Dec}$

B. Calculate the amount of operating energy required by the solar system, using standard engineering methods.

C. Calculate the total heating load for the entire year (L_{Total})

D. Knowing the total annual solar energy supplied by the heating system (E_{total}) and the total annual heating load (L_{Total}), determine F_{annual} for the entire year from the following equation:

$$F_{annual} = \frac{E_{total} - \text{operating energy}}{L_{total}}$$

E. Correction factors for F_{annual}

1. To correct for various storage capacities other than 15 Btu/($^{o}F \cdot ft^2$), use Figure 5-F to obtain the correction factor (K_1).
2. For cases where ε_L ($\dot{m}c_p$) min/UA is other than 2, use Figure 5-G to obtain the correction factor (K_2).
3. Utilizing the correction factors K_1 and K_2, the corrected and final value of F_{annual} may be calculated as follows:

$$F'_{annual} = (K_1)(K_2)F_{annual}$$

F. Calculation of fraction of cooling and other loads supplied by solar energy (f_c), (f_o). Calculation of cooling and other solar contribution shall be determined in a manner similar to the process described for calculation of heating contribution.

1. Calculate cooling and/or other loads.
2. Apply the following parameters in the same manner as in Sections D and E.
   a. Monthly incident solar radiation
   b. Component parameters
3. Calculate the monthly fraction of load (less operating energy) supplied by solar system.
4. Calculate the annual fraction of load supplied by solar energy. Calculations shall be performed with the same degree of accuracy and with the same completeness, as those for determining solar heating contribution. Tables similar to A, B and C may be used for data presentation.

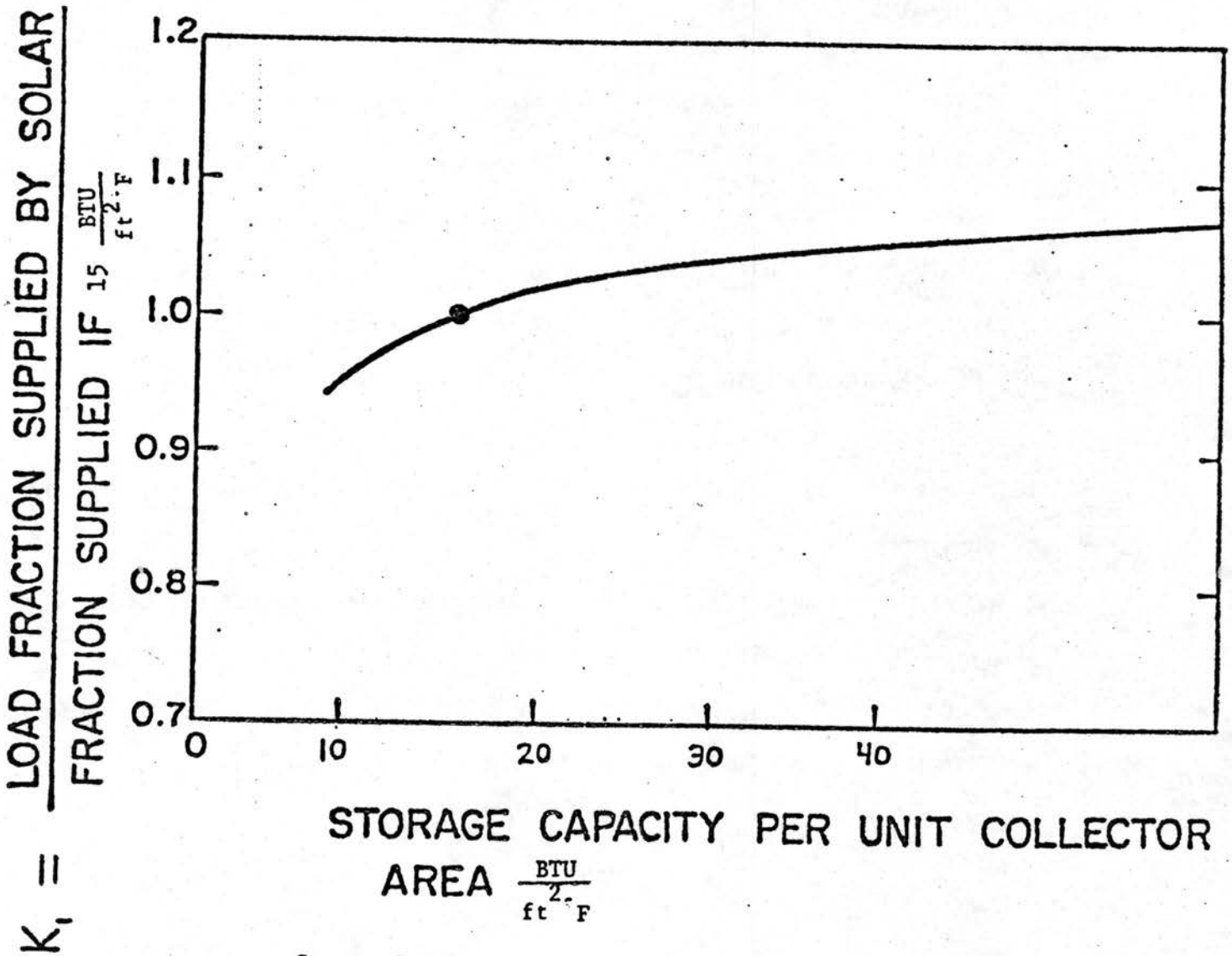


FIGURE 5-F Correction Factor (K_1) for Storage Capacities Other Than 15 BTU/ft^2 °F

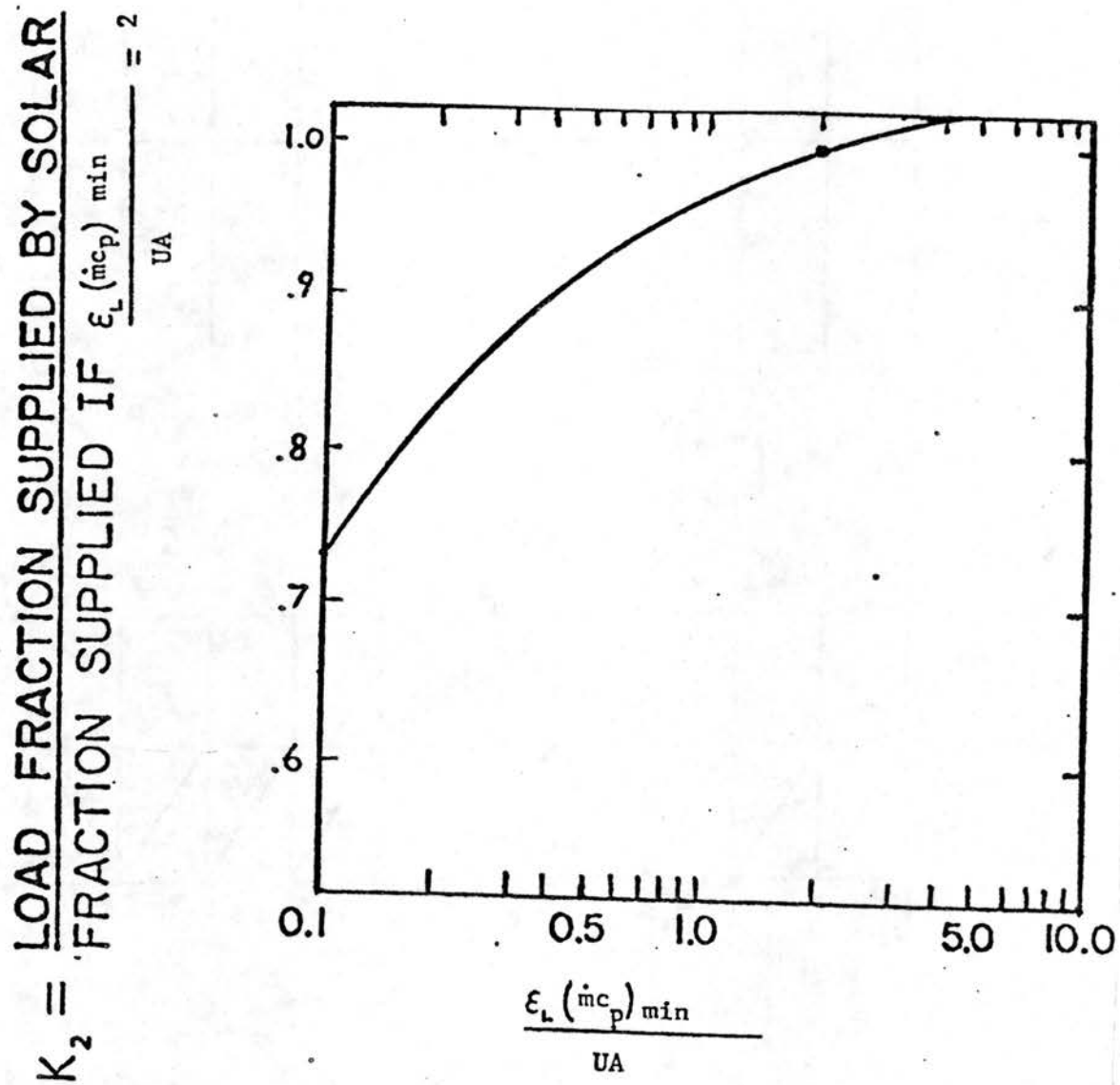


FIGURE 5-G Correction factor (K_2) for various values of $\varepsilon_L (\dot{m}c_p)_{min}$ / UA

TABLE A

DOMESTIC HOT WATER

SPACE HEATING LOAD

	DEGREE DAYS	BTU / MONTH Qs
Jan.		
Feb.		
Mar.		
April		
May		
June		
July		
Aug.		
Sept.		
Oct.		
Nov.		
Dec.		

q_d = _____ BTU/h

ΔT_H = _____ (°F)

UA = _____ BTU/h F

HEATING LOAD

	DHW MONTH m* Gal / lbm	BTU / MONTH Qw

* 1 gal=8.3 lbm

t_s = _____ °F

t_m = _____ °F

TOTAL HEATING LOAD

BTU / MONTH L=Qs + Qw	$\bar{t}_a$ (°F) Ambient Air Temperature

TABLE B

Incident Solar Radiation

	$\frac{BTU}{Day\,ft^2}$ $\overline{I_H}$		$\overline{K_t}$	$\overline{R}$	$\frac{BTU}{Day\,ft^2}$ $\overline{I_T} = \overline{I_H}\overline{R}$	$\frac{BTU}{Month\,ft^2}$ S
Jan						
Feb						
Mar						
April						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Component Parameters

latitude = ____

tilt = ____

I. Collectors

$F_R U_L =$ $\quad \dot{m} =$

$F_R(\tau\alpha)_n =$ $\quad c_p =$

$A_c =$

II. Collector-Storage Heat Exchanger

$F_R'/F_R =$ $\quad \frac{(F_R U_L)A_c}{(\dot{m}\, c_p)_c} =$

$\varepsilon_c =$ $\quad \frac{(\dot{m}\, c_p)_c}{\varepsilon_c (\dot{m} c_p)_{min}} =$

III. Storage

$M =$ $\quad c_p M/A_c =$

IV. Load Heat Exchanger

$\varepsilon_L =$ $\quad \frac{\varepsilon_L (\dot{m} c_p)_{min}}{UA} =$

$(\dot{m}\, c_p)_{min} =$

TABLE C

DIMENSIONLESS PARAMETERS

	BTU / MONTH L	BTU / MONTH ft² S	HRS / MONTH Δt	°F t_a	D1	D2
Jan.			744			
Feb.			696			
Mar.			744			
April			720			
May			744			
June			720			
July			744			
Aug.			744			
Sept.			720			
Oct.			744			
Nov.			720			
Dec.			744			

FRACTION OF THE TOTAL HEATING LOAD SUPPLIED BY SOLAR ENERGY

f	BTU / MONTH E

E total = _____

L total = _____

F annual = $\frac{\text{E total}}{\text{L annual}}$

= _____

K_1 = _____

K_2 = _____

F'annual = (K_1) (K_2) F annual

= _____

APPROVED AS TO FORM AND LEGALITY

OCT 4 1977 19

WARREN SPANNAUS, ATTORNEY GENERAL

BY: /s/ Michael B. Miller

SPECIAL ASSISTANT ATTORNEY GENERAL

STATE OF MINNESOTA
DEPARTMENT OF STATE
FILED
OCT 4 1977
Joan Anderson Growe
Secretary of State
4:05 P.M.

