

Minnesota Attorney General: Administrative Rules Proceedings

Copyright Notice:

This material may be protected by copyright law (U.S. Code, Title 17). Researchers are liable for any infringement. For more information, visit www.mnhs.org/copyright.

Version 3
August 20, 2018

MJC

RULE REVIEW CHECKLIST

File No. 1771 — Docket No. 15, 8509, 0730
DATE RECEIVED 12-12-90 — ADOPTED W/O HEARING ____
REVIEW DATE 12-21-90 — EMERGENCY RULE ____
DUE DATE 12-26-90 — TO REVISOR ON 12-13-90
(DIS)APPROVED rejected 12-26-90 — REVISOR (DIS)APPROVED 12-18-90
WITHDRAWN ____ — FILED W/SEC. OF STATE ____
RETURNED TO AGENCY ____

✓ Rule as adopted (4 copies)

✓ Notice to Solicit Outside Information/Opinion (if applicable)
June 19, 1989 Date published in State Register
____ Comments

____ Petition for Adoption of a Rule

____ Board's Authorizing Resolution
____ Date adopted

✓ Proposed Rule
✓ Revisor's Certificate

✓ Notice of Intent to Adopt Rule
216C.19 subd 8 Statutory Authority
____ Small Business Statement
____ Expenditure of public money statement
Sept 14, 1990 Signature

✓ Statement of Need and Reasonableness (if applicable)
✓ Small Business Statement
____ Fees - § 16A.128

✓ Affidavit of Mailing Notice of Intent to Adopt Rule
September 25, 1990 Dated 30/25 days before adoption
____ Notice attached indicates it is attached
____ Copy of rule or summary attached
see my notes on 30 days

✓ Publication in State Register
October 1, 1990 Date 30/25 days before adoption
see my notes on 30 days

✓ 180-day deadline from:
✓ NA Effective date of law requiring rule (14.12) (both rules) ~~amendments don't apply~~
✓ end of ~~comment period~~ (§ 14.26) (rules without hearing)
____ effective date of statutory ~~authority~~ (§ 14.29) (emergency rules)

____ ~~Resolution Adopting~~
____ Date adopted

✓ Findings of Fact, Conclusions & Order Adopting
November 29, 1990 Date

✓ Written Requests, Submissions or Comments

✓ Declaration of Attorney
Eric Swanson Name of SAAG representing agency

____ Notice of Submission to Attorney General (if applicable)

____ Affidavit of Mailing Notice to Attorney General (if applicable)

DEPARTMENT: ATTORNEY GENERAL

STATE OF MINNESOTA

OFFICE MEMORANDUM

DATE: December 26, 1990

TO: BRUCE NELSON
Senior Engineer
Department of Public Service

FROM: MARTHA J. CASSERLY
Special Assistant
Attorney General

PHONE: 296-6839

SUBJECT: **Rules Relating to Minnesota Energy Code**

The above-referenced rule has not been approved by the Attorney General because the Department of Public Service did not provide a 30-day comment period as required by Minn. Stat. §§ 14.22 and 14.25.

The Department's Notice of Intent to amend a rule without a public hearing expressly stated that "comments or requests for a public hearing must be received no later than 4:30 p.m. on October 30, 1990." While the affidavit of mailing indicates that the Notice was mailed September 25, 1990, the Notice was not published in the State Register until October 1, 1990. Under the method of calculation of the number of days pursuant to Minn. Stat. § 645.15, the 30-day comment period after the date of publication ended October 31, not October 30. Consequently, the Department provided a 29-day comment period, rather than 30 days.

To correct this deficiency, you must re-publish and re-mail the Notice of Intent and expressly provide a complete 30-day comment period. After the close of the 30-day comment period, assuming you do not get a total of 25 or more requests for a public hearing,[1] the rule may be resubmitted to the Attorney General for review. Attorney General Rule 2010.1300 provides the procedures for re-submitting the rule. In addition to the documents listed in subpart 1 of that rule, the following documents must also be submitted:

1. A copy of the Notice of Intent as signed and mailed;
2. A copy of the Notice of Intent as published in the State Register;
3. An affidavit of mailing the subsequent Notice of Intent; and
4. Any additional comments or requests received.

---

1. In counting the number of requests for a public hearing, you must include the requests received during the initial comment period, unless the requests have been withdrawn in writing.

In resubmitting the rule to our office, please enclose a cover memo specifying that the rule is being resubmitted and refer to our file number 1771, so that we may obtain our initial file in this matter.

As I stated on the phone, if you wish, I will review your Notice of Intent before it is mailed/published. Please contact me or Patty Nolte if you have additional questions.

MJC:cy.bm1

cc: William Brown, Office of Administrative Hearings
Mary Ann Hruby, Legislative Commission to Review Administrative Rules
Paul Marinac, Revisors Office
Eric Swanson, Attorney General's Office

from an abatement project. Other waste material includes both the waste material from the residential property and any waste material, such as solvents, generated as part of the abatement project. Any waste material that is determined to be a hazardous waste must be managed as a hazardous waste.

Subp. 3. **Bare soil.** The property owner must comply with the requirements of chapter 7045 for any bare soil excavated as part of an abatement project. Bare soil that contains lead in such concentration that it is a hazardous waste must be managed as a hazardous waste.

4750.0040 ABATEMENT CONTRACTOR DUTIES.

If a property owner who is required to undertake abatement of bare soil hires an abatement contractor to conduct the abatement, the abatement contractor shall comply with the requirements of parts 4750.0030 and 4750.0035.

4750.0050 VARIANCE.

Subpart 1. **Procedures.** A property owner who is required to undertake abatement of bare soil may apply for a variance from the requirements of part 4750.0030, subpart 2, item A or B, to allow for use of innovative abatement methods. The property owner shall comply with part 7000.0700 in applying for the variance and the agency shall act upon the variance request according to the procedures of part 7000.0700.

Subp. 2. **Burden of proof.** The property owner who applies for a variance has the burden of establishing that the variance should be granted.

Subp. 3. **Granting of the variance request.** The agency shall grant the variance request if the property owner establishes that the innovative abatement method will ensure that upon completion of the abatement, no person will come in contact with bare soil that exceeds the bare soil standard in part 4750.0020.

Department of Public Service

Proposed Permanent Rules Relating to Minnesota Energy Code

Notice of Intent to Amend a Rule Without a Public Hearing and Notice of Intent to Adopt a Rule With a Public Hearing if Twenty-Five or More Persons Request a Hearing

NOTICE IS HEREBY GIVEN that the Minnesota Department of Public Service intends to adopt amendments to *Minnesota Rules* Chapter 7670, without a public hearing. The Commissioner has determined that the proposed amendment of these rules will be noncontroversial in nature and has elected to follow the procedures set forth in the *Minnesota Statutes*, sections 14.22 to 14.28. Authority for the adoption of these rules is contained in *Minnesota Statutes*, section 216C.19, subdivision 8.

All persons have 30 days in which to submit comment in support of or in opposition to any part or subpart of the proposed amendments. Comment is encouraged. Each comment should identify the proposed amendment addressed, the reason for the comment, and any change proposed.

All persons may make a written request for a public hearing on the proposed amendments within the 30-day comment period. If 25 or more persons submit a written request for a public hearing within the 30-day comment period, a public hearing will be held unless a sufficient number withdraw their requests in writing. Any person requesting a public hearing must state his or her name and address and is encouraged to identify the portion of the proposed amendment addressed, the reason for the request, and any change proposed. If a public hearing is required, the agency will proceed pursuant to *Minnesota Statutes*, sections 14.131 to 14.20.

PLEASE NOTE: that if twenty five or more persons submit written requests for a public hearing within the 30 day comment period, a public hearing will be held on November 5, 1990 unless a sufficient number withdraw their requests in accordance with the notice of hearing on these rules published in the *STATE REGISTER* and mailed to persons registered with the Department of Public Service. To verify whether a hearing will be held, please call the Department of Public Service, Energy Information Center, on October 31, 1990 betwen the hours of 8:00 a.m. and 4:15 p.m. at 296-5175 or Minnesota toll free 800-652-9747 (ask for "Energy").

Comments or written requests for a public hearing must be submitted to:

Bruce Nelson, Senior Engineer
Department of Public Service, Energy Division
790 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101
phone (612) 297-2313 fax (612) 297-1959

Comments or requests for a public hearing must be received no later than 4:30 p.m. on October 30, 1990.

The proposed amendments may be modified if the modifications are supported by the data and views submitted to the Department and do not result in a substantial change in the proposed amendments as noticed.

A Copy of the proposed rule amendment is attached to this notice.

A STATEMENT OF NEED AND REASONABLENESS that describes the need for and reasonableness of each provision of the proposed amendments and identifies the data and information relied upon to support the proposed amendments has been prepared and is available by requesting a copy from Mr. Nelson at the address listed above.

The adoption of these rules will not result in additional spending by local bodies of government in excess of $100,000 per year in either of the first two years following their adoption.

If no hearing is required, upon adoption of the rule, the rule and the required supporting documents will be submitted to the Attorney General for review as to legality and form to the extent that form relates to legality. Any person may request notification of the date of submission to the Attorney General. Persons who wish to be advised of the submission of this material to the Attorney General, or who wish to receive a copy of the adopted rules, must submit a written request for such to Mr. Nelson at the address listed above.

Dated: 14 September 1990

Tony Perpich, Commissioner
Department of Public Service

Notice of Hearing and Notice of Intent to Cancel Hearing if Fewer than Twenty-Five Persons Request a Hearing in Response to Notice of Intent to Adopt Rules Without a Public Hearing

NOTICE IS HEREBY GIVEN that a public hearing on the above-entitled matter will be held on November 5, 1990 in Conference Room 4, 9th floor of the American Center Building, 150 East Kellogg Boulevard, St. Paul, Minnesota commencing at 9:00 a.m. and continuing until all interested or affected persons have an opportunity to participate. The proposed rules may be modified as a result of the hearing process. Therefore, if you are affected in any manner by the proposed rule, you are urged to participate in the rule hearing process.

PLEASE NOTE, HOWEVER, that the hearing will be cancelled if fewer than twenty-five persons request a hearing in response to the notice of intent to adopt these same rules without a public hearing published in this *State Register* and mailed to persons registered with the Department of Public Service, Energy Division. To verify whether a hearing will be held, please call the Department of Public Service, Energy Information Center on October 31, 1990 between the hours of 8:00 a.m. and 4:15 p.m. at 296-5175 or Minnesota toll free 800-652-9747 (ask for "Energy").

Following the agency's presentation at the hearing, all interested or affected persons will have an opportunity to participate. Such persons may present their views either orally at the hearing or in writing at any time prior to the close of the hearing. All evidence presented should be pertinent to the matter at hand. Written material not submitted at the time of the hearing which is to be included in the hearing may be mailed to Bruce D. Campbell, Administrative Law Judge, Office of Administrative Hearings, 310 Fourth Avenue South, Minneapolis, Minnesota 55415; telephone 612/341-7602, either before the hearing or within five working days after the public hearing ends. The Administrative Law Judge may at the hearing, order the record to be kept open for a longer period not to exceed 20 calendar days. The comments received during the comment period shall be available for review at the Office of Administrative Hearings. Following the close of the comment period the agency and all interested persons have three business days to respond in writing to any new information submitted during the comment period. During the three day period, the agency may indicate, in writing, whether there are amendments suggested by other persons which the agency is willing to adopt. No additional evidence may be admitted during the three day period. The written responses shall be added to the rulemaking record. Upon the close of the record the Administrative Law Judge will write a report as provided for in *Minnesota Statutes*, Sections 14.15 to 14.50. The rule hearing is governed by *Minnesota Statutes*, section 14.14 to 14.20 and by *Minnesota Rules*, parts 1400.0200 to 1400.1200. Questions about procedure may be directed to the Administrative Law Judge.

Authority for the adoption of these rules is contained in *Minnesota Statutes*, section 216C.19, subdivision 8.

The adoption of these rules will not result in additional spending by local bodies of government in excess of $100,000 per year in either of the first two years following their adoption.

A Copy of the proposed rule amendment is attached to this notice.

KEY: PROPOSED RULES SECTION — Underlining indicates additions to existing rule language. ~~Strike outs~~ indicate deletions from existing rule language. If a proposed rule is totally new, it is designated "all new material." **ADOPTED RULES SECTION** — Underlining indicates additions to proposed rule language. ~~Strike outs~~ indicate deletions from proposed rule language.

NOTICE: Any person may request notification of the date on which the Administrative Law Judge's report will be available, after which date the agency may not take final action on the rules for a period of five working days. If you desire to be notified, you may so indicate at the hearing. After the hearing, you may request notification by sending a written request to the Administrative Law Judge. Any person may request notification of the date on which the rules were adopted and filed with the secretary of state. The notice must be mailed on the same day the rules are filed. If you want to be so notified you may so indicate at the hearing or send a request in writing to the agency at any time prior to filing the rules with the secretary of state.

NOTICE IS HEREBY GIVEN that a Statement of Need and Reasonableness is now available for review at the Agency and at the Office of Administrative Hearings. The Statement of Need and Reasonableness includes a summary of all the evidence and argument which the agency anticipates presenting at the hearing justifying both the need for and reasonableness of the proposed rules. Copies of the Statement of Need and Reasonableness may be reviewed at the agency or the Office of Administrative Hearings and may be obtained from the Office of Administrative Hearings at the cost of reproduction.

Copies of the Statement of Need and Reasonableness are also available by submitting a request to:

Bruce Nelson, Senior Engineer
Department of Public Service, Energy Division
790 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101
phone (612) 297-2313 fax (612) 297-1959

Minnesota Statutes, Chapter 10A requires each lobbyist to register with the State Ethical Practices Board within five days after he or she commences lobbying. A lobbyist is defined in *Minnesota Statutes*, section 10A.01, subdivision 11 as any individual:

(a) engaged for pay or other consideration, or authorized by another individual or association to spend money, who spends more than five hours in any month or more than $250.00, not including travel expenses and membership dues, in any year, for the purpose of attempting to influence legislative or administrative action by communication or urging others to communicate with public officials;

(b) who spends more than $250.00, not including his own traveling expenses and membership dues, in any year, for the purpose of attempting to influence legislative or administrative action by communicating or urging others to communicate with public officials.

The statute provides certain exceptions. Questions should be directed to the Ethical Practices Board, 625 North Robert Street, St. Paul, Minnesota 55101, telephone 612-296-5148.

Dated: 14 September 1990

Tony Perpich, Commissioner
Department of Public Service

Rules as Proposed

GENERAL

7670.0100 AUTHORITY; SCOPE; CONFLICTS.

Subpart 1. **Authority.** This chapter is adopted pursuant to *Minnesota Statutes*, section 216C.19, subdivision 8 ~~and constitute amendments to~~.

Subp. 2. **Scope.** Under *Minnesota Statutes*, section 216C.19, subdivision 8, this chapter is a part of the State Building Code, adopted in accordance with *Minnesota Statutes*, sections 16B.59 to 16B.73.

Subp. 3. **Conflicts.** In cases of conflict with other parts of the State Building Code, this chapter governs in all cases not affecting safety and health requirements.

~~Additionally, this chapter is intended to serve as standards for conducting maxi audits of existing buildings owned by the state, the University of Minnesota, cities, counties, and school districts as specified in *Minnesota Statutes*, section 216C.20.~~

7670.0120 EFFECTIVE DATE.

The effective date of this chapter is ~~January~~ February 1, ~~1984~~ 1991.

7670.0125 LEGISLATIVE MANDATES CONCERNING THE MINNESOTA ENERGY CODE.

An enclosed structure or portion of an enclosed structure constructed after January 1, 1978, and used primarily as a commercial parking facility for three or more motor vehicles may not be heated. Incidental heating resulting from building exhaust air passing through a parking facility is not prohibited if substantially all useful heat previously has been removed from the air.

EXCEPTION: Parking facilities that are appurtenant to dwelling unit occupancies.

7670.0130 ~~ADOPTION~~ INCORPORATIONS BY REFERENCE ~~OF THE MODEL ENERGY CODE WITH AMENDMENTS~~.

Subpart 1. **Incorporated items.** The following standards and references are incorporated by reference:

A. The Model Energy Code, ~~1983~~ 1989 Edition, as published by the Council of American Building Officials (Falls Church, Virginia), ~~is incorporated by reference and made a part of the State Building Code, subject to the amendments in this chapter~~ as amended by parts 7670.0330 to 7670.1000.

B. Code of Federal Regulations, title 10, part 435, Energy Conservation Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; subpart 103, Lighting and subpart 105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in sheet metal construction.

C. ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality as published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (Atlanta, GA).

D. ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings.

E. AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.

F. ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box.

G. ASTM C 976-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box.

H. WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory.

Subp. 2. **Availability.** All standards and documents incorporated by reference are available for public inspection at the Minnesota State Law Library and through the Minitex interlibrary loan system. In addition:

A. ASHRAE and ANSI/ASHRAE documents and standards are available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers - Publication Sales, 1791 Tullie Circle NE, Atlanta, GA 30329;

B. AAMA standards are available from the American Architectural Manufacturers Association, 2700 River Road, Des Planes, IL 60018;

C. ASTM standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103; and

D. The WINDOW computer program is available from Bostik Construction Products, P.O. Box 8, Huntington Valley, PA 19006.

7670.0250 APPLICABILITY.

Buildings covered by this chapter must comply with the Model Energy Code as amended by parts 7670.0325 to 7670.1000. This part also applies to remodeled elements of buildings covered by the State Building Code. This chapter governs in case of conflict with the Model Energy Code.

EXCEPTION: Relocated residential buildings need not comply with this chapter, except that, where available, an energy audit must be conducted on the relocated building.

7670.0325 AMENDMENTS TO SECTION 201: DEFINITIONS.

Subpart 1. **Thermal transmittance (U).** In section 201 of the Model Energy Code, the definition of "Thermal transmittance (U)" is amended to read:

THERMAL TRANSMITTANCE (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature differential between the warm side and cold side air films (Btu/h ft^2 F).

A. Thermal transmittance of opaque wall components (U_w) and roof/ceiling components (Ur,) must be calculated using one of the following methods appropriate for the application:

(1) Parallel heat flow method:

Reference: Model Energy Code, chapter 5, equation 1.

Applications: Wood frame and masonry with surface applied thermal insulation.

KEY: PROPOSED RULES SECTION — Underlining indicates additions to existing rule language. ~~Strike outs~~ indicate deletions from existing rule language. If a proposed rule is totally new, it is designated "all new material." **ADOPTED RULES SECTION** — Underlining indicates additions to proposed rule language. ~~Strike outs~~ indicate deletions from proposed rule language.

(2) Series-parallel method:

Reference: RS-1, page 22.4.

Applications: Masonry blocks with insulation inserts or filled cores, nonmetal surface with metal framing.

(3) Thermal bridges in sheet metal construction method:

Reference: Code of Federal Regulations, title 10, part 435.105, section 5.3.3.2.1(d).

Applications: Metal framing bonded on one or both sides to a metal skin or covering.

(4) Zone method:

Reference: RS-1, page 22.10.

Applications: Metal surface with nonmetal framing.

B. Thermal transmittance of window area (U_w) and skylight elements (U_s) must be determined in accordance with one of the following methods:

(1) Reference RS-1, representative U-values for fenestration products, pages 27.16 to 27.18;

(2) AAMA Standard 1503.1;

(3) ASTM C 236 or ASTM C 976, using design conditions specified in footnote (a) of table 13, chapter 27 of reference RS-1; or

(4) WINDOW computer program.

Subp. 2. **Vapor retarder.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

VAPOR RETARDER. A material to retard air and water vapor passage designed to meet a maximum perm rating of 1.0 grain per hour per ft^2 per inch Hg pressure differential. Polyethylene material that is not cross laminated which is used to meet the requirements of this paragraph must be designed to have a minimum thickness of four mills.

Subp. 3. **Wind wash.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WIND WASH. Wind wash is the passage of unconditioned air through thermal insulation of the building envelope.

Subp. 4. **Window area.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WINDOW AREA. Window area, or glazing area, is either the area of glazing and sash, or the area used by the manufacturer to determine the window thermal transmittance.

7670.0400 AMENDMENT TO ~~302.1~~ SECTION 302: ~~FOOTNOTE 1~~ DESIGN CONDITIONS.

~~On page 12 of the code,~~ Footnote 1 ~~to~~ of section 302.1 of the Model Energy Code is amended to read:

[1]~~The~~ Outdoor design ~~temperature shall~~ conditions must be selected from ~~the columns of 99 percent values for winter and one percent values for summer from tables in~~ Standard RS-1. Heating design temperatures must be no lower than the temperature listed in the 99 percent column. Cooling design temperatures must be no greater than the temperature listed in the 2.5 percent column.

EXCEPTION: Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the median of annual extremes for heating and one percent column for cooling may be used.

Heating degree days ~~heating shall~~ must be selected from Standard RS-22. Adjustments may be made as determined by the building official to reflect local climates which differ from the tabulated temperatures or local weather experience ~~as determined by the building official~~.

7670.0450 AMENDMENT TO SECTION 303: VENTILATION.

Section 303.1 of the Model Energy Code is amended to read:

303.1 Ventilation. Ventilation systems must be designed to conform with ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality.

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE.

Section 502.2.1 of the Model Energy Code is amended by adding a new section to read:

502.2.1.7 Alternative compliance. Alternative methods of compliance with section 502.2.1 for one- and two-family residential buildings.

Minimum performance for Type A-1 (one- and two-family) buildings:

Ceilings	Walls	Floors	Windows	Doors
R-38	R-19[1]	R-19[1]	Maximum U-0.49[2]	R-3

(1) For the insulation within the cavity of opaque walls and rim joists.

(2) Maximum window area must not exceed 12 percent of the area of exterior walls, not including foundation walls.

Site-built fixed glazing must be installed in either an aluminum or steel frame having a minimum 0.25 inch low conductance thermal break or in wood or vinyl framing. The glazing must be either double-glazed with a dead air space between panes of nominal one-half inch spacing or triple-glazed with a dead air space between panes of not less than one-fourth inch.

Foundation walls must comply with part 7670.0510, slab-on-grade floors must comply with section 502.2.1.4 and crawl space walls must comply with section 502.2.1.5.

7670.0480 AMENDMENT TO SECTION 502: EFFECTIVENESS OF REQUIRED THERMAL INSULATION.

Section 502.2 of the Model Energy Code is amended by adding paragraphs to read:

Subpart 1. **Thermal insulation.** Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards.

Subp. 2. **Cold weather vapor condensation.** Building assemblies are required to maintain the thermal performance of required insulation and the integrity of building materials against cold weather water vapor condensation.

A. A vapor retarder must be installed between the interior surface and the winter design condition dew point location within each building envelope surface. Joints in the vapor retarder must be sealed between solid blocking.

EXCEPTION: A vapor barrier need not be installed on the rim joist insulation.

B. A barrier against air leakage must be installed to prevent the leakage of moisture-laden air from the house into the building envelope. An air barrier must be continuous at all plumbing and heating penetrations of interior surface of the building exterior envelope. If a tub or shower is located on an exterior wall, an air barrier must be provided at the interior surface of the building exterior envelope behind the tub or shower.

Subp. 3. **Preventing wind wash.** A barrier must be provided at the following locations to mitigate wind wash:

A. the exterior edge of attic insulation; and

B. cantilevered floors and bay windows, including corners with adjoining vertical walls above and below.

7670.0500 AMENDMENT TO ~~502.2.1.4~~ 502: SLAB ON GRADE FLOORS.

~~On page 19 of the code,~~ Section 502.2.1.4 of the Model Energy Code is amended to read:

502.2.1.4 Slab on grade floors. For slab on grade floors, the thermal resistance of the insulation around the perimeter of the floor must be not less than the value given in Table No. ~~5-1~~ 502.2.1. The insulation must extend downward from the top of the slab to the design frost line or downward to the bottom of the slab then horizontally beneath the slab for an equivalent distance, and must be an approved type.

7670.0510 AMENDMENT TO ~~502.2.1~~ SECTION 502: FOUNDATION WALLS.

~~On page 19~~ Section 502.2.1.6 of the Model Energy Code~~, 502.2.1~~ is amended ~~by adding a paragraph~~ to read:

Subpart 1. 502.2.1.6 Foundation walls. Foundation walls enclosing heated or conditioned spaces must be insulated.

Either the thermal resistance (R) of the insulation on the entire opaque foundation wall must be not less than R-5, or the thermal resistance (R) of the insulation on the opaque foundation wall must be not less than R-10 from the top of the wall down to the design frost line. If the top of the footing is at or above the design frost line, the thermal resistance (R) of the insulation on the wall must not be less than R-5 from the top of the wall to the top of the footing.

Subp. 2. **Intended use; installation.** All insulation used in or on foundation walls must be approved for the intended use. The insulation must be installed in accordance with the approved manufacturer's specifications.

Subp. 3. **Exterior insulation.** If the foundation wall insulation is on the exterior, the portion from the top of the foundation wall to six inches below grade must be covered by an approved protective coating finish to protect the insulation from deterioration due to sunlight and physical abuse.

KEY: PROPOSED RULES SECTION — Underlining indicates additions to existing rule language. ~~Strike outs~~ indicate deletions from existing rule language. If a proposed rule is totally new, it is designated "all new material." **ADOPTED RULES SECTION** — Underlining indicates additions to proposed rule language. ~~Strike outs~~ indicate deletions from proposed rule language.

7670.0550 AMENDMENT TO ~~502.4.3~~ SECTION 502: AIR LEAKAGE.

~~On page 23 of the code,~~ Section 502.4.3 of the Model Energy Code is amended to read as follows:

Subpart 1. ~~502.4.3.1~~ 502.4.3 Exterior joints in the building envelope that are sources of air leakage~~, such as around window and door frames,~~ must be caulked, gasketed, or otherwise sealed in an approved manner. These air leak sources include, but are not limited to, areas between wall cavities and window or door frames, between walls and foundations, between walls and roofs or ceilings and between wall panels, ~~openings~~ and at penetrations of utility services ~~through walls, floors, and roofs, and all other similar openings in the building envelope must be caulked, gasketed, or otherwise sealed in an approved manner. A continuous air barrier must be provided at all electrical, mechanical, and plumbing penetrations~~.

Subp. 2. **Alternative.** As an alternative to the prescriptive requirements of subpart 1 for detached single-family residential buildings, air tightness must comply with air leakage class A, B, C, or D of ANSI/ASHRAE Standard 119. In addition, this alternative requires that the ventilation system must provide a ventilation rate of not less than 0.35 air changes per hour (determined in accordance with ASHRAE Standard 62, Table 2.3) or 15 cfm per person, whichever is greater. This ventilation rate must be verified by measurement.

Subp. 3. **Fire stops.** Fire stops must be installed in accordance with the State Building Code. When mineral fiber or glass fiber materials are used as fire stop construction at ceilings and wall cavities separating conditioned and nonconditioned spaces, the fire stop must be installed to block air movement.

EXCEPTIONS: A fire stop need not block air movement if its installation would conflict with any other part of the State Building Code.

7670.0610 ~~AMENDMENT~~ AMENDMENTS TO ~~503.2~~ SECTION 503: BUILDING MECHANICAL SYSTEMS.

Subpart 1. **Calculation procedures.** ~~On page 24~~ Section 503.2.1 of the Model Energy Code~~, 503.2~~ is amended ~~by adding a paragraph~~ to read:

~~503.2.3 System design heating and cooling capacity. The rated capacity of the heating and cooling system at design conditions may not be greater than 115 percent for heating, 100 percent for cooling at design output load calculated in accordance with 503.2, whenever appropriate equipment is available.~~

~~Exceptions: 1. Equipment designed for standby purposes.~~
~~2. Cooling capacity of heat pumps.~~
~~3. Systems designed for pick up after automatic temperature setback when a registered professional engineer shows that the extra system design heating and cooling capacity is needed for pick up.~~

503.2.1 Calculation procedures. Heating and cooling system design loads for the purpose of sizing systems and equipment must be determined in accordance with the procedures described in Standard RS-1. For those design parameters addressed in part 7670.0400, the values specified must be used.

503.2.1.1 Safety factor. Design loads may at the designer's option be increased by as much as ten percent to account for unexpected loads or changes in space usage.

503.2.1.2 Pick-up loads. Transient loads such as warm-up or cool-down loads that occur after off-hour setback or shutoff may be calculated from principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be up to 30 percent for heating and ten percent for cooling of the steady-state design loads. The steady-state load may include a safety factor in accordance with section 503.2.1.1.

Subp. 2. **System and equipment sizing.** Section 503.2 of the Model Energy Code is amended by adding a paragraph to read:

503.2.3 System and equipment sizing. HVAC systems and equipment must be sized to provide no more than the space and system loads calculated in accordance with 503.2.1.

Exceptions:

(a) Equipment capacity may exceed the design load if the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Equipment whose capacity exceeds the design load may be specified if oversizing the equipment can be shown to not increase the overall annual energy costs.

(c) Stand-by equipment may be installed if controls and devices are provided that allow stand-by equipment to operate automatically only when the primary equipment is not operating.

(d) Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on load.

(e) For a single piece of equipment that has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function must be, within available equipment options, the smallest size necessary to meet the load.

7670.0660 AMENDMENT TO ~~TABLE NO. 5-7~~ SECTION 503: EQUIPMENT EFFICIENCY.

Subpart 1. **Table No. 503.4.3.** Table No. 503.4.3 of the Model Energy Code "HVAC System Heating Equipment - Gas- and Oil-Fired Minimum Steady State Combustion Efficiency" is amended by changing the requirement for forced-air furnaces and low-pressure steam or hot-water boilers for all other commercial or industrial furnaces and boilers to 80 percent.

~~On page 29~~ Subp. 2. **Table No. 503.4.8.** Section 503 of the Model Energy Code~~, Table No. 5-7~~ is amended by adding a table to read:

Table No. ~~5-7~~ 503.4.8 — Minimum EER and COP for Electrically Driven ~~HVAC System Components~~ Water Source Hydronic Heat Pumps[1]

~~Component~~	~~Type of Compressor~~	~~Condensing Means~~ ~~Air~~ ~~EER~~	~~COP~~	~~Water~~ ~~EER~~	~~COP~~	~~Evaporative~~ ~~EER~~	~~COP~~
~~Self-contained water chillers~~	~~Centrifugal~~	~~8.00~~	~~2.34~~	~~13.80~~	~~4.04~~		
	~~Positive displacement~~	~~8.40~~	~~2.46~~	~~12.00~~	~~3.51~~		
~~Condenserless water chillers Compressor and condenser units 65,000 Btu/h (19,050 watts) and over[2]~~	~~Positive displacement~~	~~9.90~~	~~2.9~~	~~12.00~~	~~3.51~~		
	~~Positive displacement~~	~~9.50~~	~~2.78~~	~~12.50~~	~~3.66~~	~~12.50~~	~~3.66~~
~~Water Source Hydronic Heat Pump~~	Size	under 19 kW (65,000 Btu/h)		19 kW (65,000 Btu/h) and over			
		~~EER~~	~~COP~~	~~EER~~	~~COP~~		
	~~Centrifugal~~	~~9.0~~	~~2.64~~	~~9.4~~	~~2.75~~		
	EER	9.0		9.4			
	COP	2.64		2.75			

[1]When tested at the standard rating conditions specified in Table No. ~~5-10C~~ 503.4.6a.

~~[2]Ratings in accordance with Standard RS-14 as applicable. COP based on condensing unit standard rating capacity and energy input to the unit, all at sea level.~~

7670.0670 AMENDMENT TO ~~503.10.2~~ SECTION 503.10: DUCT CONSTRUCTION.

~~On page 33 of the code,~~ Section 503.10.2 of the Model Energy Code is amended to read:

503.10.2. For low pressure supply and return air ducts located outside of the conditioned space, all transverse joints must be sealed using mastic, tape, or mastic ~~plus~~ and tape. For fibrous glass ductwork, pressure sensitive tape may be used.

7670.0710 ~~DELETION OF 504.5.3~~ AMENDMENTS TO SECTION 504: SERVICE WATER HEATING.

Subpart 1. **Time clocks.** ~~On page 38~~ Section 504.5 of the Model Energy Code~~,~~ is amended by deleting section 504.5.3 ~~is deleted~~.

Subp. 2. **Pipe insulation.** Section 504.7 of the Model Energy Code is amended by deleting the exception.

Subp. 3. **Devices to limit temperature.** Section 504.8.2 of the Model Energy Code is amended by deleting section 504.8.2.2.

KEY: PROPOSED RULES SECTION — Underlining indicates additions to existing rule language. ~~Strike outs~~ indicate deletions from existing rule language. If a proposed rule is totally new, it is designated "all new material." **ADOPTED RULES SECTION** — Underlining indicates additions to proposed rule language. ~~Strike outs~~ indicate deletions from proposed rule language.

7670.0800 ~~AMENDMENT OF 505.2.~~ AMENDMENTS TO SECTION 505: ELECTRIC POWER AND LIGHTING.

Subpart 1. **Electric energy determination.** The exception to section 505.2 of the Model Energy

~~On page 39 of the~~ Code~~, 505.2~~ is amended to read:

~~505.2 Electric energy determination.~~

~~In any multi tenant residential building, provisions shall be made to separately determine the electric energy consumed by each tenant. Electrical service to individual dwelling units in buildings containing two or more units shall be separately metered, with individual metering readily accessible to the individual occupants.~~

EXCEPTION: Motels, hotels, college dormitories, other transient facilities, and buildings intended for occupancy primarily by persons who are 62 years of age or older or handicapped, or which contain a majority of units not equipped with complete kitchen facilities.

Subp. 2. **Lighting power budget.** The lighting requirements of sections 505.3 and 505.4 of the Model Energy code are amended to read:

The lighting power budget must be the upper limit of the power to provide the lighting needs in accordance with the 1988 and 1989 criteria and calculation procedure specified in Code of Federal Regulations, title 10, part 435.103 (excluding section 3.2).

EXCEPTION: One- and two-family detached dwellings and the dwelling portion of multifamily buildings.

7670.0850 AMENDMENT TO SECTION 600: DESIGN BY ACCEPTABLE PRACTICE.

Section 601.1 of the Model Energy Code is amended by adding a paragraph to read:

Buildings constructed in accordance with this section must also comply with parts 7670.0480 to 7670.0800.

7670.1000 ~~AMENDMENT~~ AMENDMENTS TO ~~701.1~~ SECTION 701: REFERENCES.

~~On page 54 of the code.~~ Section 701.1~~, Code Standard No. RS-4,~~ of the Model Energy Code is amended by replacing the following code standard numbers to read:

RS-1	1989 ASHRAE Handbook of Fundamentals.
RS-3	ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality.
RS-4	ASHRAE Standard 55-1981 Thermal Environment Conditions for Human Occupancy.
RS-17 & RS-18	SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985.
RS-23	Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80 Minnesota. National Oceanic and Atmospheric Administration September 1982.

REPEALER. *Minnesota Rules*, parts 7670.0110; 7670.0200; 7670.0210; 7670.0220; 7670.0300; 7670.0310; 7670.0320; 7670.0330; 7670.0340; 7670.0520; 7670.0540; 7670.0600; 7670.0620; 7670.0630; 7670.0640; 7670.0650; 7670.0700; 7670.0720; 7670.0730; 7670.0900; 7670.0910; 7670.0920; 7670.0930; 7670.0940; 7670.0950; 7670.0960; 7670.0970; 7670.1010; 7670.1020; 7670.1030; 7670.1100; and 7670.1110 are repealed.

Adopted Rules

The adoption of a rule becomes effective after the requirements of Minn. Stat. §14.14-14.28 have been met and five working days after the rule is published in *State Register*, unless a later date is required by statutes or specified in the rule.

If an adopted rule is identical to its proposed form as previously published, a notice of adoption and a citation to its previous *State Register* publication will be printed.

