

State



STATE OF
MINNESOTA

Register

HIGHLIGHTS:

State Register Subject Matter Index

—Cumulative Index for Issues 1-39 from the Office of the State Register

Performance Standards for Solar Energy Systems

—Proposed Rules from the Department of Administration

EQC Monitor

High Voltage Transmission Line

—Notice of Permit Issuance from the Environmental Quality Council

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Deletion of Seed Tax Permit Number and Changes in Laboratory Testing Fees Schedule

The following rules are adopted and are identical in every respect to their proposed form as published at State Register Vol. 1, No. 19, p. 757, November 15, 1976 (1 S.R. 757), and are published here by reference only as provided in RGSTR 5.

Chapter Eight: Agricultural Seeds

Agr 165 Statement on analysis label required. Repealed

Agr 169 Charges for excess testing and identification of seeds.

Public Service Commission Motor Bus and Truck Division

Time Period for Filing of Claims by Motor Common Carriers

Chapter One
PSC 3 Records.

K. [k] No motor common carrier operating under authority of the Commission shall provide by rule, contract, regulation, or otherwise a shorter period for the filing of claims than nine months after delivery of the property or, in case of failure to make delivery, then within nine months after a reasonable time for delivery has elapsed; and suits shall be instituted against any carrier only within two years and one day from the day when notice in writing is given by the carrier to the claimant that the carrier has disallowed the claim or any part or parts thereof specified in the notice. Where claims are not filed or suits are not instituted thereon in accordance with the foregoing provisions, no carrier hereunder shall be liable, and such claims will not be paid.

KEY: New rules and material proposed to be added to an existing rule are printed in **boldface**. Material proposed to be deleted from an existing rule is printed in [single brackets]. Underlining indicates additions to proposed rules, while [[double brackets]] indicate matter stricken from proposed rules. Existing material is printed in standard type face.

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Department of Administration Building Code Division Performance Standards for Solar Energy Systems Sold in Minnesota

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 that 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.

Richard L. Brubacher
Commissioner of Administration

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Appendix A Disclosure Statement Forms

Appendix B Reference Standards and Test Methodology

Appendix C Calculation Procedures — Solar Systems

SBC 6101 Authorization. These Rules are authorized by Laws of 1976, ch. 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 meets or exceeds each quality and performance standard.

SBC 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 de-

PROPOSED RULES

termine performance, durability, reliability and maintainability of systems and subsystems.

SBC 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).

SBC 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.

SBC 6105 Definitions.

| | | |
|----------------|-----|--------------------|
| Abbreviations. | DHW | Domestic Hot Water |
| | H | Heating |
| | HC | Heating/Cooling |
| | UV | Ultra violet |

Absorptance. The ratio 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 regu-

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late 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 ma-

terials 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 when solar energy is used to supply a measureable 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.

SBC 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

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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 1/2 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 or 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-

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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 their 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,

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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.

SBC 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

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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 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, 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 override 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. § 326.02 et seq (1974).

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

PROPOSED RULES

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 excerpted 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 compatibility.

1. Effects of decomposition products — NASA Chapter 5, Section 15

2. Material compatibility test — NASA Chapter 5, Section 13

3. Absorbitive coatings, compatibility with heat transfer medium — ASTM D-1308-57, 1973

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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°F)] (Watts/°C) |
| c_p | Fluid capacitance [Btu/(lb°F)] (Joules/Kg -°C) |
| D_1, D_2 | Dimensionless parameters |
| Δt_d | Temperature difference for building design temperature conditions (°) |
| 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 (°) |
| 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 |

PROPOSED RULES

| | | | |
|---------------------|--|----------------------------|--|
| F_{annual} | Yearly fraction of the total heating load supplied by solar energy | Q_w | Domestic hot water heating load for a particular month (Btu/month) |
| F_R | Collector heat removal factor | q_d | Building design rate of sensible heat loss (Btu/h) (Watts) |
| F_R' | Combined form of the collector heat exchanger effectiveness and the collector heat removal factor (F_R) | \bar{R} | Ratio of the monthly average daily radiation on a tilted surface to that on a horizontal surface |
| γ | Solar collector azimuth angle (for due south = 180°) | S | Monthly incident solar radiation on a tilted surface Btu/(month · ft ²) (Joules/month · M ²) |
| \bar{I}_H | Monthly average of the daily radiation incident on a horizontal surface [Btu/(day · ft ²)] (Joule/Day – M ²) | t_a | Monthly average ambient air temperature (°F) (°C) |
| \bar{I}_T | Monthly average of the daily radiation incident on a tilted surface [Btu/(day · ft ²)] (Joule/Day – M ²) | t_s | Temperature of domestic hot water supply (°F) (°C) |
| \bar{K}_t | Ratio of the monthly averages of the daily radiation on a horizontal surface to the extra-terrestrial radiation on a horizontal surface | t_m | Temperature of water main supply (°F) (°C) |
| K_1 | Correction factor to correct f for various storage capacities other than 15 Btu/(°F · ft ²) (306,620 Joule/°C – M ²) | t_{ref} | Reference temperature, 212°F (100°C) |
| K_2 | Correction factor to correct for $L(\dot{m}c_p)_{\text{min}}/UA$ other than 2 | $\Delta \text{ time}$ | Total number of hours in each month |
| L | Total heating and hot water load for a particular month (Btu/month) (Joules/month) | $\bar{\gamma}\bar{\alpha}$ | Average transmissivity-absorptivity product for design purposes |
| L_{Total} | Total heating and hot water load for an entire year (Btu/year) (Joules/year) | $(\gamma\alpha)_n$ | Transmissivity-absorptivity product at normal incidence |
| m | Mass of domestic hot water used for a particular month (lb) (kg) | U_L | Collector heat loss factor Btu/(h · °F · ft ²) (Watt/°C – M ²) |
| \dot{m} | Flow rate of the working fluid either air or liquid (lb/hr) (kg/hr) | UA | Building heat loss factor Btu/(h · °F) (Watt/°C) |
| M | Mass of thermal storage (lb) (kg) | f_n | Monthly fraction of heating load supplied by solar energy |
| N | Number of days in a particular month | f_c | Monthly fraction of cooling load supplied by solar energy |
| ϕ | Latitude | f_o | Monthly fraction of other load supplied by solar energy |
| Q_s | Space heating load for a particular month (Btu/month) (Joules/month) | | |