PROPOSED

Standards of Performance

For Solar Energy Systems and Subsystems

Applied to Energy Needs of Buildings

Public Hearing
May 17, 1977

State of Minnesota
Department of Administration
Building Code Division
408 Metro Square Building
St. Paul 55101

INDEX

SBC 6101 . . . . . Authorization

SBC 6102 . . . . . Purpose

SBC 6103 . . . . . Enforcement

SBC 6104 . . . . . Scope

SBC 6105 . . . . . Definitions

SBC 6106 . . . . . Solar Systems

SBC 6107 . . . . . Solar Subsystems

SBC 6108 . . . . . Appendices

Appendix A Disclosure Statement Forms

Appendix B Reference Standards and Test Methodology

Appendix C Calculation Procedures - Solar Systems

Section 6101

AUTHORIZATION

These Rules are authorized by Laws of 1976, Chapter 116H.127, and established through the rule making procedures set forth in Minn. Stat. 15.0411. The purpose of these Rules is twofold: first, to establish standards of quality and performance for solar energy systems and subsystems, and second, to require disclosure to each potential purchaser of a solar energy system and subsystem of the extent to which the proposed system m-ets or exceeds each quality and performance standard.

Section 6102

PURPOSE

The purpose of these Rules is to provide standards for the performance, durability, reliability and maintainability of solar energy systems and subsystems, by which a prospective purchaser may judge the effectiveness and quality of the proposed system.

A. The standards set forth herein are in reasonable conformance with Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities (NASA), Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings (NBS), and Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (HUD).

B. The standards set forth herein provide standard methods for manufacturers, sellers and buyers to determine performance, durability,reliability and maintainability of systems and subsystems.

Section 6103

ENFORCEMENT

A. In all areas of the State which have adopted the State Building Code, the Building Official in each area shall enforce these Rules. The Building Official shall be furnished a copy of the disclosure required by Minn. Stat. 116H.127 as a condition of the issuance of the permit authorizing the installation of solar energy systems.

B. In all other areas of the State these Rules shall be enforced by the Commissioner of Administration or his designated representatives. A copy of the required disclosure shall be submitted to the State Building Inspector.

C. Any person who violates the provisions of these Rules with respect to the required disclosure made to a prospective purchaser, or knowingly submits false information in the required disclosure shall be guilty of a misdemeanor. See Minn. Stat. 116H.15, subd. 1 (1974).

Section 6104

SCOPE

A. These Rules shall apply to solar energy systems which are used to satisfy space heating and/or space cooling and/or domestic or service hot water demands of buildings.

B. These Rules provide standard criteria for the design performance of solar energy systems and subsystems.

C. These Rules require a uniform disclosure of quality and performance information to a prospective purchaser. Each prospective purchaser of a solar energy system/subsystem shall be provided with a disclosure in the form prescribed in Appendix A of these Rules.

D. These Rules shall be used for all solar energy systems and subsystems as those terms are defined herein.

E. These Rules are based on HUD, NASA, and NBS interim criteria for solar heating and combined heating and cooling systems.

Section 6105

DEFINITIONS

Abbreviations. DHW Domestic Hot Water

H Heating

HC Heating/Cooling

UV Ultra violet

Absorptance. The ration of the amount of radiation absorbed by a surface to the amount of radiation incident upon it.

Absorptivity. The capacity of a material to absorb radiant energy.

Active solar system (Flat plate or concentrating collector based). A system characterized by the use of powered mechanical equipment to move the heat transfer fluid (liquid or gas) through a collector and from a collector to load or storage.

Auxiliary energy subsystem. Equipment utilizing conventional energy sources both to supplement the output provided by the solar energy system and to provide full energy backup during periods when the solar H or DHW systems are inoperable.

Cathodic protection - Corrosion protection against electrolytic reactions.

Chemical compatibility - The ability of materials and components in contact with each other to resist mutual chemical degradation, such as the chemical degradation caused by electrolytic action or plasticizer migration.

Collector efficiency (instantaneous). The ratio of the amount of energy removed by the transfer fluid per unit of aperture (entrance window area) over a 15 minute period to the total incident solar radiation onto the same collector area for the same 15 minute period (as defined by NBSIR 74-635).

Collector subsystem. The assembly for absorbing solar radiation, converting it into thermal energy, and transferring the thermal energy to a heat transfer fluid.

Combined system (combined collectors and storage devices). A combined component system characterized by a system with integral construction and operation of the components such that the solar radiation collection and storage phenomena cannot be measured separately in terms of flow rate and temperature changes.

Control subsystem. An assembly of devices and its electrical, pneumatic or hydraulic auxiliaries used to regulate the processes of collecting, transporting, storing and utilizing energy.

Design life. The period of time during which a solar energy system or component is expected to perform without major maintenance or replacement.

Dielectric fitting. An insulating or nonconducting fitting used to isolate electrochemically dissimilar materials.

Emittance. The ratio of the radiant energy emitted by a body to the radiant energy emitted by a black body at the same temperature.

Flow condition. The condition existing in the solar energy system when the heat transfer fluid is flowing through the collector under normal operating conditions.

Fluid requiring special handling. Fluid which is a "highly toxic substance" or a "toxic substance" as defined by paragraphs 191.1(e) and (f) of the Federal Hazardous Substances Labeling Act, Regulations, Part 191, Chapter I, Title 21(A); or fluid having a degree of flammability such that it is a "flammable substance" or an "extremely flammable substance" as defined by application of the Tagliabue Open-Cup Flash Point Test (stated in the Hazardous Substances Act, Public Law 86-613, July 12, 1960).

Heat generated cooling. The use of thermal energy to operate an absorption refrigerating unit.

Heating degree days. The number of degrees that the daily mean temperature is below 18.3°C. (65°F.).

Maximum "flow" temperature - The maximum temperature obtained in a component when the heat transfer fluid is flowing through the system.

Maximum "no-flow" temperature - The maximum temperature obtained in a component when the heat transfer fluid is not flowing through the system.

Maximum service temperature - The maximum temperature to which a component will be exposed in actual service, either with or without the flow of heat transfer fluid.

Operating energy - The conventional energy required to operate the H, HC and HW systems, excluding any auxiliary energy which supplements the solar energy collected by the systems (e.g., the electrical energy required to operate the energy transport and control subsystems).

Outgassing. The emission of gases by component materials usually during exposure to elevated temperature or reduced pressure.

Passive solar system (Integral collector, storage and building). A passive system characterized by collector and storage components which are an integral part of the building. Auxiliary energy may be used for control purposes but heating is achieved by natural heat transfer phenomena. Roof ponds, modified walls, roof sections with skylights, or similar applications where solar energy is used to supply a measurable fraction of the building heating requirements are examples of passive systems.

Solar energy system. An assembly of subsystems and components which is designed to convert solar energy into thermal energy.

Transmittance. The ratio of the radiant flux transmitted through and emerging from a body to the total flux incident on it.

Section 6106

SOLAR ENERGY SYSTEMS

A. Scope. This section contains design criteria for performance and quality of solar systems.

B. Solar System Performance. The solar systems shall be capable of collecting and converting solar energy into thermal energy. The thermal energy shall be used to meet the total energy needs for space heating, cooling and water heating in combination with storage and auxiliary energy, as required. The solar system shall supply more energy to the demand of the facility for which it is installed than is required for its operation.

1. Solar energy system sizing. The solar system contribution shall be based upon monthly average heat loads determined by a degree-day method using average monthly design temperature and conditions as the maximum analytical time interval. Calculation of building heat loss for use in sizing solar energy systems shall be performed for the full heating and/or cooling season using the method described in Appendix C.

2. Solar Energy System Contribution. The average yearly contribution of solar energy to the operation of the solar systems shall be specified in the design and shall result in a reduction in the annual consumption of conventional energy. The solar energy contribution shall be determined as a percentage of the average annual space conditioning and water heating energy requirements less solar system operating energy demand. Analytical simulations or correlations based upon simulations combining the building heating and cooling loads, solar system performance and climatic conditions shall be utilized to predict the average monthly and annual energy contribution to be provided by solar energy, auxiliary energy and electrical operating energy as illustrated in Appendix C.

C. Durability and Reliability.

1. Structural. The structural design of the solar system including connections and supporting structural elements shall be based on loads anticipated during the design life of the systems.

a. Service loads. The following additional loads shall be used in the structural design of conventional and non-conventional elements and connections of H, HC and DHW systems:

(1) Constraint loads caused by the environment, normal functioning of the system and time-dependent changes within the materials of the system shall be taken as the most severe likely to be encountered during the design life.

(2) Ice loads (I) shall be taken as those produced by the accumulation of ice on surfaces exposed to the natural environment. The thickness of ice shall be taken as a radial thickness of ½ inch.

(3) Hail loads. System components and supporting structural elements that will be exposed to the natural environment in service shall be designed to resist, without excessive damage or major impairment of the functioning of the system, the perpendicular impact of falling hail having a particle diameter of 3/4 inch. "Excessive damage or major impairment" shall not include punching or local cracking of nonstructural elements such as glass cover plates of collector panels under hail impact, but shall include damage which creates a major curtailment in the functioning of the system, premature failure or hazards created by excessive shattering of glazed elements.

2. Mechanical stresses. Mechanical stresses that arise within the system shall not cause damage or malfunction of the system or its components.

   a. Vibration stress levels. Vibrations in collectors, piping, ducts, instrumentation lines, and control devices shall be controlled to reduce stress levels below those that could cause fatigue and subsequent component damage.

   b. Components involving moving parts. Components that involve moving parts shall be capable of performing their intended function without excessive wear or deterioration for their design lives with normal maintenance.

   c. Wear and fatigue. Check valves, pressure regulators, pumps, electrical switches, and similar components shall be capable of operating under in-use conditions for their design lifespans without exhibiting wear or fatigue to a degree that would effect the performance as declared in Appendix A.

   d. Flexible joints. All systems employing heat transfer fluids shall be designed to accommodate flexing of subsystems and components.