If an adopted rule differs from its proposed form, language which has been deleted will be printed with strikeouts and new language will be underlined. The rule's previous *State Register* publication will be cited.

An emergency rule becomes effective five working days after the approval of the Attorney General as specified in Minn. Stat. §14.33 and upon the approval of the Revisor of Statutes as specified in §14.36. Notice of approval by the Attorney General will be published as soon as practicable, and the adopted emergency rule will be published in the manner provided for adopted rules under §14.18.

Pollution Control Agency

Adopted Permanent Rules Relating to Infectious Waste Management

The rules noticed, proposed and published at *State Register*, Volume 14, Number 41, pages 2419-2431, April 9, 1990 (14 SR 2419) and Volume 14, Number 47, pages 2710-2711, May 21, 1990 (14 SR 2710) are adopted with the following modifications:

Department of Public Service

Proposed Permanent Rules Relating to Minnesota Energy Code

Rules as Proposed

GENERAL

7670.0100 AUTHORITY; SCOPE; CONFLICTS.

Subpart 1. **Authority.** This chapter is adopted pursuant to Minnesota Statutes, section 216C.19, subdivision 8 ~~and constitute amendments to~~.

Subp. 2. **Scope.** Under Minnesota Statutes, section 216C.19, subdivision 8, this chapter is a part of the State Building Code, adopted in accordance with Minnesota Statutes, sections 16B.59 to 16B.73.

Subp. 3. **Conflicts.** In cases of conflict with other parts of the State Building Code, this chapter governs in all cases not affecting safety and health requirements.

~~Additionally, this chapter is intended to serve as standards for conducting maxi-audits of existing buildings owned by the state, the University of Minnesota, cities, counties, and school districts as specified in Minnesota Statutes, section 216C.20.~~

7670.0120 EFFECTIVE DATE.

The effective date of this chapter is ~~January~~ February 1, ~~1984~~ 1991.

7670.0125 LEGISLATIVE MANDATES CONCERNING THE MINNESOTA ENERGY CODE.

An enclosed structure or portion of an enclosed structure constructed after January 1, 1978, and used primarily as a commercial parking facility for three or more motor vehicles may not be heated. Incidental heating resulting from building exhaust air passing through a parking facility is not prohibited if substantially all useful heat previously has been removed from the air.

Approved by Revisor

EXCEPTION: Parking facilities that are appurtenant to dwelling unit occupancies.

7670.0130 ~~ADOPTION~~ INCORPORATIONS BY REFERENCE ~~OF THE MODEL ENERGY CODE WITH AMENDMENTS~~.

Subpart 1. **Incorporated items.** The following standards and references are incorporated by reference:

A. The Model Energy Code, ~~1983~~ 1989 Edition, as published by the Council of American Building Officials (Falls Church, Virginia), ~~is incorporated by reference and made a part of the State Building Code, subject to the amendments in this chapter~~ as amended by parts 7670.0330 to 7670.1000.

B. Code of Federal Regulations, title 10, part 435, Energy Conservation Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; subpart 103, Lighting and subpart 105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in sheet metal construction.

C. ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality as published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (Atlanta, GA).

D. ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings.

E. AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.

F. ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box.

G. ASTM C 976-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box.

H. WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory.

Subp. 2. **Availability.** All standards and documents

Approved by Revisor _____

incorporated by reference are available for public inspection at the Minnesota State Law Library and through the Minitex interlibrary loan system. In addition:

A. ASHRAE and ANSI/ASHRAE documents and standards are available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers - Publication Sales, 1791 Tullie Circle NE, Atlanta, GA 30329;

B. AAMA standards are available from the American Architectural Manufacturers Association, 2700 River Road, Des Planes, IL 60018;

C. ASTM standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103; and

D. The WINDOW computer program is available from Bostik Construction Products, P.O. Box 8, Huntington Valley, PA 19006.

7670.0250 APPLICABILITY.

Buildings covered by this chapter must comply with the Model Energy Code as amended by parts 7670.0325 to 7670.1000. This part also applies to remodeled elements of buildings covered by the State Building Code. This chapter governs in case of conflict with the Model Energy Code.

EXCEPTION: Relocated residential buildings need not comply with this chapter, except that, where available, an energy audit must be conducted on the relocated building.

7670.0325 AMENDMENTS TO SECTION 201: DEFINITIONS.

Subpart 1. **Thermal transmittance (U).** In section 201 of the Model Energy Code, the definition of "Thermal transmittance (U)" is amended to read:

THERMAL TRANSMITTANCE (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature differential between the warm side and cold side air films (Btu/h ft^2 F).

A. Thermal transmittance of opaque wall components (U_w) and roof/ceiling components (U_r) must be calculated using one of the following methods appropriate for the application:

Approved by Revisor _____

(1) Parallel heat flow method:

Reference: Model Energy Code, chapter 5, equation 1.

Applications: Wood frame and masonry with surface applied thermal insulation.

(2) Series-parallel method:

Reference: RS-1, page 22.4.

Applications: Masonry blocks with insulation inserts or filled cores, nonmetal surface with metal framing.

(3) Thermal bridges in sheet metal construction method:

Reference: Code of Federal Regulations, title 10, part 435.105, section 5.3.3.2.1(d).

Applications: Metal framing bonded on one or both sides to a metal skin or covering.

(4) Zone method:

Reference: RS-1, page 22.10.

Applications: Metal surface with nonmetal framing.

B. Thermal transmittance of window area (U_g) and skylight elements (U_s) must be determined in accordance with one of the following methods:

(1) Reference RS-1, representative U-values for fenestration products, pages 27.16 to 27.18;

(2) AAMA Standard 1503.1;

(3) ASTM C 236 or ASTM C 976, using design conditions specified in footnote (a) of table 13, chapter 27 of reference RS-1; or

(4) WINDOW computer program.

Subp. 2. **Vapor retarder.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

VAPOR RETARDER. A material to retard air and water vapor passage designed to meet a maximum perm rating of 1.0 grain per hour per ft^2 per inch Hg pressure differential. Polyethylene material that is not cross laminated which is used to meet the requirements of this paragraph must be designed to have a minimum thickness of four mills.

Subp. 3. **Wind wash.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WIND WASH. Wind wash is the passage of unconditioned air

Approved by Revisor _____

through thermal insulation of the building envelope.

Subp. 4. **Window area.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WINDOW AREA. Window area, or glazing area, is either the area of glazing and sash, or the area used by the manufacturer to determine the window thermal transmittance.

7670.0400 AMENDMENT TO ~~302.1~~ SECTION 302: ~~FOOTNOTE 1~~ DESIGN CONDITIONS.

~~On page 12 of the code,~~ Footnote 1 ~~to~~ of section 302.1 of the Model Energy Code is amended to read:

[1] ~~The~~ Outdoor design ~~temperature shall~~ conditions must be ~~selected from the columns of 99 percent values for winter and one percent values for summer from tables in~~ Standard RS-1. Heating design temperatures must be no lower than the temperature listed in the 99 percent column. Cooling design temperatures must be no greater than the temperature listed in the 2.5 percent column.

EXCEPTION: Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the median of annual extremes for heating and one percent column for cooling may be used.

Heating degree days ~~heating shall~~ must be selected from Standard RS-22. Adjustments may be made as determined by the building official to reflect local climates which differ from the tabulated temperatures or local weather experience ~~as determined by the building official~~.

7670.0450 AMENDMENT TO SECTION 303: VENTILATION.

Section 303.1 of the Model Energy Code is amended to read:

303.1 Ventilation. Ventilation systems must be designed to conform with ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality.

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE.

Section 502.2.1 of the Model Energy Code is amended by

Approved by Revisor _____

adding a new section to read:

502.2.1.7 Alternative compliance. Alternative methods of compliance with section 502.2.1 for one- and two-family residential buildings.

Minimum performance for Type A-1 (one- and two-family) buildings:

Ceilings	Walls	Floors	Windows	Doors
R-38	R-19[1]	R-19[1]	Maximum U-0.49[2]	R-3

(1) For the insulation within the cavity of opaque walls and rim joists.

(2) Maximum window area must not exceed 12 percent of the area of exterior walls, not including foundation walls.

Site-built fixed glazing must be installed in either an aluminum or steel frame having a minimum 0.25 inch low conductance thermal break or in wood or vinyl framing. The glazing must be either double-glazed with a dead air space between panes of nominal one-half inch spacing or triple-glazed with a dead air space between panes of not less than one-fourth inch.

Foundation walls must comply with part 7670.0510, slab-on-grade floors must comply with section 502.2.1.4 and crawl space walls must comply with section 502.2.1.5.

7670.0480 **AMENDMENT TO SECTION 502: EFFECTIVENESS OF REQUIRED THERMAL INSULATION.**

Section 502.2 of the Model Energy Code is amended by adding paragraphs to read:

Subpart 1. **Thermal insulation.** Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards.

Subp. 2. **Cold weather vapor condensation.** Building assemblies are required to maintain the thermal performance of required insulation and the integrity of building materials against cold weather water vapor condensation.

A. A vapor retarder must be installed between the interior surface and the winter design condition dew point

Approved by Revisor _____

location within each building envelope surface. Joints in the vapor retarder must be sealed between solid blocking.

EXCEPTION: A vapor barrier need not be installed on the rim joist insulation.

B. A barrier against air leakage must be installed to prevent the leakage of moisture-laden air from the house into the building envelope. An air barrier must be continuous at all plumbing and heating penetrations of interior surface of the building exterior envelope. If a tub or shower is located on an exterior wall, an air barrier must be provided at the interior surface of the building exterior envelope behind the tub or shower.

Subp. 3. **Preventing wind wash.** A barrier must be provided at the following locations to mitigate wind wash:

A. the exterior edge of attic insulation; and

B. cantilevered floors and bay windows, including corners with adjoining vertical walls above and below.

7670.0500 AMENDMENT TO ~~502.2.1.4~~ 502: SLAB ON GRADE FLOORS.

~~On page 19 of the code,~~ Section 502.2.1.4 of the Model Energy Code is amended to read:

502.2.1.4 Slab on grade floors. For slab on grade floors, the thermal resistance of the insulation around the perimeter of the floor must be not less than the value given in Table No. ~~5-1~~ 502.2.1. The insulation must extend downward from the top of the slab to the design frost line or downward to the bottom of the slab then horizontally beneath the slab for an equivalent distance, and must be an approved type.

7670.0510 AMENDMENT TO ~~502.2.1~~ SECTION 502: FOUNDATION WALLS.

~~On page 19~~ Section 502.2.1.6 of the Model Energy Code, ~~502.2.1~~ is amended ~~by adding a paragraph~~ to read:

Subpart 1. 502.2.1.6 Foundation walls. Foundation walls enclosing heated or conditioned spaces must be insulated.

Either the thermal resistance (R) of the insulation on the entire opaque foundation wall must be not less than R-5, or the thermal resistance (R) of the insulation on the opaque

Approved by Revisor _____

foundation wall must be not less than R-10 from the top of the wall down to the design frost line. If the top of the footing is at or above the design frost line, the thermal resistance (R) of the insulation on the wall must not be less than R-5 from the top of the wall to the top of the footing.

Subp. 2. **Intended use; installation.** All insulation used in or on foundation walls must be approved for the intended use. The insulation must be installed in accordance with the approved manufacturer's specifications.

Subp. 3. **Exterior insulation.** If the foundation wall insulation is on the exterior, the portion from the top of the foundation wall to six inches below grade must be covered by an approved protective coating finish to protect the insulation from deterioration due to sunlight and physical abuse.

7670.0550 AMENDMENT TO ~~502.4.3~~ SECTION 502: AIR LEAKAGE.

~~On page 23 of the code,~~ Section 502.4.3 of the Model Energy Code is amended to read as follows:

Subpart 1. ~~502.4.3.1~~ 502.4.3 Exterior joints in the building envelope that are sources of air leakage~~, such as around window and door frames,~~ must be caulked, gasketed, or otherwise sealed in an approved manner. These air leak sources include, but are not limited to, areas between wall cavities and window or door frames, between walls and foundations, between walls and roofs or ceilings and between wall panels, ~~openings~~ and at penetrations of utility services ~~through walls, floors, and roofs, and all other similar openings in the building envelope must be caulked, gasketed, or otherwise sealed in an approved manner. A continuous air barrier must be provided at all electrical, mechanical, and plumbing penetrations~~.

Subp. 2. **Alternative.** As an alternative to the prescriptive requirements of subpart 1 for detached single-family residential buildings, air tightness must comply with air leakage class A, B, C, or D of ANSI/ASHRAE Standard 119. In addition, this alternative requires that the ventilation system must provide a ventilation rate of not less

Approved by Revisor _____

than 0.35 air changes per hour (determined in accordance with ASHRAE Standard 62, Table 2.3) or 15 cfm per person, whichever is greater. This ventilation rate must be verified by measurement.

Subp. 3. **Fire stops.** Fire stops must be installed in accordance with the State Building Code. When mineral fiber or glass fiber materials are used as fire stop construction at ceilings and wall cavities separating conditioned and nonconditioned spaces, the fire stop must be installed to block air movement.

EXCEPTIONS: A fire stop need not block air movement if its installation would conflict with any other part of the State Building Code.

7670.0610 **~~AMENDMENT~~ AMENDMENTS** TO ~~503.2~~ SECTION 503: BUILDING MECHANICAL SYSTEMS.

Subpart 1. **Calculation procedures.** ~~On page 24~~ Section 503.2.1 of the Model Energy Code~~, 503.2~~ is amended ~~by adding a paragraph~~ to read:

~~503.2.3 System design heating and cooling capacity. The rated capacity of the heating and cooling system at design conditions may not be greater than 115 percent for heating, 100 percent for cooling at design output load calculated in accordance with 503.2, whenever appropriate equipment is available.~~

~~Exceptions: 1. Equipment designed for standby purposes.~~
~~2. Cooling capacity of heat pumps.~~
~~3. Systems designed for pick up after automatic temperature setback when a registered professional engineer shows that the extra system design heating and cooling capacity is needed for pick up.~~

503.2.1 Calculation procedures. Heating and cooling system design loads for the purpose of sizing systems and equipment must be determined in accordance with the procedures described in Standard RS-1. For those design parameters addressed in part 7670.0400, the values specified must be used.

503.2.1.1 Safety factor. Design loads may at the designer's option be increased by as much as ten percent to account for unexpected loads or changes in space usage.

Approved by Revisor _____

503.2.1.2 Pick-up loads. Transient loads such as warm-up or cool-down loads that occur after off-hour setback or shutoff may be calculated from principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be up to 30 percent for heating and ten percent for cooling of the steady-state design loads. The steady-state load may include a safety factor in accordance with section 503.2.1.1.

Subp. 2. **System and equipment sizing.** Section 503.2 of the Model Energy Code is amended by adding a paragraph to read:

503.2.3 System and equipment sizing. HVAC systems and equipment must be sized to provide no more than the space and system loads calculated in accordance with 503.2.1.

Exceptions:

(a) Equipment capacity may exceed the design load if the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Equipment whose capacity exceeds the design load may be specified if oversizing the equipment can be shown to not increase the overall annual energy costs.

(c) Stand-by equipment may be installed if controls and devices are provided that allow stand-by equipment to operate automatically only when the primary equipment is not operating.

(d) Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on load.

(e) For a single piece of equipment that has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function must be, within available equipment options, the smallest size necessary to meet the load.

7670.0660 AMENDMENT TO ~~TABLE NO. 5-7~~ SECTION 503: EQUIPMENT

Approved by Revisor _____

EFFICIENCY.

Subpart 1. Table No. 503.4.3. Table No. 503.4.3 of the Model Energy Code "HVAC System Heating Equipment - Gas- and Oil-Fired Minimum Steady State Combustion Efficiency" is amended by changing the requirement for forced-air furnaces and low-pressure steam or hot-water boilers for all other commercial or industrial furnaces and boilers to 80 percent.

~~On page 29~~ Subp. 2. Table No. 503.4.8. Section 503 of the Model Energy ~~Code, Table No. 5-7~~ is amended by adding a table to read:

Table No. ~~5-7~~ 503.4.8 -- Minimum EER and COP for Electrically Driven ~~HVAC System Components~~ Water Source Hydronic Heat Pumps[1]

~~Component~~	~~Type of Compressor~~	~~Condensing Means: Air EER~~	~~Air COP~~	~~Water EER~~	~~Water COP~~	~~Evaporative EER~~	~~Evaporative COP~~
~~Self-contained water-chillers~~	~~Centrifugal~~	~~8.00~~	~~2.34~~	~~13.00~~	~~4.04~~		
	~~Positive displacement~~	~~8.40~~	~~2.46~~	~~12.00~~	~~3.51~~		
~~Condenserless water-chillers~~	~~Positive displacement~~	~~9.90~~	~~2.9~~	~~12.00~~	~~3.51~~		
~~Compressor-and condenser units 65,000 Btu/h (19,050 watts) and over[2]~~	~~Positive displacement~~	~~9.50~~	~~2.78~~	~~12.50~~	~~3.66~~	~~12.50~~	~~3.66~~

~~Water Source Hydronic Heat Pump~~ Size	under 19 kW (65,000 Btu/h)		19 kW (65,000 Btu/h) and over	
	~~EER~~	~~COP~~	~~EER~~	~~COP~~
~~Centrifugal~~	~~9.0~~	~~2.64~~	~~9.4~~	~~2.75~~
EER	9.0		9.4	
COP	2.64		2.75	

[1]When tested at the standard rating conditions specified in Table No. ~~5-10C~~ 503.4.6a.

~~[2]Ratings in accordance with Standard RS-14 as applicable, COP based on condensing unit standard rating capacity and energy input to the unit, all at sea level.~~

7670.0670 AMENDMENT TO ~~503.10.2~~ SECTION 503.10: DUCT CONSTRUCTION.

Approved by Revisor _____

~~On page 33 of the code,~~ Section 503.10.2 of the Model Energy Code is amended to read:

503.10.2. For low pressure supply and return air ducts located outside of the conditioned space, all transverse joints must be sealed using mastic, tape, or mastic ~~plus~~ and tape. For fibrous glass ductwork, pressure sensitive tape may be used.

7670.0710 ~~DELETION OF 504.5.3~~ AMENDMENTS TO SECTION 504: SERVICE WATER HEATING.

Subpart 1. Time clocks. ~~On page 38~~ Section 504.5 of the Model Energy Code~~,~~ is amended by deleting section 504.5.3 ~~is deleted~~.

Subp. 2. Pipe insulation. Section 504.7 of the Model Energy Code is amended by deleting the exception.

Subp. 3. Devices to limit temperature. Section 504.8.2 of the Model Energy Code is amended by deleting section 504.8.2.2.

7670.0800 ~~AMENDMENT OF 505.2.~~ AMENDMENTS TO SECTION 505: ELECTRIC POWER AND LIGHTING.

Subpart 1. Electric energy determination. The exception to section 505.2 of the Model Energy

~~On page 39 of the~~ Code~~,~~ ~~505.2 Electric energy determination.~~ is amended to read:

~~In any multi-tenant residential building, provisions shall be made to separately determine the electric energy consumed by each tenant. Electrical service to individual dwelling units in buildings containing two or more units shall be separately metered, with individual metering readily accessible to the individual occupants.~~

EXCEPTION: Motels, hotels, college dormitories, other transient facilities, and buildings intended for occupancy primarily by persons who are 62 years of age or older or handicapped, or which contain a majority of units not equipped with complete kitchen facilities.

Subp. 2. Lighting power budget. The lighting requirements of sections 505.3 and 505.4 of the Model Energy code are amended to read:

Approved by Revisor _____

The lighting power budget must be the upper limit of the power to provide the lighting needs in accordance with the 1988 and 1989 criteria and calculation procedure specified in Code of Federal Regulations, title 10, part 435.103 (excluding section 3.2).

EXCEPTION: One- and two-family detached dwellings and the dwelling portion of multifamily buildings.

7670.0850 AMENDMENT TO SECTION 600: DESIGN BY ACCEPTABLE PRACTICE.

Section 601.1 of the Model Energy Code is amended by adding a paragraph to read:

Buildings constructed in accordance with this section must also comply with parts 7670.0480 to 7670.0800.

7670.1000 ~~AMENDMENT~~ AMENDMENTS TO ~~701.1~~ SECTION 701: REFERENCES.

~~On page 54 of the code,~~ Section 701.1~~, Code Standard No. RS-4,~~ of the Model Energy Code is amended by replacing the following code standard numbers to read:

RS-1	1989 ASHRAE Handbook of Fundamentals.
RS-3	ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality.
RS-4	ASHRAE Standard 55-1981 Thermal Environment Conditions for Human Occupancy.
RS-17 & RS-18	SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985.
RS-23	Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80 Minnesota. National Oceanic and Atmospheric Administration September 1982.

REPEALER. Minnesota Rules, parts 7670.0110; 7670.0200; 7670.0210; 7670.0220; 7670.0300; 7670.0310; 7670.0320; 7670.0330; 7670.0340; 7670.0520; 7670.0540; 7670.0600; 7670.0620; 7670.0630; 7670.0640; 7670.0650; 7670.0700; 7670.0720; 7670.0730; 7670.0900; 7670.0910; 7670.0920; 7670.0930; 7670.0940; 7670.0950; 7670.0960; 7670.0970; 7670.1010; 7670.1020; 7670.1030; 7670.1100; and 7670.1110 are repealed.

Approved by Revisor _____

Office of the Revisor of Statutes

Administrative Rules

TITLE: Proposed Permanent Rules Relating to Minnesota Energy Code

AGENCY: Department of Public Service

MINNESOTA RULES: Chapter 7670

INCORPORATIONS BY REFERENCE:

Part 7670.0130: Model Energy Code, 1989 Edition, published by Council of American Building Officials, Falls Church, Virginia, as amended by parts 7670.0330 to 7670.1000; ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, published by American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, Georgia; ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings; AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections; ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box; ASTM C 979-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box; WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory. Available at Minnesota State Law Library and through Minitex interlibrary loan system.

The attached rules are approved for publication in the State Register

Paul M. Marinac
Assistant Deputy Revisor

Stat. Authority 216C.19 subd 8
... Therefore, the commissioner shall, pursuant to chapter 14, adopt rules governing building design and construction standards regarding heat loss control ...

end of comment period ~~November 5, 1990~~ ~~October 5, 1990~~ October 30, 1990 } 29 ~~30~~ day

published in State Register October 1, 1990 }

made many changes -

~~A~~ One day short of 30 days for comment period - didn't make 30 day deadline

12-21-90 Bruce Nelson
said he had talked to
Paul Marinc. Paul said there
was some mix up with the
rules - Bruce wasn't sure
I pulled the file there
are 4 Revisor's certificates
on the rule - 4 must have
been brought over. I told
Bruce there was a problem
with the 30 day counting
- only 29 days for comment
period

Bruce said he would
like to be called
if we are going
to reject them

STATE OF MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

In the Matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service amending the State Building Code regarding Heat Loss, Illumination, and Climate Control (Minn. Rules ch. 7670).

STATEMENT OF NEED AND REASONABLENESS

September, 1990

I. INTRODUCTION

The Commissioner of the Minnesota Department of Public Service (department) proposes to adopt amendments to Minn. Rules Chapter 7670, rules known as the Minnesota Energy Code.

The principal rule changes proposed include adoption of the new edition (1989) of the Model Energy Code, provisions to maintain the effectiveness of thermal insulation in residential buildings, and new lighting standards. Reorganization and grammatical changes also are proposed to improve clarity and to conform with current style requirements.

The department began the present rule notification process on June 19, 1989, by publishing a note in the State Register (13 S.R. 2991) soliciting opinions and information from the public on the rules regarding the Minnesota Energy Code. The deadline for receiving comments was subsequently extended to June 30, 1990.

II. STATEMENT OF DEPARTMENT'S STATUTORY AUTHORITY

The Commissioner's authority to adopt the rule amendments is set forth in Minnesota Statute § 216C.19 which provides:

> In recognition of the compelling need for energy conservation in order to safeguard the public health, safety, and welfare, it is necessary to provide building design and construction standards consistent with the most efficient use of energy. Therefore, the commissioner shall, pursuant to chapter 14, adopt rules governing building design and construction standards regarding heat loss control, illumination and climate control. To the maximum extent practicable, the rules providing for the energy portions of the building code shall be based on and conform to model codes generally accepted throughout the United States. The rules shall apply to all new buildings and remodeling affecting heat loss control, illumination and climate control. The rules shall be economically feasible in that the resultant savings in energy procurement shall exceed the cost of the energy conserving requirements amortized over the life of the building. The rules adopted pursuant to this subdivision, shall be part of the state building code. Notwithstanding the provisions of this subdivision, all applications for approval of building specifications and plans may be submitted to the state building inspector as provided in section 16B.66.

III. STATEMENT OF NEED

Minnesota rules governing the Minnesota Energy Code were last modified in January, 1984. Since then, major changes have occurred in the understanding of both residential and commercial building energy performance and the factors affecting it. These changes are reflected in new national standards regarding building design and construction. To bring Minnesota into agreement with current understanding of building energy conservation and with updated national standards, changes in the current energy code are needed.

First, the department proposes to adopt the latest (1989) edition of the Model Energy Code to replace the 1983 edition currently in place.

Second, the U. S. Department of Energy (DOE) sponsored several major studies of energy performance in new buildings. The DOE studies revealed major opportunities for energy conservation, particularly in lighting standards. Based on the results of these studies, DOE adopted in July, 1989, new energy conservation standards for new commercial and high-rise multi-family residential buildings (10 CFR Part 435). These standards also have been published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) as ASHRAE Standard 90.1-1989. The department proposes that these new standards, as they apply to determination of thermal transmittance, design conditions, equipment sizing, and lighting, be made a part of the Minnesota Energy Code.

Third, the department also proposes additional changes to requirements for low-rise residential buildings. It proposes changes to requirements covering effectiveness of required thermal insulation and air leakage.

IV. STATEMENT OF REASONABLENESS

The department is required by Minnesota Statutes Ch. 14 to make an affirmative presentation of facts establishing the reasonableness of the proposed rules. In general terms, this means that the department must set forth the reasons for its proposal, and the reasons must not be arbitrary or capricious. However, to the extent that need and reasonableness are separate, need has come to mean that a problem exists which requires administrative attention, and reasonableness means that the solution proposed by the department is appropriate. The need and reasonableness for the proposed rule

amendments are discussed below.

Part 7670.0100 Authority; Scope; Conflicts.

The department proposes adding the word "conflicts" to the title to recognize the three subparts into which this part would be reorganized. Subpart 2 is added to make clear that chapter 7670 is a part of the State Building Code and cites the Minnesota statutes that make it part of the State Building Code. In addition, the State Building Code is defined by the Minnesota statutes that authorize it. In subpart 3, the words "other parts of" are added to be consistent and clear in acknowledging that this chapter is part of the State Building Code. The last sentence in subpart 3 is deleted to minimize duplication of statutory language in accordance with Minnesota Statute § 14.07, subdivision 3(1).

Part 7670.0120 Effective Date

The department proposes to change the effective date for the proposed amendments to Chapter 7670 from January 1, 1984, to February 1, 1991. January 1, 1984, was the effective date for the previous revisions to this chapter and is no longer relevant. Selection of an effective date is permitted by Minnesota Statute § 14.18. The choice of February 1, 1991, is based on providing a reasonable amount of time for informing code users of the changes (if they are adopted) and how to implement the new requirements after the expected completion of the present rule-making process. Explanation of how to apply the new rules would be particularly important in the case of designers and building officials who would be applying and enforcing the new rules. In anticipation of proposing that new requirements be incorporated into the Minnesota Energy Code, the department conducted

educational needs assessments for architects and building officials. From these assessments, the department concludes that one to two months would be required to prepare lighting designers, engineers, and building officials to implement these changes. If the proposed requirements are adopted, the department intends to implement the appropriate education and training projects described in the needs assessments. Scheduling the effective date as February 1 also gives the department an opportunity to announce upcoming rule changes and distribute information at the Annual School for Minnesota Building Officials conducted by the University of Minnesota in January.

Part 7670.0125 Legislative Mandates Concerning the Minnesota Energy Code

The department proposes adding a part that lists a legislative mandate concerning the Minnesota Energy Code. This mandate currently is covered in two different parts of the Energy Code -- 7670.0310, subpart 1 and 7670.0600, subpart 1. Including it in a single, separate part would improve organizational clarity. The old parts are included in the repealer at the end of the proposed rule amendments.

Part 7670.0130 Incorporations by Reference

A complete explanation or citation is required for each of the standards and references referred to in the Minnesota Energy Code. Subpart 1, items B. through H., incorporates into Chapter 7670 the citations referred to in the proposed amendments to Chapter 7670. Item A. of subpart 1 changes the date of the Model Energy Code reference to the most recent edition, 1989. It also deletes the clause incorporating the Model Code by reference and making it a part of the State Building Code because this is already stated in 7670.0100,

subpart 2. The phrase "subject to the amendments in this chapter" is replaced with the specific parts of Chapter 7670 that amend the Model Energy Code.

Subpart 2 states where these standards and documents incorporated by reference are available for public inspection. This statement of availability is required by Minnesota Statute § 14.07, Subdivision 4. Items A through D list additional sources for these standards and documents for the convenience of users of this chapter.

Part 7670.0250 Applicability

A new subpart is added to make clear which buildings are covered by the Model Energy Code as amended. The Model Energy Code applies to remodeled buildings in the same way as the State Building Code applies to these buildings. It also makes clear that in cases of conflict with the Model Energy Code, Minnesota Rules Chapter 7670 governs. An exception to the scope of the Minnesota Energy Code is provided for relocated residential buildings. This exception is mandated by Minnesota Statute § 16B.61, subdivision 3 (1) (1989 Supp). It is proposed as an amendment to this chapter to inform users of the energy code of that exemption.

Part 7670.0325 Amendments to Section 201: Definitions

Subparts 1, 2, 3, and 4 are added to provide definitions of thermal transmittance, vapor retarder, wind wash, and window area.

Subpart 1 - Thermal transmittance. The department proposes to add definitions of thermal transmittance and how it must be calculated for opaque wall components (U_w), roof/ceiling

components (U_r), and windows (U_g). A definition of these terms is needed to ensure that they will be used correctly so that buildings will achieve the expected energy performance. Because these terms are not defined in the Model Energy Code, they need to be defined here.

In item A, the department proposes that, depending on the material of the framing and surface components, one of four methods be used to calculate thermal resistance. Which methods to use for which materials are illustrated in Chapter 22 of the ASHRAE Handbook of Fundamentals, 1989 Edition (Attachment 1). The reasons why different methods must be used for different materials also are set out in the ASHRAE Handbook, chapter 22 (Attachment 1). The methods and the material configurations to which they apply are set forth in subitems 1 - 4.

In subitem 1 the department proposes to require that the "parallel heat flow" method be used for wood frame construction and masonry with surface-applied insulation. According to the ASHRAE Handbook (Attachment 1, page 22.3), this method is valid for these materials. This is the simplest of the four methods and has always been used for the designated applications.

The department proposes in subitem 2 that the "series-parallel" method be required for masonry blocks with insulation inserts or filled cores and for nonmetal surfaces with metal framing. The need to use this method for masonry blocks with insulation fillings is established in the ASHRAE Handbook (Attachment 1, page 22.4). The Handbook points

out that calculations by this method agree with measured values. The need for using this method is further supported by the National Concrete Masonry Association (NCMA) Standard Series Parallel Procedure for calculating the overall coefficient of heat transfer. In response to the department's solicitation for outside facts and opinions, the Minnesota Masonry Institute (MMI) provided a table (Attachment 2) that gives further evidence of the need for application of a uniform standard. The MMI table compares masonry block R-values (based on U-values calculated by the series parallel method) with R-values listed by manufacturers and obtained by other methods. In some cases manufacturers' R-values are as much as 224 percent higher than the calculations based on the recommended series-parallel method.

Continuing the discussion of subitem 2, the need for requiring the "series-parallel" method for nonmetal surfaces with metal framing is indicated by example 3 in the ASHRAE Handbook (Attachment 1, page 22.5) which shows that the closest correlation with measured values is obtained with the series-parallel method. The ASHRAE Standard 90.1 and 10 CFR Part 435 (Attachment 3) also require use of the series-parallel method for nonmetal surfaces with metal framing.

The department proposes in subitem 3 that for assemblies with metal framing and a metal skin or covering on one or both sides, the U-value be computed using the "sheet metal construction" method. This requirement accords with ASHRAE Standard 90.1 and 10 CFR Part 435 (Attachment 3).

The department proposes in subitem 4 that for metal surfaces with non-metal framing, the "zone method" be employed to calculate the U-value. The ASHRAE Handbook (Attachment 1, pages 22.10 and 22.11) recommends this method for this type of construction. ASHRAE Standard 90.1 and 10 CFR Part 435 (Attachment 3) also require use of the zone method for metal surfaces with nonmetal framing.

The four methods listed in the proposed rule amendment (identified as 1 through 4) are reasonable because they coincide with the recommendations of the ASHRAE Handbook and NCMA and requirements of 10 CFR Part 435 and ASHRAE Standard 90.1 These requirements should not be a burden for small businesses such as home builders who can use the simple parallel heat flow method (which they have used all along) for all assemblies except insulation-filled blocks. In the case of insulation-filled blocks, the supplier of the insulation system will likely provide the analysis.

In item B a definition of window U-value (U_g) is proposed to assure accurate window U-value calculations. (See Attachment 4.) The department proposes that any one of four methods, listed in subitems 1 - 4, be acceptable for calculating U_g. Most manufacturers already use one of these alternatives, and stipulating that any one of the four is acceptable lessens the burden of these rules. Support for the acceptability of these four methods is given below.

Subitem 1 states that one acceptable method be the method prescribed in the ASHRAE 1989 Handbook, Chapter 27, pages 27.16-27.18 (Attachment 1) as discussed in the

ASHRAE Journal - June, 1989 article. (Attachment 5.) Window U-values in the 1989 Handbook consist of calculated data for a variety of glazing systems and framing materials based on computer simulations verified by laboratory measurements.

The department proposes in subitem 2 that a second acceptable method be the American Architectural Manufacturers Association (AAMA) Standard 1503.1. This method is widely used. The AAMA is a respected organization that publishes a Certified Products Directory that lists window U-values based on this method of calculation.

The department proposes in subitem 3 that a third acceptable method be the use of either American Society for Testing and Materials (ASTM) Standard C 236 or C 976 using specified design conditions. This is identical to one of the options of the Seattle Department of Construction and Land Use for demonstrating compliance with its energy code. This method is also used by several window manufacturers to determine thermal performance.

A fourth acceptable method is proposed in subitem 4: use of computer program WINDOW, developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory. WINDOW was developed in response to a lack of a widely accepted, accurate, and easy-to-use procedure to analyze window thermal performance.

All of these methods are reasonably accurate; there is no national consensus that any one of them is superior to the others. All of them are used throughout the country and

requiring them is in accordance with Minnesota Statute § 216C.19, subd. 8, that calls for energy code rules to conform to codes generally accepted throughout the United States. Providing alternatives minimizes any burden for compliance with the rule.

Subpart 2 - vapor retarder. The definition of vapor retarder, previously in part 7670.0340, is included here with the other proposed definitions; 7670.0340 is included in the repealer at the end of the proposed rule amendments. Two substantial changes are made in the proposed definition of vapor retarder. The first change adopts the term "vapor retarder" in place of the term "vapor barrier." This change is consistent with the ASHRAE Handbook of Fundamentals which uses this new term in its 1989 edition, a change from the 1985 edition. The change is also consistent with ASTM C 755-84, "Standard Practice for Selection of Vapor Retarders for Thermal Insulations." (Attachment 7) The new term more accurately describes the function of the material described; the material does not completely prevent water vapor movement, but retards it. Although the term vapor barrier is still widely used by the building industry, the terminology is changing to vapor retarder.