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.

KEY: New rules and material proposed to be added to an existing rule are printed in **boldface**. Material proposed to be deleted from an existing rule is printed in [single brackets]. Underlining indicates additions to proposed rules, while [[double brackets]] indicate matter stricken from proposed rules. Existing material is printed in standard type face.

PROPOSED RULES

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. sub-system 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 incompatibility 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/M³). 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:

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

For situations where the domestic hot water requirements cannot be reasonably estimated, a load of 1.6 × 10⁶ 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

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

(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.

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

PROPOSED RULES

Q_s = Heat flow rate, BTU/Hr.
 U = Heat transfer coefficient, BTU/(hr)

(ft²) (F°)

A = Area of transfer surface, ft²
 t_i = Design indoor temperature, °F (68°)
 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 \bar{K}_t , determine \bar{R} for each month. K_t may be interpolated.

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

5. Total monthly radiation on a tilted surface, (S). \bar{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. $S = (\bar{I}_T)(N)$

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.

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 | 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. | i_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 parame-

ters 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.

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PROPOSED RULES

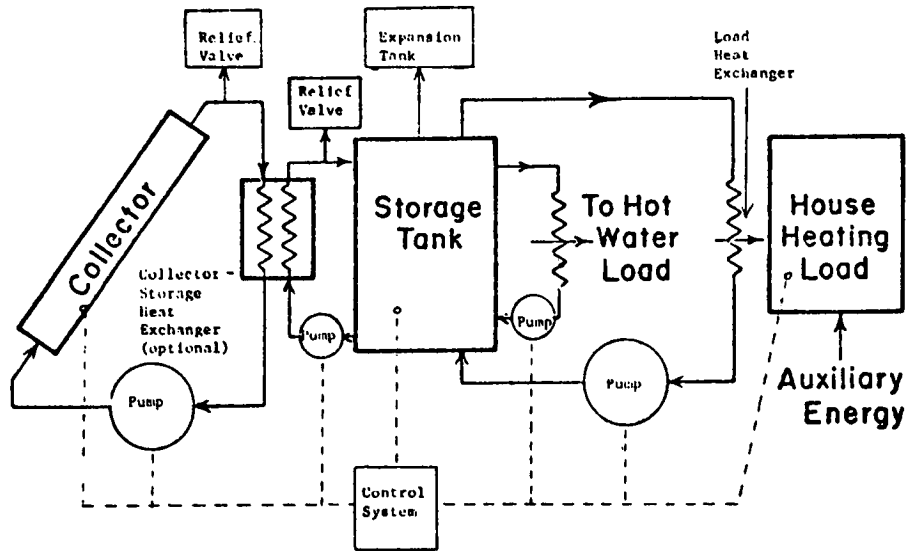


FIGURE 5-A

TABLE 4B
 \bar{R} for $\bar{K}_T = .40$

| Latitude | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | 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
 \bar{R} for $\bar{K}_T = .50$

| Latitude | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | 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 |

PROPOSED RULES

TABLE 4B

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

| Latitude | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | 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

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

| Latitude | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | 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 |