3. Temperature and pressure resistance. Components shall be capable of performing their functions for their design lives when exposed to the temperatures and pressures that may develop in the system under both flow and no-flow conditions.

   a. Thermal cycling stresses. The solar energy system shall be capable of withstanding the stresses induced by thermal cycling for their respective design lives.

   b. Thermal changes. The solar energy system shall be designed to allow for the thermal contraction and expansion that may occur over the service temperature range.

c. Thermal degradation. Solar energy systems shall not thermally degrade to the extent that their function will be reduced to a degree that will effect the performance as declared in Appendix A.

d. Relief valves and vents. As required for protection of a particular system design, combination temperature and pressure relief valves, vacuum relief valves, separate pressure relief valves, pressure reducing valves, and/or atmospheric vents shall be provided.

4. Materials Compatibility. All materials which are joined to or in contact with other materials shall have sufficient chemical compatibility with those materials to prevent deterioration that may impair their functions to a degree that would effect the performance as declared in Appendix A. Allowances shall be made for differences in the expansion of joined materials.

a. Corrosion of dissimilar materials. Non-isolated dissimilar materials with or without corrosion resistant finishes, where used either in contact with a transfer fluid, or without such contact, shall not be corroded to the extent that their function is or may be impaired under in-use conditions during their intended design lives. Dissimilar materials joined to form the transport system shall be electrically isolated from each other unless documentation is provided to demonstrate that the joints are sufficiently compatible to prevent corrosive wear and deterioration to the extent that their function would be impaired to a degree that would effect the performance as declared in Appendix A.

b. Corrosion by leachable substances. Chemical substances that can be leached by moisture from any of the materials within the system shall not cause corrosive deterioration of any other components that may impair the ability of these components to perform their intended function as declared in Appendix A.

c. Effects of decomposition products. Chemical decomposition products that are expelled from components under in-use conditions shall not cause the degradation of other components within the system to the extent that it would impair their ability to perform their intended functions to a degree that would effect the performance as declared in Appendix A.

5. Erosion/Corrosion. The solar system and components shall not be adversely affected by erosive wear (such as by the flow of a liquid transfer medium) to an extent that will impair theri functions during their intended design lives.

6. Function. The design and use of the facility and site shall not interfere with the function of the solar system. The solar system shall likewise not impair the function of the facility and site.

7. Heat or humidity transfer effects. Heat or humidity transfer from the collector, thermal storage, piping or other components of the solar system or subsystem shall not interfere with the efficiency operation of the solar system or cause loss of control of temperature, humidity or other controlled conditions.

8. Effects of external environment. The systems for heating (H) and combined heating and cooling (HC) and the hot water (HW) system/subsystem and their components shall not be affected by external environmental factors to an extent that will impair their functions during their design lives.

   a. Solar Degradation. Components or materials that are exposed to sunlight shall not undergo changes in their properties during their design lives that would impair the function of the system to a degree that would effect the performance as declared in Appendix A. When components or materials are exposed to UV radiation in combination with an intermittent water spray at their maximum "no-flow" temperature, there

shall be no excessive deterioration such as cracking, crazing, embrittlement, etching, loss of adhesion, changes in permeability, loss in flexural strength or any other changes that may affect the performance of the components in the system.

b. Soil Corrosion. Materials that are intended to be buried in soils shall not be degraded under in-use conditions to an extent that may impair their functions during their intended design lives.

c. Airborne Pollutants. Materials exposed under in-use conditions to airborne pollutants such as ozone, salt spray, sulfur dioxide, oxides of nitrogen and/or hydrogen chloride shall not be affected by those pollutants to an extent that may impair their functions during their intended design lives.

d. Growth of fungi. Components and materials used in the solar systems shall not allow the growth of fungi, mold or mildew.

D. Maintainability.

1. Accessibility for maintenance and servicing. The solar system shall be designed, constructed, and installed to provide adequate access for general maintenance and convenient servicing. The facility or site shall not prevent the practical maintenance of the solar energy system(s), nor shall the solar energy system prevent the practical maintenance of the facility or site.

2. Service Personnel. The solar systems shall be capable of being serviced with a minimum amount of special equipment by a trained service technician using a maintenance manual.

3. Replacement Parts. Parts, components, and equipment required for service, repair or replacement shall be commercially available or available from the system or subsystem manufacturer or supplier.

4. Draining and filling of liquids. To facilitate system or subsystem maintenance and repair, subsystems employing liquids shall be capable of being

filled and drained.

5. Flushing of liquid subsystems. Suitable connections shall be provided for the flushing (cleaning) of liquid energy systems and subsystems.

6. Installation, operation and maintenance manual. A manual shall be provided for the installation, operation and maintenance of the solar energy system/subsystem.

   a. Installation instructions. The manual shall include physical, functional and procedural instructions describing how the components of the solar energy system are to be installed. These instructions shall include descriptions of both interconnections among the system components and their connections with the dwelling and site.

   b. Maintenance and operation instructions. The manual shall completely describe the H, HC and DHW systems, their breakdown into subsystems, their relationship to external systems and elements, their performance characteristics, and their required parts and procedures for meeting specified capabilities. The manual shall list all parts of the system, by subsystem, describing as necessary for clear understanding of operation, maintenance, repair and replacement such characteristics as shapes, dimensions, materials, weights, functions and performance characteristics. The manual shall include a tabulation of those specific performance requirements which are dependent upon specific maintenance procedures. The maintenance procedures, including ordinary, preventive and minor repairs, shall be cross-referenced for all subsystems and organized into a maintenance cycle. The manual shall fully describe operation procedures for all parts of the system including those required for implementation of specified planned changes in mode of operation. The manual shall include instructions for the inspection, treatment, and disposal of transfer fluids used in the system.

c. Maintenance Plan. The manual shall include a comprehensive plan for maintaining the specified performance of the solar system for its design life. The plan shall include all the necessary ordinary maintenance, preventive maintenance and minor repair work and projections for equipment replacement.

d. Manual adjustment. If manual control adjustments are required during normal operation of the system/subsystem, the operating instructions shall enumerate the time period over which these adjustments must be made and the environmental conditions requiring such adjustments.

Section 6107

SOLAR SUBSYSTEMS

A. Scope. This section contains design criteria for performance and quality of solar subsystems. Solar subsystems shall include but not be limited to the following:

1. Collector subsystems.
2. Energy transport subsystems.
3. Storage subsystems.
4. Control subsystems.

B. Collector Subsystems.

1. Transmission losses due to outgassing. Outgassing of volatiles that will reduce collector performance below specified design values shall not occur when the collector is exposed to the temperature and pressure that will occur in actual service.
2. Condensation. Condensation formed on the underside of the cover plate(s) shall not reduce its transmittance during its design life to a degree that would effect the performance as declared in Appendix A.
3. Dirt retention. The cover plate(s) shall not, with normal maintenance, collect or retain dirt to an extent that would measurably reduce its ability to transmit sunlight.
4. Damage by impact. Refer to SBC 6106C.1.a.(3).

C. Transport and Storage Subsystems.

1. Entrapped air. When liquid heat transfer fluids are used, the system shall provide suitable means for air removal.
2. Protection against blockage of fluid flow. The entire heat transport system shall be protected to prevent contamination by foreign substances that may impair the flow and quality of the heat transfer fluid to a degree that would effect the performance as declared in Appendix A. Duct and fan systems shall

be protected against accumulations of deposits of dust, dirt or fungi that reduce flow and efficiency.

3. Automatic pressure and temperature relief valves for flammable or combustible fluids. The fluid transfer systems shall include a pressure relief valve. The valve and its discharge system shall not permit fluid discharge into occupied space. A holding tank shall be included in the system for collection of discharge expected from the relief valve. The pressure relief valve shall be designed based on maximum temperature criteria for abnormal operating conditions. (ΔP must be limited to comply with temperature criteria.) It shall prevent further increase in temperature and provide discharge in the same manner as the pressure relief valve. Maximum fluid temperature at which temperature relief valve shall operate:
   a. 37.8°C. (100°F.) below flashpoint of fluid.

4. Detection of highly toxic and flammable fluids. If heat transfer fluids that are highly toxic and/or flammable are used, means shall be provided for the detection of leaks and the warning of occupants when leaks occur.
5. System Drainage. System designs incorporating automatic drainage of heat transfer fluid or storage to prevent freezing of the fluid in solar collectors shall not be constructed of materials which corrode in the presence of air or shall be suitable protected against such corrosion. Liquid systems, system components, piping or storage tanks shall be designed for complete isolation and drainage for maintenance purposes.
6. Heat Transfer Fluids. The heat transfer fluid shall not cause deleterious effects to those parts of the solar energy system with which it comes into contact. Except when such changes are allowed by the design of the system,

the heat transfer fluid shall not freeze, give rise to excessive precipitation, otherwise lose its homogeneity, boil, change pH or undergo large changes in viscosity when exposed to its intended service temperature and pressure range.

7. Contamination. Thermal transfer system and storage materials, including any interior protective coatings and the heat storage medium used, shall not contaminate potable water nor ventilation air.

D. Control Subsystems. The control subsystem shall provide for the safe and efficient operation of the solar systems/subsystems.

1. The solar energy system controls shall prevent major damage to system components in the event of power failure or other system malfunction.
2. Identification and location of controls. Main shutoff valves and switches shall be conspicuously marked and placed in readily accessible locations.
3. Bypass. The control subsystem shall include such provision for manual bypass, adjustment, or over-ride of automatic controls as is required to facilitate installation, startup, shutdown and maintenance.

APPENDIX A

Disclosure Statement

A. Seller _____ _____

B. System _____ _____

C. Scope. This is a standard form for the documentation of performance and quality levels for a solar energy system or subsystem. The level of performance and quality stated by the manufacturer or seller is intended to reflect professional, experienced and thoughtful estimates of what is reasonably expected of the system/subsystem under a full range of anticipated operating conditions. The Disclosure Statement is not intended to imply in any manner warranty or guarantee by the seller to the buyer. This Disclosure Statement covers the following aspects of the solar energy system/subsystem:

1. Performance
2. Design life
3. Compliance with Sections 6106 and 6107 of these Rules, and
4. Physical data describing the system as required in SBC 6106D.7.

NOTE: Under some circumstances the disclosure statement may require the signature of an engineer or architect registered in the State of Minnesota (Mn. Stat. 1974, 326.02 et seq).

APPENDIX A

Disclosure Statement

SOLAR ENERGY SYSTEM PERFORMANCE

Sizing. Sizing of the previously identified solar energy system is outlined below. All load calculations are performed in accordance with Appendix B and/or C.

Calculated facility heating demand _____

Calculated service hot water demand _____

Calculated facility cooling demand _____

Other calculated facility energy demand as may be offset by solar energy system _____

TOTAL CALCULATED FACILITY DEMAND _____

Solar Contribution. Solar contribution, as calculated in accordance with Appendix C, shall be provided as follows: (Calculations which have been substantiated by field testing of solar systems/subsystems and components are an acceptable submission in lieu of Appendix C Calculation Procedures)

Calculated solar contribution to space heating demand _____ %

Calculated solar contribution to service hot water demand _____ %

Calculated solar contribution to facility cooling demand _____ %

Calculated solar contribution to other demand _____ %

Solar contribution to total demand _____ %

APPENDIX A

Disclosure Statement

DESIGN LIFE

The manufacturer of solar energy systems shall outline herein the design life of systems and subsystems under anticipated design conditions. This is not a warranty or a guarantee of this life.