The second change alters the maximum perm rating from 0.1 to 1.0. The 0.1 perm rating is too stringent. Four mil polyethylene (found to work satisfactorily in this application) is, in fact, greater than 0.1 perm, as indicated by laboratory tests (Attachment 6). Measurements of permeability and thickness were made on 23 specimens of polyethylene, taken in 1989 from recently constructed Minneapolis-St. Paul area houses, and on two large rolls of polyethylene sheeting from Minnesota retail outlets. Although many of the thicknesses were less than 4 mils, even those over 4 mils (underlined on table) had average

permeability measures of 0.17 to 0.31 perms. This change in the maximum perm rate is needed for builders to continue to use 4-mil polyethylene without violating these rules. The change will not significantly affect the amount of water moving into the insulated cavity, since only a very small amount of water vapor moves into the wall by diffusion through the vapor retarder, as indicated by the ASHRAE Handbook, pages 21.4 and 21.5 (Attachment 1). The 1.0 perm rating also conforms to the national standard ASTM C 755-84, Table 1 (Attachment 7) for residential buildings. In addition, this change is consistent with the Council of American Building Officials 1990 amendments to the 1989 Model Energy Code requiring a vapor retarder of 1.0 perm or less.

In a previous rulemaking for this chapter, a perm rating of 0.1 was specified to help ensure thickness or durability of polyethylene. This thickness is ensured, however, by the rule requiring the polyethylene to be not less than 4 mils (i.e., four thousandths of an inch) thick. It is anticipated that the change in perm rating will not, in fact, alter current construction practices.

Subpart 3 -- Wind wash. Wind wash is a new term referred to in proposed amendment to 7670.0480, subdivision. 3. Home Builders' Energy Update (Attachment 8) illustrates the use of this term. The term is also used in Cold Climate Housing News, Volume 2 issue 3. (Attachment 9). A definition is needed because the term is just now coming into use and is not widely understood.

Subpart 4 -- Window area. The department proposes to add a new term, "window area," to

the Model Energy Code. It defines the term as including the glazing and sash or the area used to determine window thermal transmittance.

The Model Energy Code uses the term "glazing area" to refer to windows. This term is not defined in the Model Energy Code, and since "glazing" is often understood to mean only the glass area, the term is misleading. The term "window area" more accurately conveys the meaning of the term as it is used in determining the thermal performance of windows.

Part 7670.0400 Amendment to Section 302: Design Conditions

The proposed changes make the Model Energy Code consistent with 10 CFR Part 435 and ASHRAE/IES Standard 90.1 - 1989, which are nationally accepted standards. Although the cooling design condition may appear more restrictive (Minneapolis-St. Paul summer design condition of 89° instead of 92°F.), when combined with the proposed amendment to Part 7670.0610 (calculation procedures and equipment sizing), it is not.

Part 7670.0450 Amendment to Section 303: Ventilation

An amendment is proposed to incorporate the latest ASHRAE standard for ventilation. Because the Model Energy Code was published before ASHRAE came out with the new standard, an older version of the standard is referenced in the Model Energy Code.

Chapter 7670.0470 Amendment to Section 502: Envelope Thermal Transmittance

This amendment is moved from 7670.0940 with two slight modifications. (Part 7670.0940

is included in the repealer at the end of these proposed rule amendments.) The purpose of these modifications is to make this alternative approach equivalent to the revised requirements of the 1989 Model Energy Code and to simplify the language.

Footnote 1 is proposed to clarify that the R-values required in the alternate approach are for insulation only, and not the entire cross-section of walls or floors. Because the R-values apply to insulation only, the values are lowered from R-20 to R-19.

In footnote 2, the department proposes to change the specification for windows from "double-glazed" to U-0.49. As discussed in Part 7670.0330, subpart 1, item B, window performance measurements have improved. Change is needed because "double-glazed" is an inadequate description of how a window will perform. A double-glazed window with aluminum or metal frames and without thermal breaks performs poorly. The value of U-0.49 is reasonable because most manufacturers of residential windows offer a window meeting this standard in their moderately-priced product line. Furthermore, the value can be achieved without using more expensive "low-e" glass, argon-gas filling, or other special window construction methods. Finally, meeting this requirement is optional; the builder can still use the component performance approach which allows more glass area if higher performance windows are used.

Part 7670.0480 Amendment to Section 502: Effectiveness of Required Thermal Insulation

Subpart 1. Thermal insulation. The rule cited here is established in Minnesota Rules

Chapter 7640 and is enforced by the department. The department proposes to restate this requirement here (with a cross reference to 7640) because of its relevance and importance in meeting the Energy Code.

Subpart 2, item A. For organizational clarity, this item is moved from Part 7670.0520 and that part is included in the repealer at the end of these proposed rule amendments. There are three proposed modifications -- deletion of "continuous and uninterrupted," deletion of "rips in vapor barrier must be patched," and addition of a new sentence: "Joints in the vapor retarder must be sealed between solid blocking." Meeting the requirement in the added sentence would more effectively accomplish the objectives sought by the deleted phrases.

Subpart 2, item B. This item is added to give attention to air movement as a factor in transporting moisture into insulated cavities. The importance of air movement is reflected by the ASHRAE Handbook of Fundamentals, 1989 edition, on page 21.4 and 21.5. (Attachment 1). The Handbook points out that movement of air carrying water vapor is far more influential than vapor diffusion in transporting water vapor within the building envelope. The Handbook also notes that although a good quality vapor retarder eliminates condensation by vapor diffusion, it is of little use if it can be bypassed by air. Additional explanation of the importance of preventing air movement into insulated cavities and description of simple techniques for preventing this movement are in Home Builders Energy Update, Summer, 1988 (Attachment 10).

Subpart 3. The department proposes to add this amendment requiring that a barrier be provided to mitigate wind wash. Recent investigations using infrared scans reveal that wind can penetrate insulation, resulting in heat loss and possible moisture damage. (See Home

Builders Energy Update, Winter 1989, Attachment 8). The energy savings potential of this requirement has not been quantified, but the proposed methods are easy and inexpensive to apply.

Part 7670.0510 Foundation Walls

This part is divided into subparts to improve clarity; there are no word changes in subparts 1 and 2. Subpart 3 is added, requiring that exterior foundation wall insulation be protected from deterioration due to sunlight and physical abuse.

A study of exterior foundation wall insulation conducted in Minnesota by the department found insulation damage caused by failure to apply an adequate protective coating. (See Attachment 11.) Similar findings of inadequate protection also were reported in a study by the Wisconsin Energy Conservation Corporation*. The Minnesota study concluded that not only is the damage unsightly, but insulation exposed to the elements will soon lose at least some of its effectiveness. An additional requirement for adequate protection is needed to ensure that the exterior insulation functions as intended.

The proposed addition is not new; it is already required by Minnesota Rules part 7640.0140, subpart 3, (Minnesota Residential Thermal Insulation Standards). Adding it to this rule reinforces its importance and increases awareness of the need to comply with it. Furthermore, builders have the choice of installing either exterior or interior foundation insulation; if they choose exterior insulation, it is reasonable to require that they take steps to ensure that the insulation performs as intended.

* Schlegel, J.A., O'Leary, L.A., Post, L.K., Foundation Insulation Field Survey - Final Report, Wisconsin Energy Conservation Corporation,

1045 East Division St., #117, Madison, WI 53703. December, 1986, unpublished.

Part 7670.0550 Air Leakage

Subpart 1 is reorganized, for greater clarity, into two sentences rather than one. The prescriptive measures for sealing air leaks are included in the first sentence, and examples of where these measures are to be applied are listed in the second sentence.

Subpart 2. An alternative to meeting the requirements specified in Subpart 1 is provided for detached single-family residential buildings. These buildings can meet the requirements specified in Subpart 1, or they can meet air leakage classifications A, B, C, or D of the ANSI/ASHRAE Standard 119. If this alternative is selected, the building ventilation system must provide for a minimum of 0.35 air changes per hour, or 15 cfm per person, whichever is greater. This rate must be verified by measurement.

This change is needed for the following reason: A wide variety of construction methods can be used to achieve the same level of airtightness as the methods specified in subpart 1. The department feels that builders would like greater flexibility in selecting methods of achieving airtightness. Providing the option of meeting the ASHRAE Standard 119 gives builders this greater flexibility. It also provides home buyers and builders with an objective measure of air tightness and an accurate basis on which to calculate the home's ventilation needs. The proposed amendment also includes a minimum, verified air change rate, thereby assuring a minimum level of ventilation is installed. This latter is important, since very tight construction may result in indoor air quality problems if adequate ventilation is not provided. Studies in the United States and Canada show that actual performance rates

of ventilation systems are often much lower than the systems' rated capacity; therefore, verification of ventilation rates by measurement is needed.

The proposed change is reasonable because it simply adds an option that allows builders to replace design specifications with a performance standard. This change complies with Minnesota Statute § 14.115, subd. 2 (d), that requires the department to consider establishing performance standards to replace design or operational standards. Also, the proposed performance standard is nationally recognized, and including it as an option complies with Minnesota Statute § 216C.19, subd. 8, requiring energy code rules, "to the maximum extent practicable," to conform to model codes generally accepted throughout the United States. In practice, the standard is already in effect in Minnesota, since homes meeting the specifications set out in subpart 1 above would meet Standard 119-1988 classifications A-D, according to a consultant's report to the department (see attachment 12). The standard also conforms to ASHRAE Standard 62.

Subpart 3. Fire stops are required by the State Building Code. The department proposes that for those fire stops made of mineral or fiber glass that separate conditioned and unconditioned spaces, steps be taken to prevent air leakage. In case of possible conflict between these two requirements, the State Building Code should take precedence.

Fire stops made of mineral fiber or fiber glass are sources of air leakage that can cause many problems, including energy loss, ice buildup on roofs, and possible contribution to back drafting of combustion appliances (see attachment 13). A separate provision is needed

to call attention to the need to air seal these fires stops.

Weatherization agencies routinely seal "attic bypasses" on existing low-income residences. Attic bypasses (open paths through which warm air flows out of the heated house and into the attic) are acknowledged as a major source of heat loss. Most, if not all attic bypasses are, in fact, simply fire stops that are not air sealed. Since these fire stops are routinely air sealed during weatherization of older houses, it is reasonable -- and certainly efficient -- to require them to be air-sealed during new home construction.

Finally, the provision simply calls attention to the need for sealing air leaks in these fire stops; the methods for sealing these leaks are relatively simple (see attachment 13), and the choice of methods is left to the builder. To resolve any possible conflict with the State Building Code, a provision is added clearly establishing the State Building Code as taking precedence.

Part 7670.0610 Building Mechanical Systems

The department proposes to change the calculation procedures for sizing heating and cooling systems and equipment. The limitation of equipment sizing to 115 percent for heating and 100 percent for cooling is too restrictive and does not allow engineering judgement to be used in this calculation. The procedures described in subparts 1 and 2 will accomplish the goal of not wasting energy and also will allow engineering judgement concerning safety factors, pick-up loads, and other sizing considerations. These procedures are identical with those in 10 CFR Part 435 and ASHRAE Standard 90.1 and are therefore

consistent with other proposed changes which bring the Minnesota Energy Code into agreement with national standards.

Part 7670.0660 Amendment to Section 503: Equipment Efficiency

Subpart 1 is moved from 7670.0540, which is repealed. The subpart proposes to replace the entire table, previously included in 7670.0540, with a single sentence. Including the Table is not necessary since it is in the 1989 Model Energy Code, which is incorporated by reference.

In proposed subpart 2, the numbers from Table No. 503.4.8. are largely deleted since they are part of the 1989 Model Energy Code, which is incorporated by reference. The numbers not deleted are retained because they do not appear in the 1989 Model Energy Code. Neither of the two proposed subparts would substantively change the rule.

Part 7670.0670 Amendment to Section 503.10: Duct Construction

Minor changes are proposed to improve clarity; they would make no substantive change in the rule.

Part 7670.0710 Amendments to Section 504: Service Water Heating

The proposed changes merge parts 7670.0710, .0720, and .0730, all relating to water heating, into a single part for greater clarity. Parts 7670.0720 and .0730 are included in the repealer.

Part 7670.0800 Amendments to Section 505: Electric Power and Lighting

Subpart 1. The department proposes to delete the first paragraph of the rule since it is already in the 1989 edition of the Model Energy Code and is therefore not needed. The amended exception, proscribed by Minnesota Statute § 216C.19 subd. 8, differs from the language in the Model Energy Code and therefore is needed.

Subpart 2. The department proposes to amend the lighting requirements of the Model Energy Code to bring them into agreement with U.S. Department of Energy performance standards, 10 CFR, Part 435.103 (excluding section 3.2) and ASHRAE/IES Standard 90.1 - 1989.

The proposed lighting requirements are a change from the Model Energy Code requirements in at least two respects. First, lighting criteria are dramatically simplified. Lighting requirements in the Model Energy Code are difficult to understand without extensive knowledge of the field. They also are highly subjective -- for example, "where good color rendition is important" and "where visual comfort is important" are among the criteria for determining lighting requirements. These are virtually unenforceable. In contrast, proposed criteria specify maximum watts per square foot. (Attachment 14) They are simple and enforceable. The second significant change, and one that well may raise comment, is the rather strict limitations of allowed lighting power. The new requirements will mandate the use of more efficient (and probably more costly) fixtures and control technologies that may be unfamiliar to today's lighting engineers. The department believes, however, that technology and techniques are available to achieve the stricter standards

readily and cost effectively. One example is a lighting analysis of the First Bank/IBM Tower under construction in downtown Minneapolis. Attachment 15 indicates that if more efficient lighting design were implemented in this building, capacity demand could be reduced by 690 kilowatts for lighting and 41 kilowatts for air conditioning.

Other states have adopted lighting specifications from either the U.S. Department of Energy Performance Standard 10 CFR Part 435 or ASHRAE/IES 90.1. New York state's commercial building code's Lamp and Fixture Efficiency section is very similar to 10CFR Part 435. According to the New York State Energy Division, the standard was not overly stringent and its format aided enforcement. Massachusetts adopted an early draft of ASHRAE/IES Standard 90.1, effective October 1, 1988. The Massachusetts Safety Division reports that the standard has been both manageable and achievable. Since July 1978, California has had mandatory lighting requirements for all nonresidential buildings. The requirements are, in fact, more stringent than the changes proposed here.

Further evidence that the proposed lighting requirements are reasonable is reported in *Lighting Design and Application* magazine. (Attachment 16) A study conducted by the New England Power Company and an independent consulting firm found that "standards such as (ASHRAE/IES) 90.1 are not unduly strict and will save significant amounts of energy." The authors of the report also note that "those buildings in our study that exceeded the requirements of 90.1 indicate that additional energy savings is possible in many cases. As standards such as 90.1 are incorporated into building codes, designers will find that incorporating simple energy saving measures into their designs will be enough to ensure

compliance in most cases. Adoption of 90.1 will be a significant step toward improving lighting energy efficiency without causing undue hardship on the practice of lighting design."

The exemption for one- and two-family detached buildings and the dwelling portions of multifamily buildings from these requirements is identical to an exemption for lighting requirements in the Model Energy Code.

Part 7670.0850 Design by Acceptable Practice

A sentence is proposed to replace parts 7670.0900 through 7670.0970 which are included in the repealer. This sentence is needed because buildings designed in accordance with this method should conform to the same amendments made to the Model Energy Code, Chapter 5, "Building Design by Component Performance Approach."

Part 7670.1000 Amendments to Section 701: References

Amendments of standards and references are included in this part instead of in five parts; 7670.1010, 7670.1020, 7670.1030, 7670.1100, and 7670.1110 are included in the repealer. Two new items are included in the list of standards and references -- the updated versions of ASHRAE Handbook 1989 edition and ASHRAE Standard 62-89.

The department proposes to replace two reference standards (RS-17 and RS-18) with the single document, "SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985." The two SMACNA reference standards being replaced (1975 and 1976 documents) have been superseded by the Sheet Metal and Air Conditioning Contractors

National Association (SMACNA) with the single document cited above.

V. SMALL BUSINESS CONSIDERATIONS IN RULEMAKING

Minnesota Statue § 14.115, subdivision 2 (1988) requires the department, when proposing rules which may affect small business, to consider the following methods for reducing the impact on small businesses:

> (a) the establishment of less stringent compliance or reporting requirements for small business;
>
> (b) the establishment of less stringent schedules or deadlines for compliance or reporting requirements for small business;
>
> (c) the consolidation or simplification of compliance or reporting requirements for small business;
>
> (d) the establishment of performance standards for small businesses to replace design or operational standards required in the rule;
>
> (e) the exemption of small businesses from any or all requirements of the rule.

The adoption of these rule amendments will affect small businesses in Minnesota. The department has evaluated the effect of the proposed rules on small businesses and has considered each of the methods listed above for reducing the impact of the rules on small businesses.

In conformance with item (a) above, small businesses would benefit from the proposed amendments to Minn. Rules Part 7670.0325, subpart 1, item B, relating to definition of window thermal performance. Some of the subitems (2 and 3) require costly physical

testing to implement, but others do not. Since Chapter 7670 includes no reporting requirements, Minnesota Statute § 14.115, subd. 2, (b) and (c) are not applicable.

The proposed rules include several significant performance standards in conformance with Minn. Statute § 14.115, subd. 2(d). Part 7670.0325, subpart 1, item B, includes four performance options for determining the thermal performance of windows. In the Model Energy Code, Chapter 4 (Building Design Systems Analysis) is entirely performance based. The Model Energy Code Chapter 5 (Building Design by Component Performance Approach) is also performance based. The lighting criteria proposed in Part 7670.0800 subpart 2 are also performance based.

In regard to item (e) above, Minnesota Statute § 16B.62 establishes the scope of application of the State Building Code. It would be inappropriate for the department to usurp statutory requirements by changing the applicability to exempt small business. In Part 7670.0250, the applicability is changed to exempt relocated residential buildings in conformance with Minn. Statute § 16B.61, subd. 3(i).

VI. ATTACHMENTS

The following attachments are incorporated by reference into this Statement of Need and Reasonableness.

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals, 1989 edition, pages 21.4, 21.5, 22.3, 22.4, 22.5, 22.10, 22.11, 27.16, 27.17, and 27.18.

2. Minnesota Masonry Institute table, "R-value Comparison -- 8-inch Insulated Concrete Masonry Systems."

3. 10CFR Part 435, Table 5.3-1, "Calculation Procedures for Thermal Transmittance Through Opaque Envelope Assemblies."

4. "Window R-Values Substantially Overstated," Energy Efficient Building Association (EEBA) Alert, 1990.

5. "Window U-Values: Revisions for the 1989 ASHRAE Handbook -- Fundamentals," ASHRAE Journal, June, 1989,

6. Twin City Testing report on polyethylene vapor retarder thickness, June 29, 1989.

7. "Standard Practice for Selection of Vapor Retarders for Thermal Insulation," American Society for Testing and Materials (ASTM) C 755-85, Table 1.

8. "Cold Ceiling Corner Mystery Examined," Home Builders' Energy Update, Winter 1989.

9. "Windwashing and Its Effects on Wood Frame Buildings," Cold Climate Housing News, Volume 2, Issue 3.

10. "Moisture Problems in Bathroom Exterior Walls," Home Builders' Energy Update, Summer, 1988.

11. "Exterior Foundation Wall Insulation," Home Builders' Energy Update, Winter, 1990.

12. "Report on the Suitability of Incorporating ASHRAE 119-1988 -- Air Leakage Performance for Detached Single Family Residential Buildings -- into the Minnesota Energy Code," April, 1990.

13. "Preventing Air Leaks at Fire Stops," Home Builders' Energy Update, Summer 1990.

14. 10CFR Part 435, Table 3.4-1 "Prescriptive unit lighting power allowance," and Table 3.5-1 "Base unit power density for area/activity."

15. Sylvania Information Analysis for the First Bank/IBM Tower, downtown Minneapolis.

16. "Is ASHRAE/IES Standard 90.1P Being Followed?," *Lighting Design and Application*, Match, 1990.

VII. CONCLUSION

Based on the foregoing, the proposed amendments to Minnesota Rules Chapter 7670 are both needed and reasonable.

Dated: Sept 12, 1990

TONY PERPICH
Commissioner

graded to drain the crawl space so that surface water will not rise above the vapor retarder. Floor insulation eliminates the need for dampers on crawl space vent openings, but does not allow these spaces to be used for utilities or a heating distribution system unless it is efficiently insulated.

Floor construction with joists can be insulated between the joists (Figure 12). Insulation between joists must have supplemental support. Material with an integral vapor retarder, installed with the vapor retarder up, can be secured by the flange provided for this purpose. Laced wires, barbed-end wires spanning the joist space, wire mesh, screening, or ceiling finish will support loose-fill insulation. Floor construction can also be insulated by placing flexible blanket material over the joists before laying the subfloor.

Another floor insulation method uses double-sided, perforated aluminum foil draped and stapled over floor joists (BRANZ 1983). For about a 4-in. sag depth, laboratory R-values were 5.7 to 14.2 °F · ft² · h/Btu with a mean of 6.8, depending on the humidity above the floor space. Field measurements have shown R-values up to 14 °F · ft² · h/Btu for carpeted floors over good installations with a 4 in. sag.

Roof Deck Construction

Almost all structural roof deck construction systems require thermal insulation to economically maintain the design indoor environment. For level or nearly level roofed structures, insulation should be placed on top of the deck, on the outside of the structure. This location moderates the deck temperature, which reduces thermal movement of the deck and the potential for underdeck condensation. Traditionally, the insulation is placed under the roof membrane so it functions as a base for the built-up roof (BUR) membrane. For a stable base, a good bond must be established between the insulation, through the vapor retarder, to the roof deck, and between the insulation and the BUR. Ineffective bonds that allow the BUR to move in reaction to stresses from temperature changes often cause the roof to fail.

In this configuration, a vapor retarder should be placed between the deck and the insulation when required by interior environmental conditions. An alternate method for obtaining the required vapor retarder for a solid-shaped metal deck is to seal the deck at all overlaps and joints.

Single-ply membrane roofs are frequently installed with ballasted or loose-laid systems. Adhesion to the insulation is usually not desirable.

Insulation can also be placed above the membrane in a Protected Membrane Roof (PMR) system. With this approach, the roof membrane is installed on the deck, where it functions as a water and vapor retarder. Insulation can be placed above and below membranes to function both as the base for the membrane and the membrane protector, as well as for the insulator. An insulation with the required structural and/or water resistance properties required for a particular application can reduce the severity of moisture effects. Some insulation can be wetted and then successfully dried; while wet, however, it has a greatly reduced insulation value.

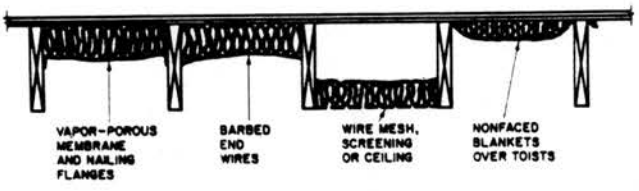


Fig. 12 Insulation Methods for Framed Floors

Roof systems designed for continual heavy traffic should have a secondary structure, supported on a curb system, above the water membrane of the roof system.

Insulation for pitched roofs covered with shingles, tile, or similar mechanically fastened watershedding materials should be placed above the ceiling directly on the attic floor. A vapor retarder should be placed on the winter warm side of the insulation, and the attic space must be adequately ventilated.

If the undersurface of the pitched roof is exposed to the interior, the winter warm side vapor retarder and insulation can be applied over the roof framing or decking. The insulation is then covered with a nailing base for the roofing application. Prefinished roof planks with the required thermal resistance can also be placed over the rafters.

Ventilation may be needed between the insulation and the roofing nailing base depending on the influence the permeance of the insulation and vapor retarder has on interior environmental conditions.

If insulation must be placed on a suspended ceiling, the space between the insulation and roof deck must be adequately ventilated for condensation control. Power-driven ventilators are usually necessary for flat decks, and shallow concealed spaces and inlet vents should be located to provide the desired air movement.

INSULATION FIELD PERFORMANCE CHARACTERISTICS

Convection and air infiltration in some insulation systems may increase the heat transfer across them. Low density loose-fill, large open-cell, and fibrous insulations and poorly designed or installed reflective systems are most susceptible to increased heat transfer caused by natural and forced convection (air infiltration). A change of temperature differential across an insulation, as well as the height, thickness, or width of the insulated space, influences the amount of convection. When an impermeable membrane is applied to one surface or when the cavity is filled with insulation, natural convection is reduced significantly and apparent thermal conductivities measured by standard test methods apply.

The effectiveness of thermal insulation is seriously impaired when it is installed incorrectly. For example, a 4% void area in R-2 wall insulation increases heat loss by 15%. A 4% void in R-3.3 ceiling insulation causes a 50% increase in heat loss. When insulation is properly installed, the wall or ceiling system performs as shown in Table 4, Chapter 22. Verschoor (1977) found that air interchange around thin wall insulation installed vertically with air spaces on both sides increases heat loss by 60%. Other factors, including vibration, temperature cycling, and other mechanical forces, can affect thermal performance by causing settling or other dimensional changes. Section A3 of the CIBSE Guide (1986) gives more information on the effect of moisture on thermal properties of building structures.

MOISTURE IN BUILDINGS

MIGRATION OF WATER VAPOR

Importance of Air Leakage

Vapor retarders have been advocated to avoid condensation problems in buildings, since water vapor migrates by diffusion through the building envelope materials because of a vapor pressure difference. Wilson and Garden (1965), Dickens and Hutcheon (1965), Latta (1976), Handegord (1979), Tamura (1975) and Chapter 23 showed that air movement carrying the water vapor with it is far more powerful in transporting water vapor

within the building envelope. Condensation will occur if the air/vapor mixture is cooled to its dew point and latent heat is removed.

Air passing quickly on a direct path through a wall may not be cooled sufficiently to condense until it mingles with and is diluted by the outdoor air. Air following a longer path on the cold side of the insulation (for example, when it flows down an air space to escape at weep holes) may deposit water on the back of a cold cladding or sheathing.

The relative amounts of water deposited in a wall or roof by vapor diffusion or by a current of air cannot be calculated with certainty. Under one set of conditions, six or seven times as much water can be deposited as a result of air leakage as by vapor diffusion through a wall without a vapor retarder. Under different circumstances, the rates could be 100:1 or higher.

A good quality vapor retarder eliminates condensation by vapor diffusion, but even an excellent vapor retarder is of little benefit if it can be bypassed by a current of air. Therefore, the first defense against condensation is control of humid air movement within a building structure by airtight construction. The section on concealed condensation in this chapter and the section on water vapor retarders in Chapter 20 include further details.

In many buildings, moist air leaking outward into a wall in winter is a major problem; rarely is vapor diffusion a major factor. Water entering between two layers with high resistance to vapor diffusion may damage the construction if it does not dry out again. As a result, the double vapor retarder compounds the problem initiated by the defect that allowed the water to enter. Walls and roofs should be designed so any water that enters can be removed by ventilation or by drainage to the outdoors or to a location capable of withstanding the water. Drainage may not be sufficient in low-slope roofs and is addressed in the section on membrane roof systems.

Controlling Air Movement

A controlled amount of ventilation air must be provided to disperse moisture, but dispersion should not be left to uncontrolled air leakage. To control air leakage, either the holes through which the air passes or the driving pressure difference must be eliminated. Since the pressure differences arise from the natural phenomena of wind, air, and temperature differences, they can only be balanced by changing the pressure inside the building. But the complex controls and equipment needed to sense and balance the pressure difference under constantly changing conditions make this solution impractical. The most practical approach is to minimize the size and number of holes.

It may be simple to design a satisfactory wall or roof construction for clear uninterrupted areas, but intersections with other building components require planning to link the airtightness of a wall section to the airtight glass in a window or an airtight membrane in the roof or ceiling. Leakage paths are often found in the inside of the outer wall where a partition wall joins it. Similar leakage paths can be found in electrical outlet boxes, at openings for piping, up through the hollow core of a partition wall, and through the ceiling, if ceiling airtightness is not carried across the top of the partition. A designer should work closely with construction workers to find practical solutions to construction problems, but in considering alternatives, airtightness of the envelope must be maintained.

Airtightness and Location of Air Barriers

In striving to eliminate air leaks, but realizing that perfection is not attainable, construction should include drainage or ventilation to carry away unwanted water. Ventilation or drainage must go to the outside of the airtight layer of construction or it will increase air leakage of the building. To avoid condensation on the airtight layer, the layer must either be kept above dewpoint by locating it on the warm side of the insulation or be of adequate permeance to permit vapor to move to the outside.

There must be no gaps between the airtight layer and the insulation, or cold air will penetrate the ventilation or drainage openings into the warm side of the insulation and reduce its effectiveness. Generally, the air barrier is placed on the warm side of, and in contact with, the insulation. The air barrier must be sufficiently strong and well supported to resist wind loads.

Air leakage through the building envelope does not necessarily occur at doors and windows. Tamura and Wilson (1964) showed that leakage from windows and doors in houses constitute only about 20% of the total leakage. Leakage cracks and openings in walls and ceilings, especially at intersections of walls, floors, and ceilings, make a far greater contribution to total leakage. Depending on the particular house, up to 70% of the total leakage openings was in walls, and up to 67% was through the ceiling.

Holes for wiring or plumbing in upper plates of exterior walls and interior partitions may cause about 50% of the total leakage through the ceiling. An equivalent leakage area may develop from shrinkage of upper wall plates after construction. Substantial leakage openings can be caused by wood shrinkage or cantilevering of floor constructions at the foundation wall or second-floor level. Chimney or plumbing stack penetrations and access hatches or fans are also likely leakage locations. In some residential construction, more leakage has been found between a window frame and wall than between a window frame and sash. Unsealed joints in ductwork and around exhaust fan openings are also common leakage areas.

Not all cracks and openings can be sealed in existing houses, nor is absolutely tight construction achieved in new housing. However, an effort should be made to provide as tight an enclosure as possible to reduce leakage and so minimize potential condensation within the envelope. Such measures also reduce energy loss.

Air Leakage in Buildings

The direction and rate of air leakage through cracks and holes depends on the direction and magnitude of air pressure differences created by stack effect and wind, and by the action of chimneys, fans, and blowers. Most significant is the stack effect from the winter temperature difference between inside and outside. Warm inside air, lighter than cold outside air, rises and flows outward through cracks and openings in the upper walls and ceilings. Condensation occurs on contact with cold surfaces below the dew point. The magnitude of the pressures depends on the height of the heated space and the temperature difference, as indicated by Equation (9) and Figures 1 and 2, Chapter 23.

Air pressure differences created by wind may be of the same magnitude as those of stack effect for low-rise buildings in cold climates (see Figure 3, Chapter 23). Wind pressure acts inward over the windward walls and outward over leeward walls and walls parallel to the wind. Although suction pressures are generally created over all flat or sloped roofs, the sustained pressure difference from wind across the ceiling in a ventilated roof space is usually near zero.

Electrically Heated and Fuel-heated Houses

In electrically heated houses or houses without a chimney, the midwinter pattern of pressure differences from average wind and stack effect is likely to be similar to that shown in Figure 13. Out-

Table 2 Thermal Resistances of Plane Airspaces[a,b,c], °F · ft² · h/Btu (*Concluded*)

Position of Airspace	Direction of Heat Flow	Airspace Mean Temp.[d], °F	Airspace Temp. Diff.[d], °F	1.5-in. Airspace[c] Effective Emittance, E[d,e] 0.03	0.05	0.2	0.5	0.82	3.5-in. Airspace[c] Effective Emittance, E[d,e] 0.03	0.05	0.2	0.5	0.82
Horiz.	Up ↑	90	10	2.55	2.41	1.71	1.08	0.77	2.84	2.66	1.83	1.13	0.80
		50	30	1.87	1.81	1.45	1.04	0.80	2.09	2.01	1.58	1.10	0.84
		50	10	2.50	2.40	1.81	1.21	0.89	2.80	2.66	1.95	1.28	0.93
		0	20	2.01	1.95	1.63	1.23	0.97	2.25	2.18	1.79	1.32	1.03
		0	10	2.43	2.35	1.90	1.38	1.06	2.71	2.62	2.07	1.47	1.12
		−50	20	1.94	1.91	1.68	1.36	1.13	2.19	2.14	1.86	1.47	1.20
		−50	10	2.37	2.31	1.99	1.55	1.26	2.65	2.58	2.18	1.67	1.33
45° Slope	Up ↗	90	10	2.92	2.73	1.86	1.14	0.80	3.18	2.96	1.97	1.18	0.82
		50	30	2.14	2.06	1.61	1.12	0.84	2.26	2.17	1.67	1.15	0.86
		50	10	2.88	2.74	1.99	1.29	0.94	3.12	2.95	2.10	1.34	0.96
		0	20	2.30	2.23	1.82	1.34	1.04	2.42	2.35	1.90	1.38	1.06
		0	10	2.79	2.69	2.12	1.49	1.13	2.98	2.87	2.23	1.54	1.16
		−50	20	2.22	2.17	1.88	1.49	1.21	2.34	2.29	1.97	1.54	1.25
		−50	10	2.71	2.64	2.23	1.69	1.35	2.87	2.79	2.33	1.75	1.39
Vertical	Horiz. →	90	10	3.99	3.66	2.25	1.27	0.87	3.69	3.40	2.15	1.24	0.85
		50	30	2.58	2.46	1.84	1.23	0.90	2.67	2.55	1.89	1.25	0.91
		50	10	3.79	3.55	2.39	1.45	1.02	3.63	3.40	2.32	1.42	1.01
		0	20	2.76	2.66	2.10	1.48	1.12	2.88	2.78	2.17	1.51	1.14
		0	10	3.51	3.35	2.51	1.67	1.23	3.49	3.33	2.50	1.67	1.23
		−50	20	2.64	2.58	2.18	1.66	1.33	2.82	2.75	2.30	1.73	1.37
		−50	10	3.31	3.21	2.62	1.91	1.48	3.40	3.30	2.67	1.94	1.50
45° Slope	Down ↘	90	10	5.07	4.55	2.56	1.36	0.91	4.81	4.33	2.49	1.34	0.90
		50	30	3.58	3.36	2.31	1.42	1.00	3.51	3.30	2.28	1.40	1.00
		50	10	5.10	4.66	2.85	1.60	1.09	4.74	4.36	2.73	1.57	1.08
		0	20	3.85	3.66	2.68	1.74	1.27	3.81	3.63	2.66	1.74	1.27
		0	10	4.92	4.62	3.16	1.94	1.37	4.59	4.32	3.02	1.88	1.34
		−50	20	3.62	3.50	2.80	2.01	1.54	3.77	3.64	2.90	2.05	1.57
		−50	10	4.67	4.47	3.40	2.29	1.70	4.50	4.32	3.31	2.25	1.68
Horiz.	Down ↓	90	10	6.09	5.35	2.79	1.43	0.94	10.07	8.19	3.41	1.57	1.00
		50	30	6.27	5.63	3.18	1.70	1.14	9.60	8.17	3.86	1.88	1.22
		50	10	6.61	5.90	3.27	1.73	1.15	11.15	9.27	4.09	1.93	1.24
		0	20	7.03	6.43	3.91	2.19	1.49	10.90	9.52	4.87	2.47	1.62
		0	10	7.31	6.66	4.00	2.22	1.51	11.97	10.32	5.08	2.52	1.64
		−50	20	7.73	7.20	4.77	2.85	1.99	11.64	10.49	6.02	3.25	2.18
		−50	10	8.09	7.52	4.91	2.89	2.01	12.98	11.56	6.36	3.34	2.22

[a]See Chapter 20, section on "Factors Affecting Heat Transfer Across Airspaces." Thermal resistance values were determined from the relation, $R = 1/C$, where $C = h_c + Eh_r$; h_c is the conduction-convection coefficient, Eh_r is the radiation coefficient $\equiv 0.00686E[(t_m + 460)/100]^3$, and t_m is the mean temperature of the airspace. Values for h_c were determined from data developed by Robinson *et al.* (1954). Equations 5 through 7 in Yarbrough (1983) show the data in Table 2 in analytic form. For extrapolation from Table 2 to airspaces less than 0.5 in. (as in insulating window glass), assume

$$h_c = 0.159(1 + 0.0016\,t_m)/l$$

where l is the airspace thickness in in., and h_c is heat transfer through the airspace only.