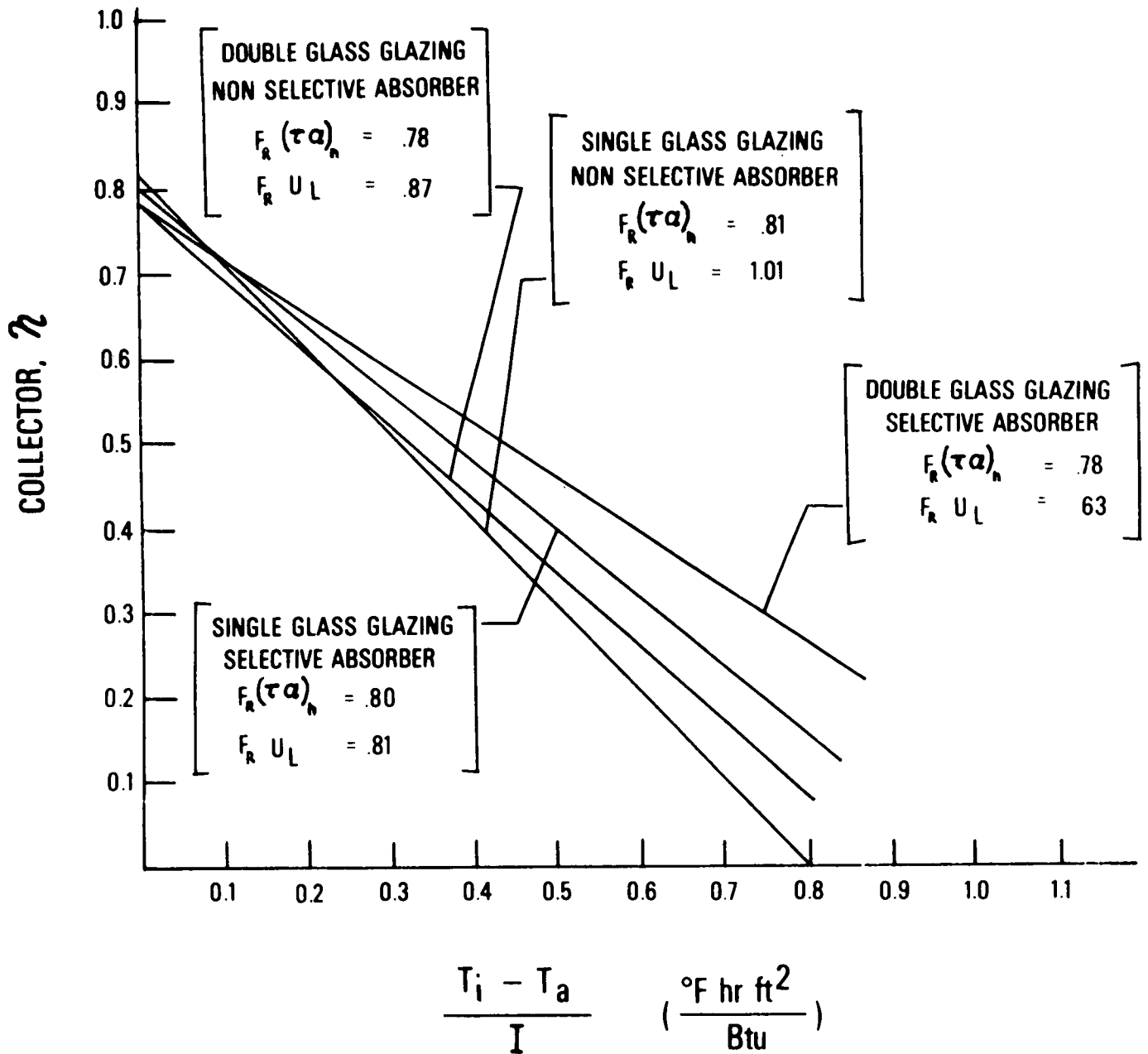
Component parameters. The component parameters characterize the various components that make up the system. In cases of design where several different solar heating systems may be considered for the same location and collector tilt, incident radiation on a tilted surface (\bar{I}_T) need only be calculated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