Design life of solar energy system, with normal maintenance as described by manufacturer ___ _____

Design life of subsystems and components, with normal maintenance as described by manufacturer

Collector subsystem _____

Transport subsystem _____

Storage subsystem _____

Control subsystem _____

APPENDIX A

Disclosure Statement

COMPLIANCE

Solar energy systems. The total solar energy system complies with all applicable Minnesota State Building Codes:

Yes _____

If yes, documentation available _____

No (explain) _____

Solar energy subsystems. All subsystems and components are in substantial compliance with Minnesota State Building Codes:

Yes _____

If yes, documentation available _____

No (explain) _____

APPENDIX B

Reference Standards and Test Methodology

The following standards have been exerpted from the documents referenced below. Use of these standards and tests is mandatory for evaluation of systems, subsystems and components.

ASTM American Society for Testing and Materials

HUD NBSIR 76-1059 Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems April, 1976

NASA 98M 10001 Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities February 28, 1975

NBS Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings January 1, 1975

NBSIR 74-635 National Bureau of Standards Method of Testing for Rating Solar Collectors Based on Thermal Performance

SOLAR SYSTEM - Durability/Reliability

A. Materials Compatability

1. Effects of decomposition products - NASA Chapter 5, Section 15
2. Material compatability test - NASA Chapter 5, Section 13
3. Absorbtive coatings, compatibility with heat transfer medium - ASTM D-1308-57, 1973
4. Transport subsystem, materials used for transporting fluids - HUD Appendix Table B-2

   Materials/transfer fluid compatibility - ASTM D 2570-73

   NBS Appendix Section 12
5. Gaskets and sealants

   Chemical and physical compatibility - ASTM F82-67, 1973

   Deterioration of gaskets and sealants - NASA Chapter 5, Section 10

B. Effects of the external environment

1. Growth of fungi, mold or mildew

   Section 10, UL 181-74

   Method 508 MIL-STD-810

2. Solar degradation - NASA Chapter 5, Sections 01, 02, 03

3. Soil corrosion - NASA Chapter 5, Section 04

4. Airborne pollutants - NASA Chapter 5, Section 5

5. Collector subsystem

   Cover plate, UV stability - ASTM E-424-71

   Absorber plate, UV stability - ASTM D822-60, 1973

   (modification of above) HUD 515 2.4.3

   Moisture stability - ASTM D2247-68, 1973

6. Organic coupling hoses

   UV stability - ASTM D750-68, 1974

   Compatibility with heat transfer fluid - ASTM F82-67, 1973

   Ozone degradation - ASTM D1149-64, 1970

C. Temperature and pressure resistance

1. Thermal cycling stresses - NBS Appendix, Section 08

2. Thermal degradation test - NASA Chapter 5, Appendix, Section 06

3. Leakage - NBS Appendix, Section 09

4. Absorptive coatings, thermal stability

   ASTM D660-44, 1970; D661-44, 1975; D714-56, 1974; D772-47, 1975

5. Gaskets and sealing pressurized systems test - ASTM D1081-60, 1974

COLLECTOR SUBSYSTEMS

A. Collector performance. Collector thermal performance test - NBSIR 74-635

B. Durability and reliability of collector subsystems. Outgassing, transmission losses due to - NASA Chapter 5, Section 11

C. Durability/reliability of transport subsystems. Deterioration of heat transfer fluids - NBS Appendix, Section 07.

APPENDIX C

Calculation Procedures - Solar Systems

NOMENCLATURE

A_c	Collector aperture area (ft^2) (M^2)
$(\dot{m}c_p)$	Min fluid capacitance [Btu/(h^oF)] (Watts/^oC)
c_p	Fluid capacitance [Btu/(lb^oF)] (Joules/Kg - ^oC)
D_1, D_2	Dimensionless parameters
Δt_d	Temperature difference for building design temperature conditions (^oF)
Δt	Total number of hours in a particular month (h)
ε_c	Effectiveness of the collector-storage heat exchanger
ε_L	Effectiveness of the load heat exchanger
θ	Collector tilt (^{o})
E	Solar energy supplied for a particular month (Btu/month)(Joule/month)
E_{total}	Solar energy supplied for an entire year (Btu/year) (Joules/year)
f	Monthly fraction of total heating load supplied by solar energy
F_{annual}	Yearly fraction of the total heating load supplied by solar energy
F_R	Collector heat removal factor
F_R'	Combined form of the collector heat exchanger effectiveness and the collector heat removal factor (F_R)
γ	Solar collector azimuth angle (for due south = 180^o)
$\bar{I}_H$	Monthly average of the daily radiation incident on a horizontal surface [Btu/($day \cdot ft^2$)] (Joule/Day - M^2)
$\bar{I}_T$	Monthly average of the daily radiation incident on a tilted surface [Btu/($day \cdot ft^2$)] (Joul /Day - M^2)
$\bar{K}_t$	Ratio of the monthly averages of the daily radiation on a horizontal surface to the extraterrestrial radiation on a horizontal surface
K_1	Correction factor to correct f for various storage capacities other than 15 Btu/($^oF \cdot ft^2$) (306,620 Joule/^oC - M^2)

K_2	Correction factor to correct for $_L(\dot{m}c_p)$min/UA other than 2
L	Total heating and hot water load for a particular month (Btu/month) (Joules/month)
L_{Total}	Total heating and hot water load for an entire year (Btu/year) (Joules/year)
m	Mass of domestic hot water used for a particular month (lb)(kg)
$\dot{m}$	Flow rate of the working fluid either air or liquid (lb/hr) (kg/hr)
M	Mass of thermal storage (lb) (kg)
N	Number of days in a particular month
ϕ	Latitude
Q_s	Space heating load for a particular month (Btu/month) (Joules/month)
Q_w	Domestic hot water heating load for a particular month (Btu/month)
q_d	Building design rate of sensible heat loss (Btu/h) (Watts)
$\bar{R}$	Ratio of the monthly average daily radiation on a tilted surface to that on a horizontal surface
S	Monthly incident solar radiation on a tilted surface Btu/(month·ft^2) (Joules/month·M^2)
$\bar{t}_a$	Monthly average ambient air temperature (^oF) (^oC)
t_s	Temperature of domestic hot water supply (^oF) (^oC)
t_m	Temperature of water main supply (^oF) (^oC)
t_{ref}	Reference temperature, 212^oF (100^oC)
Δ time	Total number of hours in each month
$\overline{\tau\alpha}$	Average transmissivity-absorptivity product for design purposes
$(\tau\alpha)_n$	Transmissivity-absorptivity product at normal incidence
U_L	Collector heat loss factor Btu/(h·^oF·ft^2) (Watt/^oC - M^2)
UA	Building heat loss factor Btu/(h·^oF) (Watt/^oC)
f_n	Monthly fraction of heating load supplied by solar energy
f_c	Monthly fraction of cooling load supplied by solar energy
f_o	Monthly fraction of other load supplied by solar energy

References Cited

1. Klein, S. A., Beckman, W. A., and J. A. Duffie, "Design Procedure for Solar Heating Systems," presented at the 1975 International Solar Energy Congress, UCLA, Los Angeles, California, July, 1975.

2. B. Y. H. Liu, R. C. Jordan, "Availability of Solar Energy for Flat-Plate Solar Heat Collectors," Low Temperature Engineering Application of Solar Energy, ASHRAE, New York, 1967.

APPENDIX C

Calculation Procedures - Solar Systems

A. Performance measurements for a solar system shall be made using the following outline:

1. Calculate the monthly energy load (heating, cooling).
2. Calculate the monthly incident solar radiation on the collector array.
3. Determine the component parameters, i.e. subsystem efficiencies, capacities, required operating energies, etc.
4. Calculate the monthly fraction of load supplied by solar system.
5. With the monthly loads and monthly fractions supplied by solar, calculate the annual fraction of load supplied by solar energy.

B. Specifically, performance measurements for different solar systems shall be made as follows:

1. Combined collector and storage devices. The system thermal performance is determined by the short term (1 to 3 days) collection and storage of thermal energy obtained from solar radiation and the amount of useful energy delivered to the load from storage for part and full load conditions. Experimental performance data, in terms of heat collected and stored or delivered to load, shall be provided for the design conditions including solar power density, heat transfer fluid temperature, ambient temperature, wind, solar radiation incident angle, and flow rates. The daily and average test period electrical operating requirements shall be reported with system performance.
2. Passive (integral) solar systems. The thermal performance of an integral solar system shall be obtained from a detailed simulation analysis of the climate, building thermal properties and occupancy thermal influence.

3. Active solar systems. Where applicable, collector based solar systems shall use the calculation procedures outlined in paragraph C. below. When different procedures are used due to an incompatability between the system (or subsystem) under study and the outlined procedures, the elected calculation procedure shall be representative of realistic demand, solar radiation, component capacities, efficiencies, required operating energies, etc.

C. Determining monthly load. The monthly load is comprised of heating, cooling, and other service loads that might be offset by the solar system.

1. Total heating load. The total heating load is determined on a monthly basis for both space and hot water heating. The space and hot water heating loads are calculated separately and for combined systems, the monthly individual loads are added to get a monthly total load.

a. Hot water load. Determine the required volume of domestic hot water (gal) required on a monthly basis. Then, knowing the volume, calculate the mass (m) using a value of 8.33 lb/gal (119.8 kg/M^3). Determine the water main temperature (t_m) or assume t_m = 55°F. (12.8°C). Calculate the monthly domestic hot water heating load using the following equation:

$$Q_w = \left[\frac{\text{(lb or kg) DHW consumed}}{\text{Month}}\right] \left[\text{Specific Heat of Water } \left(\frac{\text{Joule}}{\text{kg-}^\circ\text{C}}\right)\right] \left[\text{Temp. Supply} - \text{Temp. Water Main}\right]$$

For situations where the domestic hot water requirements cannot be reasonably estimated, a load of 1.6×10^6 Btu/month may be assumed for a typical residence. This is equivalent to approximately 90 gallons of hot water use per day.

b. Space heating load. The space heating load for each month shall be calculated using the degree-day method. A value of 0.75 shall be used unless practical experience in the locality dictates the use of a different value, and this is approved by the local Building Official.

(1) To calculate space heating load. Building heat loss shall be calculated according to methods described in the ASHRAE Handbook of Fundamentals or other recognized means. The loss calculations shall include:

Heat loss by transmission:

$Q_{st} = U\ A\ (t_i - t_o)$

Heat loss by infiltration - use (a) or (b):

(a) Air change method

(b) Crack method

In either case, $Q_{si} = .018\ V(t_i - t_o)$

(2) Obtain the monthly total degree days from the ASHRAE Systems Handbook for the particular location for each month.

(3) Add infiltration and transmission losses to obtain design total instantaneous loss. $Q_s = Q_{st} + Q_{si}$

(4) Obtain BTU's per degree day for month.

$$P.F. \times \frac{Q_s}{DD} \times 24 = BTU/DD$$

Q_s = Heat flow rate, BTU/Hr.