[b]Values are based on data presented by Robinson *et al.* (1954). (Also see Chapter 3, Tables 3 and 4, and Chapter 39). Values apply for ideal conditions, *i.e.*, airspaces of uniform thickness bounded by plane, smooth, parallel surfaces with no air leakage to or from the space. When accurate values are required, use overall U-factors determined through calibrated hot box (ASTM C 976) or guarded hot box (ASTM C 236) testing. Thermal resistance values for multiple airspaces must be based on careful estimates of mean temperature differences for each airspace.

[c]A single resistance value cannot account for multiple airspaces; each airspace requires a separate resistance calculation that applies only for the established boundary conditions. Resistances of horizontal spaces with heat flow downward are substantially independent of temperature difference.

[d]Interpolation is permissible for other values of mean temperature, temperature difference, and effective emittance E. Interpolation and moderate extrapolation for airspaces greater than 3.5 in. are also permissible.

[e]Effective emittance E of the airspace is given by $1/E = \epsilon_1 + 1/\epsilon_2 - 1$ where ϵ_1 and ϵ_2 are the emittances of the surfaces of the airspace (see Table 3).

Wood Frame Walls

The average overall R-values and U-factors of wood frame walls can be calculated by assuming parallel heat flow paths through areas with different thermal resistances. Equations (1) through (5) from Chapter 20 are used.

For simple stud walls 16 in. on center (OC), the fraction of framing is assumed to be approximately 0.15; for studs 24 in. OC, approximately 0.12. These fractions contain an allowance for multiple studs, plates, sills, and extra framing around windows and doors but do not allow for headers or band joists.

Example 1. Calculate the U-factor of the 2 by 4 stud wall shown in Figure 2. The studs are at 16 in. OC. There is a 3.5- in. mineral fiber batt insulation (R-11) in the stud space. The inside finish is 0.5-in. gypsum board; the outside is finished with 0.5-in. vegetable fiber board sheathing and 0.5-in. by 8-in. wood lapped siding. The framing occupies approximately 15% of the transmission area.

Solution: Obtain the R-value of the various building elements from Tables 1 and 4.

Element	R(Insulation)	R(Framing)
1. Outside surface (15 mph wind)	0.17	0.17
2. Wood bevel lapped siding	0.81	0.81
3. 0.5-in. sheathing	1.32	1.32
4. 3.5-in. mineral fiber batt insulation	11	—
5. Nominal 2 by 4 wood stud	—	4.38
6. 0.5-in. gypsum wallboard	0.45	0.45
7. Inside surface (still air)	0.68	0.68
	$R_1 = 14.43$	$R_2 = 7.81$

Therefore $U_1 = 0.069$; $U_2 = 0.128$ Btu/h · ft² · °F.

If the wood framing (*i.e.*, thermal bridging) is not included, Equation (3) from Chapter 20 may be used to calculate the U-factor of the wall as follows:

$$U_{av} = U_1 = 1/R_1 = 0.069 \text{ Btu/h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$$

If the wood framing is accounted for using the parallel flow method, the U-factor of the wall is determined using Equation (5) from Chapter 20 as follows:

$$U_{av} = (0.85 \times 0.069) + (0.15 \times 0.128) = 0.078 \text{ Btu/h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$$

If the wood framing is included using the isothermal planes method, the U-factor of the wall is determined using Equations (2) and (3) from Chapter 20 as follows:

$$R_{T(av)} = 2.30 + 1/[(0.85/11.00) + (0.15/4.38)] + 1.13$$
$$= 12.44\ F \cdot ft^2 \cdot h/Btu$$
$$U_{av} = 0.080\ Btu/h \cdot ft^{2} \cdot °F$$

For a frame wall with a 24 in. OC stud space, the average overall R-value becomes 13.16 °F·ft²·h/Btu. Similar calculation procedures can be used to evaluate other wall designs.

Masonry Walls

The average overall R-values of masonry walls can be estimated by assuming a combination of layers in series, one or more of which provides parallel paths. This method is used because heat flows laterally through block face shells so that transverse isothermal planes result. Average total resistance $R_{T(av)}$ is the sum of the resistances of the layers between such planes, each layer calculated as shown in Example 2.

Example 2. Calculate the overall thermal resistance and average U-factor of the 7-5/8-in. thick insulated concrete block wall shown in Figure 3. The two-core block has an average web thickness of 1-in. and a face shell thickness of 1-1/4-in. Overall block dimensions are 7-5/8 by 7-5/8 by 15-5/8 in. Thermal resistances of 112 lb/ft³ concrete and 5 lb/ft³ expanded perlite insulation are 0.10 and 2.90 °F·ft²·h/Btu per in., respectively.

Solution: The equation used to determine the overall thermal resistance of the insulated concrete block wall is derived from Equations (2) and (5) from Chapter 20 and is given below:

$$R_{T(av)} = R_i + R_f + \frac{R_w R_c}{a_c R_w + a_w R_c} + R_o$$

where

$R_{T(av)}$ = overall thermal resistance based on the assumption of isothermal planes
R_i = thermal resistance of inside air surface film (still air)
R_o = thermal resistance of outside air surface film (15 mph wind)
R_f = total thermal resistance of face shells
R_c = thermal resistance of cores between face shells
R_w = thermal resistance of webs between face shells
a_w = fraction of total area transverse to heat flow represented by webs of blocks
a_c = fraction of total area transverse to heat flow represented by cores of blocks

From the information given and the data in Table 1, determine the values needed to compute the overall thermal resistance.

$R_i = 0.68$
$R_o = 0.17$
$R_f = (2)(1.25)(0.10) = 0.25$
$R_c = (5.125)(2.90) = 14.86$
$R_w = (5.125)(0.10) = 0.51$
$a_w = 3/15.625 = 0.192$
$a_c = 12.625/15.625 = 0.808$

Using the equation given, the overall thermal resistance and average U-factor are calculated as follows:

$$R_{T(av)} = 0.68 + 0.25 + (0.51)(14.86)/[(0.808)(0.51) + (0.192)(14.86)] + 0.17$$
$$= 0.68 + 0.25 + 2.33 + 0.17 = 3.43\ °F \cdot ft^2 \cdot h/Btu$$
$$U_{av} = 1/3.43 = 0.292\ Btu/h \cdot ft^2 \cdot °F$$

Based on guarded hot box tests, Van Geem (1985) measured the average R-value for this insulated concrete block wall as 3.13 °F·ft²·h/Btu.

Assuming parallel heat flow only, the calculated resistance is usually higher than that calculated on the assumption of isothermal planes. The actual resistance generally is some value between the two calculated values. In the absence of test values, examination of the construction usually reveals whether a value closer to the higher or lower calculated R-value should be used. Generally, if the construction contains a layer in which lateral conduction is high compared with transmittance through the construction, the calculation with isothermal planes should be used. If the construction has no layer of high lateral conductance, the parallel heat flow calculation should be used.

Hot box tests of insulated and uninsulated masonry walls constructed with block of conventional configuration show that thermal resistances calculated using the isothermal planes heat flow

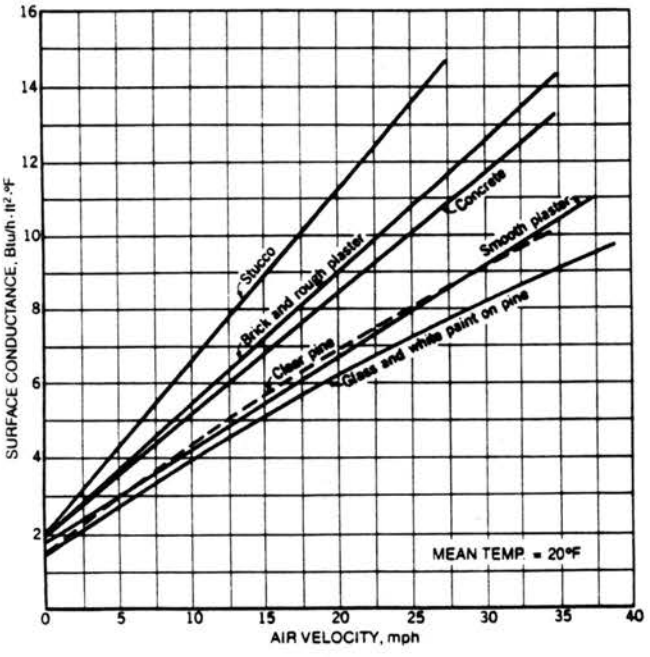
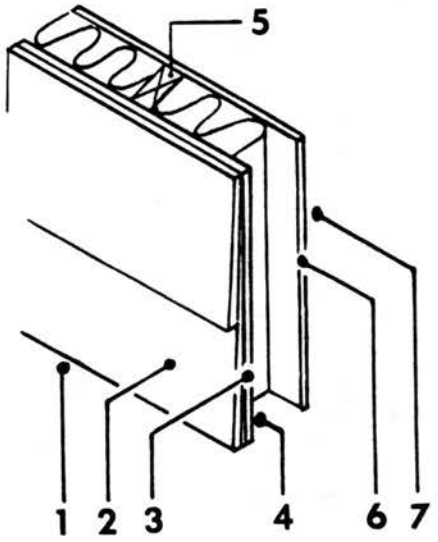


Fig. 1 Surface Conductance for Different 12-Inch-Square Surfaces as Affected by Air Movement



1. Outside surface (15 mph wind)
2. Wood siding, 0.5 in. by 8 in. lapped
3. Sheating, 0.5 in. vegetable fiber board
4. Mineral fiber batt insulation, 3.5 in.
5. Nominal 2 by 4 wood stud
6. Gypsum wallboard, 0.5 in.
7. Inside surface (still air)

Fig. 2 Insulated Wood Frame Wall (Example 1)

method agree well with measured values (see Van Geem 1985, Valore 1980, Shu *et al.* 1979). Neglecting horizontal mortar joints can result in thermal transmittance values up to 16% lower than actual, depending on the density and thermal properties of the masonry, and 1 to 6% lower depending on the core insulation material (Van Geem 1985, McIntyre 1984). Horizontal mortar joints usually found in concrete block wall construction are neglected in Example 2.

Panels Containing Metal

Curtain wall constructions often include metallic and other thermal bridges. Thermal resistance of panels can be significantly reduced by metallic thermal bridges. However, the capacity of the adjacent facing materials to transmit heat transversely to the metal is limited, and some contact resistance between all materials in contact limits the reduction. Contact resistances in building structures are only 0.06 to 0.6 °F·ft²·h/Btu which are too small to be of concern in many cases. However, the contact resistances of steel framing members are important to consider. Also, in many cases (as illustrated in Example 3) the area of metal in contact with the facing greatly exceeds the thickness of the metal which mitigates the influence.

Thermal characteristics for panels of sandwich construction can be computed by combining the thermal resistances of the various layers. However, few panels are true sandwich constructions; many have ribs and stiffeners that create complicated heat flow paths. R-values for the assembled sections should be determined on a representative sample by using a hot box method. If the sample is a wall section with air cavities on both sides of fibrous insulation, the sample must be of representative height since convective airflow can contribute significantly to heat flow through the test section. Computer modeling can also be useful, but all heat transfer mechanisms must be considered.

In Example 3, the metal member is only 0.020 in. thick, but it is in contact with adjacent facings over a 1.25 in.-wide area. The steel member is 3.50 in. deep, has a thermal resistance of approximately 0.011 °F·ft²·h/Btu, and is virtually isothermal. The calculation involves careful selection of the appropriate thickness for the steel member. If the member is assumed to be 0.020 in. thick, the fact that the flange transmits heat to the adjacent facing is ignored. If the member is assumed to be 1.25 in. thick, the heat flow through the steel is overestimated. In Example 3, the steel member behaves in much the same way as a rectangular member 1.25 in. thick and 3.50 in. deep with a thermal resistance of 0.69 °F·ft²·h/Btu [(1.25/0.020) × 0.011] does. The Building Research Association of New Zealand (BRANZ) commonly uses this approximation.

Table 3 Emittance Values of Various Surfaces and Effective Emittances of Airspaces[a]

Surface	Average Emittance ϵ	Effective Emittance, E of Airspace: One surface emittance ϵ; the other 0.9	Effective Emittance, E of Airspace: Both surfaces emittance ϵ
Aluminum foil, bright	0.05	0.05	0.03
Aluminum foil, with condensate just visible (> 0.7gr/ft²)	0.30[b]	0.29	—
Aluminum foil, with condensate clearly visible (> 2.9 gr/ft²)	0.70[b]	0.65	—
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper, polished	0.20	0.20	0.11
Steel, galvanized, bright	0.25	0.24	0.15
Aluminum paint	0.50	0.47	0.35
Building materials: wood, paper, masonry, nonmetallic paints	0.90	0.82	0.82
Regular glass	0.84	0.77	0.72

[a]These values apply in the 4 to 40 μm range of the electromagnetic spectrum.
[b]Values are based on data presented by Bassett and Trethowen (1984).

Example 3. Calculate the C-factor of the insulated steel frame wall shown in Figure 4. Assume that the steel member has an R-value of 0.69 °F·ft²·h/Btu and that the framing behaves as though it occupies approximately 8% of the transmission area.

Solution: Obtain the R-values of the various building elements from Table 4.

Element	R(Insulation)	R(Framing)
1. 0.5-in. gypsum wallboard	0.45	0.45
2. 3.5-in. mineral fiber batt insulation	11	—
3. Steel framing member	—	0.69
4. 0.5-in. gypsum wallboard	0.45	0.45
	R_1 = 11.90	R_2 = 1.59

Therefore, $C_1 = 0.084$; $C_2 = 0.629$ Btu/h·ft²·°F.

If the steel framing (*i.e.*, thermal bridging) is not considered, the C-factor of the wall is calculated using Equation (3) from Chapter 20 as follows:

$$C_{av} = C_1 = 1/R_1 = 0.084 \text{ Btu/h·ft}^2\text{·°F}$$

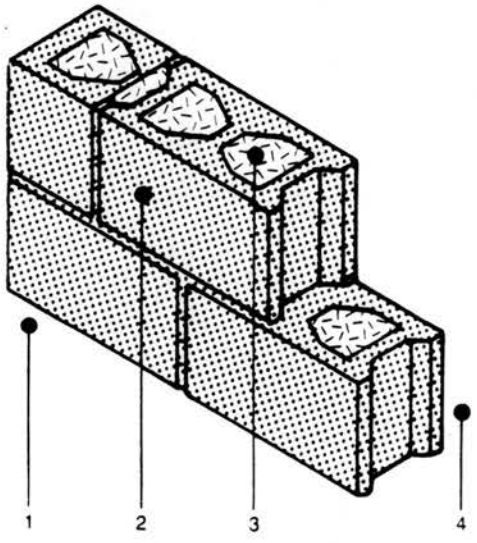
If the steel framing is accounted for using the parallel flow method, the C-factor of the wall is determined using Equation (5) from Chapter 20 as follows:

$$C_{av} = (0.92 \times 0.084) + (0.08 \times 0.629)$$
$$= 0.128 \text{ Btu/h·ft}^2\text{·°F}$$
$$R_{T(av)} = 7.81 \text{°F·ft}^2\text{·h/Btu}$$

If the steel framing is included using the isothermal planes method, the C-factor of the wall is determined using Equations (2) and (3) from Chapter 20 as follows:

$$R_{T(av)} = 0.45 + 1/[(0.92/11.00) + (0.08/0.69)] + 0.45$$
$$= 5.91 \text{°F·ft}^2\text{·h/Btu}$$
$$C_{av} = 0.169 \text{ Btu/h·ft}^2\text{·°F}$$

Farouk and Larson (1983) measured an average R-value of 6.61 °F·ft²·h/Btu for this insulated steel frame wall.



1. Outside surface (15 mph wind)
2. Concrete block
3. Expanded perlite insulation
4. Inside surface (still air)

Fig. 3 Insulated Concrete Block Wall (Example 2)

Table 4 Footnotes (*Concluded*)

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.753 \times 10^{-4} M)\,\rho}{1 + 0.01M}$$

where ρ is density based on oven-dry mass in lb/ft^3 and M is the moisture content in percent.

[n]From Adams (1971), an empirical equation for the specific heat of moist wood at 75°F is as follows:

$$c_p = \frac{(0.299 + 0.01M)}{(1 + 0.01M)} + \Delta c_p$$

where Δc_p accounts for the heat of sorption and is denoted by

$$\Delta c_p = M\,(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

where M is the moisture content in percent by mass.

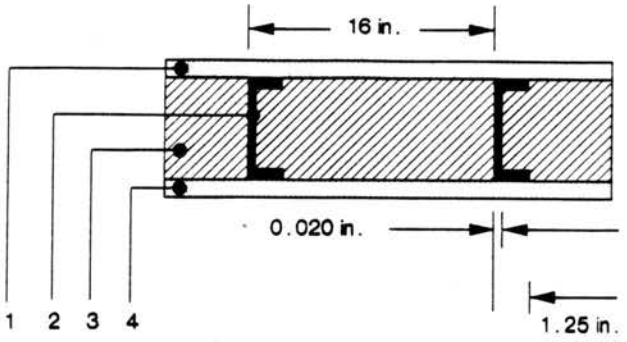


Fig. 4 Insulated Steel Frame Wall (Example 3)

The Zone Method of Calculation

For structures with widely spaced metal members of substantial cross-sectional area, calculation by the isothermal planes method can result in thermal resistance values that are too low. For these constructions, the Zone Method can be used. This method involves two separate computations—one for a chosen limited portion, Zone A, containing the highly conductive element; the other for the remaining portion of simpler construction, Zone B. The two computations are then combined using the parallel flow method, and the average transmittance per unit overall area is calculated. The basic laws of heat transfer are applied by adding the area conductances, CA, of elements in parallel, and adding area resistances, R/A, of elements in series.

The surface shape of Zone A is determined by the metal element. For a metal beam (see Figure 5), the Zone A surface is a strip of width W that is centered on the beam. For a rod perpendicular to panel surfaces, it is a circle of diameter W. The value of W is calculated from Equation (1), which is empirical. The value of d should not be less than 0.5 in. for still air.

$$W = m + 2d \qquad (1)$$

where

m = width or diameter of the metal heat path terminal, in.
d = distance from panel surface to metal, in.

Generally, the value of W should be calculated using Equation (1) for each end of the metal heat path; the larger value, within the limits of the basic area, should be used as illustrated in Example 4.

Example 4. Calculate transmittance of the roof deck shown in Figure 5. Tee-bars at 24 in. OC support glass fiber form boards, gypsum concrete, and built-up roofing. Conductivities of components are: steel, 314.4 Btu·in./h·ft²·°F; gypsum concrete, 1.66 Btu·in./h·ft²·°F; and glass fiber form board, 0.25 Btu·in./h·ft²·°F. Conductance of built-up roofing is 3.00 Btu/h·ft²·°F.

Solution: The basic area is 2 ft² (24 in. by 12 in.) with a tee-bar (12-in. long) across the middle. This area is divided into *Zones A* and *B*.

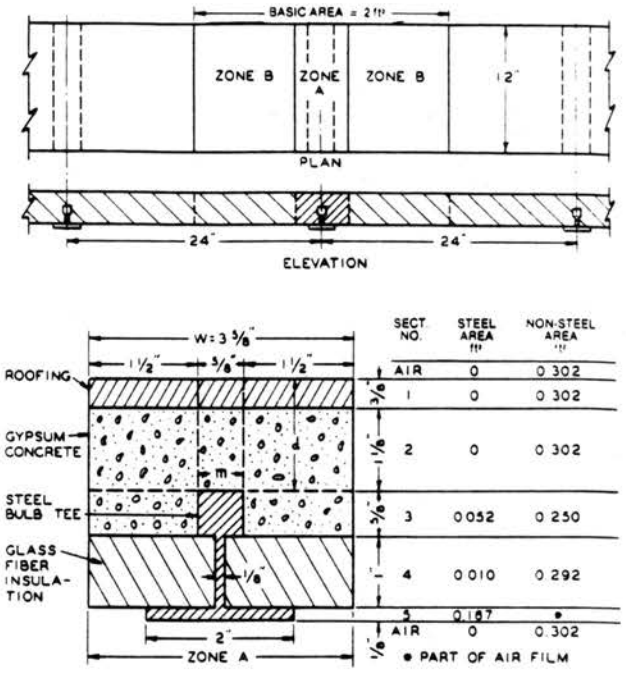


Fig. 5 Gypsum Roof Deck on Bulb Tees (Example 4)

Zone A is determined from Equation 1 as follows:

Top side $W = m + 2d = 0.625 + (2 \times 1.5) = 3.625$ in.
Bottom side $W = m + 2d = 2.0 + (2 \times 0.5) = 3.0$ in.

Using the larger value of W, the area of *Zone A* is $(12 \times 3.625)/144 = 0.302$ ft². The area of *Zone B* is $2.0 - 0.302 = 1.698$ ft².

To determine area transmittance for *Zone A*, divide the structure within the zone into five sections parallel to the top and bottom surfaces (Figure 5). The area conductance, CA, of each section is calculated by adding the area conductances of its metal and nonmetal paths. Area conductances of the sections are converted to area resistances, R/A, and added to obtain the total resistance of *Zone A*.

Section	Area × Conductance	= CA	$\frac{1}{CA} = \frac{R}{A}$
Air (outside, 15 mph)	0.302 × 6.00	1.81	0.55
No. 1, Roofing	0.302 × 3.00	0.906	1.10
No. 2, Gypsum concrete	0.302 × 1.66/1.125	0.446	2.24
No. 3, Steel	0.052 × 314.4/0.625	26.2	0.04
No. 3, Gypsum concrete	0.250 × 1.66/0.625	0.664	
No. 4, Steel	0.010 × 314.4/1.00	3.14	0.31
No. 4, Glass fiberboard	0.292 × 0.25/1.00	0.073	
No. 5 Steel	0.167 × 314.4/0.125	420.0	0.002
Air (inside)	0.302 × 1.63	0.492	2.03
			Total R/A = 5.2

Area transmittance of *Zone A* = $1/(R/A) = 1/6.27 = 0.159$.

For *Zone B*, the unit resistances are added and then converted to area transmittance, as shown in the following table.

Section	Resistance, *R*	
Air (outside, 15 mph)	1/6.00	= 0.17
Roofing	1/3.00	= 0.33
Gypsum concrete	1.75/1.66	= 1.05
Glass fiberboard	1.00/0.25	= 4.00
Air (inside)	1/1.63	= 0.61
Total resistance		= 6.16

Since unit transmittance = $1/R = 0.162$, the total area transmittance, *UA*, is calculated as follows:

Zone B = 1.698 × 0.162 =	0.275
Zone A =	0.159
Total area transmittance of basic area =	0.434
Transmittance per ft² = 0.434/2.0 =	0.217
Resistance per ft² =	4.61

Overall R-values of 4.57 and 4.85 °F·ft²·h/Btu have been measured in two guarded hot box tests of a similar construction.

When the steel member represents a relatively large proportion of the total heat flow path, as in Example 4, detailed calculations of resistance in sections 3, 4, and 5 of Zone A are unnecessary; if only the steel member is considered, the final result of Example 4 is the same. However, if the heat flow path represented by the steel member is small, as for a tie rod, detailed calculations for sections 3, 4, and 5 are necessary. A panel with an internal metallic structure and bonded on one or both sides to a metal skin or covering, presents special problems of lateral heat flow not covered in the zone method.

Ceilings and Roofs

The overall R-value for ceilings of wood frame flat roofs can be calculated using Equations (1) through (5) from Chapter 20. Properties of the materials are found in Tables 1, 2, 3, and 4. The fraction of framing is assumed to be 0.10 for joists at 16 in. OC and 0.07 for joists at 24 in. OC. The calculation procedure is similar to that shown in Example 1. Note that if the ceiling contains plane airspaces (see Table 2), the resistance depends on the direction of heat flow, *i.e.*, whether the calculation is for a winter (heat flow up) or summer (heat flow down) condition.

For ceilings of pitched roofs under winter conditions, calculate the R-value of the ceiling using the procedure for flat roofs. The heat loss from these ceilings can be obtained using a calculated attic temperature (see Chapter 25). Table 5 can be used to determine the effective resistance of the attic space under summer conditions for varying conditions of ventilation air temperature, airflow direction and rates, ceiling resistance, roof or sol-air temperatures, and surface emittances (Joy 1958).

Table 5 Effective Thermal Resistance of Ventilated Attics[a] (Summer Condition)

PART A. NONREFLECTIVE SURFACES

		No Ventilation[b]		Natural Ventilation				Power Ventilation[c]			
		Ventilation Rate, cfm/ft²									
		0		0.1[d]		0.5		1.0		1.5	
Ventilation Air Temp., °F	Sol-Air[f] Temp., °F	Ceiling Resistance, R[e], °F·ft²·h/Btu									
		10	20	10	20	10	20	10	20	10	20
80	120	1.9	1.9	2.8	3.4	6.3	9.3	9.6	16	11	20
	140	1.9	1.9	2.8	3.5	6.5	10	9.8	17	12	21
	160	1.9	1.9	2.8	3.6	6.7	11	10	18	13	22
90	120	1.9	1.9	2.5	2.8	4.6	6.7	6.1	10	6.9	13
	140	1.9	1.9	2.6	3.1	5.2	7.9	7.6	12	8.6	15
	160	1.9	1.9	2.7	3.4	5.8	9.0	8.5	14	10	17
100	120	1.9	1.9	2.2	2.3	3.3	4.4	4.0	6.0	4.1	6.9
	140	1.9	1.9	2.4	2.7	4.2	6.1	5.8	8.7	6.5	10
	160	1.9	1.9	2.6	3.2	5.0	7.6	7.2	11	8.3	13
PART B. REFLECTIVE SURFACES[g]											
80	120	6.5	6.5	8.1	8.8	13	17	17	25	19	30
	140	6.5	6.5	8.2	9.0	14	18	18	26	20	31
	160	6.5	6.5	8.3	9.2	15	18	19	27	21	32
90	120	6.5	6.5	7.5	8.0	10	13	12	17	13	19
	140	6.5	6.5	7.7	8.3	12	15	14	20	16	22
	160	6.5	6.5	7.9	8.6	13	16	16	22	18	25
100	120	6.5	6.5	7.0	7.4	8.0	10	8.5	12	8.8	12
	140	6.5	6.5	7.3	7.8	10	12	11	15	12	16
	160	6.5	6.5	7.6	8.2	11	14	13	18	15	20

[a] Although the term effective resistance is commonly used when there is attic ventilation, this table includes values for situations with no ventilation. The effective resistance of the attic, added to the resistance ($1/U$) of the ceiling yields the effective resistance of this combination based on sol-air (see Chapter 26) and room temperatures. These values apply to wood frame construction with a roof deck and roofing that has a conductance of 1.0 Btu/h·ft²·°F.

[b] This condition cannot be achieved in the field unless extreme measures are taken to tightly seal the attic.

[c] Based on air discharging outward from attic.

[d] When attic ventilation meets the requirements stated in Chapter 23, 0.1 cfm/ft² is assumed as the natural summer ventilation rate for design purposes.

[e] When determining ceiling resistance, do not add the effect of a reflective surface facing the attic, as it is accounted for in Table 5, Part B.

[f] Roof surface temperature rather than sol-air temperature (see Chapter 26) can be used if 0.25 is subtracted from the attic resistance shown.

[g] Surfaces with effective emittance *E* of 0.05 between ceiling joists facing the attic space.

Table 13 Overall Coefficients of Heat Transmission of Various Fenestration Products

Part A: U-Values for Vertical Installation[a], Btu/h·ft²·°F

Glazing Type[b]	Glass Only: Center of Glass	Glass Only: Edge[c] of Glass	Aluminum Frame no thermal break ($U_f = 1.9$): Product[d] Type R	Aluminum Frame no thermal break ($U_f = 1.9$): Product[d] Type C	Aluminum Frame thermal break ($U_f = 1.0$): Product[d] Type R	Aluminum Frame thermal break ($U_f = 1.0$): Product[d] Type C	Wood or Vinyl Frame ($U_f = 0.4$): Product[d] Type R	Wood or Vinyl Frame ($U_f = 0.4$): Product[d] Type C
Single glazing								
glass	(1.11)	(n/a)	1.31	1.23	1.09	1.10	0.90	0.98
1/8 in. acrylic	(1.03)	(n/a)	1.26	1.16	1.02	1.03	0.84	0.92
Double glass								
1/4 in. air space	(0.57)	(0.66)	0.92	0.78	0.70	0.65	0.54	0.55
3/8 in. air space	(0.52)	(0.62)	0.88	0.74	0.66	0.60	0.50	0.51
1/2 in. and greater air space	(0.49)	(0.59)	0.87	0.72	0.64	0.59	0.49	0.49
Double glass, $\varepsilon = 0.40$ on surface 2 or 3								
1/4 in. air space	(0.50)	(0.60)	0.87	0.73	0.65	0.59	0.49	0.50
3/8 in. air space	(0.43)	(0.55)	0.83	0.67	0.60	0.54	0.45	0.45
1/2 in. and greater air space	(0.41)	(0.54)	0.81	0.65	0.58	0.52	0.43	0.42
Double glass, $\varepsilon = 0.15$ on surface 2 or 3								
1/4 in. air space	(0.45)	(0.56)	0.84	0.68	0.61	0.55	0.46	0.46
3/8 in. air space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
1/2 in. air space	(0.34)	(0.50)	0.76	0.60	0.54	0.46	0.39	0.37
Double glass								
1/4 in. argon space	(0.52)	(0.62)	0.88	0.74	0.66	0.61	0.50	0.51
3/8 in. argon space	(0.48)	(0.59)	0.86	0.71	0.63	0.57	0.48	0.48
1/2 in. and greater argon space	(0.46)	(0.57)	0.82	0.69	0.62	0.56	0.47	0.47
Double glass, $\varepsilon = 0.40$ on surface 2 or 3								
1/4 in. argon space	(0.43)	(0.55)	0.83	0.67	0.60	0.54	0.45	0.45
3/8 in. argon space	(0.38)	(0.52)	0.79	0.63	0.57	0.49	0.42	0.40
1/2 in. and greater argon space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
Double glass, $\varepsilon = 0.15$ on surface 2 or 3								
1/4 in. argon space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
3/8 in. argon space	(0.30)	(0.48)	0.74	0.57	0.51	0.43	0.37	0.34
1/2 in. and greater argon space	(0.28)	(0.47)	0.73	0.55	0.50	0.42	0.36	0.33
Double glazing, 1/8 in. acrylic or polycarbonate								
1/4 in. air space	(0.52)	(0.62)	0.89	0.74	0.67	0.61	0.51	0.51
3/8 in. air space	(0.48)	(0.59)	0.86	0.71	0.64	0.57	0.48	0.48
1/2 in. and greater air space	(0.46)	(0.57)	0.85	0.69	0.62	0.56	0.47	0.47
Double glazing, 1/4 in. acrylic or polycarbonate								
1/4 in. air space	(0.48)	(0.59)	0.86	0.71	0.64	0.57	0.48	0.48
3/8 in. air space	(0.44)	(0.56)	0.84	0.68	0.61	0.54	0.46	0.45
1/2 in. and greater air space	(0.42)	(0.54)	0.82	0.66	0.60	0.53	0.45	0.43
Triple glass								
1/4 in. air space	(0.38)	(0.52)	0.79	0.64	0.57	0.50	0.42	0.41
3/8 in. air space	(0.34)	(0.50)	0.76	0.60	0.54	0.46	0.39	0.38
1/2 in. and greater air space	(0.32)	(0.49)	0.75	0.58	0.53	0.45	0.38	0.36
Triple glass, $\varepsilon = 0.40$ on surface 2, 3, 4 or 5								
1/4 in. air spaces	(0.35)	(0.50)	0.77	0.61	0.55	0.48	0.40	0.39
3/8 in. air spaces	(0.30)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
1/2 in. and greater air spaces	(0.28)	(0.47)	0.72	0.55	0.50	0.41	0.36	0.33
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surface 2, 3, 4, or 5								
1/4 in. air spaces	(0.33)	(0.49)	0.76	0.59	0.53	0.45	0.39	0.37
3/8 in. air spaces	(0.27)	(0.46)	0.72	0.54	0.50	0.41	0.35	0.32
1/2 in. and greater air spaces	(0.24)	(0.45)	0.70	0.52	0.48	0.39	0.34	0.30
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surfaces 2 or 3 and 4 or 5								
1/4 in. air spaces	(0.28)	(0.47)	0.73	0.55	0.53	0.42	0.36	0.33
3/8 in. air spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.32	0.29
1/2 in. and greater air spaces	(0.19)	(0.44)	0.67	0.48	0.45	0.35	0.31	0.26
Triple glass								
1/4 in. argon spaces	(0.34)	(0.50)	0.77	0.60	0.54	0.46	0.39	0.38
3/8 in. argon spaces	(0.31)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
1/2 in. and greater argon spaces	(0.29)	(0.47)	0.73	0.56	0.51	0.42	0.36	0.34
Triple glass, $\varepsilon = 0.40$ on surface 2, 3, 4 or 5								
1/4 in. argon spaces	(0.30)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
3/8 in. argon spaces	(0.26)	(0.46)	0.72	0.54	0.49	0.41	0.35	0.32
1/2 in. and greater argon spaces	(0.25)	(0.46)	0.71	0.53	0.48	0.39	0.34	0.31

Table 13 Overall Coefficients of Heat Transmission of Various Fenestration Products (*Concluded*)

Part A: U-Values for Vertical Installation[a], Btu/h·ft²·°F

Glazing Type[b]	Glass Only		Aluminum Frame no thermal break ($U_f = 1.9$)		Aluminum Frame thermal break ($U_f = 1.0$)		Wood or Vinyl Frame ($U_f = 0.4$)	
	Center of Glass	Edge[c] of Glass	Product[d] Type		Product[d] Type		Product[d] Type	
			R	*C*	*R*	*C*	*R*	*C*
Triple glass or double glass with polyester film suspended in between, ε = 0.15 on surface 2, 3, 4, or 5								
1/4 in. argon spaces	(0.27)	(0.46)	0.72	0.54	0.50	0.41	0.35	0.32
3/8 in. argon spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.33	0.29
1/2 in. and greater argon spaces	(0.20)	(0.44)	0.68	0.50	0.46	0.36	0.31	0.28
Triple glass or double glass with polyester film suspended in between, ε = 0.15 on surfaces 2 or 3 and 4 or 5								
1/4 in. argon spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.32	0.29
3/8 in. argon spaces	(0.17)	(0.43)	0.66	0.47	0.44	0.34	0.30	0.25
1/2 in. and greater argon spaces	(0.15)	(0.43)	0.65	0.46	0.43	0.32	0.29	0.24

Part B: U-Value Conversion Table for Sloped and Horizontal Glazing for Upward Heat Flow

Slope	U-Value, Btu/h·ft²·°F												
90° (vertical)	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30
45°	0.14	0.25	0.36	0.47	0.57	0.68	0.79	0.90	1.00	1.11	1.22	1.33	1.44
0 (horiz.)	0.19	0.29	0.40	0.51	0.61	0.72	0.82	0.93	1.04	1.14	1.25	1.35	1.46

[a]All U-values are based on standard ASHRAE winter conditions of 70°F indoor and 0°F outdoor air temperature with 15 mph outdoor air velocity and zero solar flux. The outside surface coefficient at these conditions is approximately 5.1 Btu/hr·ft²·°F, depending on the glass surface temperature. With the exception of single glazing, small changes in the interior and exterior temperatures do not significantly affect overall U-values.