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PROPOSED RULES



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

FIGURE 5-B

PROPOSED RULES

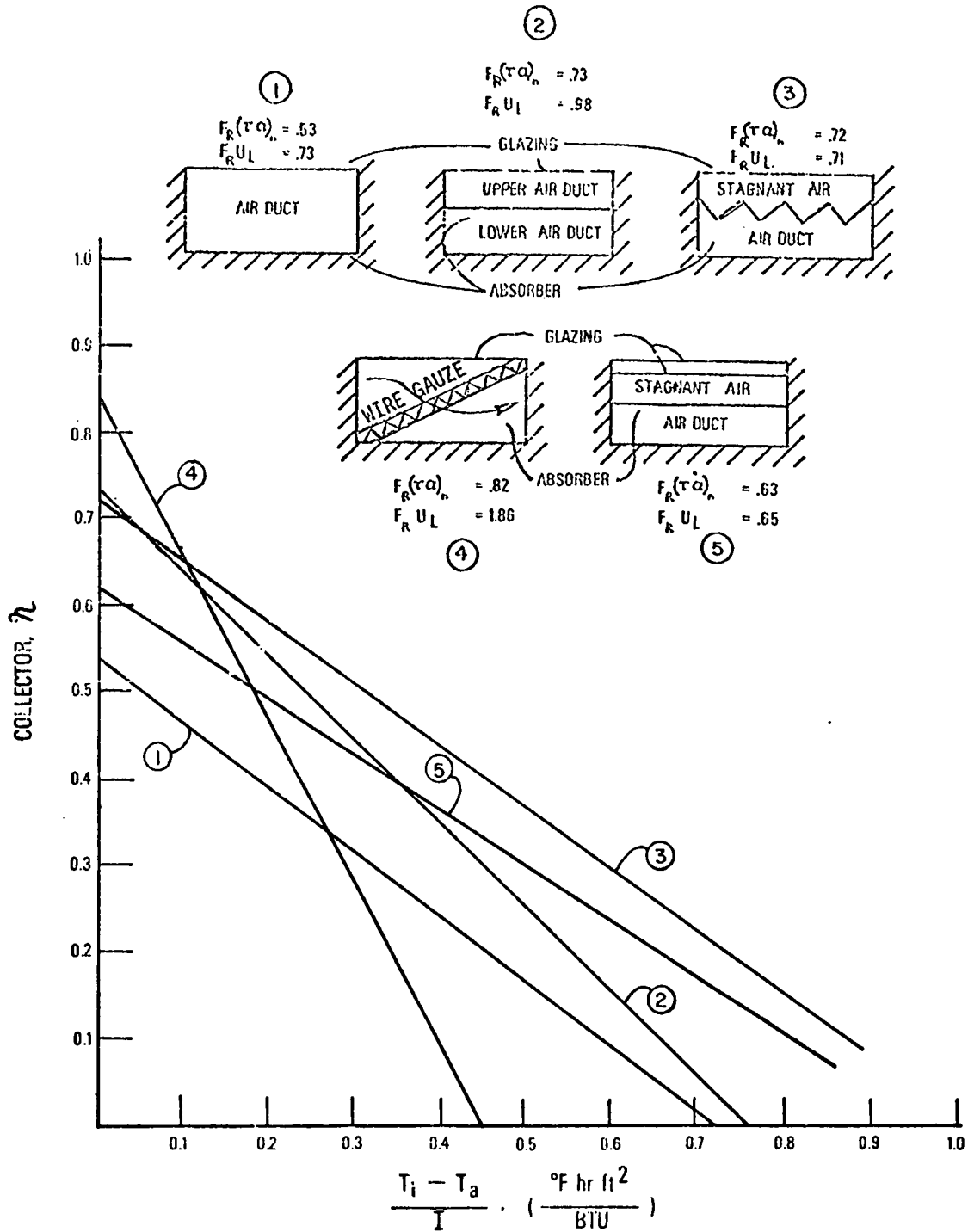


FIGURE 5-C Thermal Efficiency Curves for Typical Flat Plate Collectors Using Air as a Working Fluid

KEY: New rules and material proposed to be added to an existing rule are printed in **boldface**. Material proposed to be deleted from an existing rule is printed in [single brackets]. Underlining indicates additions to proposed rules, while ~~[[double brackets]]~~ indicate matter stricken from proposed rules. Existing material is printed in standard type face.

PROPOSED RULES

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.

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

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.

$$\begin{aligned} (\dot{m} c_p)_c &= \text{fluid capacitance rate of the collector working fluid.} \\ \epsilon_c &= \text{effectiveness of the collector heat exchanger} \\ &= \frac{\text{actual heat transfer}}{\text{maximum possible heat transfer}} \end{aligned}$$

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.

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

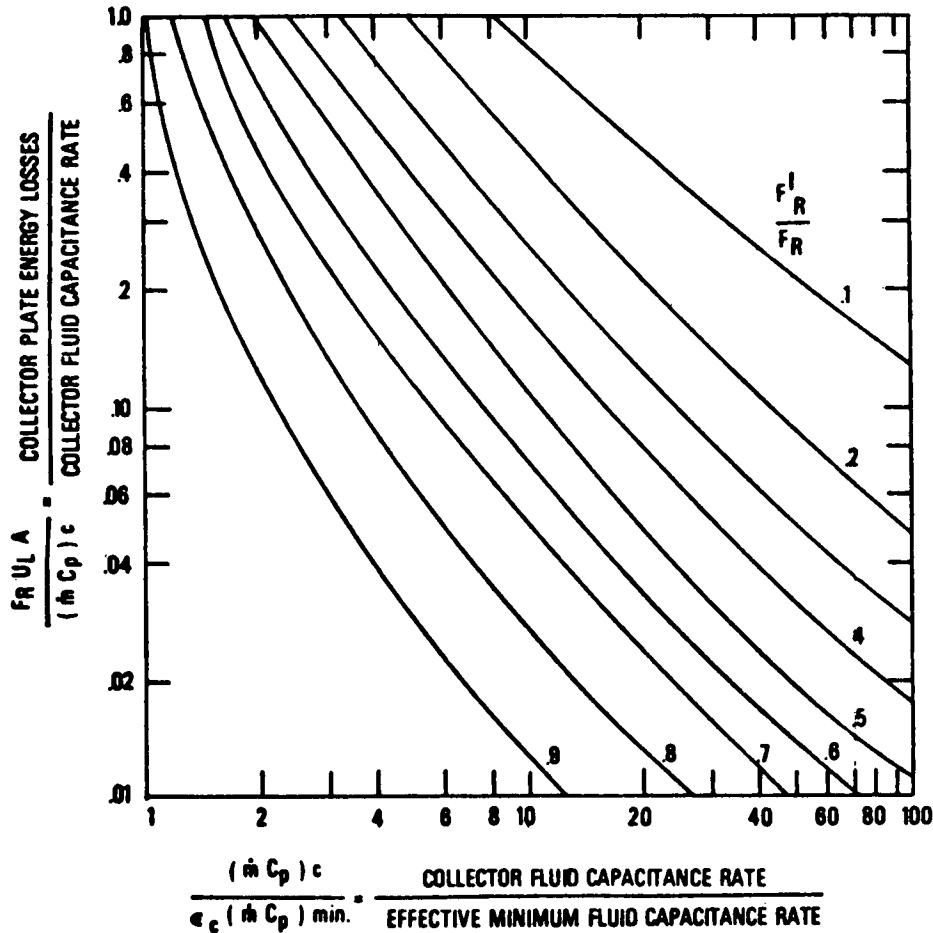


FIGURE 5-D F_R'/F_R as a function of $F_R U_L A_c / (\dot{m} c_p)_c$ and $(\dot{m} c_p)_c / \epsilon_c (\dot{m} c_p)_{\min}$