U = Heat transfer coefficient, $BTU/(hr)(ft^2)(F^o)$

A = Area of transfer surface, ft^2

t_i = Design indoor temperature, ^oF (68^o)

t_o = Design outdoor temperature,

P.F. = Proportionality factor

V = Volume of air (c.f. per hour)

D.D. = Degree day

2. Calculation of cooling and other loads. Calculations of cooling loads and/or other loads that might be offset by the solar system shall be according to the ASHRAE Handbook of Fundamentals or other recognized means.

3. Table A is included for tabulating loads.

D. Determining the monthly incident solar radiation. Table B is included for tabulating the incident solar radiation calculation.

1. Monthly average of the daily radiation incident on a horizontal surface, I_H. For locations near St. Cloud, I_H shall be taken from Table 4A. For other locations, alternate means of determining I_H, such as interpolation from radiation maps, may be used.

2. Ratio of the monthly averages of the daily radiation on a horizontal surface to the extraterrestrial radiation, (K_t). For locations near St. Cloud, K_t shall be taken from Table 4A. For other locations, alternate means may be used.[1] [2]

3. Ratio of the monthly average daily radiation on a tilted surface to that on a horizontal surface for collectors facing due south (R). Using Table 4B and knowing collector tilt (θ), latitude (ϕ), and $\overline{K}_t$, determine $\overline{R}$ for each month. K_t may be interpolated.

4. Monthly average daily radiation on a tilted surface, $(\overline{I}_T)$. Knowing $\overline{I}_H$ and $\overline{R}$ for each month, calculate $\overline{I}_T$ on a monthly basis using the equation:
$\overline{I}_T = (\overline{I}_H)(\overline{R})$

5. Total monthly radiation on a tilted surface, (S). $\overline{I}_T$, the monthly average daily radiation on a tilted surface, must be multiplied by the total days in each month, (N) to obtain total insolation for each month.
$S = (\overline{I}_T)(N)$

6. Shading. Shading should not be neglected in calculating the incident solar radiation on a particular collector array. The amount of shading is strongly dependent on the collector site and orientation; thus, each case must be analyzed separately.

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[1] Donald G. Baker and John C. Klink, Solar Radiation Reception, Probabilities and Areal Distribution in the North-Central Region, Agricultural Experiment Station, University of Minnesota, Technical Bulletin 300 (1975).

[2] Donald G. Baker, Climate of Minnesota Part VI Solar Radiation at St. Paul, Agricultural Experiment Station, University of Minnesota, Technical Bulletin 280 (1971).

TABLE 4-A

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
St. Cloud, Minn.	$\overline{I}_H$	632.8	976.7	1383	1598.1	1859.4	2003.3	2087.8	1828.4	1369.4	890.4	545.4	483.1
Lat. 45°35'N	$\overline{K}_t$	0.595	0.629	0.614	0.534	0.530	0.533	0.573	0.570	0.539	0.490	0.435	0.504
El. 1034 ft.	$\overline{t}_q$	13.6	16.9	29.8	46.2	58.8	68.5	74.4	71.9	62.5	50.2	32.1	18.3

Values from "A Rational Procedure for Predicting a Long Term Average Performance of Flat Plate Collectors." Solar Energy, 17, No. 2, 1963. B.Y.H. Liu, R. C. Jordan.

E. Predicting system performance. This procedure does not apply to passive systems or to active systems that do not generally conform to the configuration of Figure 5A. The procedure cannot be used for systems in latitudes farther north than sixty degrees. The procedure is intended for use by architects and engineers to evaluate long-term performance of most solar heating systems using a simple desk calculator or slide rule. Since in most instances flat plate collectors are utilized for heating buildings, the collector component parameters are only valid for modeling flat plate collectors. Concentrating collectors or evacuated tubular collectors cannot be incorporated into the solar heating system evaluation as it is presently written in this Appendix. The system evaluation procedure as outlined in this Appendix can only accurately predict system performance for systems using south facing collector arrays. Cases of different collector orientations must be analyzed using a different procedure.

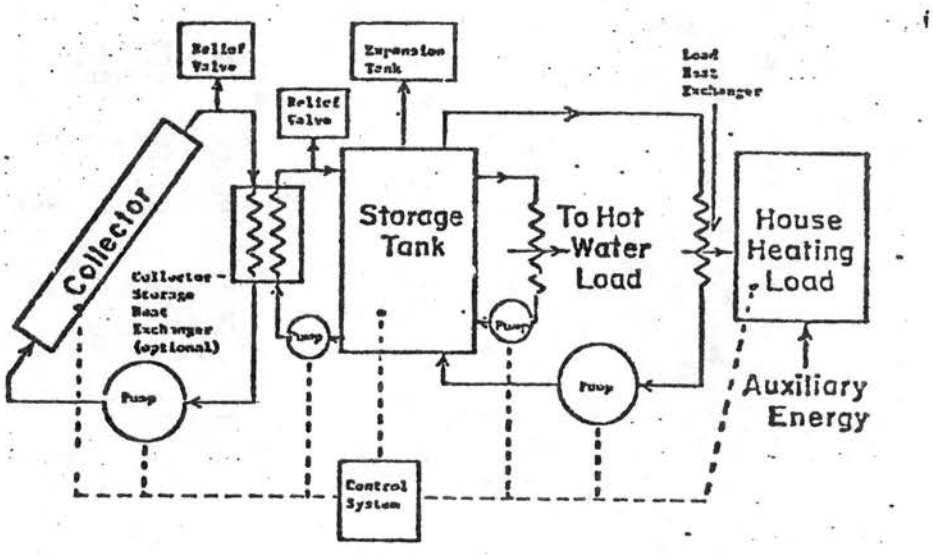


FIGURE 5-A

TABLE 4B

$\bar{R}$ for $\bar{K}_T$ = .40

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt)= 15.0							
40	1.44	1.35	1.17	1.06	.99	.97	.98	1.03	1.12	1.27	1.39	1.51
45	1.68	1.40	1.24	1.09	1.00	.97	.98	1.05	1.17	1.39	1.58	1.85
50	1.90	1.58	1.32	1.12	1.01	.97	.99	1.06	1.23	1.46	1.92	2.11
					(Latitude - Tilt)= .0							
40	1.61	1.45	1.19	1.03	.93	.89	.91	.98	1.12	1.34	1.53	1.70
45	1.88	1.49	1.26	1.05	.93	.89	.91	.99	1.16	1.47	1.75	2.12
50	2.13	1.69	1.35	1.08	.94	.88	.90	1.01	1.22	1.54	2.14	2.40
					(Latitude - Tilt)=-15.0							
40	1.68	1.48	1.15	.95	.83	.78	.80	.89	1.06	1.34	1.58	1.80
45	1.98	1.51	1.22	.96	.83	.77	.80	.90	1.10	1.47	1.82	2.27
50	2.24	1.72	1.30	.99	.83	.76	.79	.91	1.16	1.53	2.24	2.56
					Vertical							
40	1.51	1.25	.86	.61	.48	.44	.46	.55	.75	1.08	1.39	1.65
45	1.84	1.30	.96	.67	.53	.48	.50	.60	.83	1.25	1.66	2.17
50	2.13	1.54	1.08	.74	.58	.52	.54	.66	.93	1.34	2.12	2.47

TABLE 4B

$\overline{R}$ for $\overline{K}_T$ = .50

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt) = 15.0							
40	1.52	1.40	1.20	1.08	1.00	.97	.98	1.04	1.14	1.32	1.46	1.60
45	1.80	1.47	1.28	1.11	1.08	.97	.98	1.06	1.20	1.45	1.69	1.99
50	2.06	1.68	1.38	1.14	1.02	.97	.99	1.08	1.27	1.54	2.08	2.30
					(Latitude - Tilt) = .0							
40	1.72	1.53	1.24	1.04	.93	.88	.90	.99	1.15	1.41	1.63	1.83
45	2.05	1.59	1.32	1.07	.93	.88	.90	1.01	1.20	1.56	1.89	2.31
50	2.34	1.83	1.42	1.10	.94	.88	.91	1.03	1.28	1.64	2.35	2.65
					(Latitude - Tilt) = -15.0							
40	1.82	1.58	1.20	.96	.82	.77	.79	.90	1.10	1.42	1.71	1.96
45	2.18	1.62	1.28	.98	.83	.76	.79	.91	1.15	1.57	1.99	2.50
50	2.48	1.87	1.38	1.01	.83	.76	.79	.93	1.21	1.65	2.48	2.84
					Vertical							
40	1.66	1.35	.90	.61	.46	.41	.43	.54	.77	1.16	1.51	1.83
45	2.05	1.42	1.01	.68	.52	.45	.48	.60	.86	1.35	1.83	2.42
50	2.37	1.70	1.16	.76	.57	.50	.53	.67	.97	1.46	2.37	2.77

TABLE 4B

$\bar{R}$ for $\bar{K}_T$ = .60

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt) = 15.0							
40	1.60	1.46	1.23	1.09	1.00	.96	.98	1.05	1.17	1.37	1.53	1.68
45	1.92	1.54	1.32	1.12	1.01	.97	.99	1.07	1.23	1.52	1.79	2.13
50	2.22	1.79	1.44	1.17	1.03	.97	.99	1.10	1.32	1.63	2.24	2.49
					(Latitude - Tilt) = 0							
40	1.84	1.61	1.28	1.06	.93	.88	.90	1.00	1.18	1.47	1.73	1.96
45	2.21	1.69	1.37	1.09	.94	.88	.90	1.02	1.25	1.65	2.03	2.50
50	2.54	1.96	1.50	1.13	.95	.88	.91	1.05	1.33	1.75	2.55	2.90
					(Latitude - Tilt) = -15.0							
40	1.96	1.68	1.25	.98	.82	.76	.78	.90	1.13	1.50	1.83	2.12
45	2.37	1.73	1.34	1.01	.83	.75	.78	.92	1.19	1.68	2.16	2.73
50	2.71	2.07	1.46	1.04	.83	.75	.79	.94	1.27	1.77	2.72	3.13
					Vertical							
40	1.81	1.45	.94	.61	.44	.38	.40	.53	.79	1.23	1.64	2.00
45	2.26	1.53	1.07	.69	.50	.43	.46	.60	.90	1.45	2.01	2.66
50	2.62	1.85	1.23	.78	.56		.52	.67	1.02	1.58	2.61	3.07