[b]Glazing layer surfaces are numbered from the outside to the inside. Double and triple refer to the number of glazing lites. All data are based on 1/8 in. glass unless otherwise noted. Thermal conductivities are: 0.53 Btu/h·ft·°F for glass, and 0.11 Btu/h·ft·°F for acrylic and polycarbonate.

[c]Based on aluminum spacers data (see Figure 6). Edge of glass effect assumed to extend over the 2.5 in. band around perimeter of each glazing unit as seen in Figure 7.

[d]Product types described in Figure 7.

edge-of-glass U-values as a function of the center-of-glass U-value. The spacer edge is assumed to be even with the line of sight of the glazing. Data are given for aluminum spacers with sealants and non-metal spacers including fiberglass, wood, and butyl. Values for glass edges and steel spacers fall between the aluminum and the non-metal spacers. This edge effect does not occur with single glazing. For highly insulating glazing, edge heat transfer can significantly increase overall U-value. Thus, test data or design-specific computations should account for this effect.

Estimation of the rate of heat transfer through the framing elements of a fenestration system is complicated by (1) the variety of frame configurations for operable windows, (2) the different combinations of materials used for sash and frames, and (3) the difference in sizes available in residential and commercial applications. Available windows are usually framed in either wood, aluminum, or vinyl; and many manufacturers combine materials for structural or aesthetic purposes. Some aluminum-framed units have *thermal breaks* that reduce the conductive heat transfer through the framing element. Standard methods for calculating frame heat transfer are not generally available, however Energy Mines and Resources Canada (1987) and Johnson (1985) have developed computer programs that analyze frame conduction.

Representative U-Values for Fenestration Products

Table 13 can be used to select a particular fenestration product to obtain a desired U-value. Part A of this table presents computed overall U-values for a wide range of glazing units and framing materials installed vertically and based on component U-values shown in parentheses. Part B presents approximate U-values for non-vertical installation. The overall U-values in part A are appropriate for calculating compliance with the requirements of ASHRAE Standard 90. However, the values apply only to the specific design conditions described in the footnotes and are typically used to determine peak load conditions for sizing heating equipment. While these U-values have been determined for winter conditions, they can be used to estimate heat gain during peak cooling conditions since conductive gain which is one of several factors, is usually a small portion of the total heat gain for windows in direct sunlight. Glazing designs and framing materials may be compared to choose a fenestration system that needs a specific winter design U-value.

The overall U-values in Table 13 are based on the rough opening area for representative generic glazing products. Test data, when available, may provide more accurate results for specific products. However, a wide range of measured U-values for similar products has been reported (Hogan 1988). Standard test methods for fenestration systems are still under development and different test methods sometimes give different U-values (McCabe *et al.* 1986).

The multiple glazing categories are appropriate for sealed glass units, acrylic domes, and the addition of storm sash to other glazing units. No distinction is made between flat and domed units such as skylights. For acrylic domes, use average airspace width to determine U-value. Unless otherwise noted, all multiple glazed units are filled with dry air. Argon units are assumed filled with 100% Argon. U-values for CO_2 filled units are similar to Argon fills. For spaces up to 0.5 in., Argon/SF_6 mixtures up to 70% SF_6 are generally the same as Argon fills. (A unit with 0.25 in. Krypton fill gas has about the same U-value as a unit with 0.5 in. Argon fill gas.)

Table 13, Part A lists data for three values of hemispherical emittance. Uncoated glass has an emittance of 0.84. Emittance of various low-emittance glasses vary considerably between manufacturers and processes. When the emittance is known to be between the listed values, interpolation is recommended. When manufacturers data are not available for low-emittance

glass, assume glass with a pyrolytic (hard) coating has an emittance of 0.40, and glass with a sputtered (soft) coating has an emittance of 0.15. Some coated glazings have lower values of emittance. The use of tinted glass does not change the winter U-value. Also some reflective glass may have an emittance less than 0.84.

Frame type refers to the primary unit. Thus, when storm sash is added over other glazing, use the values for the non-storm frame. For glazing with a steel frame, use aluminum frame values. The wood frame category represents wood frames with and without cladding as well as vinyl frames.

Product Types R (residential) and C (commercial) refer to the proportions of frame to glass area as shown in Figure 7. The U-values in Table 13 and the definition of these two products are based on frame sizes for operable windows. The Type R category is based on products in which the glazing units are about 6 ft² in area and the overall size corresponds to a 3 by 4 ft window. For aluminum windows, this corresponds to 25% frame area, 27% edge of glass, and 48% center of glass; for wood and vinyl, the frame, edge, and center of glass areas are 30%, 26%, and 44%, respectively. The Type C category is based on products in which the panes of glazing are about 24 ft² in area and the overall size corresponds to a 4 by 6 ft window. For aluminum windows, Type C category correspond to 15% frame, 15% edge, and 70% center of glass. For wood and vinyl, the breakdown is 18%, 15%, and 67%, respectively. In this case the key determinant for selecting the appropriate product is glazing unit size, *not* overall window size. For products with glazing unit sizes 16 ft² or less, use the Type R category. For products with glazing unit sizes greater than 16 ft², such as sliding glass doors, use the Type C category. For large sealed glass units with mullions or grilles that form a thermal bridge in the airspace between the glazing, use the Type R category.

Part B of Table 13 lists approximate U-values for simple single and double glazed units installed in non-vertical installations where heat flows upward. After determining a U-value for vertical installation from Part A, enter Part B on the 90° slope line (vertical) and find that value. Then read down and find the U-value corresponding to the desired slope. For simplicity, use the 90° value for products installed 60 to 90° above horizontal, the 45° value for installations 30 to 60° above horizontal, and the zero degree value (horizontal) for installations within 30° of horizontal.

Example 5. Calculate the U-value for a skylight that has a double-glazed, 0.125 in. acrylic dome with 0.75 in. airspace and a thermally-broken aluminum frame installed on a roof with a 4 in 12 slope.

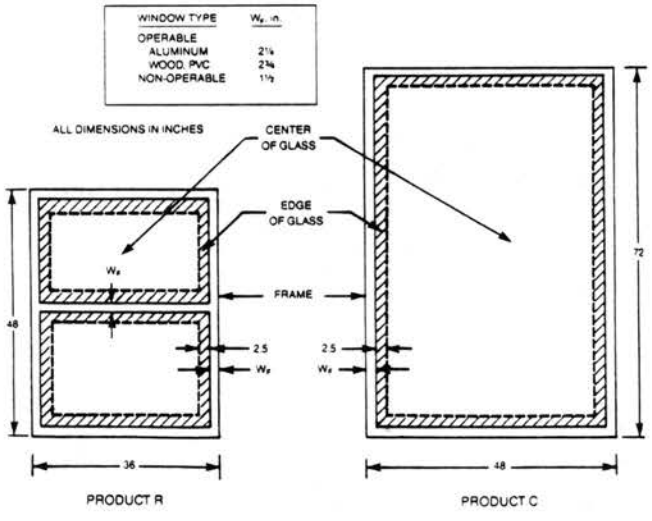


Fig. 7 R and C Category Frame Dimensions

Solution: Assume Product Type R. From Table 13, Part A, the U-value of a thermally-broken, aluminum-framed, double glazing, with 0.125 in. acrylic and 0.5 in. or greater airspace is 0.62 Btu/h·ft²·°F, if mounted vertically. From Part B, the U-value for a 4-in-12 slope (18°) is 0.74 Btu/h·ft²·°F.

To estimate the overall U-value of a fenestration product that differs significantly from the assumptions of Table 13, Figure 7, or both, first determine the percentage area that is frame/sash, center-of-glass, and edge-of-glass (based on a 2.5 in. band around the perimeter of each glazing unit). Next, determine the appropriate component U-values. These can be either from the standard values listed in parentheses in the table or from some other source such as test data or computed values. Finally, multiply the percent area and the component U-value and sum these products to obtain the overall U-value, U_o.

Example 6. Calculate the U-value for a wood-framed, 30 by 80 in., swinging French door with eight 11 by 16 in. panes, each consisting of clear double-glazing with a 0.5 in. airspace.

Solution: First calculate the areas and percentages that correspond to the frame, edge-of-glass, and center-of-glass. These are 41%, 37%, and 22%, respectively. Next, select the corresponding component U-values from the data in Table 13, Part A. These component U-values are 0.4, 0.59, and 0.49 Btu/h·ft²·°F respectively. The French door U-value is:

$$U_o = 0.41(0.4) + 0.37(0.59) + 0.22(0.49)$$
$$= 0.49 \text{ Btu/h·ft}^2\text{·°F}$$

Fenestration system performance is likely to be different than the data in Table 13, when products are installed in buildings, due to the combined effects of solar gain, wind, ambient temperature and cloud cover. Since all of these factors influence the rate of heat transfer through fenestration, seasonal or annual energy flows can not be accurately determined solely on the basis of the design-day U-values. Where it is desired to compare U-values at different wind speeds, Table 14 provides approximate data to convert the overall U-value data at one specific wind condition to a U-value at another wind condition. Performance data in Table 13, Part A is based on the assumption of an overcast sky, which implies that the effective sky temperature for radiative heat transfer is equal to the outdoor air temperature. That assumption gives reasonable results with 7.5 and 15 mph wind speeds, however, with a clear sky and nearly still wind conditions, significant heat transfer occurs by radiation and the data in Table 14 may underestimate the actual U-Values.

Air Infiltration

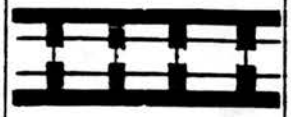
Air infiltration through fenestration products is significant in determinating a building's heating and cooling loads. It should

Table 14 Glazing U-Value Conversion from 15 mph Wind to 7.5 mph Wind and Still Air

Wind speed, mph		
15	7.5	0
U-Value, Btu/h·ft²·°F		
0.10	0.10	0.10
0.20	0.20	0.19
0.30	0.29	0.28
0.40	0.38	0.37
0.50	0.47	0.45
0.60	0.56	0.53
0.70	0.65	0.61
0.80	0.74	0.69
0.90	0.83	0.78
1.00	0.92	0.86
1.10	1.01	0.94
1.20	1.10	1.02
1.30	1.19	1.10

R - V A L U E C O M P A R I S O N

8" Insulated Concrete Masonry Systems
(Steady-State Values Before Mass
Adjustments Which Varies With Climate)

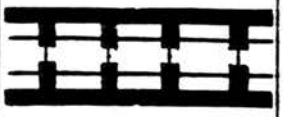
INSULATED CONCRETE BLOCK SYSTEM	INSERT THICK	SERIES-PARALLEL (ISOTHERMAL PLANES) CALCULATION METHOD[1] LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF	PARALLEL-PATH CALCULATION METHOD (I N A C C U R A T E) LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF	COMPANY PUBLISHED LITERATURE[2] LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF
 EnerBlock™ (Continuous Between Block)	1.25"	6.2	5.3	4.5	3.6	7.8	7.1	6.4	5.9	SAME AS SERIES-PARALLEL CALCULATION METHOD			
	2.00"	6.9	5.7	4.7	3.8	9.6	8.7	7.8	7.0				
	2.50"	8.7	7.1	5.9	4.6	11.0	9.8	8.7	7.8				
	4.00"	10.1	8.1	6.4	4.9	13.7	12.0	10.5	9.2				
 C-SHAPED INSERTS (Cores Only)	1.125" Each Side	4.0	3.5	3.0	2.6	5.8	5.0	4.4	3.9	7.7 (93%)	6.3 (80%)	5.3 (77%)	4.2 (62%)
 PLAIN INSERTS (Cores Only)	2.00"	3.8	3.3	2.8	2.4	5.5	4.8	4.2	3.9	7.7 (103%)	6.3 (91%)	5.3 (89%)	4.2 (75%)
 CUT-DOWN WEB (NOT Continuous Between Block)	1" Plus	4.2	3.6	3.0	2.5	6.8	6.1	5.5	5.0	6.7 (60%)	5.5 (53%)	4.4 (33%)	3.1 (24%)
 CUT-DOWN WEB (Continuous Between Block)	2.375"	7.4	6.0	4.8	3.8	10.7	9.6	8.6	7.8	11.1 (50%)	9.1 (52%)	7.7 (60%)	—

NOTES: (1) Series-Parallel R-values are according to the "STANDARD PROCEDURE FOR CALCULATING THE OVERALL COEFFICIENT OF HEAT TRANSFER OF CONCRETE MASONRY" as developed by the National Concrete Masonry Association (NCMA). This calculation procedure is mandated by the U.S. Department of Energy (DOE) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), STANDARD 90.1. Values for insulated bloc other than EnerBlock were calculated using the best dimensional information available. For additional comparison, results from the same NCMA "STANDARD PROCEDURE" should be obtained from other companies marketing insulated concrete masonry.

(2) The figure in parenthesis for published literature is the percentage above the R-Values as calculated according to the ASHRAE Series-Parallel (Isothermal Planes) calculation method.

10/89

R - V A L U E C O M P A R I S O N
8" Insulated Concrete Masonry Systems
(Steady-State Values Before Mass
Adjustments Which Varies With Climate)

INSULATED CONCRETE BLOCK SYSTEM	INSERT THICK	SERIES-PARALLEL (ISOTHERMAL PLANES) CALCULATION METHOD[1] LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF	PARALLEL-PATH CALCULATION METHOD (I N A C C U R A T E) LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF	COMPANY PUBLISHED LITERATURE[2] LIGHT WEIGHT 80 PCF	LIGHT WEIGHT 100PCF	MEDIUM WEIGHT 120PCF	HEAVY WEIGHT 140PCF
 EnerBlock™ (Continuous Between Block)	1.25"	6.2	5.3	4.5	3.6	7.8	7.1	6.4	5.9	SAME AS SERIES-PARALLEL CALCULATION METHOD			
	2.00"	6.9	5.7	4.7	3.8	9.6	8.7	7.8	7.0				
	2.50"	8.7	7.1	5.9	4.6	11.0	9.8	8.7	7.8				
	4.00"	10.1	8.1	6.4	4.9	13.7	12.0	10.5	9.2				
 C-SHAPED INSERTS (Cores Only)	1.125" Each Side	4.0	3.5	3.0	2.6	5.8	5.0	4.4	3.9	7.7 (93%)	6.3 (80%)	5.3 (77%)	4.2 (62%)
 PLAIN INSERTS (Cores Only)	2.00"	3.8	3.3	2.8	2.4	5.5	4.8	4.2	3.9	7.7 (103%)	6.3 (91%)	5.3 (89%)	4.2 (75%)
 CUT-DOWN WEB (NOT Continuous Between Block)	1" Plus	4.2	3.6	3.0	2.5	6.8	6.1	5.5	5.0	6.7 (60%)	5.5 (53%)	4.4 (33%)	3.1 (24%)
 CUT-DOWN WEB (Continuous Between Block)	2.375"	7.4	6.0	4.8	3.8	10.7	9.6	8.6	7.8	11.1 (50%)	9.1 (52%)	7.7 (60%)	—

NOTES: (1) Series-Parallel R-values are according to the "STANDARD PROCEDURE FOR CALCULATING THE OVERALL COEFFICIENT OF HEAT TRANSFER OF CONCRETE MASONRY" as developed by the National Concrete Masonry Association (NCMA). This calculation procedure is mandated by the U.S. Department of Energy (DOE) and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), STANDARD 90.1. Values for insulated blo other than EnerBlock were calculated using the best dimensional information available. For additional comparison, results from the same NCMA "STANDARD PROCEDURE" should be obtained from other companies marketing insulated concrete masonry:

(2) The figure in parenthesis for published literature is the percentage above the R-Values as calculated according to the ASHRAE Series-Parallel (Isothermal Planes) calculation method.

10/89

ATTACHMENT 3

Table 5.3-1
Calculation Procedures for Thermal Transmittance
Through Opaque Envelope Assemblies

Material Attached To Thermal Bridge Material	Thermal Bridge Material	Calculation Procedure(s)
Metal	Metal	Thermal Bridges Sheet Metal Construction, 5.3.3.2.1 (d)
Metal	Non-Metal	Parallel/Series 5.3.3.2.2
Non-Metal	Metal	Case Specific Correction 5.3.3.2.1 (b), or 5.3.3.2.1 (c)
Non-Metal	Non-Metal	Parallel/Series 5.3.3.2.2

5.3.3.2.1 For envelope assemblies containing metal framing, the U_i shall be determined by using one of the following methods:

(a) Results from laboratory or field test measurements, using one of the procedures specified in Section 5.1.5.

(b) For non-metal surfaces attached to metal framing, where data from

EEBA
Energy Efficient Building Association
Technology Center, University of Southern Maine
Gorham, Maine 04038, USA • Fax (207) 780-5129
Telephone: (207) 780-5449 or (207) 780-5143

EEBA ALERT

WINDOW R-VALUES SUBSTANTIALLY OVERSTATED !!

For several years EEBA has reported at it's annual conferences that published window **R-Values** were **inflated** and **unrealistic.** The window industry has touted numbers based upon an antiquated ASHRAE formula. The calculated results which were consistently and substantially higher than accurate laboratory testing results have been consciously reported by the industry for many years. As this ALERT is being prepared most window manufacturers product literature and advertising still list these artificially high R-Values.

The basic problem? The window manufacturing industry, almost unanimously, has been using calculations provided by ASHRAE in it's 1985 (and earlier) Handbook of Fundamentals. Unfortunately, that ASHRAE formula did not include many factors widely known about windows.

The **1989 ASHRAE Handbook of Fundamentals** has a drastically different and substantially improved formula for these calculations. The result is significantly greater accuracy **but substantially LOWER R-Values.** The new formula includes the following criteria:

R-Values at center of glass.	Inside (70°F) & Outside (0°F) Temperatures
Insulation value of frame materials.	A standard size unit (3" x 4" for residential)
Wind velocity of 15 MPH.	The "edge effect"

What does all of this mean? To illustrate the point let's consider a very popular "Low E" casement unit gas filled insulating glass. It has been advertised, through the last day of 1989, as having a **4.2 R-Value.** Starting January 1, 1990 that **exact same window** will have only a 3.2 R-Value, or about **26% less.** Windows smaller than 3' x 4' are even more dramatically downgraded.

Further, the numbers for inside glass surface temperatures, % RH when condensation occurs, shading coefficients and relative heat gain are all **adversely lower** than previously reported.

EEBA believes this is **very significant** information effecting all heat loss calculations. We caution all designers, architects, contractors, builders, weatherization staff, utility auditors and others to **use the new more accurate R-Values** based upon the **1989** ASHRAE Handbook of Fundamentals. **Possibly less glazing area should be seriously considered in some buildings.**

Only two or three major manufacturers have made the corrections in their latest literature; however not all dealers have this information at this time. Most manufacturers have not published the corrected R-Values. It is not clear when or if they will.

Consequently, the status of window product literature in the market place today relative to correct R-Values is shamefully chaotic. The problem is further compounded by the fact that several manufacturers are using inert gases and claiming additionally higher R-Values for units with these gases. Unfortunately, some manufacturers do not explain this in their literature. Thus, frequently the consumer has great difficulty in knowing the true R-Value of the product being purchased.

As a suggestion, when only "old" **R-Values** are known, subtract one (1) R-Value from the old published numbers. This will be close to the newer more accurate values.

Congratulations to our friends at LBL Berkeley who developed the new comprehensive calculations. Special recognition also to the very able researchers at Energy, Mines and Resources, Canada for their "edge effect" work. And thanks to ASHRAE for recognizing this problem and doing something about it.

Now the window industry must be encouraged to provide this new correct data without delay. The newly formed National Fenestration Rating Council (NFRC) should play a major role in this important task.

9002 Copyright 1990 by EEBA.

ATTACHMENT 5

Window U-Values

Revisions for the 1989 ASHRAE Handbook—Fundamentals

By Michael E. McCabe, P.E., Dsc
Member ASHRAE

Editor's Note: Chapter 27 in the *1989 ASHRAE Handbook—Fundamentals* is the authoritative source of technical information on fenestration products such as windows, patio doors, skylights, shading devices, etc. Its revision every four years is the responsibility of Technical Committee 4.5 (Fenestration). *Table 13* in this chapter lists Overall Coefficients of Heat Transfer (U-Values) for a variety of fenestration, based on standard outdoor design conditions. This data has been used by engineers, architects, manufacturers, code officials, etc., for many purposes; including design calculations for sizing heating and cooling equipment, for estimating building energy consumption, and for comparing thermal performance between competing fenestration products. The *1989 ASHRAE Handbook—Fundamentals* was printed and mailed to ASHRAE members entitled to receive the book in May.

Recently, the thermal resistance of insulated glazing units has undergone significant improvement due to commercialization of products having low-emittance coatings and or low-conductance gas fills. Thus, heat conduction in the non-glazed portion such as the frame and sash has become more important in determining the overall U-Value of the system. The U-Value Subcommittee of T.C. 4.5 has recommended a number of changes to be made to *Table 13* in the 1989 Handbook. This article discusses the technical basis for the changes and illustrates the differences between data in the 1989 Handbook and previous Handbooks.

Overall coefficient of heat transfer

The general equation used to estimate the total rate of heat transfer, Q_o, through a fenestration system from inside to outside is:

$$Q_o = U_o \cdot A_o (t_{i,air} - t_{o,air}) \qquad (1)$$

where

U_o = overall heat transfer coefficient (U-Value). Btu/h · ft^2 · F (W/m^2 · K).

A_o = combined glazing plus frame area projected to a plane parallel to glass as viewed from outside. ft^2 (m^2).

$t_{i,air}$ = temperature of warm space air. F (C).

$t_{o,air}$ = temperature of cold space air. F (C).

The total rate of heat transfer through a fenestration system can be calculated knowing the separate heat transfer contributions of the glazing and frame. With insulating glass, the glazing heat transfer contribution includes a center of glass component and an edge of glass component that is due to the presence of a spacer. The overall U-Value is estimated using area-weighted U-Values for each contribution by:

$$U_o = (U_{cg} \cdot A_{cg} + U_{eg} \cdot A_{eg} + U_f \cdot A_f) / (A_{cg} + A_{eg} + A_f). \qquad (2)$$

where the subscripts *cg*, *eg*, and *f* refer to, respectively, the center-of-glass, edge-of-glass and frame.

Center-of-glass coefficient

Center-of-glass U-Values are calculated based on one-dimensional heat flow theory using convective heat transfer correlations for enclosures (El Sherbiny, 1982) and standard computational methodologies (Rubin, 1982). Values for U_{cg} depend on the surrounding air temperatures and velocities, and the glazing construction features, including the number of glazing lites, the air-space dimensions, the orientation relative to vertical, the emittance of each surface and the composition of the fill gas. Public-domain computer programs, such as WINDOW3 (Lawrence Berkeley Laboratory, 1987), and VISION (University of Waterloo, 1987) provide rapid estimates of U-Value for a wide range of glazing constructions.

Figure 1 shows values of U_{cg} for double and triple-glazed, vertical fenestration at standard winter design conditions calculated using WINDOW3. The plot shows the important effects of low-emittance coatings and argon gas fill. The reduced importance of air-space dimensions greater than about 1/2 in. (13 mm) are evident. Emittance values of 0.84, 0.40, and 0.15 correspond, respectively, to conventional glass (uncoated), pyrolitic coated glass and sputter coated glass. The vertical lines in *Figure 1* show the gas space widths listed in the *1989 ASHRAE Handbook—Fundamentals*.

Edge-of-glass coefficient

Insulating glass units have continuous members around the glass perimeter to separate the glazing lites and provide an edge seal. The spacers are often made of highly conductive materials (aluminum), which locally degrades thermal performance of the glazing unit. Alternate spacer materials include thermally insulating materials such as fiberglass and butyl rubber, and partly insulating glass edges. Edge heat transfer can make a significant difference in the U-Value of the glazing unit, especially those with small glazing dimensions or with high-performance insulating glass. Thus, it is important to use test data or design specific computations to account for this important feature.

Laboratory measurements reported by Peterson (1987) have shown this conductive region to be limited to a band approximately 2-1/2 in. (63 mm) wide around the perimeter of the glazing unit. *Figure 2* shows the heat flow in the edge region of an insulating glass unit to be two-dimensional, as depicted by the computer generated isotherms for a glazing unit with an aluminum spacer. *Figure 3* shows the edge-of-glass U-Value as a function of the center-of-glass U-Value for different spacer materials. Data for aluminum spacers and insulating spacers will appear in the 1989 Handbook. Test data are shown for aluminum spacers. Calculated values are also

shown for the three spacing materials (Carpenter and McGowan, 1989). Data for partly insulating glass edges also apply to stainless steel spacers. Computer simulations indicate the edge-of-glass effect is independent of the framing material and design.

Frame geometry and coefficient

Fenestration products are usually framed in either wood, aluminum or vinyl, and some products utilize a combination of these materials for structural, durability or aesthetic purposes. Aluminum-framed units are sometimes available with "thermal breaks" that reduce the conductive heat transfer through the framing element. Fenestration products also come in many sizes, with frame cross-section and glass-to-frame ratio differing between the larger commercial windows and the smaller residential windows. The U-Value Subcommittee recommended that two product types, Type R (residential), and Type C (commercial) distinguish between the different frame geometries and glass-to-frame ratios. *Figure 4* shows the geometry of these two product types.

Characterization of frame heat transfer coefficients is complicated by the variety of frame configurations for operable windows, the different materials and the different product sizes. Standard methods for measuring frame heat transfer are not generally available. Also, calculations are difficult due to the two- and three-dimensional nature of the heat conduction path and the uncertainties of contact resistance at moving joints. However substantial progress has recently been made in analyzing frame heat conduction. Energy Mines and Resources Canada (1987) developed a computer program specifically for frame heat transfer. Ongoing research is expected to provide additional frame conduction data for a range of fenestration products.

Frame heat transfer coefficients recommended for the 1989 Handbook are as follows:

Material	U_f, Btu/hr · ft² · F (W/m² · K)	
Aluminum (without thermal break)	1.9	(10.8)
Aluminum (with thermal break)	1.0	(5.68)
Wood or Vinyl	0.4	(2.27)

These coefficients are based on laboratory testing of specific window products provided by Bulger (1987), which were judged to be representative. Computer simulations by Carpenter and McGowan (1989) confirmed that the laboratory data are reasonable. Significant variation in these frame coefficients is expected between the different commercial products in the market.

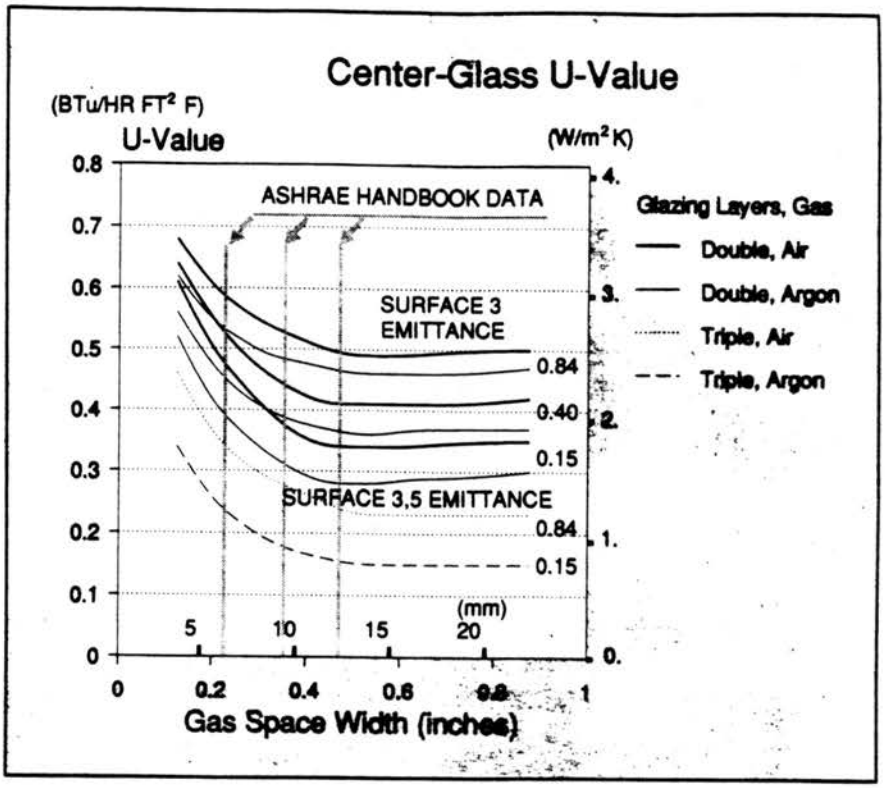


Figure 1. Center-of-glass U-Value for double and triple-glass at ASHRAE winter design conditions.

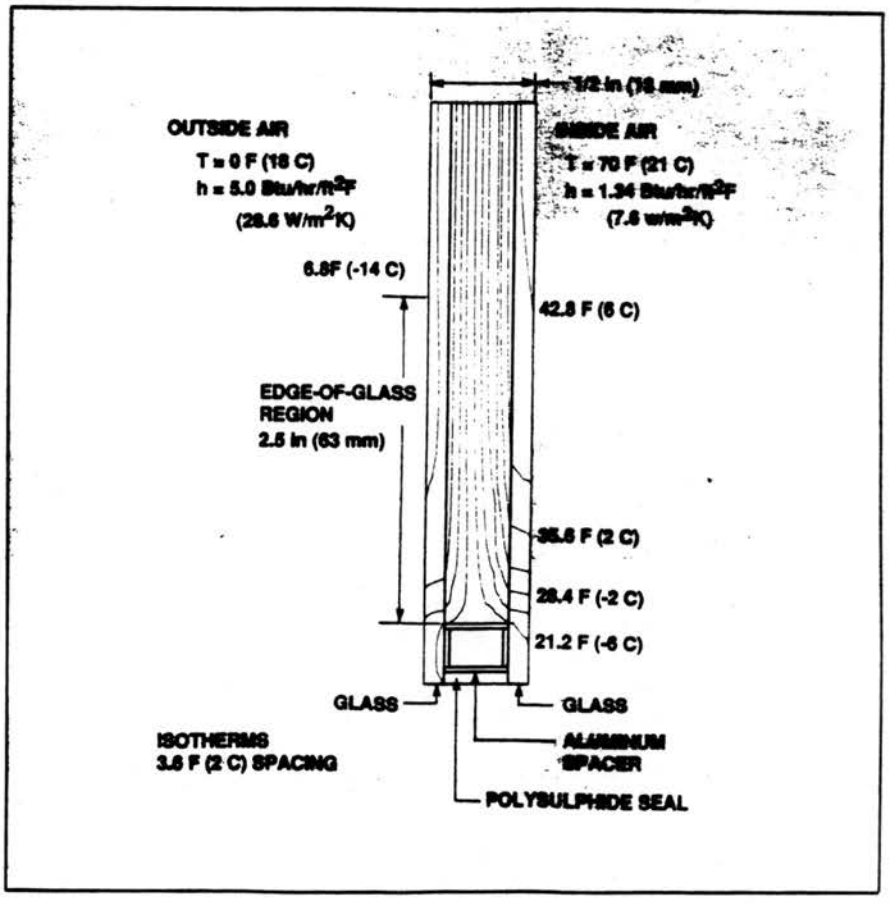


Figure 2. Isotherms in edge-of-glass region for 4-3/4 in. (120 mm) long region of 1/2 in. (13 mm) insulating, uncoated glazing unit.

Revisions in the 1989 Handbook

The 1985 Handbook includes a set of "adjustment factors" that multiply the center-of-glass U-value to account for the thermal conductivity of the different frame materials. The original frame adjustment factors were constants derived from laboratory test data. However, in recent Handbook revisions, a range of adjustment factors was provided instead of a single value for each frame type, apparently to reflect the measured variation in U-Value for commercial products based on laboratory testing. However, the current data have limited value because the frame adjustment factors do not consider different product sizes or glass to frame ratios, and the frame factors are not applicable for the newer framing materials such as extruded vinyl, or composites of aluminum or vinyl-clad wood.

These limitations have been partially addressed in the 1989 Handbook. The format has been revised to provide a consistent set of winter design day data for currently important products. U-Value data in previous Handbooks for summer design conditions, and for combinations of added shades and storm sash are no longer considered important and have been eliminated. The revised format for *Table 13* in the 1989 Handbook should permit comparison between alternative products based on product size, glazing design and framing material. The actual table is too lengthy to present in this article. Therefore, the pertinent changes are summarized in the 1985 Handbook illustrations.

U-Values in the 1989 Handbook consist of calculated data for a variety of glazing systems and framing materials for two product types designated Type R (residential) and Type C (commercial). Part A of the table provides winter design U-Values for vertical glazing. Part B provides approximate factors to convert vertical data to sloped (45 deg) and horizontal orientation. Glazing unit descriptors include: one, two, or three glazing layers; glass, acrylic, or polyester film, and spacing dimensions of 1/4-, 3/8- or 1/2-in. (6, 10 or 13 mm) with emittance values of 0.84, 0.40 or 0.15; and gas fills of air or argon. The spacer material is assumed to be aluminum. Whenever a fenestration system differs from that assumed in the Handbook, such as due to different glazing spacings, emittances, spacer materials, frame conductances, etc., Equation 2 can be used to calculate the appropriate U-Value.

Comparison between uncoated insulating windows

To illustrate the changes appearing in the 1989 ASHRAE Handbook, uncoated insulating glass (e = 0.84) with an air fill is compared with previous Handbook data. *Figure 5a* displays overall U-Values for a double-glazed window with a 1/2-in. (13 mm) airspace having either a thermally-broken aluminum frame, a non-thermally-broken aluminum frame or a wooden or vinyl frame. *Figure 5b* displays similar data, however for triple-glazed windows with two 1/2-in. (13 mm) air spaces. (Note that the center-of-glass U-Value for these glazing units are identical with the 1985 Handbook data, therefore the differences are due to the edge-of-glass factors, frame geometry and thermal conductance.)

Figures 5a and *5b* show a significant increase in the 1989 U-Value data for aluminum-framed windows, especially without thermal breaks. These changes reflect the importance of frame geometry and thermal conductivity in computing overall U-Value. There are no significant changes noted for wooden-framed windows. Aluminum-framed windows show a greater difference between the Product Types R and C as compared to differences attributed to the range of adjustment factors previously used. The graphs depict both double glass and triple glass U-Values.