PROPOSED RULES

Storage. In general for solar heating systems utilizing water or air as heat transfer fluids an average storage capacity of 15 Btu/°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. Determining 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:

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

$$= (A_c) (F_R (\gamma\alpha)_n) \left(\frac{(\gamma\alpha)}{(\gamma\alpha)_n} \right) \left(\frac{F_R'}{F_R} \right) \frac{S}{L}$$

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

$$+ (A_c) (F_R U_L) \left(\frac{F_R'}{F_R} \right) (t_{\text{ref}} - \bar{t}_a) \left(\frac{\Delta \text{ time}}{L} \right)$$

$t_{\text{ref}} = 212^\circ\text{F}$ (arbitrarily chosen reference temperature)

$\Delta \text{ time} =$ average ambient air temperature for the particular month

$\left(\frac{\gamma\alpha}{(\gamma\alpha)_n} \right) = 0.90$ 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.

KEY: New rules and material proposed to be added to an existing rule are printed in **boldface**. Material proposed to be deleted from an existing rule is printed in [single brackets]. Underlining indicates additions to proposed rules, while [[double brackets]] indicate matter stricken from proposed rules. Existing material is printed in standard type face.

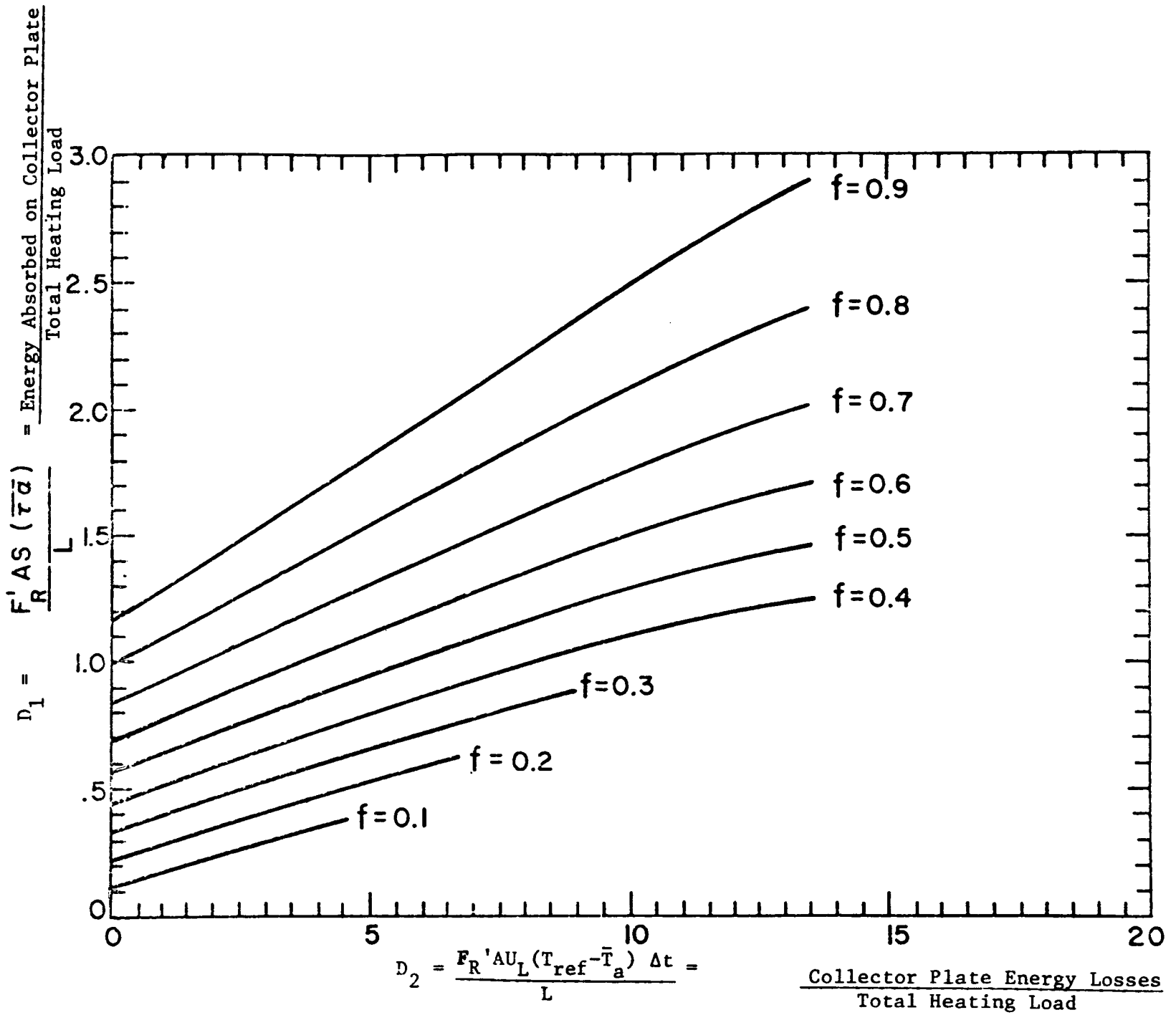


FIGURE 5-E Relationship between solar fraction and dimensionless parameters D_1 and D_2 .