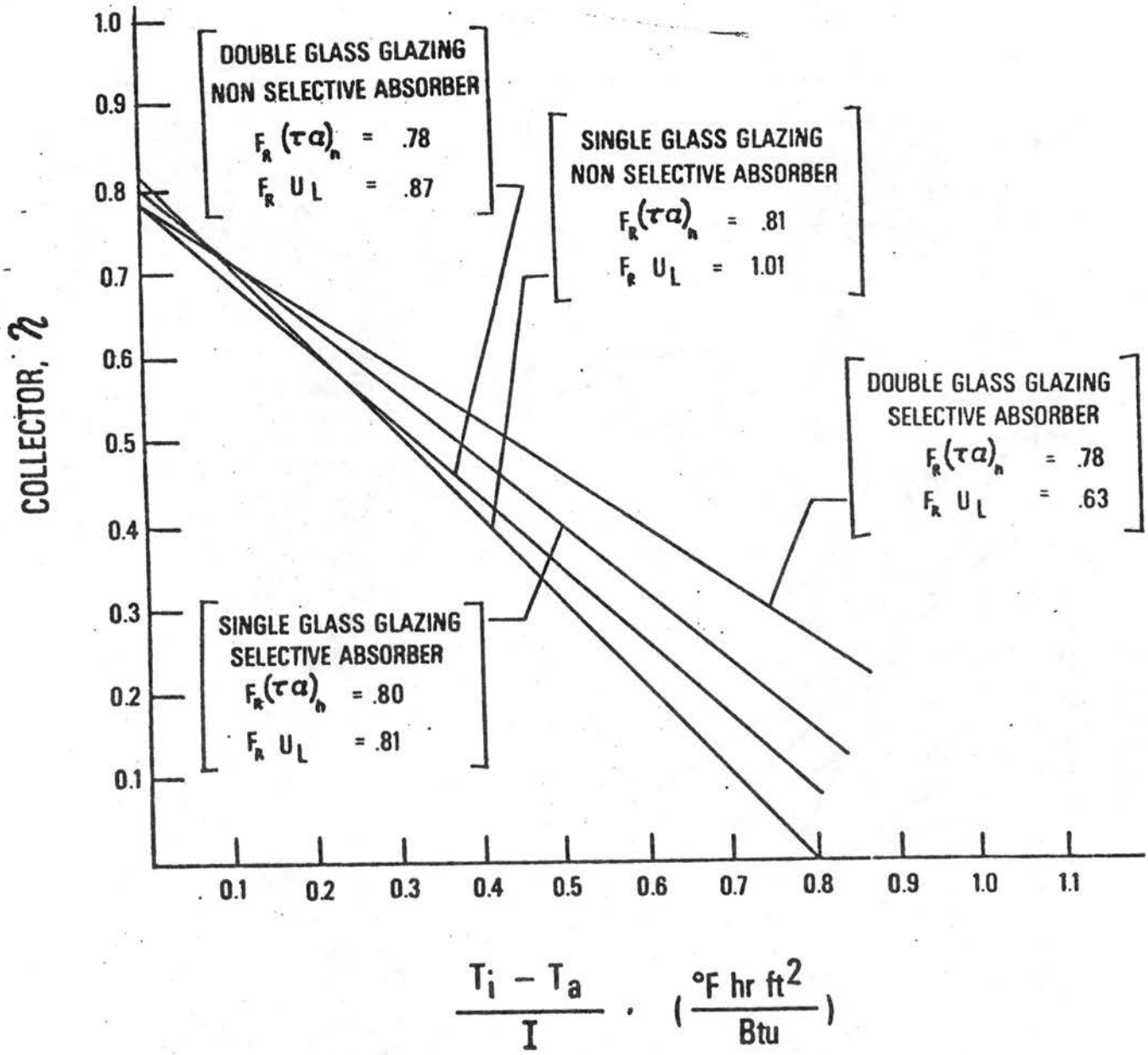
TABLE 4-B

$\overline{R}$ for $\overline{K}_T$ = .70

LATITUDE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					(Latitude - Tilt) = 15.0							
40	1.66	1.50	1.26	1.10	1.00	.96	.98	1.05	1.19	1.40	1.58	1.75
45	2.01	1.60	1.36	1.14	1.02	.97	.99	1.08	1.26	1.57	1.87	2.23
50	2.34	1.87	1.49	1.19	1.03	.97	1.00	1.11	1.35	1.69	2.36	2.63
					(Latitude - Tilt) = .0							
40	1.92	1.68	1.31	1.07	.93	.57	.89	1.00	1.21	1.52	1.80	2.06
45	2.34	1.76	1.42	1.11	.94	.67	.90	1.03	1.28	1.71	2.14	2.65
50	2.70	2.07	1.55	1.16	.95	.68	.91	1.06	1.37	1.83	2.71	3.09
					(Latitude - Tilt) = -15.0							
40	2.07	1.75	1.29	.99	.81	.75	.78	.91	1.16	1.56	1.92	2.25
45	2.52	1.82	1.39	1.02	.83	.75	.78	.93	1.23	1.75	2.28	2.90
50	2.89	2.14	1.53	1.07	.84	.75	.79	.96	1.32	1.87	2.90	3.35
					Vertical							
40	1.92	1.52	.97	.61	.42	.36	.39	.52	.81	1.29	1.74	2.13
45	2.42	1.61	1.11	.70	.49	.41	.45	.59	.93	1.53	2.14	2.85
50	2.81	1.96	1.29	.79	.55	.47	.51	.68	1.06	1.47	2.80	3.30

Component Parameters. The component parameters characterize the various components that make up the system. In cases of design where several different solar heating systems may be considered for the same location and collector tilt, incident radiation on a tilted surface ($\overline{I}_T$) need only be calculated once. In such a case, only the values of the component parameters need to be adjusted for the different systems.

Solar Collector. Using collector thermal performance efficiency curves provided by the manufacturer covering the appropriate range of operational temperature, insolation, tilt angles and flow rates determine the collector parameters $F_R U_L$ and $F_R(\tau\alpha)$. The thermal efficiency collector curve must be plotted such that the y-axis is the thermal efficiency (η) and the x-axis, the temperature difference between the collector fluid inlet and the ambient air divided by the incident solar radiation ($t_i - t_a/I_T$) . The thermal efficiency is the ratio of useful output thermal energy to the incident solar energy on the collector apperture area. To determine $F_R U_L$ calculate the slope of a linear curve fit for the efficiency curve. The y-axis intercept is equal to $F_R(\tau\alpha)$. When thermal performance efficiency curves or parameters are not available for a specific collector, Figures 5-A,5-B may be used to get typical values for typical kinds of flat-plate collector designs.



Thermal Efficiency Curves for Typical Flat Plate Collectors using a Liquid Working Fluid

FIGURE 5-B

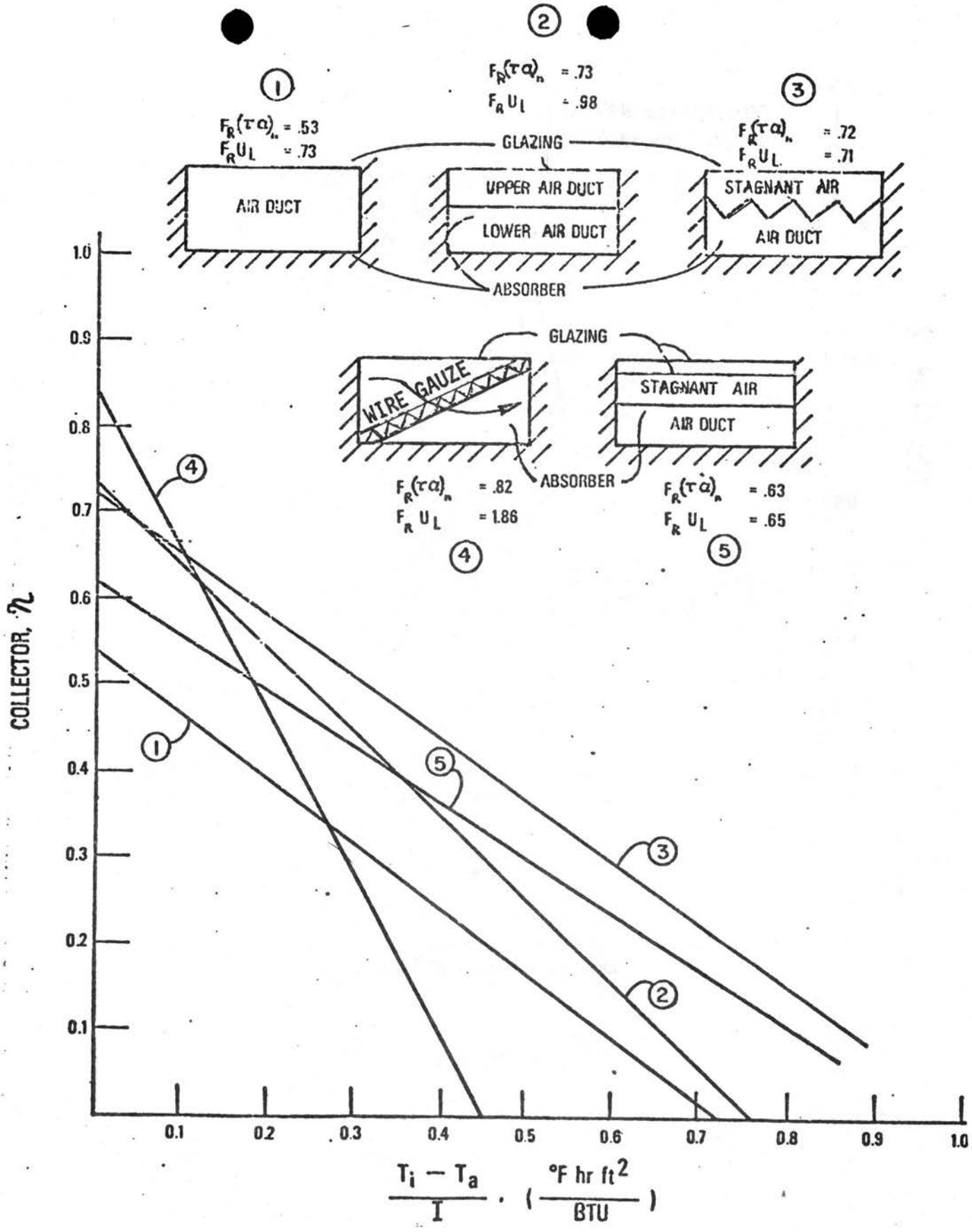


FIGURE 5-C. Thermal Efficiency Curves for Typical Flat Plate Collectors Using Air as a Working Fluid

Collector-Storage Heat Exchanger. To simplify the number of input parameters, the collector-storage heat exchanger effectiveness ε_c, and the collector heat removal factor, F_R, can be combined in a single parameter F_R'. Determine F_R'/F_R by the following equation, or the graphical representation in Figure 5-D .

$$\frac{F_R'}{F_R} = \frac{1}{1 + \left[\frac{F_R U_L A_C}{(\dot{m}\, c_p)_c}\right]\left[\frac{(m\, c_p)_c}{\varepsilon_c (\dot{m}\, c_p)_{min}} - 1\right]}$$

where A_c = aperature area of the collector array

$(\dot{m}\, c_p)_{min}$ = minimum fluid capacitance rate of the working fluids across the collector-storage heat exchanger.

$(m\, c_p)_c$ = fluid capacitance rate of the collector working fluid.

ε_c = effectiveness of the collector heat exchanger

$$= \frac{\text{actual heat transfer}}{\text{maximum possible heat transfer}}$$

The water-to-water collector storage heat exchanger effectiveness (ε_c) is easily calculated from methods given in the ASHRAE Handbook of Fundamentals or from data supplied by the manufacturer.