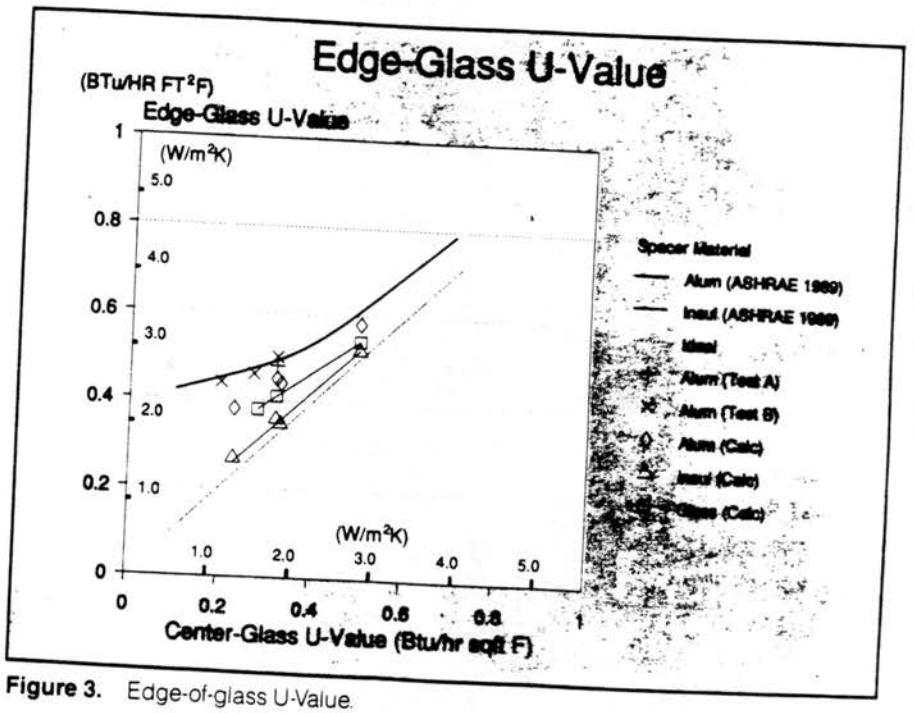


Figure 3. Edge-of-glass U-Value.

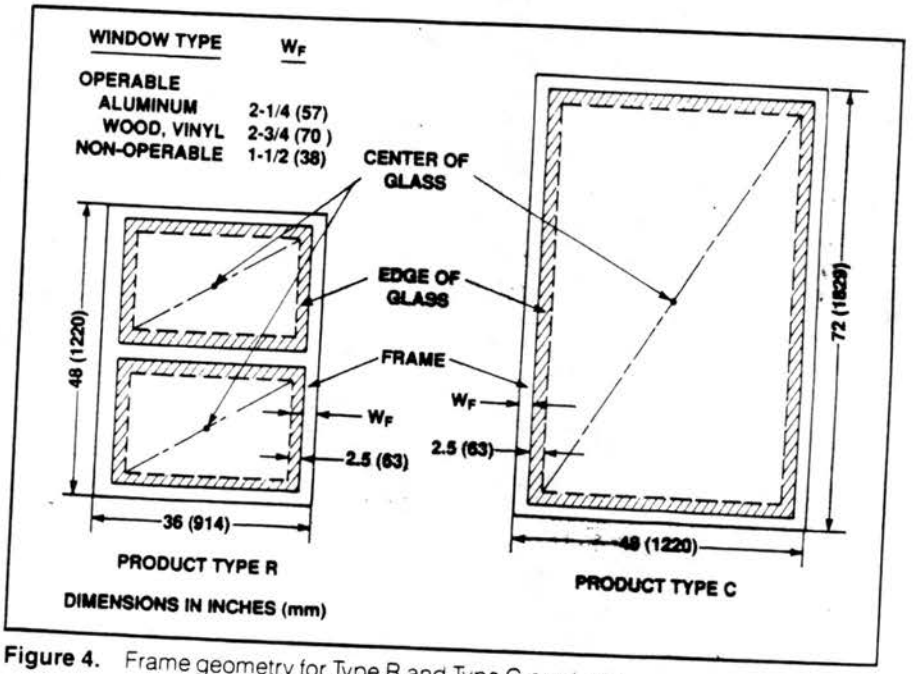


Figure 4. Frame geometry for Type R and Type C products

Conclusions

Significant progress in reducing center-of-glass heat transfer has recently been made with commercially-available glazing units. However, reduction in edge and frame heat transfer still needs to be addressed. It is anticipated that the revised table of U-Values published in the *1989 ASHRAE Handbook—Fundamentals* will provide sufficient technical information to enable rational decisions to be made in specifying generic window products, and also would encourage manufacturers to develop improved products. It is apparent that additional subclassification of the different materials and construction techniques are required for framing members. Both analytical and experimental methods need to be further refined to assist in this important undertaking.

Acknowledgements

Revisions to *Table 13* (Window U-Value Table), in the Fenestration Chapter of the *1989 ASHRAE Handbook—Fundamentals* were conducted by the U-Value Subcommittee of TC 4.5. Major contributions to these efforts were provided by D. Arasteh, Lawrence Berkeley Laboratory, Stephen Carpenter, Enermodal Engineering Ltd., Harry Sullivan, University of Waterloo, and John Hogan, Seattle (Washington) Department of Construction and Land Use.

References

Bulger, M.L., 1987. Private communication between PPG Industries Inc. and TC 4.5 (U-Value Subcommittee).

Carpenter, S.C., and McGowan, A.G., 1989. "Frame and Spacer Effects on Window U-Value." *ASHRAE TRANSACTIONS 1989*, Vol. 95, Pt. 1 (preprint).

El Sherbiny, S.M. et al., 1982. "Heat Transfer by Natural Convection Across Vertical and Inclined Air Layers." *Journal of Heat Transfer*, Vol. 104, pp. 96-102.

Energy Mines and Resources Canada, 1987. "The Effect of Frame Design on Window Heat Loss-Phase I," report prepared by Enermodal Engineering Ltd. for Renewable Energy Branch.

Lawrence Berkeley Laboratory, 1988. "Window 3.1: A PC Program for Analyzing Window Thermal Performance", LBL-25-686, (available from Bostik Construction Products, PO. Box 8, Huntingdon Valley, PA 19006).

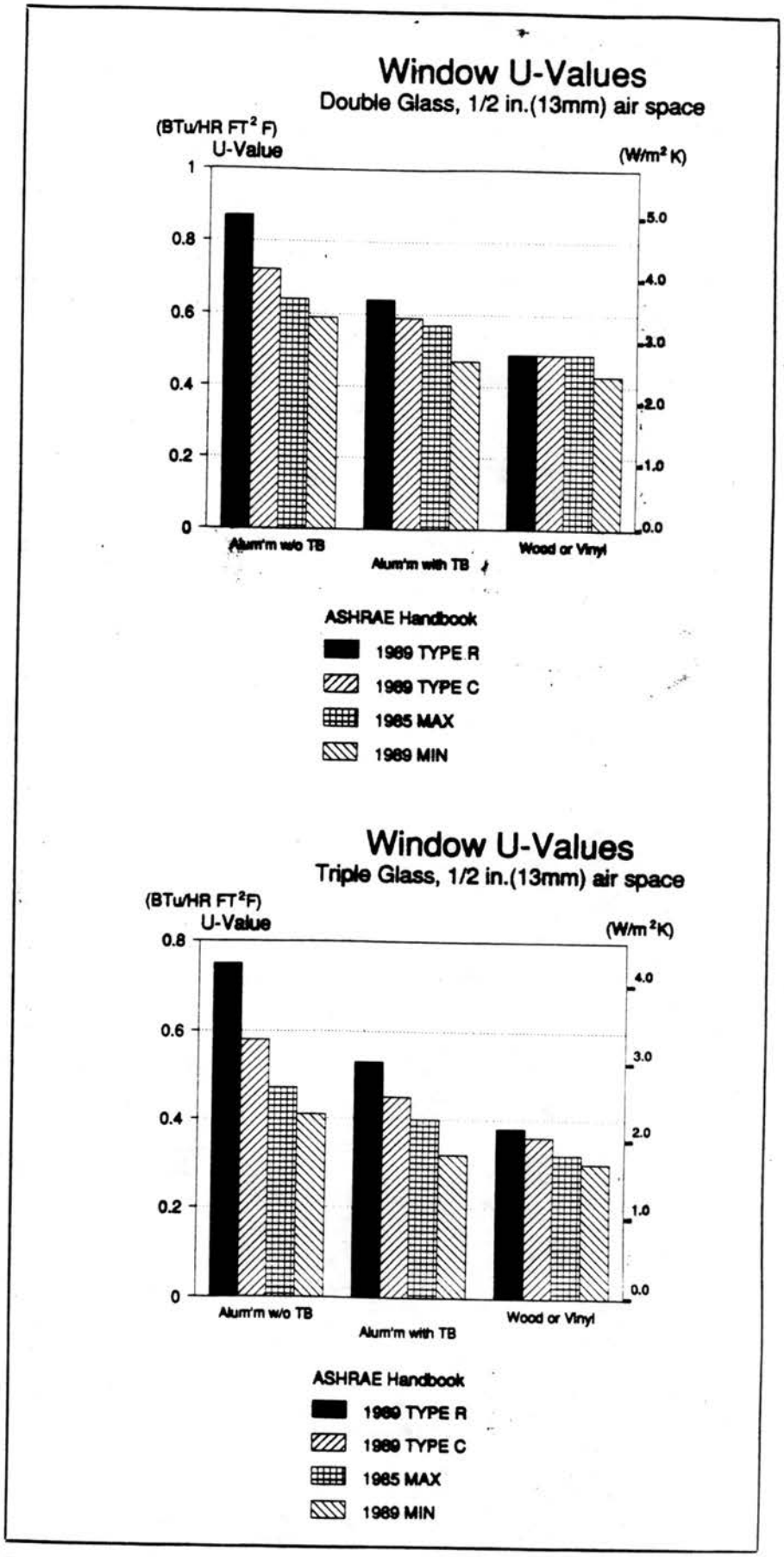
Peterson, C.O., Jr. 1987. "How is Low-E Performance Criteria Determined?" *Glass Digest*, pp. 70-76.

Rubin, M., 1982. "Calculating Heat Transfer Through Windows." *Energy Research*, Vol. 6, pp. 341-349.

University of Waterloo, 1987. "Vision: A Computer Program to Evaluate the Thermal Performance of Innovative Glazing Systems."

About the author

Michael McCabe is a staff evaluator, Office of Energy Related Inventions, National Institute of Standards and Technology (previously the National Bureau of Standards). He holds a bachelor's, master's and doctoral degree in Mechanical Engineering, and is a Registered Professional Engineer.



Figures 5A & 5B. Comparison of U-Values between 1985 and 1989 Handbooks. (a) double-glazed window, (b) triple-glazed window.

Table 13 Overall Coefficients of Heat Transmission of Various Fenestration Products

Part A: U-Values for Vertical Installation[a], Btu/h·ft²·°F

Glazing Type[b]	Glass Only		Aluminum Frame no thermal break ($U_f = 1.9$)		Aluminum Frame thermal break ($U_f = 1.0$)		Wood or Vinyl Frame ($U_f = 0.4$)	
	Center of Glass	Edge[c] of Glass	Product[d] Type *R*	Product[d] Type *C*	Product[d] Type *R*	Product[d] Type *C*	Product[d] Type *R*	Product[d] Type *C*
Single glazing								
glass	(1.11)	(n/a)	1.31	1.23	1.09	1.10	0.90	0.98
1/8 in. acrylic	(1.03)	(n/a)	1.26	1.16	1.02	1.03	0.84	0.92
Double glass								
1/4 in. air space	(0.57)	(0.66)	0.92	0.78	0.70	0.65	0.54	0.55
3/8 in. air space	(0.52)	(0.62)	0.88	0.74	0.66	0.60	0.50	0.51
1/2 in. and greater air space	(0.49)	(0.59)	0.87	0.72	0.64	0.59	0.49	0.49
Double glass, $\varepsilon = 0.40$ on surface 2 or 3								
1/4 in. air space	(0.50)	(0.60)	0.87	0.73	0.65	0.59	0.49	0.50
3/8 in. air space	(0.43)	(0.55)	0.83	0.67	0.60	0.54	0.45	0.45
1/2 in. and greater air space	(0.41)	(0.54)	0.81	0.65	0.58	0.52	0.43	0.42
Double glass, $\varepsilon = 0.15$ on surface 2 or 3								
1/4 in. air space	(0.45)	(0.56)	0.84	0.68	0.61	0.55	0.46	0.46
3/8 in. air space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
1/2 in. air space	(0.34)	(0.50)	0.76	0.60	0.54	0.46	0.39	0.37
Double glass								
1/4 in. argon space	(0.52)	(0.62)	0.88	0.74	0.66	0.61	0.50	0.51
3/8 in. argon space	(0.48)	(0.59)	0.86	0.71	0.63	0.57	0.48	0.48
1/2 in. and greater argon space	(0.46)	(0.57)	0.82	0.69	0.62	0.56	0.47	0.47
Double glass, $\varepsilon = 0.40$ on surface 2 or 3								
1/4 in. argon space	(0.43)	(0.55)	0.83	0.67	0.60	0.54	0.45	0.45
3/8 in. argon space	(0.38)	(0.52)	0.79	0.63	0.57	0.49	0.42	0.40
1/2 in. and greater argon space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
Double glass, $\varepsilon = 0.15$ on surface 2 or 3								
1/4 in. argon space	(0.36)	(0.51)	0.78	0.62	0.56	0.48	0.41	0.39
3/8 in. argon space	(0.30)	(0.48)	0.74	0.57	0.51	0.43	0.37	0.34
1/2 in. and greater argon space	(0.28)	(0.47)	0.73	0.55	0.50	0.42	0.36	0.33
Double glazing, 1/8 in. acrylic or polycarbonate								
1/4 in. air space	(0.52)	(0.62)	0.89	0.74	0.67	0.61	0.51	0.51
3/8 in. air space	(0.48)	(0.59)	0.86	0.71	0.64	0.57	0.48	0.48
1/2 in. and greater air space	(0.46)	(0.57)	0.85	0.69	0.62	0.56	0.47	0.47
Double glazing, 1/4 in. acrylic or polycarbonate								
1/4 in. air space	(0.48)	(0.59)	0.86	0.71	0.64	0.57	0.48	0.48
3/8 in. air space	(0.44)	(0.56)	0.84	0.68	0.61	0.54	0.46	0.45
1/2 in. and greater air space	(0.42)	(0.54)	0.82	0.66	0.60	0.53	0.45	0.43
Triple glass								
1/4 in. air space	(0.38)	(0.52)	0.79	0.64	0.57	0.50	0.42	0.41
3/8 in. air space	(0.34)	(0.50)	0.76	0.60	0.54	0.46	0.39	0.38
1/2 in. and greater air space	(0.32)	(0.49)	0.75	0.58	0.53	0.45	0.38	0.36
Triple glass, $\varepsilon = 0.40$ on surface 2, 3, 4 or 5								
1/4 in. air spaces	(0.35)	(0.50)	0.77	0.61	0.55	0.48	0.40	0.39
3/8 in. air spaces	(0.30)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
1/2 in. and greater air spaces	(0.28)	(0.47)	0.72	0.55	0.50	0.41	0.36	0.33
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surface 2, 3, 4, or 5								
1/4 in. air spaces	(0.33)	(0.49)	0.76	0.59	0.53	0.45	0.39	0.37
3/8 in. air spaces	(0.27)	(0.46)	0.72	0.54	0.50	0.41	0.35	0.32
1/2 in. and greater air spaces	(0.24)	(0.45)	0.70	0.52	0.48	0.39	0.34	0.30
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surfaces 2 or 3 and 4 or 5								
1/4 in. air spaces	(0.28)	(0.47)	0.73	0.55	0.53	0.42	0.36	0.33
3/8 in. air spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.32	0.29
1/2 in. and greater air spaces	(0.19)	(0.44)	0.67	0.48	0.45	0.35	0.31	0.26
Triple glass								
1/4 in. argon spaces	(0.34)	(0.50)	0.77	0.60	0.54	0.46	0.39	0.38
3/8 in. argon spaces	(0.31)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
1/2 in. and greater argon spaces	(0.29)	(0.47)	0.73	0.56	0.51	0.42	0.36	0.34
Triple glass, $\varepsilon = 0.40$ on surface 2, 3, 4 or 5								
1/4 in. argon spaces	(0.30)	(0.48)	0.74	0.57	0.52	0.44	0.37	0.35
3/8 in. argon spaces	(0.26)	(0.46)	0.72	0.54	0.49	0.41	0.35	0.32
1/2 in. and greater argon spaces	(0.25)	(0.46)	0.71	0.53	0.48	0.39	0.34	0.31

Table 13 Overall Coefficients of Heat Transmission of Various Fenestration Products (*Concluded*)

Part A: U-Values for Vertical Installation[a], Btu/h·ft²·°F

Glazing Type[b]	Glass Only: Center of Glass	Glass Only: Edge[c] of Glass	Aluminum Frame no thermal break ($U_f = 1.9$): Product[d] Type R	Aluminum Frame no thermal break ($U_f = 1.9$): Product[d] Type C	Aluminum Frame thermal break ($U_f = 1.0$): Product[d] Type R	Aluminum Frame thermal break ($U_f = 1.0$): Product[d] Type C	Wood or Vinyl Frame ($U_f = 0.4$): Product[d] Type R	Wood or Vinyl Frame ($U_f = 0.4$): Product[d] Type C
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surface 2, 3, 4, or 5								
1/4 in. argon spaces	(0.27)	(0.46)	0.72	0.54	0.50	0.41	0.35	0.32
3/8 in. argon spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.33	0.29
1/2 in. and greater argon spaces	(0.20)	(0.44)	0.68	0.50	0.46	0.36	0.31	0.28
Triple glass or double glass with polyester film suspended in between, $\varepsilon = 0.15$ on surfaces 2 or 3 and 4 or 5								
1/4 in. argon spaces	(0.22)	(0.45)	0.69	0.51	0.47	0.37	0.32	0.29
3/8 in. argon spaces	(0.17)	(0.43)	0.66	0.47	0.44	0.34	0.30	0.25
1/2 in. and greater argon spaces	(0.15)	(0.43)	0.65	0.46	0.43	0.32	0.29	0.24

Part B: U-Value Conversion Table for Sloped and Horizontal Glazing for Upward Heat Flow

Slope	U-Value, Btu/h·ft²·°F												
90° (vertical)	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30
45°	0.14	0.25	0.36	0.47	0.57	0.68	0.79	0.90	1.00	1.11	1.22	1.33	1.44
0 (horiz.)	0.19	0.29	0.40	0.51	0.61	0.72	0.82	0.93	1.04	1.14	1.25	1.35	1.46

[a]All U-values are based on standard ASHRAE winter conditions of 70°F indoor and 0°F outdoor air temperature with 15 mph outdoor air velocity and zero solar flux. The outside surface coefficient at these conditions is approximately 5.1 Btu/hr·ft²·°F, depending on the glass surface temperature. With the exception of single glazing, small changes in the interior and exterior temperatures do not significantly affect overall U-values.

[b]Glazing layer surfaces are numbered from the outside to the inside. Double and triple refer to the number of glazing lites. All data are based on 1/8 in. glass unless otherwise noted. Thermal conductivities are: 0.53 Btu/h·ft·°F for glass, and 0.11 Btu/h·ft·°F for acrylic and polycarbonate.

[c]Based on aluminum spacers data (see Figure 6). Edge of glass effect assumed to extend over the 2.5 in. band around perimeter of each glazing unit as seen in Figure 7.

[d]Product types described in Figure 7.

edge-of-glass U-values as a function of the center-of-glass U-value. The spacer edge is assumed to be even with the line of sight of the glazing. Data are given for aluminum spacers with sealants and non-metal spacers including fiberglass, wood, and butyl. Values for glass edges and steel spacers fall between the aluminum and the non-metal spacers. This edge effect does not occur with single glazing. For highly insulating glazing, edge heat transfer can significantly increase overall U-value. Thus, test data or design-specific computations should account for this effect.

Estimation of the rate of heat transfer through the framing elements of a fenestration system is complicated by (1) the variety of frame configurations for operable windows, (2) the different combinations of materials used for sash and frames, and (3) the difference in sizes available in residential and commercial applications. Available windows are usually framed in either wood, aluminum, or vinyl; and many manufacturers combine materials for structural or aesthetic purposes. Some aluminum-framed units have *thermal breaks* that reduce the conductive heat transfer through the framing element. Standard methods for calculating frame heat transfer are not generally available, however Energy Mines and Resources Canada (1987) and Johnson (1985) have developed computer programs that analyze frame conduction.

Representative U-Values for Fenestration Products

Table 13 can be used to select a particular fenestration product to obtain a desired U-value. Part A of this table presents computed overall U-values for a wide range of glazing units and framing materials installed vertically and based on component U-values shown in parentheses. Part B presents approximate U-values for non-vertical installation. The overall U-values in part A are appropriate for calculating compliance with the requirements of ASHRAE Standard 90. However, the values apply only to the specific design conditions described in the footnotes and are typically used to determine peak load conditions for sizing heating equipment. While these U-values have been determined for winter conditions, they can be used to estimate heat gain during peak cooling conditions since conductive gain which is one of several factors, is usually a small portion of the total heat gain for windows in direct sunlight. Glazing designs and framing materials may be compared to choose a fenestration system that needs a specific winter design U-value.

The overall U-values in Table 13 are based on the rough opening area for representative generic glazing products. Test data, when available, may provide more accurate results for specific products. However, a wide range of measured U-values for similar products has been reported (Hogan 1988). Standard test methods for fenestration systems are still under development and different test methods sometimes give different U-values (McCabe *et al.* 1986).

The multiple glazing categories are appropriate for sealed glass units, acrylic domes, and the addition of storm sash to other glazing units. No distinction is made between flat and domed units such as skylights. For acrylic domes, use average airspace width to determine U-value. Unless otherwise noted, all multiple glazed units are filled with dry air. Argon units are assumed filled with 100% Argon. U-values for CO_2 filled units are similar to Argon fills. For spaces up to 0.5 in., Argon/SF_6 mixtures up to 70% SF_6 are generally the same as Argon fills. (A unit with 0.25 in. Krypton fill gas has about the same U-value as a unit with 0.5 in. Argon fill gas.)

Table 13, Part A lists data for three values of hemispherical emittance. Uncoated glass has an emittance of 0.84. Emittance of various low-emittance glasses vary considerably between manufacturers and processes. When the emittance is known to be between the listed values, interpolation is recommended. When manufacturers data are not available for low-emittance

ATTACHMENT 6

twin city testing corporation
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

JUL 05 1989

REPORT OF: PHYSICAL PROPERTIES

PROJECT: POLYETHYLENE SHEETING

REPORTED TO: Minnesota Department of Public Service
Attn: Bruce Nelson
900 American Center
150 East Kellogg Boulevard

DATE: June 29, 1989

CC Robert Anderson

LABORATORY NO: 4141 89-572

P.O. NO: 80500/05328

INTRODUCTION:

This report presents the results of thickness and water vapor transmission tests conducted on 24 samples of polyethylene sheeting. Twenty-three samples of polyethylene sheeting were submitted to our laboratory on May 2, 1989. Two additional large rolls of polyethylene sheeting were submitted to our laboratory on June 21, 1989. All samples were submitted by Mr Bruce Nelson of the Minnesota Department of Public service. Our work was completed on June 29, 1989.

The scope of our work was limited to conducting thickness and water vapor transmission tests on the samples of polyethylene sheeting submitted.

RESULTS:

Sample Identification	Thickness in	Permeance, perms				Average Permeability, perm·in
		Specimen 1	Specimen 2	Specimen 3	Average	
1	0.0039	0.18	0.14	0.16	0.16	0.00062
2	0.0032	0.14	0.11	0.13	0.13	0.00041
3A	0.0032	0.21	0.26	0.18	0.22	0.00070
3B	0.0019	0.14	0.18	0.20	0.18	0.00034
4	0.0031	0.16	0.19	0.15	0.17	0.00051
5	0.0031	0.25	0.16	0.17	0.19	0.00059
6	0.0039	0.18	0.24	0.22	0.22	0.00085
7	0.0033	0.21	0.27	0.17	0.22	0.00071
8	0.0052	0.12	0.20	0.18	0.17	0.00087
9	0.0078	0.15	0.12	0.22	0.17	0.00129
10	0.0034	0.13	0.15	0.19	0.16	0.00053
11	0.0038	0.23	0.19	0.25	0.22	0.00083
12	0.0042	0.12	0.16	0.15	0.14	0.00061
13	0.0038	0.38	0.20	0.27	0.28	0.00109
14	0.0032	0.15	0.16	0.23	0.18	0.00058
15	0.0032	0.25	0.33	0.27	0.28	0.00090
16	0.0028	0.12	0.19	0.17	0.16	0.00045
17	0.0039	0.11	0.15	0.15	0.14	0.00054
18	0.0037	0.11	0.12	0.13	0.12	0.00045
19	0.0039	0.10	0.13	0.16	0.13	0.00050
20	0.0034	0.25	0.27	0.32	0.28	0.00096
21	0.0038	0.16	0.18	0.21	0.18	0.00071
22	0.0036	0.12	0.15	0.16	0.14	0.00052
23	0.0040	0.33	0.27	0.33	0.31	0.00125
24	0.0038	0.30	0.25	0.24	0.26	0.00099

AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS, CONCLUSIONS OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL.

twin city testing
corporation
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

REPORT OF: PHYSICAL PROPERTIES

LABORATORY NO: 4141 89-572

DATE: June 29, 1989

SAMPLE IDENTIFICATION:

Twenty-three small samples of polyethylene sheeting were received. These samples were marked 1 through 22, sample number 3 contained two different types of material these were arbitrarily identified as 3A and 3B. Two large roll of polyethylene sheeting were received and are identified as 23 and 24.

TEST METHOD:

The thickness of each sample was determined using the following formula:

$$T = W/(A \times 0.03613 \times D)$$

Where : T = average thickness, inches
W = net weight, pounds
A = area of the specimen, in^2
D = specific density of polyethylene

The water vapor transmission test was conducted according to ASTM:E96, "Standard Test Methods for Water Vapor Transmission of Materials," procedure E, "Desiccant Method at 100°F." ASTM:D4397, "Standard specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications," was also used as a reference. Three, 3 inch diameter specimens were removed from each sample. Each specimen was placed in a test dish filled with anhydrous calcium chloride. The specimen was sealed to the mouth of the dish with a metal ring and rubber gasket. The test assemblies were weighed and placed in an environmental chamber maintained at 100°F and 90% relative humidity. The specimens were weighed twice a day until a constant rate of weight gain could be determined. A mathematical least squares regression of the weight as a function of time was used to determine the water vapor transmission rate. The permeance of each specimen was calculated from the water vapor transmission rate. The permeability of the sample was determined by multiplying the average permeance by the average thickness of the sample.

REMARKS:

The test samples will be retained for thirty days from the date of this report then discarded unless notified otherwise.

TWIN CITY TESTING CORPORATION

Jeffrey K Johnson
Senior Mechanical Technician
Mechanical Engineering Department

Reviewed by:

Arnis L Kurmis
Manager
Mechanical Engineering Department

JKJ/ALK/89-572

AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS, CONCLUSIONS OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL.

Designation: C 755 – 85ε1

Standard Practice for Selection of Vapor Retarders for Thermal Insulation[1]

This standard is issued under the fixed designation C 755; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—The phrase "vapor barrier" was editorially corrected to "vapor retarder" throughout to agree with the title of the practice in March 1987.

1. Scope

1.1 This practice outlines factors to be considered, describes design principles and procedures for vapor retarder selection, and defines water vapor transmission values appropriate for established criteria. It is intended for the guidance of design engineers in preparing vapor retarder application specifications for control of water vapor flow through thermal insulation. It covers commercial and residential building construction and industrial applications in the temperature range from −40 to +80°F (−40 to +27°C) within the structure. Emphasis is placed on the control of moisture penetration by choice of the most suitable components of the system.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 781 Test Methods for Puncture and Stiffness of Paperboard and Corrugated and Solid Fiberboard[2]

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard[3]

E 84 Test Method for Surface Burning Characteristics of Building Materials[4]

E 96 Test Methods for Water Vapor Transmission of Materials[5]

E 398 Test Method for Water Vapor Transmission Rate of Sheet Materials Using a Rapid Technique for Dynamic Measurement[5]

F 372 Test Method for Water Vapor Transmission of Flexible Barrier Materials Using an Infrared Detection Technique[3]

3. Definitions

3.1 *dew-point temperature (Dp)*—the temperature at which a specific atmosphere is saturated with water vapor. (Cooling below the dew point will cause release of water vapor in the form of condensation. In problem analysis for vapor barrier selection it is the dew-point temperature, not the relative humidity, that is pertinent. Dew-point temperature is directly related to saturation water vapor pressure and may be obtained from tables.)

3.2 *thermal insulation system*—thermal insulation for resistance to heat flow combined with means for attachment to the surface to be insulated, and with facings, vapor retarders, joint sealants, or protective coatings as installed.

3.3 *vapor retarders*—those materials or systems which adequately retard the transmission of water vapor under specified conditions. (For practical purposes it is assumed that the permeance of an adequate retarder will not exceed 1 perm, although at present this value may be adequate only for residential construction. For certain other types of construction the permeance must be very low.)

3.4 *water vapor diffusion*—the process by which water vapor spreads or moves through permeable materials caused by a difference in water vapor pressure.

3.5 *water vapor permeability (permeability)*—the water vapor transmission of a homogeneous material under unit vapor pressure difference between two specific surfaces, per unit thickness. An acceptable unit of permeability is the perm-inch: grain-in./h·ft²·in. Hg (the metric perm-cm = 1 g·cm/24 h·m²·mm Hg).

3.6 *water vapor permeance (permeance)*—the water vapor transmission of a material under unit vapor pressure difference between two specific surfaces. An acceptable unit of permeance is the perm: grain/h·ft² in. Hg (1 metric perm = 1 g/24 h·m² mm Hg).

3.7 *water vapor transmission (WVT)*—the steady-state time rate of water vapor diffusion or flow through unit area of a material, normal to specific parallel surfaces under specific conditions of temperature and humidity at each surface. An acceptable unit of WVT is grain/h·ft² (1 g/24 h·m²).

4. Significance and Use

4.1 Experience has shown that uncontrolled water entry into thermal insulation is the most serious factor causing

[1] This practice is under the jurisdiction of ASTM Committee C-16 on Thermal Insulation and is the direct responsibility of Subcommittee C 16.33 on Thermal Insulation Finishes and Vapor Transmission.

Current edition approved June 28, 1985. Published August 1985. Originally published as C 755 – 73. Last previous edition C 755 – 73 (1979).

[2] Discontinued; see *1983 Annual Book of ASTM Standards*, Vol 15.09.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 04.07.

[5] *Annual Book of ASTM Standards*, Vol 04.06.

TABLE 2 Recommended Maximum Permeance of Vapor Retarder Systems[A]

Insulation Application	Group I Insulation Permeability 0.3 to 4.0 perm-in.	Group 2 Insulation Permeability, Greater than 4.0 perm-in.
Vapor Retarder Permeance, perms[A]		
Wall (residential)	1.0	1.0
Underslab (residential and commercial)	1.0	0.4
Roof deck	1.0	0.4[B]
Pipe and vessels (33 to 80°F (1 to 27°C))	1.0	0.3
Pipe and vessels (−40 to 32°F (−40 to 0°C))	0.05	0.02
Ducts	1.0	0.03[B]
Metal buildings	0.1	0.3[B]
Cold storage	0.1	0.1

[A] Water vapor permeance of the vapor retarder system in perms when tested in accordance with Test Methods E 96.
[B] Subject to climatic and service conditions.

continuous coats, and suitable membrane reinforcement may also be required. The system must be adequately strong to resist cracking caused by substrate movement. Good workmanship in application is essential to attain design vapor diffusion resistance.

7.2.2.2 The permeance of mastics and coatings varies with varying dry thickness and data showing this relationship for specific products are available from manufacturers. Comparison of permeance values for various mastics and coatings should not be based on wet thickness, but rather on dry thickness (after curing and evaporation of all volatile ingredients).

7.2.3 Structural retarders may be formed from rigid or semirigid materials of low permeability, which form a part of the structure. They include some insulation materials, as well as prefabricated composite units comprising insulation and finish, and metal curtain walls. They require careful sealing of joints and seams.

7.3 *Test Method and Values:*

7.3.1 The latest issue of Test Methods E 96 is acceptable for determining water vapor transmission of materials.

7.3.1.1 This test method provides isothermal conditions for testing materials by the cup method. In the "dry cup" or desiccant method, relative humidity inside is approximately 0 %. In the "wet cup" or water method, the relative humidity inside is approximately 100 %. When evaluating WVT data it is preferable to use data obtained by the procedure in which the test conditions approximate the service conditions.

7.3.1.2 This test method does not permit measurement of WVT values under all conditions of temperature and moisture found in service. It does provide values that permit the selection of suitable barrier materials.

7.3.2 Test Method E 398 covers the dynamic evaluation of the rate of transfer of water vapor through a retarder material and conversion to the generally recognized units of water vapor transmission (WVT) as obtained by the standard gravimetric method given in Test Methods E 96.

7.3.2.1 Test Method E 398 is limited to retarder sheet materials composed of either completely hydrophobic materials, or combinations of hydrophopic and hydrophilic materials having at least one surface which is hydrophobic.

7.3.2.2 The minimum test value obtained by Test Method E 398 is limited by the leakage of water vapor past the clamping seals. A reasonable limit value may be approximately 0.015 g/24 h·m^2 for Procedure E values of Test Methods E 96 and can be checked for each instrument with an impervious specimen. Calibration procedures compensate for this leakage at less than terminal times.

7.3.3 Test Method F 372 covers a rapid procedure for determining the rate of water vapor transmission of flexible retarder materials in film or sheet form. The test method is applicable to sheets and films up to 3 mm in thickness, consisting of single or multilayer synthetic or natural polymers and metal foils including coated materials.

7.3.3.1 A dry chamber is separated from a wet chamber of known temperature and humidity by the retarder material to be tested. The time for a given increase in water vapor concentration of the dry chamber is measured by monitoring the differential between two bands in the infrared spectral region, one in which water molecules absorb and the other where they do not. This information is then used to calculate the water vapor movement through a known area of retarder material.

7.4 *Recommended Vapor Retarder Practices*—Two design principles of vapor control have been presented: flow-through and moisture storage. Both systems are used in general practice.

7.4.1 The intent of the flow-through principle is to eliminate all possibility of condensation within the insulation system; therefore, this system is used with insulation materials with higher permeability to prevent accumulation of moisture.

7.4.2 The moisture-storage principle allows some accumulation of moisture within the insulation system. This principle is used with lower permeability insulation systems because the rate of accumulation is small.

7.4.3 The rate and quantity of moisture accumulation in insulation used in a given end-use application is a function of the permeability of the insulation and the operating conditions of the application as well as being a function of the vapor retarder materials. Therefore, the vapor retarder requirements necessary to control moisture and ensure successful operation can deviate from indicated theory. A case in point is the practice of using higher permeance vapor retarder systems with lower permeability insulations, whereas the flow-through theory would indicate the opposite. This is where the moisture-storage theory comes into practice. From a practical standpoint, a lower permeability insulation collects and stores less water in case of moisture entry and therefore a higher permeance vapor retarder is tolerable.

Designation: C 755 – 85[ε1]

Standard Practice for Selection of Vapor Retarders for Thermal Insulation[1]

This standard is issued under the fixed designation C 755; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

[ε1] NOTE—The phrase "vapor barrier" was editorially corrected to "vapor retarder" throughout to agree with the title of the practice in March 1987.

1. Scope

1.1 This practice outlines factors to be considered, describes design principles and procedures for vapor retarder selection, and defines water vapor transmission values appropriate for established criteria. It is intended for the guidance of design engineers in preparing vapor retarder application specifications for control of water vapor flow through thermal insulation. It covers commercial and residential building construction and industrial applications in the temperature range from −40 to +80°F (−40 to +27°C) within the structure. Emphasis is placed on the control of moisture penetration by choice of the most suitable components of the system.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 781 Test Methods for Puncture and Stiffness of Paperboard and Corrugated and Solid Fiberboard[2]

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard[3]

E 84 Test Method for Surface Burning Characteristics of Building Materials[4]

E 96 Test Methods for Water Vapor Transmission of Materials[5]

E 398 Test Method for Water Vapor Transmission Rate of Sheet Materials Using a Rapid Technique for Dynamic Measurement[5]

F 372 Test Method for Water Vapor Transmission of Flexible Barrier Materials Using an Infrared Detection Technique[3]

3. Definitions

3.1 *dew-point temperature (Dp)*—the temperature at which a specific atmosphere is saturated with water vapor. (Cooling below the dew point will cause release of water vapor in the form of condensation. In problem analysis for vapor barrier selection it is the dew-point temperature, not the relative humidity, that is pertinent. Dew-point temperature is directly related to saturation water vapor pressure and may be obtained from tables.)