PROPOSED RULES

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:

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

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

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

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

$$E_{\text{Total}} = E_{\text{Jan}} + E_{\text{Feb}} + \dots + E_{\text{Dec}}$$

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:

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

E. Correction factors for F_{annual}

1. To correct for various storage capacities other than $15 \text{ Btu}/(^{\circ}\text{F} \cdot \text{ft}^2)$, use Figure 5-F to obtain the correction factor (K_1).

2. For cases where $\epsilon_L (\dot{m}c_p) \text{ min}/UA$ 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:

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

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.

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PROPOSED RULES

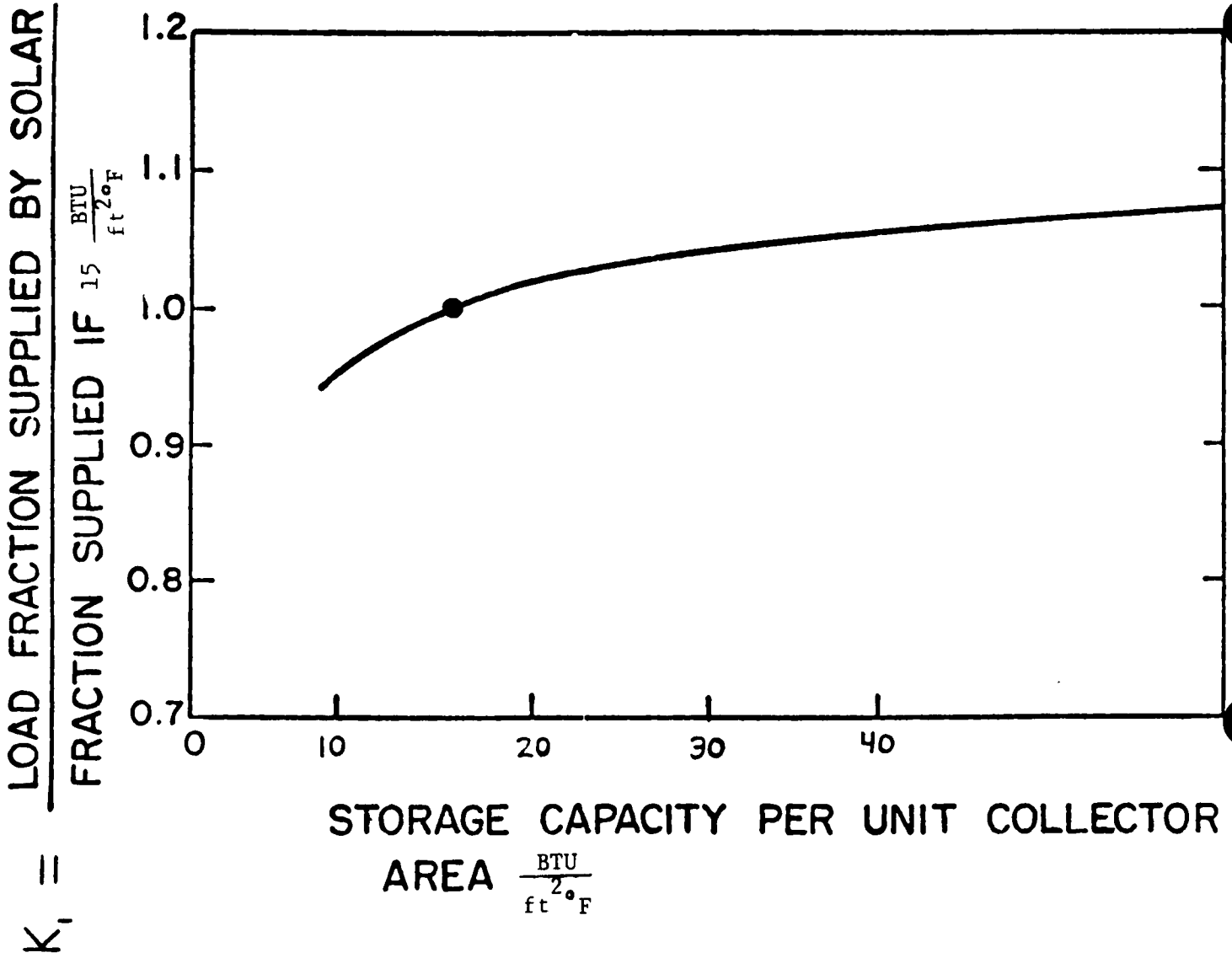


FIGURE 5-F Correction Factor (K₁) for Storage Capacities Other Than 15 BTU/ft² °F

$$K_2 = \frac{\text{LOAD FRACTION SUPPLIED BY SOLAR}}{\text{FRACTION SUPPLIED IF } \epsilon_L (\dot{m}c_p)_{\min} / UA} = 2$$