Note: In systems that do not use a collector to storage heat exchanger, the ratio of F_R' to F_R is equal to 1.

$$\frac{F_R'}{F_R} = 1$$

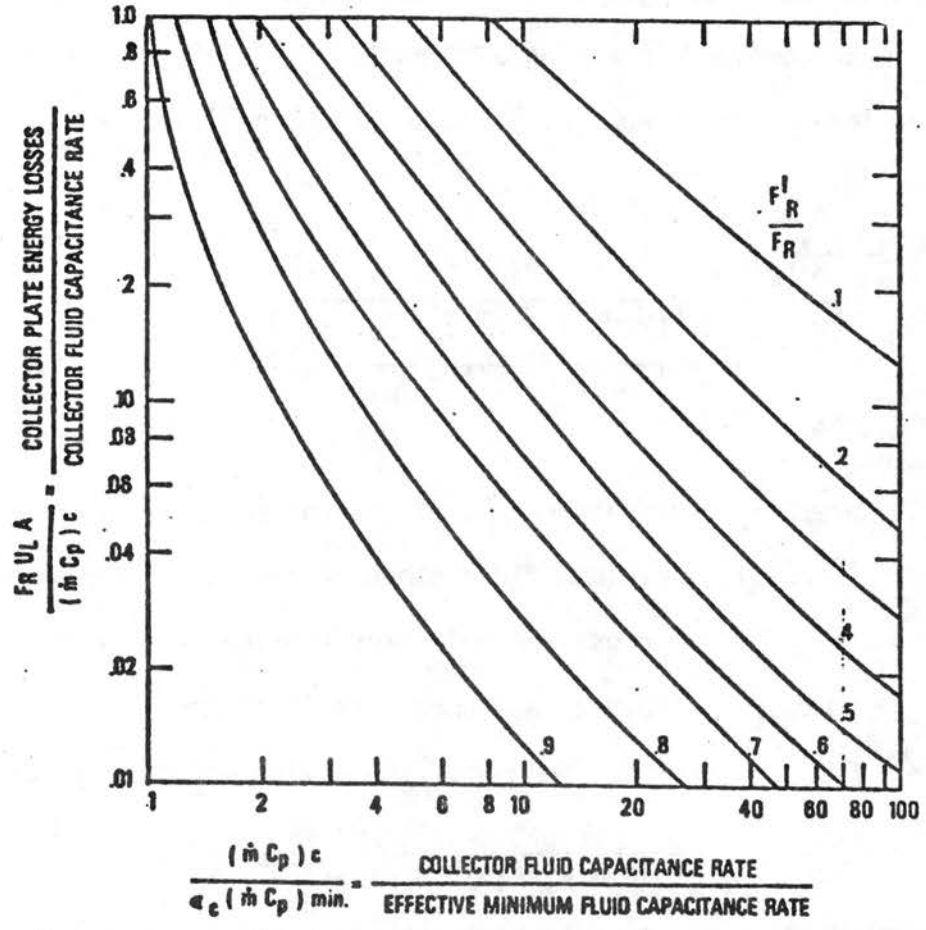


FIGURE 5-D. F_R'/F_R as a function of $F_R U_L A/(\dot{m} C_p)_c$ and $(\dot{m} C_p)_c/\epsilon_L (\dot{m} E_p)_{min}$

Storage. In general for solar heating systems utilizing water or air as heat transfer fluids an average storage capacity of 15 Btu/^{o}F per square foot of collector has been determined as near economic optimum. For storage capacities other than 15 a correction factor will be introduced later to correct the value of the predicted system thermal performance.

Load Heat Exchanger. Determing from the manufacturer's specifications the load heat exchanger effectiveness (ε_L) and calculate minimum fluid capacitance $(\dot{m}c_p)_{min}$ rate across the exchanger. Where ε_L is not provided, values can be determined using procedures in the ASHRAE Handbook of Fundamentals.

Note: Since a load heat exchanger is not usually incorporated into a system using air collectors and air as the transport medium, the load heat exchanger effectiveness may be assumed equal to 1.

Dimensionless Parameters (D_1, D_2). The dimensionless parameters D_1 and D_2 characterize the entire solar heating system thermal effectiveness. Calculate the two dimensionless parameters for each month using the factors defined previously on a monthly basis according to the following equations:

$$D_1 = \frac{\text{energy absorbed by collector plate}}{\text{total heating load}}$$

$$= \left[A_c\right]\left[F_R\,(\tau\alpha)_n\right]\left[\frac{(\overline{\tau\alpha})}{(\tau\alpha)_n}\right]\left[\frac{F_R'}{F_R}\right]\frac{S}{L}$$

$$D_2 = \frac{\text{ref. collector plate energy losses}}{\text{total heating load}}$$

$$= \left[A_c\right]\left[F_R U_L\right]\left[\frac{F_R'}{F_R}\right]\left[t_{ref} - \bar{t}_a\right]\frac{\Delta\,\text{time}}{L}$$

t_{ref} = 212°F (arbitrarily chosen reference temperature)

Δ time = average ambient air temperature for the particular month

$\left[\frac{\overline{\tau\alpha}}{(\tau\alpha)_n}\right]$ = 0.90 to account for the change in the value of the effective transmission-absorption product with incident angle throughout a day.

Monthly Fraction of Total Heating Load Supplied by Solar Energy (f_n) The fraction of the heating load supplied by solar energy (f_n) can be determined from Figure as a function of the dimensionless parameters, D_1 and D_2. Locate the two dimensionless parameters on Figure 5-E and determine the fraction of total heating load supplied by solar energy (f_n) on a monthly basis.

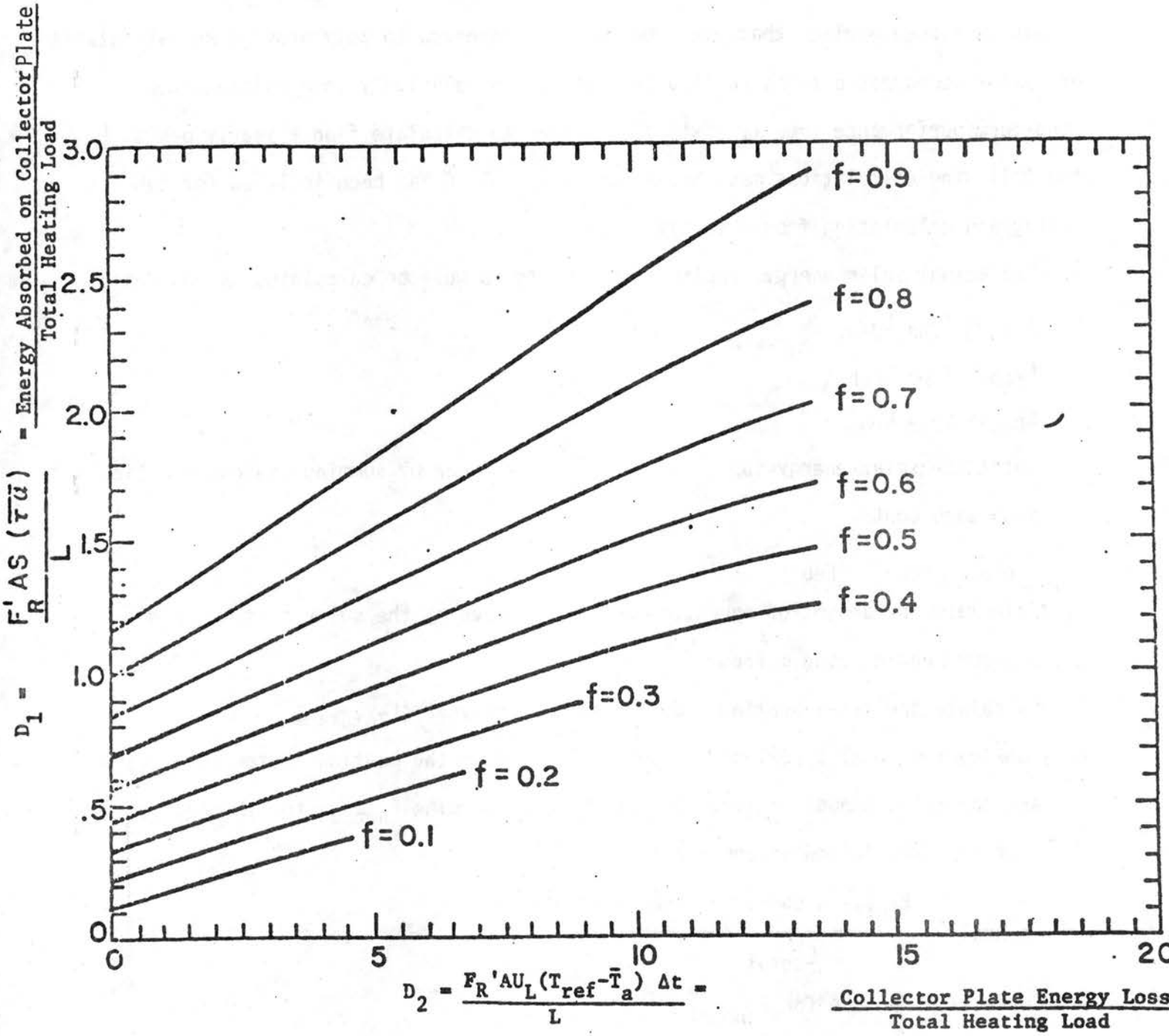


FIGURE 5-E. Relationship between solar fraction and dimensionless paramters D_1 and D_2.

Annual fraction of the total heating load supplied by solar energy (F_{annual}).

It was mentioned earlier that the procedure was intended to only provide an estimate of system performance for a particular month but a relatively good estimate for long-term performance (yearly basis). In order to calculate f on a yearly basis, the following calculations must be performed. Table C has been included for tabulating and calculating f on a yearly basis.

A. The actual solar energy supplied for each month must be calculated as follows:

$E_{Jan} = f_{Jan} L_{Jan}$

$E_{Feb} = f_{Feb} L_{Feb}$

$E_{Dec} = f_{Dec} L_{Dec}$

Total the solar energy supplied for the entire year by summing the contributions from each month.

$E_{Total} = E_{Jan} + E_{Feb} \cdot \cdot \cdot E_{Dec}$

B. Calculate the amount of operating energy required by the solar system, using standard engineering methods.

C. Calculate the total heating load for the entire year (L_{Total})

D. Knowing the total annual solar energy supplied by the heating system (E_{total}) and the total annual heating load (L_{Total}), determine F_{annual} for the entire year from the following equation:

$$F_{annual} = \frac{E_{total} - \text{operating energy}}{L_{total}}$$

E. Correction factors for F_{annual}

1. To correct for various storage capacities other than 15 Btu/($^{o}F \cdot ft^2$), use Figure 5-F to obtain the correction factor (K_1).
2. For cases where ε_L ($\dot{m}c_p$) min/UA is other than 2, use Figure 5-G to obtain the correction factor (K_2).
3. Utilizing the correction factors K_1 and K_2, the corrected and final value of F_{annual} may be calculated as follows:

$$F'_{annual} = (K_1)(K_2)F_{annual}$$

F. Calculation of fraction of cooling and other loads supplied by solar energy (f_c), (f_o). Calculation of cooling and other solar contribution shall be determined in a manner similar to the process described for calculation of heating contribution.

1. Calculate cooling and/or other loads.
2. Apply the following parameters in the same manner as in Sections D and E.
   a. Monthly incident solar radiation
   b. Component parameters
3. Calculate the monthly fraction of load (less operating energy) supplied by solar system.
4. Calculate the annual fraction of load supplied by solar energy. Calculations shall be performed with the same degree of accuracy and with the same completeness, as those for determining solar heating contribution. Tables similar to A, B and C may be used for data presentation.