3.2 *thermal insulation system*—thermal insulation for resistance to heat flow combined with means for attachment to the surface to be insulated, and with facings, vapor retarders, joint sealants, or protective coatings as installed.

3.3 *vapor retarders*—those materials or systems which adequately retard the transmission of water vapor under specified conditions. (For practical purposes it is assumed that the permeance of an adequate retarder will not exceed 1 perm, although at present this value may be adequate only for residential construction. For certain other types of construction the permeance must be very low.)

3.4 *water vapor diffusion*—the process by which water vapor spreads or moves through permeable materials caused by a difference in water vapor pressure.

3.5 *water vapor permeability (permeability)*—the water vapor transmission of a homogeneous material under unit vapor pressure difference between two specific surfaces, per unit thickness. An acceptable unit of permeability is the perm-inch: grain-in./h·ft²·in. Hg (the metric perm-cm = 1 g·cm/24 h·m²·mm Hg).

3.6 *water vapor permeance (permeance)*—the water vapor transmission of a material under unit vapor pressure difference between two specific surfaces. An acceptable unit of permeance is the perm: grain/h·ft² in. Hg (1 metric perm = 1 g/24 h·m² mm Hg).

3.7 *water vapor transmission (WVT)*—the steady-state time rate of water vapor diffusion or flow through unit area of a material, normal to specific parallel surfaces under specific conditions of temperature and humidity at each surface. An acceptable unit of WVT is grain/h·ft² (1 g/24 h·m²).

4. Significance and Use

4.1 Experience has shown that uncontrolled water entry into thermal insulation is the most serious factor causing

[1] This practice is under the jurisdiction of ASTM Committee C-16 on Thermal Insulation and is the direct responsibility of Subcommittee C 16.33 on Thermal Insulation Finishes and Vapor Transmission.

Current edition approved June 28, 1985. Published August 1985. Originally published as C 755 – 73. Last previous edition C 755 – 73 (1979).

[2] Discontinued; see *1983 Annual Book of ASTM Standards*, Vol 15.09.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 04.07.

[5] *Annual Book of ASTM Standards*, Vol 04.06.

TABLE 2 Recommended Maximum Permeance of Vapor Retarder Systems[A]

Insulation Application	Group I Insulation Permeability 0.3 to 4.0 perm-in.	Group 2 Insulation Permeability, Greater than 4.0 perm-in.
Vapor Retarder Permeance, perms[A]		
Wall (residential)	1.0	1.0
Underslab (residential and commercial)	1.0	0.4
Roof deck	1.0	0.4[B]
Pipe and vessels (33 to 80°F (1 to 27°C))	1.0	0.3
Pipe and vessels (−40 to 32°F (−40 to 0°C))	0.05	0.02
Ducts	1.0	0.03[B]
Metal buildings	0.1	0.3[B]
Cold storage	0.1	0.1

[A] Water vapor permeance of the vapor retarder system in perms when tested in accordance with Test Methods E 96.
[B] Subject to climatic and service conditions.

continuous coats, and suitable membrane reinforcement may also be required. The system must be adequately strong to resist cracking caused by substrate movement. Good workmanship in application is essential to attain design vapor diffusion resistance.

7.2.2.2 The permeance of mastics and coatings varies with varying dry thickness and data showing this relationship for specific products are available from manufacturers. Comparison of permeance values for various mastics and coatings should not be based on wet thickness, but rather on dry thickness (after curing and evaporation of all volatile ingredients).

7.2.3 Structural retarders may be formed from rigid or semirigid materials of low permeability, which form a part of the structure. They include some insulation materials, as well as prefabricated composite units comprising insulation and finish, and metal curtain walls. They require careful sealing of joints and seams.

7.3 *Test Method and Values:*

7.3.1 The latest issue of Test Methods E 96 is acceptable for determining water vapor transmission of materials.

7.3.1.1 This test method provides isothermal conditions for testing materials by the cup method. In the "dry cup" or desiccant method, relative humidity inside is approximately 0 %. In the "wet cup" or water method, the relative humidity inside is approximately 100 %. When evaluating WVT data it is preferable to use data obtained by the procedure in which the test conditions approximate the service conditions.

7.3.1.2 This test method does not permit measurement of WVT values under all conditions of temperature and moisture found in service. It does provide values that permit the selection of suitable barrier materials.

7.3.2 Test Method E 398 covers the dynamic evaluation of the rate of transfer of water vapor through a retarder material and conversion to the generally recognized units of water vapor transmission (WVT) as obtained by the standard gravimetric method given in Test Methods E 96.

7.3.2.1 Test Method E 398 is limited to retarder sheet materials composed of either completely hydrophobic materials, or combinations of hydrophopic and hydrophilic materials having at least one surface which is hydrophobic.

7.3.2.2 The minimum test value obtained by Test Method E 398 is limited by the leakage of water vapor past the clamping seals. A reasonable limit value may be approximately 0.015 g/24 h·m^2 for Procedure E values of Test Methods E 96 and can be checked for each instrument with an impervious specimen. Calibration procedures compensate for this leakage at less than terminal times.

7.3.3 Test Method F 372 covers a rapid procedure for determining the rate of water vapor transmission of flexible retarder materials in film or sheet form. The test method is applicable to sheets and films up to 3 mm in thickness, consisting of single or multilayer synthetic or natural polymers and metal foils including coated materials.

7.3.3.1 A dry chamber is separated from a wet chamber of known temperature and humidity by the retarder material to be tested. The time for a given increase in water vapor concentration of the dry chamber is measured by monitoring the differential between two bands in the infrared spectral region, one in which water molecules absorb and the other where they do not. This information is then used to calculate the water vapor movement through a known area of retarder material.

7.4 *Recommended Vapor Retarder Practices*—Two design principles of vapor control have been presented: flow-through and moisture storage. Both systems are used in general practice.

7.4.1 The intent of the flow-through principle is to eliminate all possibility of condensation within the insulation system; therefore, this system is used with insulation materials with higher permeability to prevent accumulation of moisture.

7.4.2 The moisture-storage principle allows some accumulation of moisture within the insulation system. This principle is used with lower permeability insulation systems because the rate of accumulation is small.

7.4.3 The rate and quantity of moisture accumulation in insulation used in a given end-use application is a function of the permeability of the insulation and the operating conditions of the application as well as being a function of the vapor retarder materials. Therefore, the vapor retarder requirements necessary to control moisture and ensure successful operation can deviate from indicated theory. A case in point is the practice of using higher permeance vapor retarder systems with lower permeability insulations, whereas the flow-through theory would indicate the opposite. This is where the moisture-storage theory comes into practice. From a practical standpoint, a lower permeability insulation collects and stores less water in case of moisture entry and therefore a higher permeance vapor retarder is tolerable.

HOME BUILDERS' ENERGY UPDATE

Winter 1989

COLD CEILING CORNER MYSTERY EXAMINED

It may show up as patches of frost or accumulations of dirt on the ceiling at the corner of an outside wall. Or, in cases of high moisture levels inside the house, mold may even form.

The most common explanation for this "cold area" is that the ceiling insulation is thinner near the soffit. However, we have solved the thin insulation problem with the use of raised-heel energy trusses (see side-bar – Raised heel trusses). Another reason for the cold spot might be thinner insulation over the double-top plate. In this case, using insulated sheathing will help keep the wall warmer at the top plate. Yet, despite these measures, the problem still occurs. Could there be another reason for the cold ceiling near the soffit?

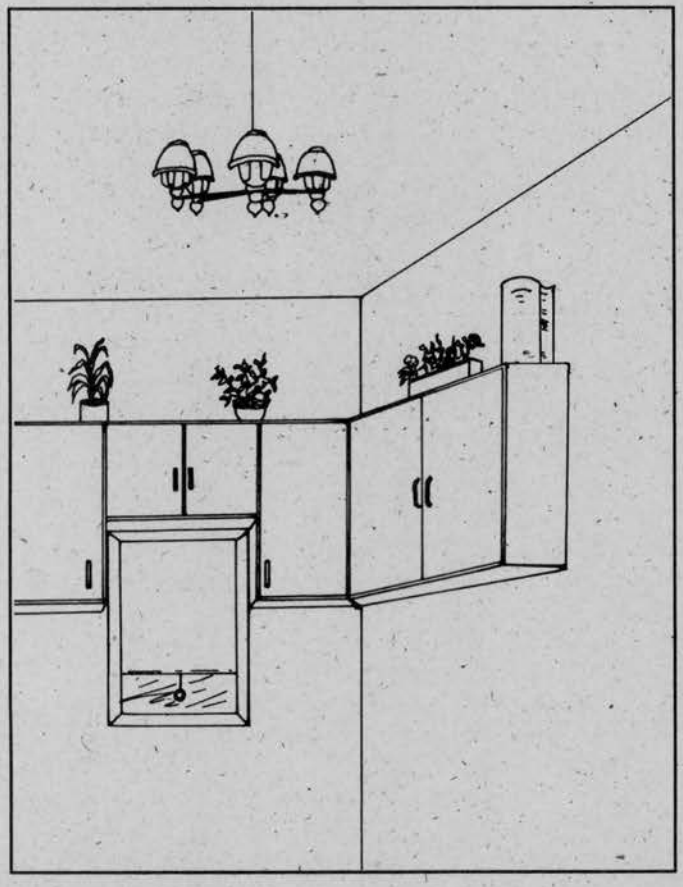
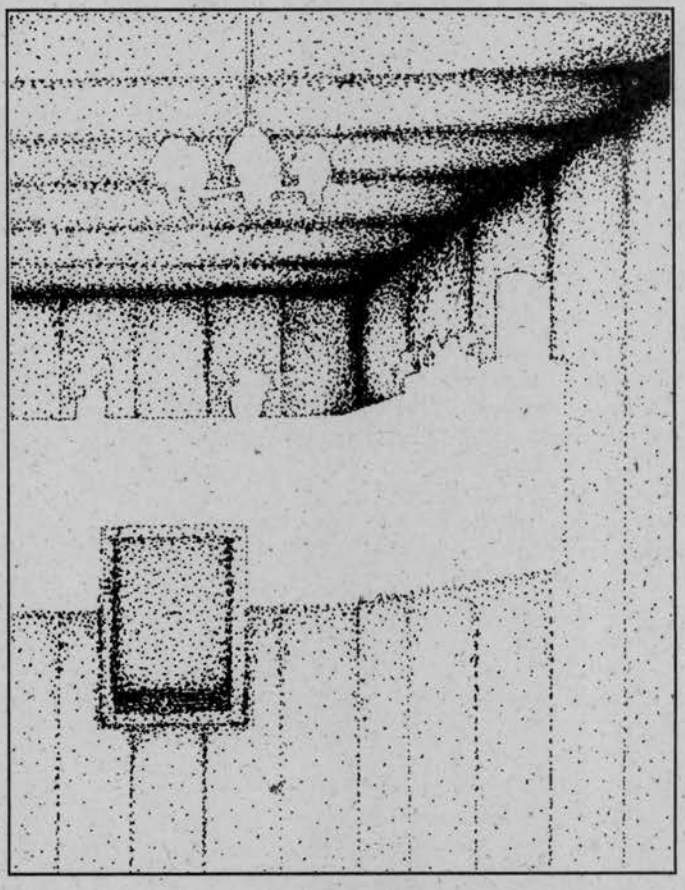


Figure 1
A drawing to represent a "visual" picture of a residential kitchen.



An "infrared scan" of the same scene portrays a "ghostly" image where colder surfaces appear in dark shades.

A new look at the problem

A look at an infrared scan of this area would surprise most builders (see side-bar – What is an infrared scan?). The scan might show that on the windward side of the building the cold area on the ceiling is not limited to the area next to the top plate. Rather, it may show dark streaks representing even colder areas that extend along the ceiling inward from the wall (Figure 1). Yet, on the downwind side of the house, this is not the case. What could be causing this difference?

What happens is that cold air entering the soffit vents on the windward side blows *through* the attic insulation on its way into the attic (see Figure 2). In batt-insulated ceilings, cold air may also travel along small gaps between the batts and the truss bottom chords. As the cold ventilation air blows through the insulation, it creates the effect of less insulation between the ceiling and the cold. The result is that cold areas (shown as dark) are formed which can cause condensation of moisture and formation of frost (See Figure 1).

But wait – I'm paying extra for the energy truss and extra insulation, and now you're telling me that it's not doing much good? Sure, the extra insulation is helping on all but the windward side, or when there is no wind (most nights) as well as in the summer. However, under some conditions, it may seem as if that extra insulation is not even there.

Surprisingly, it is only a small oversight in our construction that allows this to happen. Usually, in blown attics, a piece of batt insulation is folded and placed in this area to block the loose-fill insulation from the soffit. And, in a batt insulated house, the ends of the batts are often exposed to the air flow.

What is an infrared scan?

An infrared scan (or thermograph) is a television-like image of surface temperatures. It is based on the principle that a warm surface emits more infrared energy than a cold surface. On the infrared scanner warm surfaces appear light and cold surfaces appear dark. We suggest that all builders examine one or more of their completed houses with an infrared scanner. Also, don't neglect to show your crew! Contractors with infrared equipment may be listed in the Yellow Pages under Energy Conservation Products & Services, or Energy Management & Conservation Consultants. Contact the Energy Information Center for a listing of Minnesota contractors with such equipment.

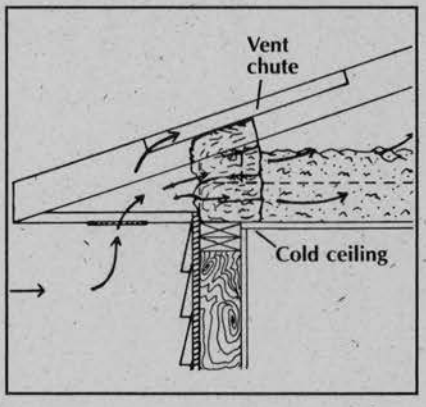


Figure 2
Attic ventilation air commonly passes through ceiling insulation on its way into the attic.

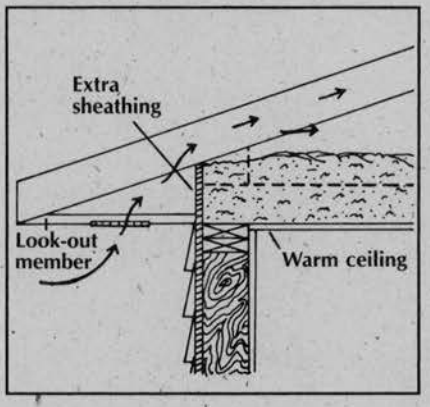


Figure 3
Extending the sheathing up to touch the truss top chord can block air from flowing through the insulation.

The Solution

The solution to the problem is to prevent cold air from blowing through the insulation at this point. This can be done by installing a barrier that covers the edge of the insulation. This covering needs to be nothing more than a piece of sheathing (see Figure 3) which can be installed at the same time that the house is being sheathed. The details, of course, depend on the particular truss design.

Raise heel truss. In this case, the sheathing would run up to touch the top web of the truss. This is easy to do before the look-out member is attached. For blown attics, depending upon the height of the heel, this sheathing might also serve as the insulation block.

Cantilevered truss. Here, the bottom chord extends out to the full length of the soffit. To block air movement with pieces of sheathing, the sheathing would have to be cut and blocked in between each truss and extended to the bottom of the vent chutes. A simpler solution would be to install waxed cardboard vent chutes that can be bent to extend down to the top plate (as shown in Figure 5).

What about remodeling? The attic near the soffit is one of the worst places for the remodeler to work. The National Center for Appropriate Technology recommends scraping back the existing insulation, installing vent chutes and spraying polyurethane in the area between the ceiling and vent chutes. A simpler solution might be to snugly fit in a piece of batt insulation covered with a sheet of polyethylene (Figure 6).

More benefits

Taking care of this problem, whichever method is used, will certainly benefit the homeowner who will avoid future condensation problems, realize energy savings, and feel more comfortable with a warmer ceiling.

For the builder there will be one less potential cause for a callback, and an all-around improved energy performance of that builder's houses. In addition, for blown attics, using a sheathing baffle will make the insulation job simpler because it can replace both the batt insulation plug and vent chutes, that is if the raised heel is tall enough to allow the sheathing to extend to the top of the attic insulation (as shown in Figure 3).

North Dakota builders are offered solution

Harvey Hirning, with the North Dakota State University Extension Service, has helped many builders in his area solve this problem. "Once they recognize that the reason behind cold wall/ceiling corners is cold air blowing through the attic insulation," Hirning says, "they easily take care of it, and they never call back with that problem again."

Raised Heel Trusses – Once a Custom Item, Now Commonplace

The old-fashioned no-heel truss (Figure 4-A) is now used only for garages and less efficient housing. And, while it used to be the standard in all climates, some people now consider it suitable only for southern climates. In contrast, any raised heel, which is common today, used to be a custom item.

Today's standard is the wedged heel (Figure 4-B), and it is used for most medium priced housing. It allows for some increase in thickness of insulation above the plate and also allows for some extension of the sheathing to cover the edge of the insulation for reducing air flow into the insulation.

The raised heel truss (Figure 4-C) is currently the standard in both good quality homes and nearly all of the higher-priced homes and usually costs about 10 percent more than the standard wedged heel trusses. With this truss, sheathing can be extended to stop cold air flow into the insulation in order to take full advantage of its energy saving potential.

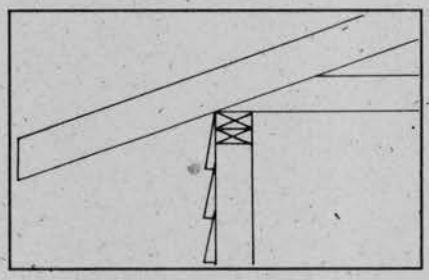


Figure 4-A
Old-fashioned no-heel truss or rafter framed house.

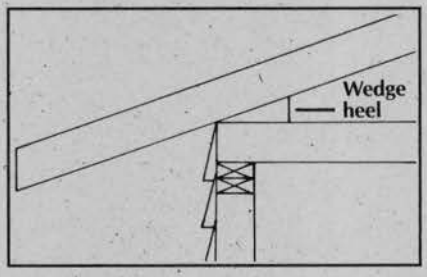


Figure 4-B
Standard wedged heel truss.

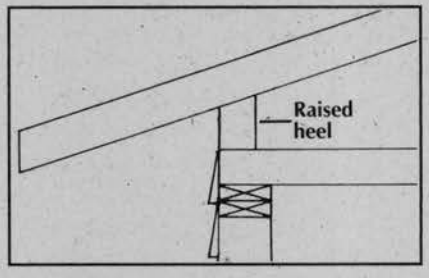


Figure 4-C
Raised heel (or energy) truss.

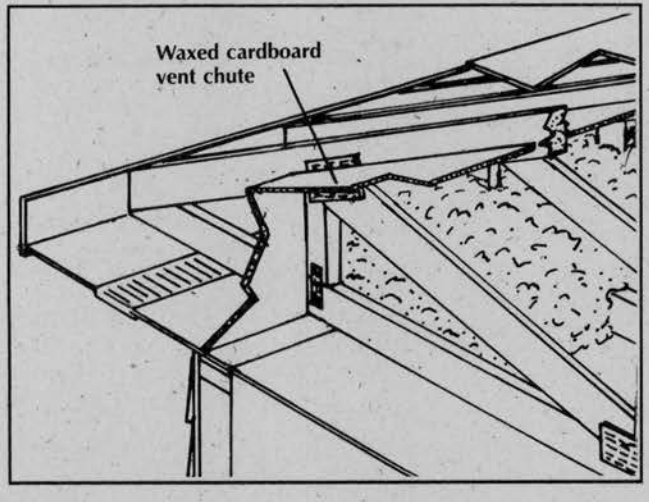


Figure 5
Cantilevered truss.

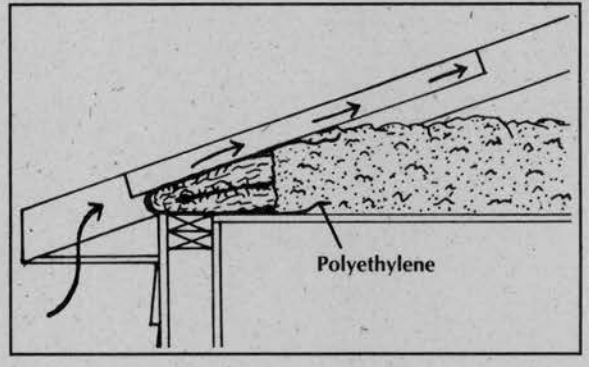


Figure 6
Spray urethane or a snug fitting piece of batt insulation covered with polyethylene can be used to block air passage into the ceiling insulation in a retrofit or cantilevered truss application.

Radiant barrier advisory

Minnesotans are being cautioned about the purchase of radiant barrier home energy products. A radiant barrier is a sheet of aluminum foil installed in the attic which may be useful in reducing ceiling heat gain on summer days by resisting downward heat flow. However, it is the ability of the aluminum foil to save energy in the winter by resisting upward heat flow that has been questioned.

Some radiant barrier sales literature has shown heat flowing down through roofs or up through ceilings, only to be turned back by a radiant barrier. The fact is that roofs and ceilings alone are barriers to radiant heat flow.

Studies conducted by the Florida Solar Energy Center show that reasonably priced radiant barrier products can be worthwhile in hot climates, such as in Florida and Texas, or where the cooling requirements are at least twice as much as the Twin Cities had this past summer. In Minnesota, radiant barriers would not be as worthwhile as in the south because our main concern is heating, not cooling.

Single sheet aluminum foil products are being sold as radiant barriers in southern states for 15 cents or less per square foot. The Minnesota Department of Public Service has learned that some companies have been trying to sell radiant barriers in Minnesota for as much as two dollars per square foot!

continued from page 3

Report Available

The problem of air movement through attic insulation was recognized in research performed on a group of energy efficient homes in Minnesota. In this 1985 project, investigators looked closely at the characteristics of more than 100 energy efficient homes. The report based on this research, titled the "Energy Efficient House Research Project," reveals much about what works best to make a home energy efficient.

A summary of this report is available free from the Energy Information Center. Ask for the "Energy Efficient House Research Summary."

The entire 193-page research report can be ordered from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (Order number DE86015941). The cost is $11.95, postage included.

Previous editions of the **Update** are available free from the Energy Information Center.

Fall 1985	**Household Ventilation**
Winter 1986	**Water Heating**
Spring 1986	**Energy Calculations**
Winter 1987	**Heating Systems**
Spring 1987	**Ice Dam Causes**
Summer 1987	**Effective Sealing Methods: Interior Partition Walls**
Winter 1988	**Indoor Moisture a Problem for Homeowner, Home Builder Alike**
Summer 1988	**Moisture Problems in Bathroom Exterior Walls**

To receive past editions, or to be put on the mailing list to receive future editions of Home Builders Energy Update, call the Energy Information Center at 296-5175, or Minnesota toll free, 800/652-9747.

Minnesota Department of Public Service, Energy Division, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101

Energy
INFORMATION CENTER
Twin Cities: 296-5175
MN toll free: 800-652-9747
Ask for "Energy"

Forwarding and Address Correction Requested

Celebrate MINNESOTA 1990

Bulk Rate
U.S. Postage
PAID
Permit No. 171
St. Paul, MN

Cold Climate Housing NEWS

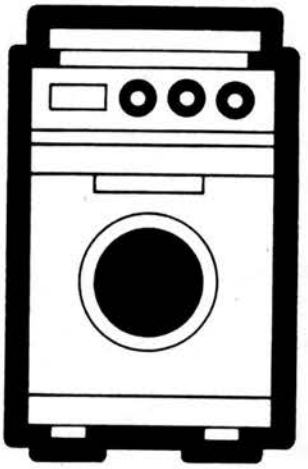
Cold Climate Housing Center, Minnesota Extension Service
Minnesota Cold Climate Building Research Center, University of Minnesota

MnBRC Volume 2, Issue 3

Appliances And Energy Use: 1990's

Wanda Olson, Design, Housing and Apparel

Consumers can benefit by selecting energy-efficient appliances. To help consumers with their selections, appliance efficiency standards have been established. The law establishing the standards, the National Appliance Energy Conservation Act (NAECA), was signed in 1987. The standards for clothes washers (requiring a cold water rinse option), for dishwashers (requiring an "air dry" option), and for gas clothes dryers (electric ignition) took effect in 1988. Electric ignition rather than standing pilot for gas ranges and ovens with a power cord is scheduled to take effect on January 1, 1990. In Minnesota electric ignition has been required since 1979. The standards for refrigeration and water heating appliances are scheduled to take effect, on all models manufactured, on or after January 1, 1990.



Refrigerators and Freezers

There will need to be many new models of refrigerators and freezers introduced, since only 25% of the models available in 1987 meet the new requirements. The standards specify the maximum energy consumption according to volume (cubic feet), type of defrost, features such as through-the-door ice (refrigerator), and style such as upright or chest (freezer). These features are considered to be a benefit to the consumer and additional kilowatt hours (kwhs) are allowed for them. Table 1 gives some indication of how current models listed in the *1989 AHAM Directory of Certified Refrigerators and Freezers* fit with the NAECA requirements.

Water Heaters

The efficiency standards for water heaters are based on storage tank volume. The efficiency is indicated by its energy factor (EF), which is an overall efficiency based on heating 64 gallons of water per day.

Continued on page 2.

INSIDE THIS ISSUE

PAGE

U.S. Energy Use Growing 2

Windwashing And Its Effects On Wood Frame Buildings 3

Windows Make A Home 4

The House Doctor 6

Radon Policy Action 7

Publications 8

Windows Make A Home

Patrick Huelman, Forest Products

Windows are a very important component of our homes. First, they play an important role in our physical and psychological comfort, health, and well-being in the home by providing a vital connection with the exterior environment. Secondly, they provide architectural interest and character to both the interior and exterior of the home. Thirdly, they are a major contributor to the energy efficiency or inefficiency of the home. This article will address the energy aspects of window location as well as the individual window unit.

Continued on page 4.

Windwashing And Its Effects On Wood Frame Buildings

Timothy D. Larson, Forest Products

Windwashing is defined as the penetration of the building envelope by outside air. The discovery that air leakage (or *exfiltration*) in cold climates leads to more moisture condensation problems than diffusion alone has increased interest in developing a good air barrier within the building envelope. Builders have used polyethylene and/or drywall in combination with caulks and gaskets on the warm side of the envelope to establish the air barrier. This has become particularly effective in reducing air leakage through ceilings into attic spaces. This article focuses on the areas of the building where intrusion or entry of air from the outside occurs and the problems it may create.

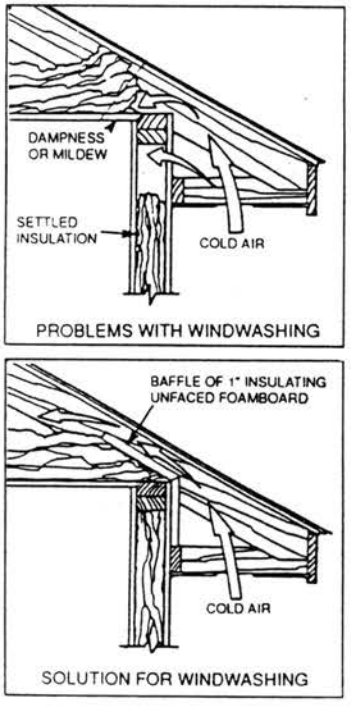


Figure 1.

The Minnesota Energy Division has written an excellent piece on the entry of air into the insulation at the truss heel/exterior wall intersection (see References). Figure 1 shows the problem and the solution with this type of windwashing. Air is shown entering through the soffit and then penetrating the attic insulation. This type of windwashing leads to interior condensation and energy loss. Signs of this condensation include thermal dusting, paint failure, drywall deterioration, water staining, mold, and mildew. Placing a baffle at the truss heel location to direct the ventilation air up over the insulation into the attic space can solve the problem. When continuous soffit venting is used, it is advisable to use baffles between each of the trusses. For more detailed information on this type of windwashing, contact the Minnesota Energy Division at (612) 297-5175; or in Minnesota call toll free 1-800-652-9747. Ask for the 1989 winter edition of the *Home Builders' Energy Update*.

Danish research on cathedral ceilings has demonstrated a number of problems associated with windwashing. The most serious of these problems was the use of batts too small to fill spaces between the insulation and the rafters. This caused a tremendous drop in ceiling insulation performance. Oversized batts and poor installation also degraded the performance of ceiling insulation. Furthermore, it was found that increasing the air speed from 0.65 ft/sec to 1.3 ft/sec dropped the R-value of the ceiling from 18.1 to 14.1 (a 21.9% reduction in R-value). This reduction took place in what was defined as perfectly installed fiberglass batt insulation. This research emphasizes the importance of proper insulation installation in cathedral ceilings and the protection of that insulation from windwashing, particularly at the junction of the ceiling and the exterior wall (by use of a baffle) so that ventilation air does not enter the insulation.

Windwashing also affects exterior walls. This is particularly visible at corners during the winter when mold and mildew appear because of condensation. There are many reasons for the condensation. Thermal bridging is one. This occurs when the number of studs at the corner reduces the potential to insulate and causes a greater heat loss. Natural convection or air movement in the corner is restricted so interior surfaces at this point are colder than other interior surfaces. Also radiant heat exchange is not good at the corner of exterior walls which leads to reduced surface temperatures. Furniture in corners contributes even further to the reduction of air flow and radiant heat exchange that takes place at corners. The geometry at the corner causes more conductive heat loss than at other places in the exterior wall. This is referred to as two-dimensional heat flow.

Research at the University of Toronto indicates that the preceding reasons were generally not enough to account for the condensation that was taking place at the corners of exterior walls. Laboratory research reveals that wind pressure differences at the exterior corners resulted in cold outside air entering, traveling through, and then exiting the wall at exterior corners (see Figure 2). It was shown that the wind

Continued on page 7.

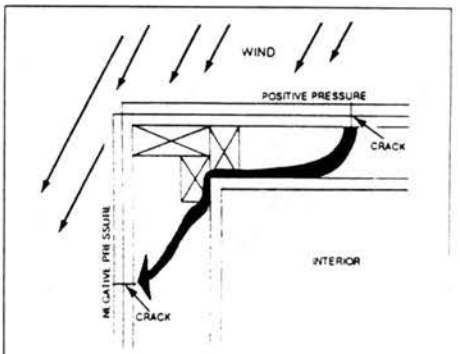


Figure 2. Windwashing at exterior wall corners.

Windwashing And Its Effects On Wood Frame Buildings

Continued from page 3.

factor alone would lower the interior surface temperature enough so that interior relative humidities had to be reduced from 65% to 40% to prevent condensation at the corners under the experimental conditions. In addition to reducing interior surface temperatures, this cold air traveling through the corner of the exterior walls would increase heat loss. This research indicates that one needs to be careful when installing exterior sheathing and/or weather barriers so that windwashing will not take place at exterior wall corners or at other places where wind may penetrate the envelope.

Research in Norway has shown that the lack of a weather barrier (wind barrier) can increase the heat loss through an exterior wall by 50% when it is exposed to a wind velocity of about 13.6 miles per hour. A builder can use the exterior sheathing as a weather barrier if installed correctly.

Attention should be directed towards the design and construction of the building envelope to prevent windwashing. Windwashing can lead to deterioration of interior surfaces as in the cases of exterior wall corners and ceiling/exterior wall intersections. Windwashing can also degrade the R-Value of both ceiling and wall insulation. The remedy to windwashing is to have controlled pathways for attic ventilation and an adequate weather barrier near the exterior surface of the wall.

References

Minnesota Energy Division. 1989. "Cold ceiling corner mystery examined." *Home Builders' Energy Update*, Minnesota Department of Public Service, Energy Division, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101.

Nisson, J.D. Ned (editor). July, 1988. "The effect of excessive roof ventilation on ceiling insulation." *Energy Design Update*, P.O. Box 1709, Ansonia Station, New York, NY 10023. Page 7.

Timusk, J., A.L. Seskus, and N.Ary. 1988. "The control of wind cooling of wood frame building enclosure." *Technical Papers and Abstracts*, Energy Efficient Building Association, University of Maine, Gorham, Maine.

Uvslokk, Sivert. 1987. *The importance of wind barriers for wood frame constructions*. Norwegian Building Research Institute, Division Trondheim, Hogskoleringen 7, 7034 Trondheim NTH, Norway.

Fixing A Home Radon Problem

Continued from page 6.

house been built according to new construction recommendations by EPA, at minimum it would have a sealed sump, gravel under the slab, and a roughed-in PVC pipe from the basement ceiling to the attic floor, capped at both ends. Another option being researched by EPA investigators is to connect the PVC from the sump lid through to the roof, creating a "passive stack" for the radon. If this stack fails, a fan can be inexpensively added.

For more information on radon, the following publications are available: "Application of Radon Reduction Methods," (EPA/625/5-88/024), which can be obtained from the Center for Environmental Research Information, 26 West Martin Luther King Drive, Cincinnati, Ohio, 45268; "Radon Issues in House Buying and Selling," (Folder HE-FO-3532), and "Radon Facts for House Sellers and Buyers," (Fact Sheet HE-FS-3533), both of which can be obtained by writing or calling the Cold Climate Housing Center.

Radon Policy Action

William J. Angell,
Extension Housing Specialist

Mortgage lenders, commercial property owners, and school officials have recently learned that some of the most important radon policy actions flow from the administrative decisions of government agencies.

Savings and loan (S&L's) associations have been advised that radon is a potential risk and liability in a February 16 bulletin from the federal Home Loan Bank System's Office of Regulatory Activities. The risks to S&L's include borrower loan default if corrective action is costly, direct lender liability for the cost of repairs in the case of foreclosure or S&L ownership or management of the property, and liability in the case of personal injury of an occupant. The Bank System advises lenders to limit risk and liability through a number of steps including defining criteria to reject mortgage applications when radon levels are unacceptably high.

Commercial property owners who desire to lease space or to sell buildings to the federal government are learning that the General Services Administration (GSA) has initiated a radon policy. The policy calls for indoor radon testing. If test results are confirmed above the Environmental Protection Agency's (EPA) threshold for action (4 pCi/L), radon levels must be reduced. Furthermore, GSA advises that temporary employee relocation should be considered if radon levels are above 200 pCi/L.

School officials are receiving further details from EPA and state agencies about how to test school rooms for radon. While EPA believes the radon threat to the general population may be several thousand times greater than that related to asbestos, the cost of radon testing and reduction is comparatively cheap. For example, school radon testing is expected to cost less than $1.00 per child.

On the state legislative front, the 1989 Minnesota Senate failed to pass Senate File 342 that would have funded radon research and education as well as qualified Minnesota to receive federal matching grants. The 1990 legislative sessions will be the next opportunity for Minnesota to join 20 other states that have acted on the radon issue.