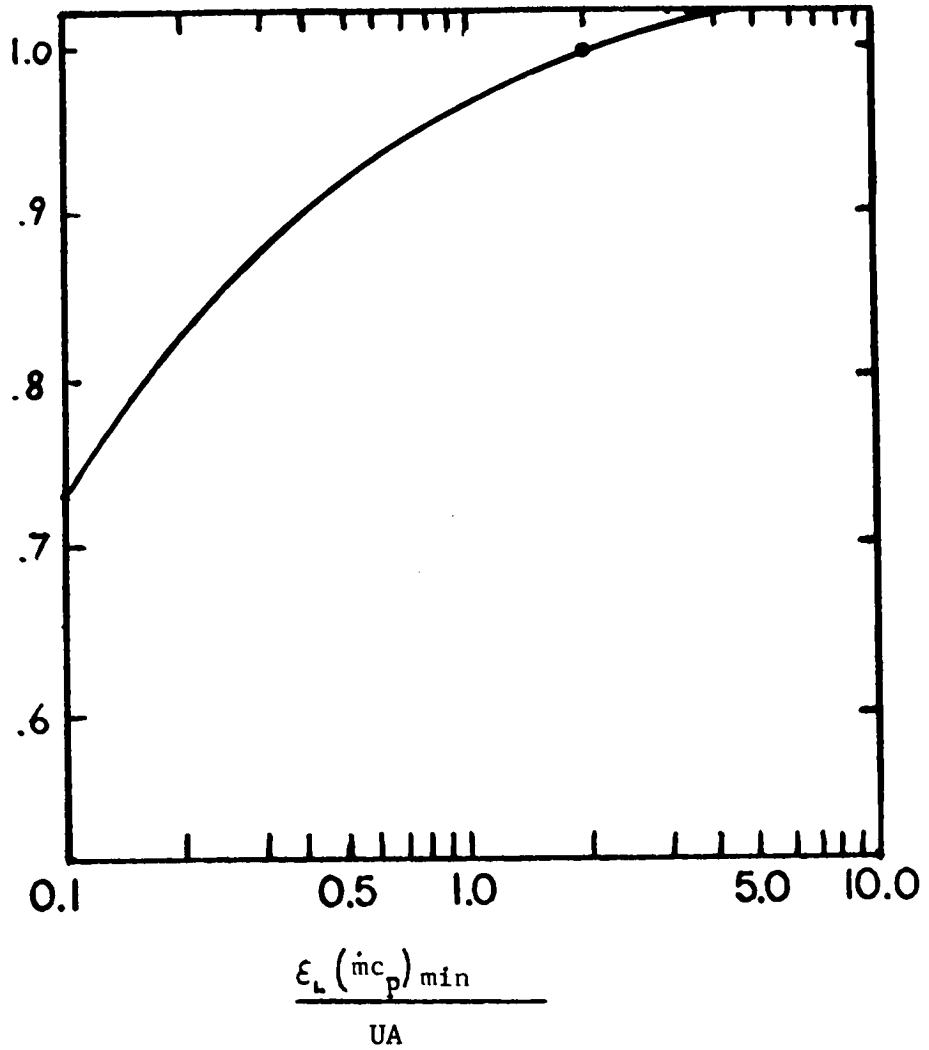


FIGURE 5-G Correction factor (K_2) for various values of $\epsilon_L(\dot{m}c_p)_{\min}/UA$

KEY: New rules and material proposed to be added to an existing rule are printed in **boldface**. Material proposed to be deleted from an existing rule is printed in [single brackets]. Underlining indicates additions to proposed rules, while [[double brackets]] indicate matter stricken from proposed rules. Existing material is printed in standard type face.

TABLE B

Incident Solar Radiation

Component Parameters

(CITE 1 S.R. 1501)

STATE REGISTER, MONDAY, APRIL 11, 1977

Page 1501

| | $\frac{\text{BTU}}{\text{Day ft}^2}$ \bar{I}_H | \bar{K}_t | R | $\frac{\text{BTU}}{\text{Day ft}^2}$ $\bar{I}_T = \bar{I}_H R$ | $\frac{\text{BTU}}{\text{Month ft}^2}$ S |
|-------|---|-------------|-----|---|---|
| Jan | | | | | |
| Feb | | | | | |
| Mar | | | | | |
| April | | | | | |
| May | | | | | |
| June | | | | | |
| July | | | | | |
| Aug. | | | | | |
| Sept. | | | | | |
| Oct. | | | | | |
| Nov. | | | | | |
| Dec. | | | | | |

latitude = _____

tilt = _____

I. Collectors

$F_{RU_L} =$ $\dot{m} =$

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

$A_c =$

II. Collector-Storage Heat Exchanger

$F_{R'}/F_R =$ $\frac{(F_{RU_L})A_c}{(\dot{m} c_p)_c} =$

$\epsilon_c =$ $\frac{(\dot{m} c_p)_c}{\epsilon_c (\dot{m} c_p)_{\min}} =$

III. Storage

$M =$ $c_p M/A_c =$

IV. Load Heat Exchanger

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

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

PROPOSED RULES

TABLE C

DIMENSIONLESS PARAMETERS

FRACTION OF THE TOTAL HEATING LOAD SUPPLIED BY SOLAR ENERGY

PROPOSED RULES

| | BTU | BTU | HRS | °F | D1 | D2 | f | BTU |
|-------|-------|-------|-------|----------------|----|----|---|-------|
| | MONTH | MONTH | MONTH | t _a | | | | MONTH |
| | L | S | Δt | | | | | |
| Jan. | | | 744 | | | | | |
| Feb. | | | 696 | | | | | |
| Mar. | | | 744 | | | | | |
| April | | | 720 | | | | | |
| May | | | 744 | | | | | |
| June | | | 720 | | | | | |
| July | | | 744 | | | | | |
| Aug. | | | 744 | | | | | |
| Sept. | | | 720 | | | | | |
| Oct. | | | 744 | | | | | |
| Nov. | | | 720 | | | | | |
| Dec. | | | 744 | | | | | |

E total = _____
 L total = _____
 F annual = $\frac{E \text{ total}}{L \text{ annual}}$
 = _____
 K₁ = _____
 K₂ = _____
 F' annual = (K₁)
 (K₂) F annual
 = _____

OFFICIAL NOTICES

Department of Education

Notice of Intent to Solicit Outside Opinion on Rules Defining the Length of a School Day for Secondary School Students

The Department of Education is considering a revision of the definition of the length of a school day for secondary school students as it appears in the State Board of Education

Rules. The present definition appears in Edu 44 and was last revised in 1974.