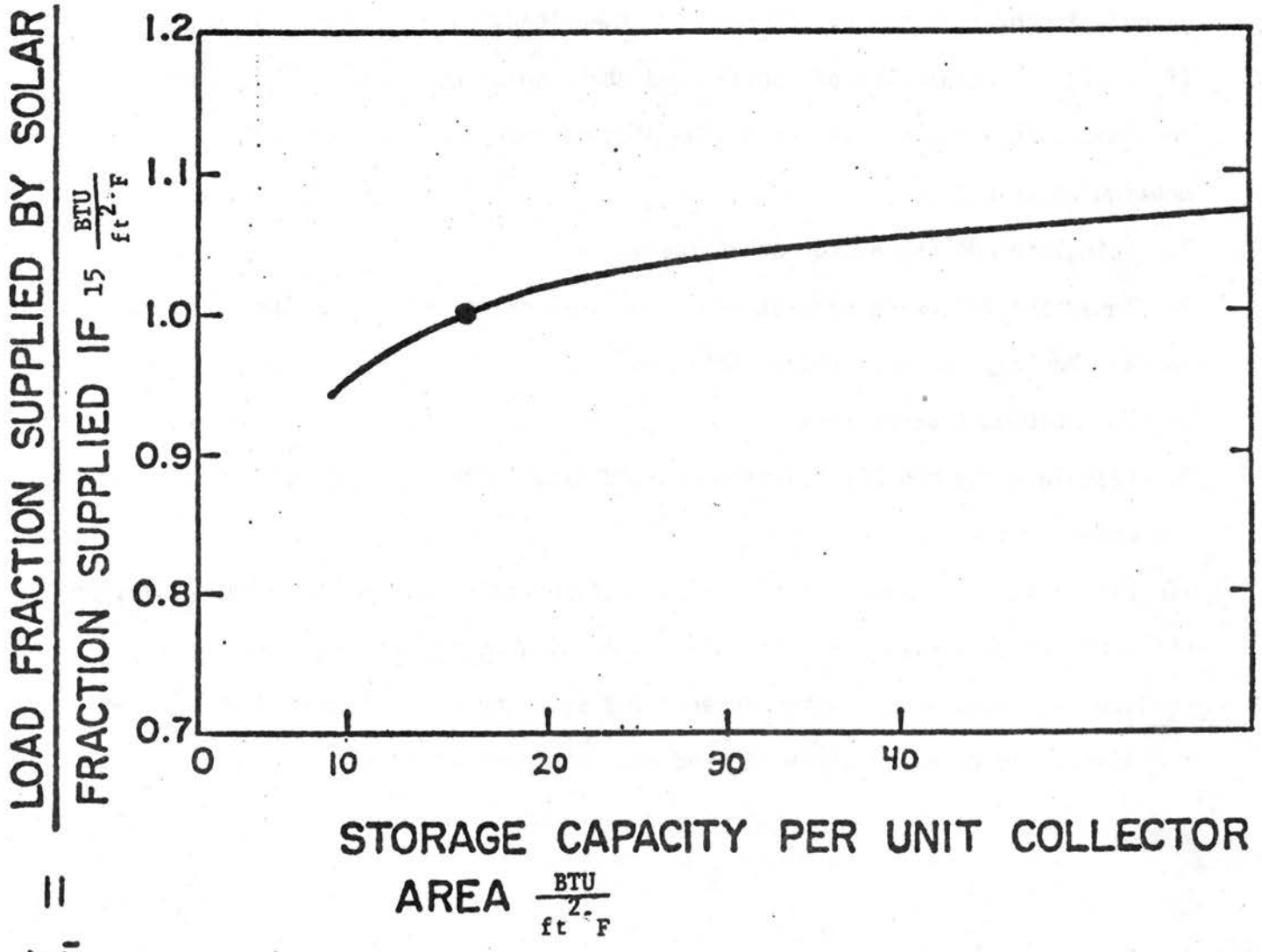


FIGURE 5-F **Correction Factor (K_1) for Storage Capacities Other Than 15 BTU/ft^2 °F**

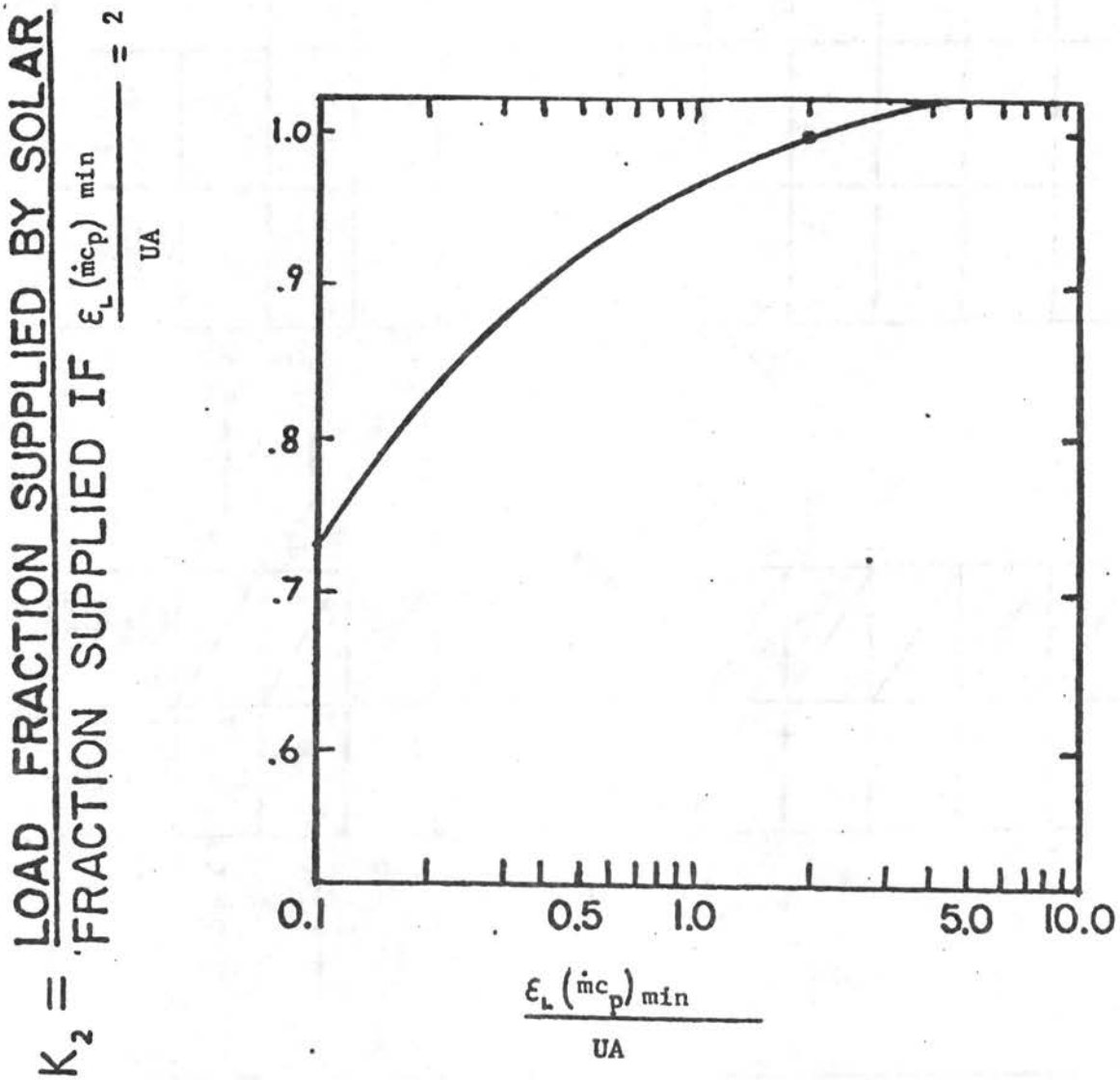


FIGURE 5-G Correction factor (K_2) for various values of $\varepsilon_L (\dot{m}c_p)_{min}$ / UA

TABLE A

DOMESTIC HOT WATER

SPACE HEATING LOAD

	DEGREE DAYS	BTU / MONTH Qs
Jan.		
Feb.		
Mar.		
April		
May		
June		
July		
Aug.		
Sept.		
Oct.		
Nov.		
Dec.		

q_d = _____ BTU/h

ΔT_d = _____ (°F)

UA = _____ BTU/h F

HEATING LOAD

DHW MONTH m* Gal / lbm	BTU / MONTH Qw

* 1 gal=8.3 lbm

t_s = _____ °F

t_m = _____ °F

TOTAL HEATING LOAD

BTU / MONTH L=Qs + Qw	$\bar{t}_a$ (°F) Ambient Air Temperature

TABLE B

Incident Solar Radiation

	$\frac{BTU}{Day\,ft^2}$ $\overline{I_H}$		$\overline{K_t}$	$\overline{R}$	$\frac{BTU}{Day\,ft^2}$ $\overline{I_T} = \overline{I_H}\overline{R}$	$\frac{BTU}{Month\,ft^2}$ S
Jan						
Feb						
Mar						
April						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

latitude = ____

tilt = ____

Component Parameters

I. Collectors

$F_R U_L =$ $\qquad \dot{m} =$

$F_R(\tau\alpha)_n =$ $\qquad c_p =$

$A_c =$

II. Collector-Storage Heat Exchanger

$F_R'/F_R =$ $\qquad \frac{(F_R U_L)A_c}{(\dot{m}\, c_p)_c} =$

$\varepsilon_c =$ $\qquad \frac{(\dot{m}\, c_p)_c}{\varepsilon_c (\dot{m} c_p)_{min}} =$

III. Storage

$M =$ $\qquad c_p M/A_c =$

IV. Load Heat Exchanger

$\varepsilon_L =$ $\qquad \frac{\varepsilon_L (\dot{m} c_p)_{min}}{UA} =$

$(\dot{m}\, c_p)_{min} =$

TABLE C

DIMENSIONLESS PARAMETERS

	BTU / MONTH L	BTU / MONTH ft² S	HRS / MONTH Δt	°F t_a	D1	D2
Jan.			744			
Feb.			696			
Mar.			744			
April			720			
May			744			
June			720			
July			744			
Aug.			744			
Sept.			720			
Oct.			744			
Nov.			720			
Dec.			744			

FRACTION OF THE TOTAL HEATING LOAD SUPPLIED BY SOLAR ENERGY

f	BTU / MONTH E

E total = _____

L total = _____

F annual = $\frac{\text{E total}}{\text{L annual}}$

= _____

K_1 = _____

K_2 = _____

F'annual = (K_1) (K_2) F annual

= _____

ADMIN 1000

STATE OF MINNESOTA

DEPARTMENT ADMINISTRATION

Office Memorandum

TO : Mike Miller
Special Assistant
Attorney General

DATE: August 29, 1977

FROM : DarlaMae Hormann
Building Code Division

SUBJECT: DOCUMENTATION OF MAY 17, 1977 PUBLIC HEARING

Enclosed are the necessary documents for your reviewal and filing with the Secretary of State's Office regarding the May 17, 1977 hearing.

If anything has been omitted, please let me know at 64626.

d

335

Sheila S. Fishman
Special Assistant
Attorney General

10/5/77

- SBC 6101 - 6108