The Department invites interested persons or groups to provide information, comment, and advice on the subject, in writing or orally, to Dr. E. Raymond Peterson, Assistant Commissioner of Education, State Department of Education, 657 Capitol Square Building, 550 Cedar Street, St. Paul, Minnesota 55101.

Written statements will be made part of the public hearing record.

EQC MONITOR

Environmental Quality Council

Actions Taken at the March 29, 1977 EQC Meeting

1. Adopted Permit Coordination rules.
2. Received exemption application from Cooperative Power Association/United Power Association on Bunker substation, Anoka County.
3. Found Environmental Assessment on Capitol Annex adequate and determined that this is a major governmental action but without potential for significant environmental effects and no Environmental Impact Statement is required.

Notice of Permit Issuance for CPA-UPA High Voltage Transmission Line

Notice is hereby given that on Monday, April 11, 1977, the Minnesota Environmental Quality Council (EQC) designated a route for and issued a construction permit to Cooperative Power Association (CPA) and United Power Association (UPA) for the construction of a 345 kilovolt (kV) alternating current (ac) single-circuit high voltage transmission line (HVTL) from CPA-UPA's Dickinson Substation, near Delano, Wright County, Minnesota, to substation facilities to be constructed by CPA-UPA on the site of Northern States Power Company's (NSP) Wilmarth Generating Station, near Mankato, Blue Earth County, Minnesota.

Copies of the EQC's Findings of Fact, Conclusions and Order, the Construction Permit and maps showing the designated route will be filed by EQC in the following Regional Libraries:

Region 1

Polk County-Crookston Library
120 North Ash Street
Crookston, MN 56716
218/281-4522

Region 2

Bemidji Public Library
Sixth and Beltrami
Bemidji, MN 56601
218/751-3963

Region 3

Duluth Public Library
101 West Second
Duluth, MN 55802
218/722-5803

Region 4

Fergus Falls Public Library
125 North Union
Fergus Falls, MN 56537
218/739-9387

Region 5

Kitchigami Regional Library
Pine River, MN 56474
218/587-2171

Region 6E

Crow River Regional Library
410 West Fifth
Willmar, MN 56201
Attn: Burt Sundberg
612/235-3162

Region 6W

Chippewa County Library
224 South First Street
Montevideo, MN 56265
612/269-6501

Region 7E

East Central Regional Library
240 Third Avenue S.E.
Cambridge, MN 55008
612/689-1901

Region 7W

Great River Regional Library
124 South Fifth Avenue
St. Cloud, MN 56301
612/251-7282

Region 8

Marshall-Lyon County Library
301 West Lyon Street
Marshall, MN 56258
507/532-2849

Region 9

Minnesota Valley Regional Library
120 South Broad Street
Mankato, MN 56001
507/387-3431

Region 10

Rochester Public Library
Broadway at First Street, S.E.
Rochester, MN 55901
507/288-9070

ECOL

Environmental Conservation Library
(ECOL)
300 Nicollet Mall
Minneapolis, MN 55401
612/372-6609

Copies may also be obtained by writing to the EQC at:
EQC, 100 Capitol Square Building, 550 Cedar Street, St.
Paul, Minnesota 55101. Request should be referenced to
MEQC Docket No. CU-TR-2.

Peter Vanderpoel
Chairman, MEQC

Pollution Control Agency Receipt of Natural Resource Permit Application

Name of Permit: Section 401 Certification and State Dis-
posal System

Applicant: City of St. James, Minnesota

Project Location: St. James, Watonwan County

Project Description: Hydraulically dredging 1.25 million
cubic yards of material from the bottom of St. James Lake,
approximately 225,000 cubic yards of which will be placed
in an area known as Miest Slough.

Questions on this project should be directed to: Louis L.
Flynn, MPCA, 1935 W. Co. Rd. B-2, Roseville, Minnesota
55113 at (612) 296-7225.

Comments on this project should be directed to: Division
of Water Quality, Attn: Terry Mader, MPCA, address as
above.

Errata

1. 1 S.R. 1302: Change title from "Certificate of
Need and Criteria for Assessment of Need for Large Coal
Storage Facilities" to "Contents of Applications for Cer-
tificates of Need and Criteria for Assessment of Need for
Large Coal Storage Facilities for Coal Suppliers and Coal
Transshipment Facilities."

2. 1 S.R. 1308: Change "or" to "of" after "area"
and before "the proposed facility" at EA 944 A.1.

3. 1 S.R. 1310: Change "Dislocation" to "Reloca-
tion" at EA 945 D.5.

4. 1 S.R. 1303: Begin new paragraph with "plus such
additional fees as are reasonably" at EA 905 B.

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Room 211 Capitol
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I