HOME BUILDERS' ENERGY UPDATE

Summer 1988

Moisture Problems in Bathroom Exterior Walls

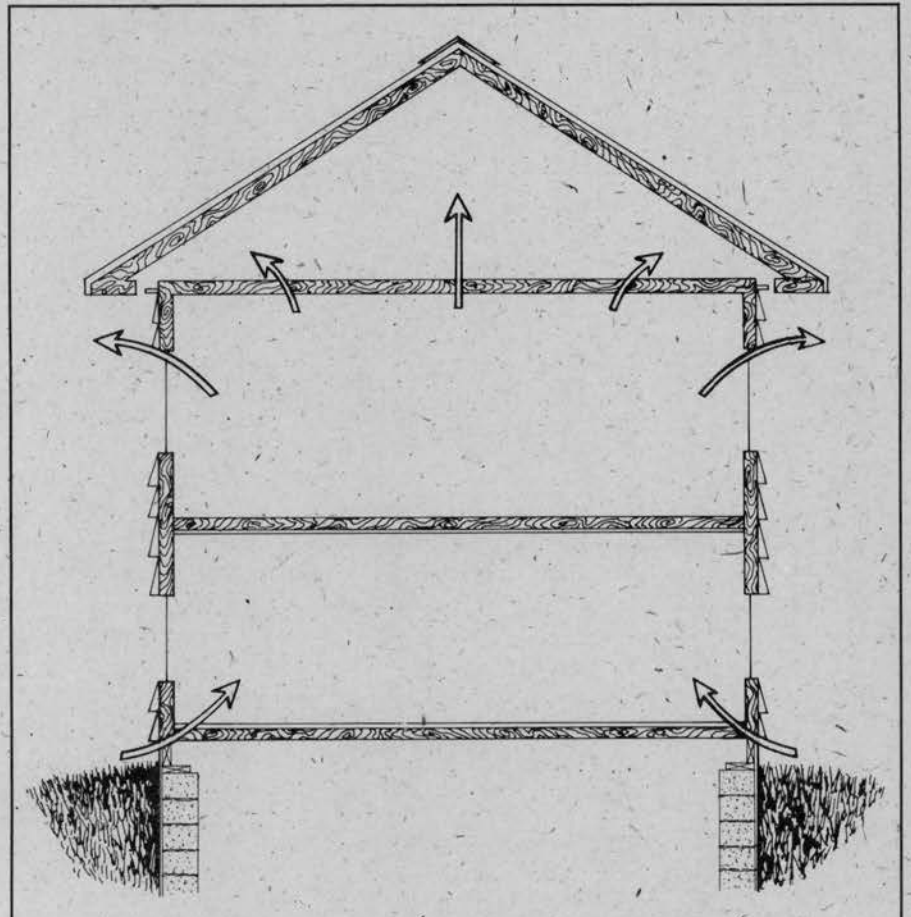


Figure 1

During the winter warm air inside a house will cause the house to act like a big chimney, drawing air in at the lower parts of the house and exhausting the warm and moistened air wherever there is an opening in the wall or ceiling. This is called the "stack effect."

It's a familiar problem for many builders: a call back because the siding outside the bathroom wall is buckling, peeling—sometimes even sprouting icycles—or the interior gypsum board is damp, resulting in paint, wallpaper, and tiles peeling off. This may be especially frustrating for a homeowner who has been regularly using the bathroom fan for several minutes after each shower in an effort to minimize moisture problems.

Of course, sometimes these problems are caused by liquid water from a leaky pipe inside the wall or from a roof with a severe ice dam. When the problem is not liquid water, however, different explanations have been offered and many different solutions tried. Perhaps, as with ice dams (see **Update** Spring 1987), the problem needs to be examined in a slightly different way.

Is a double vapor barrier the culprit?

Until recently, the vapor barrier behind the gypsum board has been routinely blamed for both interior and exterior wall moisture problems. The theory was that water was being "trapped" between the wall board and the vapor barrier, resulting in condensation. It was a reasonable explanation, especially in this high humidity area. However, the theory was flawed; it didn't ex-

plain why the water condensing in this space just didn't harmlessly evaporate back through the wall board from where it came or how the water got through the vapor barrier to the siding. It was the only explanation that seemed to make sense, however.

Now we know that the vapor barrier may have little or nothing to do with this problem.

The real cause: moisture-laden air

Transportation of moisture through walls by "diffusion" is relatively small (see sidebar, next page). Recently, researchers have found that air movement into wall cavities is a very important cause of moisture problems. Helped by the stack effect (see Figure 1) air will carry tremendous amounts of water into the wall. If the interior wall covering is missing behind the tub or behind a one-piece shower, there is nothing to stop the moisture-laden air from flowing into the wall cavity.

The air comes from plumbing trap cut-outs, the trap access, and miscellaneous cracks and holes in the interior wall around the tub (Figure 2). Adding to the problem is the lack of a return grille in most baths. This means that this area will be slightly pressurized if the door is closed when the furnace is running.

We have also heard of cases where, with a cold wind blowing, air comes in through the wall by this path and freezes pipes.

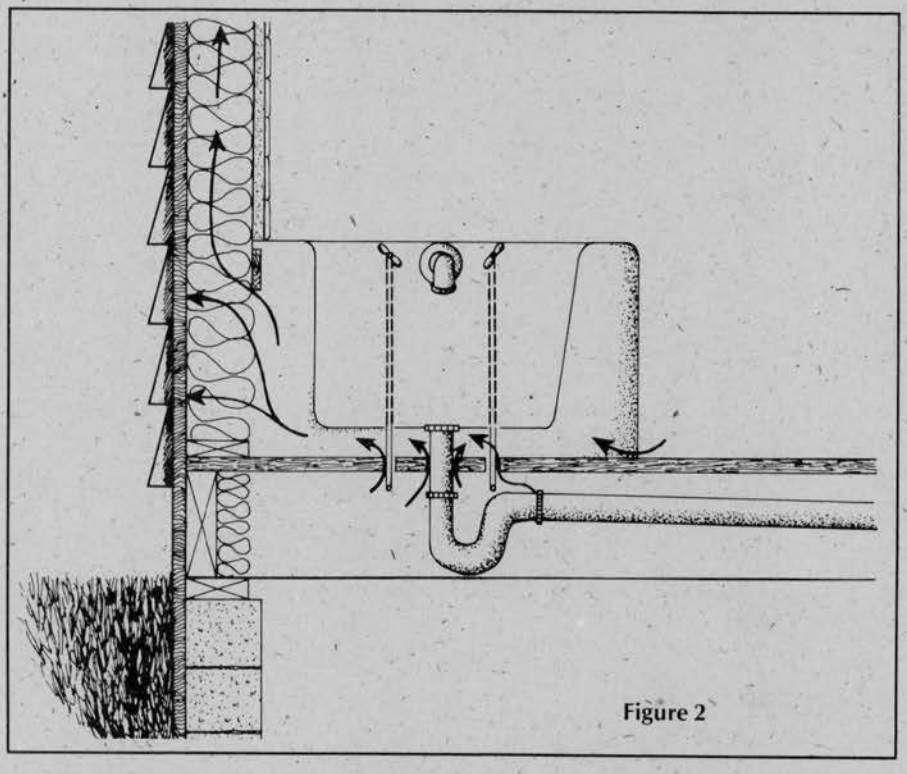


Figure 2

Typical construction leaves a gap into which moist house air can move. Although a vapor barrier protects the insulation; it is often not sealed to stop air movement. The barrier also can be damaged during tub installation.

Causes of two separate problems identified

Most warped siding and icicles on siding are probably a direct result of moisture laden air leaking into the wall. Once there, the water condenses and moves as a liquid to the siding.

The second and separate problem of condensation on the interior wall surface may be only indirectly related to interior air leaking into the wall. Water condenses out of the air as it cools inside the wall. The insulation becomes damp and less effective. This makes the interior wall surface cooler and more prone to condensation than other walls in the house. As discussed in the section below, "Start with the right base," if water is getting through the grout or caulking behind the tiles, it will likely stay there if the wall is cool.

Prevention

With a new house, preventing air leaks isn't difficult. It isn't necessary to interrupt construction schedules to install gypsum board before the plumber comes. It may be very difficult to permanently seal all of the possible sources of air leakage around the tub, so we recommend stopping the air at the exterior wall. Scrap pieces of subflooring or roof plywood and some vapor barrier material installed in the outside wall from the tub support to the floor will do the job (Figure 3).

If tub hangers are used, the task is more difficult. Boards may have to

Start with the right base

Due to the likelihood of moisture condensation around the tub, normal gypsum board is not used in this area. Special water resistant gypsum board has often been used, but some builders have commented that water resistant gypsum board has sometimes not held up. They recommend using a cement wall board product. In addition, tile grout may allow water to penetrate behind the tiles. Caulking around the tub must also be impermeable to water. We're looking into these issues further and hope to have some specific recommendations in future editions of the **Update.**

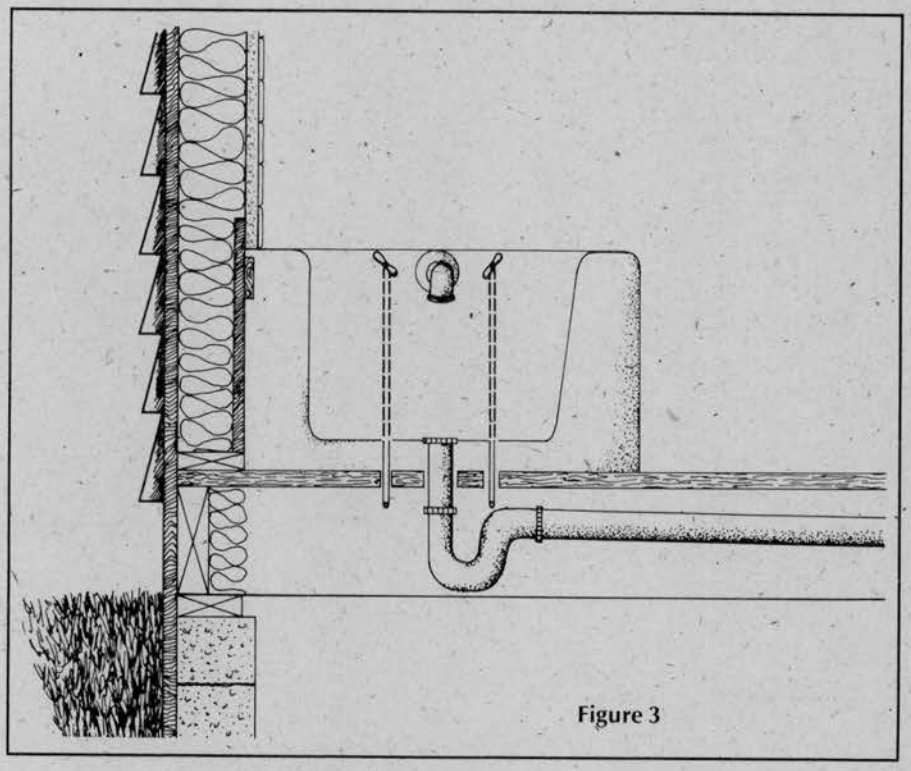


Figure 3

Improved construction to block movement of air into the wall beneath the tub.

be cut to fit around the hangers, and a liberal amount of caulk may be needed to stop the air passageways around the hangers. Caulk any cracks to prevent any air movement.

Similar care is required for a one-piece shower. The plywood should cover the exterior wall completely or up to where the one-piece shower ends and wall board would begin. If the one-piece shower extends to the ceiling, don't forget to block bypasses that would allow air to flow into the attic (see Figure 4).

The scrap plywood costs nothing and takes but a few minutes to cut and attach while the tub support is being installed.

Don't stop at the tub!

Other penetrations in the exterior wall will also carry moisture laden air into the wall cavities and the attic (Figure 4). Electrical and plumbing penetrations should be sealed against air movement. Air should not be allowed to flow from the interior of the house into the exterior walls or attic (see sidebar).

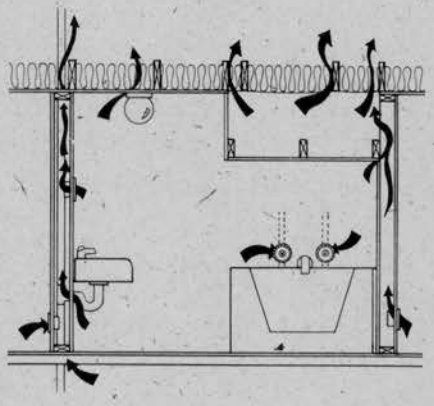


Figure 4

What about call backs?

We don't know of anyone who has had any experience trying to block air flow in a bathroom wall retrofit. We'll provide some ideas and hope that you contact us if you have a chance to try them.

First, if the wall is not deteriorated, do what you can to retard air flow into the wall. One option would be to build a box around the bathtub trap (of course, leave enough room to clean the trap). Seal other penetrations in the floor beneath the tub and in the interior walls next to the tub.

Another option is to move the tub out of the way and install an air stop just as recommended for new construction. This would require disconnecting the plumbing and removing caulking and trim holding the tub in place. Be sure to use high quality caulk when reinstalling the tub. Since this would be so much work, it might be worthwhile doing only if other major bath remodeling is planned.

If the interior wall must be replaced, it will be easier to block the air passage at the exterior wall. A material such as plywood or an insulation board that will allow air to pass through (such as foil-backed or extruded polystyrene) could be used for this purpose. When the wall is open, cut the plywood or insulation board to fit tightly between the studs from above the tub support to the floor plate. (Extending this mate-

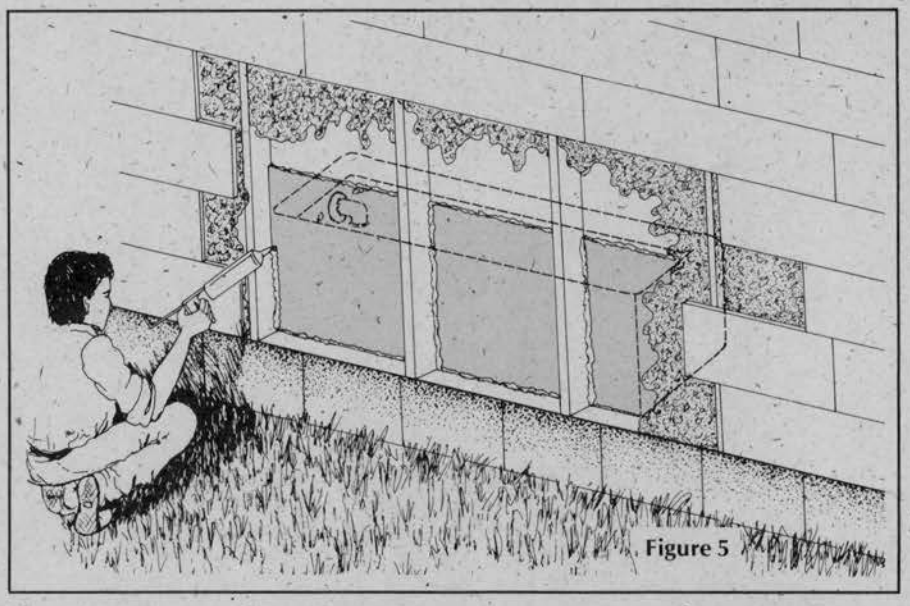
Why blocking air flow is so important

A vapor barrier slows water vapor diffusion through walls and ceilings. Even if no vapor barrier is present, diffusion is a very slow process. However, it is important when a large area is involved. Think of it as water evaporating from a pail. A pail of normal-sized (surface area approximately 1 square foot) doesn't lose much water by evaporation, but if the pail has a surface area the size of a house ceiling, a lot of water evaporates.

Again, think of an air leak as similar to having a small hole in the bottom of the pail. The water runs out quickly. Similarly, air flow will carry a great deal of moisture through a relatively small hole in the wall or ceiling.

rial to above the tub support will reduce the chance of an air leak at this seam.) Slide the air blocking material in to fit tightly on the tub side of the wall to block the air passage.

Finally, if the siding in this area is removed, slide the air stopping insulation board or plywood into the tub side of the wall extending from above the tub support to the floor plate. Because you have more access to the wall in this case, you might as well caulk it into place to completely stop air flow (Figure 5). Replace the insulation or put in new insulation if the material removed has deteriorated.



If the siding must be replaced in a retrofit application, the material used to block air flow should be caulked into place to assure stoppage of air movement.

Reports available

A 12-page Canadian report of investigations of moisture problems in walls, including exterior bathroom walls, is available free from the Energy Information Center. Ask for "Field Visits to Moisture Troubled Housing in a Maritime Climate."

Previous editions of the **Update** are available free from the Energy Information Center.

Summer 1985	**Foundation Wall Insulation**
Fall 1985	**Household Ventilation**
Winter 1986	**Water Heating**
Spring 1986	**Energy Calculations**
Winter 1987	**Heating Systems**
Spring 1987	**Ice Dam Causes**
Summer 1987	**Effective Sealing Methods: Interior Partition Walls**
Winter 1988	**Indoor Moisture a Problem for Homeowner, Home Builder Alike**

Other publications related to the topic of this edition are also available from the Energy Information Center:

Wall Insulation
Attic Bypasses

Call the Energy Information Center at 296-5175, or Minnesota toll free, 800-652-9747.

The Minneapolis Energy Office has published several reports which may be of interest to some readers. Two titles are: "Measured vs. Predicted Savings from Single Retrofits: A Sample Study (cost $2.20), and Measured Energy Savings from Vent Dampers in Low Rise Apartment Buildings (cost $3.80). Order from their office at 334 City Hall, Minneapolis, MN 55415. A complete list of available titles may be requested by calling 612-348-6829.

Minnesota Department of Public Service, Energy Division, 900 American Center Bldg., 150 E. Kellogg Blvd., St., Paul, MN 55101

INFORMATION CENTER
Twin Cities: 296-5175
MN toll free: 800-652-9747
Ask for "Energy"

Forwarding and Address Correction Requested

Celebrate MINNESOTA 1990

BULK RATE
U.S. Postage
PAID
Permit No. 171
St. Paul, MN

HOME BUILDERS' ENERGY UPDATE

Winter 1990

EXTERIOR FOUNDATION WALL INSULATION

Over the past six years, foundation wall insulation has become standard building practice in Minnesota. Placing the foundation wall insulation on the exterior has several advantages which are discussed on page 2. This edition of Update discusses the results of a study of exterior foundation wall insulation conducted in Minnesota by the Department of Public Service. Based on the results, we have certain recommendations for builders installing exterior foundation wall insulation.

The project

The Minnesota research project, conducted in the spring of 1988, looked at the exterior foundation insulations of 59 Twin Cities houses ranging from two to seven years old. We examined all five materials commonly used in this application (see page 3). Rather than focusing on the energy savings potential, this study investigated how the insulation materials and their protective coatings survived both above and below ground. Several general recommendations are drawn from the study that relate to all five insulation types; however, limitations of the study make it hard to determine the relative performance of the products in below ground application.

Recommendations

1. Insulate the exposed foundation wall

In several cases, we found that the exterior foundation wall was insulated below grade only, leaving the wall above grade exposed. From a comfort and energy standpoint, this doesn't make any sense. The uninsulated exposed wall loses much more heat than an uninsulated below grade wall. In fact, the exposed wall may actually be "pumping" heat right out of the basement due to air circulation inside the block wall (see Figure 4). Furthermore, the State Energy Code specifically requires foundation wall insulation to extend "from the top of the foundation wall" to either the frost line or to the footing. Therefore, when you apply insulation to the exterior *be sure* to extend it to the top of the foundation wall.

2. Adequately protect the exposed foundation insulation

Some types of the above grade protective coatings used in the study were found to be in excellent condition. Unfortunately, at 62 percent of the sites where insulation covered most of the above grade wall, the protective coating was either missing or already damaged. This left the insulation exposed to deterioration from sunlight



Figure 1. A house with an uninsulated foundation is hard to keep warm.

or abuse. Large gouges were found ranging between 1/4 inch to over 1 inch in depth and sometimes spanned the entire length of the wall. Not only is this unsightly, but insulation exposed to the elements will soon lose at least some of its effectiveness.

Some of the insulated foundation walls had no protective coating over the insulation at all. After only two to four years, the insulation at these sites had already begun to deteriorate.

Following is a performance report on the types of coatings used in the study:

Paint: Nineteen sites had insulation protected only by paint. At all of these sites the insulation was either gouged, flaking or both. Because the insulation material provides only a soft base, paint alone is not a suitable protective coating.

Bitumen: This coating was applied to most of the sites with spray-applied urethane insulation. In nearly all of these cases the insulation was gouged (see Figure 2) or the coating was dried and cracking. The exposed insulation was beginning to deteriorate from exposure to weather and sunlight. Again, because the insulation material provides only a soft base, bitumen alone, even if painted, is not a suitable protective coating above grade.

Troweled-on cement: Three sites had a coating of troweled-on cement. One was in excellent condition, but the other two were reported to be cracked and were breaking off in many places. Most likely, it is product quality that determines the ability to withstand impact in this application. This material may be a suitable coating, but it should be of high quality, with fiber reinforcement, to withstand impacts and it must be applied correctly.

Fiberglass reinforced panels: The insulation at five sites was protected with rigid fiberglass panels. Three were in excellent condition while two were reported in poor condition. The difference again may be due to the quality of panel material and care of installation.



Figure 2. A poor quality protective coating on the exterior foundation wall is easily damaged.

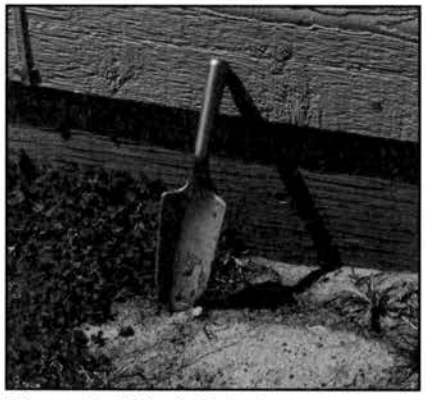


Figure 3. This 1/2 inch pressure treated plywood protective coating has been painted to maintain its good condition.

Pressure treated plywood: The above grade insulation at one site was covered with unpainted 1/4-inch pressure preservative treated plywood, which was slightly warped. Another four sites used 1/2-inch pressure treated plywood, all in excellent condition (see Figure 3).

In conclusion, it is obvious that this area of the house takes a lot of abuse, so a durable protective coating is essential. We'd recommend that the protective coating be *as durable* as the siding applied over insulated sheathing. Specifically, paint and bitumen applied directly to insulation materials are generally not adequate as protective coatings.

Advantages of exterior application

A few years ago, most builders applied the insulation on the exterior. Now we hear that more are insulating the interior. While builders have found that the interior method has certain advantages, we'd recommend a careful look at the exterior options. Canadian research has found that not insulating the outside of the exterior wall above grade can result in freezing temperatures at the footing. This is probably due to air movement within the block cores as shown below. Exterior foundation wall insulation has other advantages: there is no loss of interior floor space, thermal short circuits are minimized and the damp-proofing can be protected.

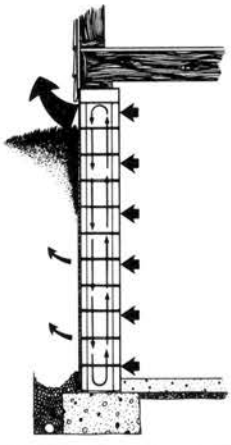


Figure 4. With no exterior foundation wall insulation, convection currents inside the block core can literally pump heat out of the basement.

High quality stucco coatings and fiberglass panel materials are suitable.

Half-inch pressure treated plywood also worked well at four sites observed in this study. The American Wood Preservers' Association specifies a minimum level of treatment for ground contact that is indicated by an "LP-22" stamp on the

material. In addition, two coats of a semi-transparent stain will increase the durability of pressure treated plywood in exposed applications.

3. Take appropriate steps to avoid moisture build-up in insulation

The specimens with high moisture content were taken from those sites where one of three conditions existed:

- The below grade protective coating was damaged (for some spray urethane and polyisocyanurate specimens).
- The above grade protective coating was deteriorating or absent.
- A gap existed between the bottom of the siding and the insulation, allowing moisture to get between the insulation and wall.

These findings lead directly to the following recommendations:

1) Protect insulation material below ground if necessary (backfilling can gouge lightweight coating materials).

2) Install a durable above ground protective coating.

3) Cover the entire above grade foundation wall with insulation and either overlap the insulation with siding, or install a drip cap to prevent water flow behind the insulation.

How did various materials fair below grade?

The limitations of the research project have not allowed us to reach many conclusions about the relative performance of materials below ground. This is because the sample size was small, were all taken from one depth and during one narrow period of time. In addition, most of the specimens were only two or three years old. The moisture content of most of the samples was calculated to result in less than 10 percent loss of R-value, although there was enough moisture in some specimens to cause an R-value loss of up to 34%! The discussion in recommendation #3 indicates some of the conditions where high moisture was found.

A number of the specimens were tested for R-value after they had dried. When combining the tested R-value with the calculated effect of moisture, the change in average net R-value (from an assumed base) for each insulation type ranged between a slight gain to a 17% loss.

As you recall, the spring of 1988 was particularly dry; so, from these results we can't say for sure what would happen over the course of a normal year.

Conclusions

We learned from this study that in many cases we need to do a much better job of protecting exterior foundation wall insulation materials above grade. This protection should be at least as durable as siding. Furthermore, we need to be sure that the insulation extends over the entire wall up to the siding.

Some of the insulation specimens absorbed quite a bit of moisture below grade. However, we still don't know what installation practice is needed for each type of material to minimize water absorption and R-value loss below grade. The recommendations given earlier might help. Also good practice is to employ proven techniques to keep water away from the foundation: proper surface drainage, overhangs, and for poor draining soil conditions, gutters.

What is it?

Extruded polystyrene is a foam plastic manufactured by a continuous extrusion process. There are four brands of this material sold in the state and the printing on the face of each sheet identifies the manufacturer, as does the color: either blue, yellow, pink or green.

Molded EPS, short for molded expanded polystyrene, is also a foam plastic, but is made by first being molded into a large block and then cut into sheets of the desired thickness. It can always be distinguished from extruded polystyrene because it has no printing on its face. It is usually white, but can be colored.

Mineral fiber board is a rigid high density fiberglass board with the fiberglass strands running parallel to the face of the board to facilitate drainage.

Foil faced polyisocyanurate is another form of foam plastic insulation that is distinguished from others by its foil facing on both sides.

Spray-applied urethane is, of course, a spray applied foam plastic.

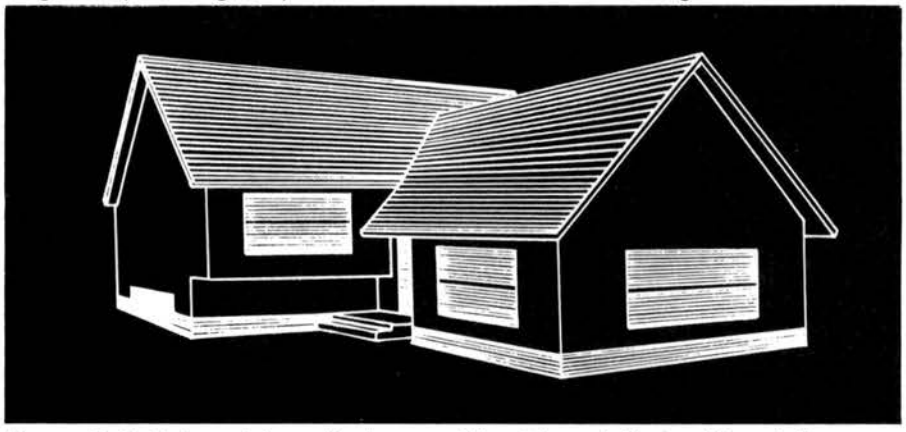


Figure 5. An infrared view of a house without foundation wall insulation usually shows the foundation wall as having as much or more heat loss as the windows.

A simple installation tip

Here's an idea to simplify the installation of exterior foundation wall insulation. With 2x6 walls, the bottom plate can be cantilevered 1" - 2" over the rim joist. The space below will easily accommodate the 1 to 2 inches of exterior foundation insulation (see Figure 6). An additional advantage of this design is that the rim joist is easily insulated, which reduces infiltration.

Report available

This edition of the Update was based on a research project conducted in 1988 by the Minnesota Department of Public Service. For a free copy of the complete report, call the Energy Information Center at 296-5175; or, call toll-free 800-652-9747.

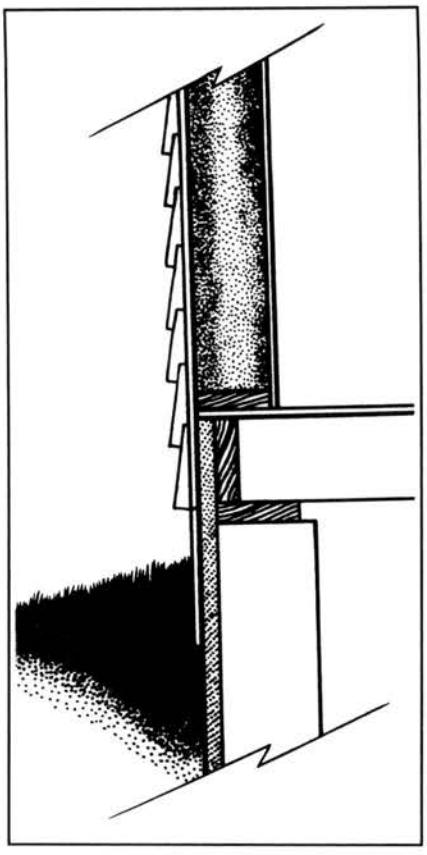


Figure 6. Cantilevering the bottom plate leaves room for exterior foundation wall insulation to cover the rim joist.

Back issues available

Previous editions of the **Update** are available free from the Energy Information Center.

Fall 1985	**Household Ventilation**
Winter 1986	**Water Heating**
Spring 1986	**Energy Calculations**
Winter 1987	**Heating Systems**
Spring 1987	**Ice Dam Causes**
Summer 1987	**Effective Sealing Methods: Interior Partition Walls**
Winter 1988	**Indoor Moisture a Problem for Homeowner, Home Builder Alike**
Summer 1988	**Moisture Problems in Bathroom Exterior Walls**
Winter 1989	**Cold Ceiling Corner Mystery Examined**
Summer 1989	**Band Joist is Hidden Problem Area**

To receive past editions, or to be put on the mailing list to receive future editions of **Home Builders' Energy Update**, call the Energy Information Center at 296-5175, or Minnesota toll-free, 800-652-9747 and ask for "Energy."

Minnesota Department of Public Service, Energy Division, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101

Energy INFORMATION CENTER

Twin Cities: 296-5175
MN toll free: 800-652-9747
Ask for "Energy"

Forwarding and Address Correction Requested

Printed on recycled paper

Celebrate MINNESOTA 1990

Bulk Rate U.S. Postage PAID Permit No. 171 St. Paul, MN

ATTACHMENT 12

REPORT ON THE SUITABILITY OF INCORPORATING ASHRAE 119-1988 "AIR LEAKAGE PERFORMANCE FOR DETACHED SINGLE FAMILY" "RESIDENTIAL BUILDINGS" INTO THE MINNESOTA ENERGY CODE

April, 1990

Prepared for:
Minnesota Department of Public Service
Energy Division

Prepared by:
Advanced Certified Thermography
Lakeland, Minnesota

ADVANCED CERTIFIED THERMOGRAPHY

672 QUIXOTE AVE., LAKELAND, MINN. 55043

STEPHEN R. KLOSSNER (612) 436-5120

Advanced Certified Thermography is a six year old company that specializes in a wide variety of diagnostic work, and consulting, on new homes.

Overview of ASHRAE 119-1988

This is an American National Standard adopted in 1988. The stated purpose of the standard is to establish performance requirements for single family detached residences. In doing this, it provides a method to classify our housing stock.

This standard would prescribe upper limits of leakage area and provide a quantitative number for infiltration measurement. This standard also carefully separates the need for combustion air and ventilation air for indoor air quality.

This standard also references, in Appendix A, ASHRAE 62-1989, and allows the infiltration to be quantified and supplemented with additional ventilation, if required.

This standard uses the height of the home, the measured leakage area at 4 Pascals of pressure difference, and the square feet of living area to classify normalized leakage.

The standard then classifies the normalized leakage area from A to E for for the southern two thirds of Minnesota, and A to D for the northern one third.

Recommendations

I would recommend the following:

1. Adopt ASHRAE 119-1988 into the Minnesota Energy Code, as an alternative to prescriptive measures
2. Amend ASHRAE 119-1988 to include classifications A-D only
3. Support this document with brochures or other informational material from the State level

Discussion

As ASHRAE 119-1988 will be adopted as an alternative to prescriptive measures, it will not be required unless the

builder or buyer request it. This should negate any disadvantage of adopting this into code, while still allowing the builders who choose it, or who are already building homes to this level of tightness, benefit from the advantages.

As the the E classification exceeds .35 air changes per hour, and is little improvement over existing building practices, it is my opinion that the E classification should be dropped as a classification. In addition, if homes truly were built to the intent of the Minnesota Energy Code, they would already meet the A-D classification of ASHRAE standard 119-1988.

The disadvantages of adopting ASHRAE 119-1988 will be discussed first.

1. Added costs to comply

This was the primary disadvantage stated by builders interviewed. Any additional costs incurred to the home builder would be passed on to the home buyer. Testing and the additional sealing may add $100-$1,000 additional cost to the price of a home. As many builders are already building to this standard, the only additional cost would be for testing. Even with the extra sealing and testing costs, energy savings could easily offset any additional mortgage costs on the home.

I am also aware of many builders and insulators who are already offering this "standard of tightness" on their homes. To date, there is some difficulty for the builders and buyers in defining exactly what benefits are derived from this. In my view, the State could go a long way toward increasing awareness of the benefits of current building technology and proper ventilation by adopting this into code.

The advantages of adopting ASHRAE 119-1988 would include:

1. Better definition of Energy Efficient Home.

Almost all homes built with six inches of wall insulation are marketed as Energy Efficient homes. With uncontrolled infiltration, the cost to heat two identically insulated homes can vary by a factor of two or more. As tightness is something that cannot be seen after the finish work, the home buyer has little to go on until he experiences a winter in the home. The home builder, likewise, has no effective means of differentiating between bids to insulate his homes. A common comment I hear from builders is "they are all putting six mil poly and six inches of fiberglass in my walls, and 12 inches of fiberglass in my attic, what's the difference in the bids?"

2. A method of quality control for builders.

A builder can request insulation/sealing bids from a variety of subcontractors. If he specifies that his homes are to meet "Classification A" of ASHRAE standard 119-1988, he can compare bids as apples to apples. He will also be able to check the work upon completion to confirm compliance.

3. Thermal Recognition

There are currently many builders who are requiring the Canadian standard of "3 Air Changes Per Hour at 50 Pascals" for insulation/sealing work on their homes. This is often difficult to understand to an average builder or buyer. Also, Air Changes Per Hour at 50 Pascals does not correlate well to building size, and is difficult to understand for the average home buyer. To date there is no simple, and understandable, method to help in quantifying what he is doing. If a builder can say his home meets State Building Code and rates an A for thermal integrity, that is something the buyer can understand. It will also allow the builder to offer this as an easily understandable option to home buyers, and allow the buyer to evaluate his level of tightness. This standard could be referenced in the Energy Agencies current "HouseWarming Guide on New Homes".

4. Relation to Ventilation Standards

This is probably one of the better applications of this standard. For years, the need for ventilation has been poorly understood in the home building and buying markets. The need for ventilation has been recognized, but there has been little guidance as to when ventilation is required. We are currently building the vast majority of our homes with no ventilation. That is, we are assuming that the homes are loose enough to provide adequate indoor air quality by virtue of infiltration. As infiltration is partially controlled by outside weather conditions, this is not a consistent form of ventilation. This standard does reference ASHRAE Standard 62-1989, and can be used to help estimate infiltration's role in ventilation. This will allow the builders and designers to reference the building's tightness when making ventilation recommendations.

In closing, I believe that this standard would be a benefit to the builders, buyers, both present and future, our natural resources and our environment. Any additional costs for compliance can be easily offset by decreased conditioning costs, both present and future, and increased structural integrity. In addition, any added costs will be spent for Minnesota labor and material, and the decreased conditioning costs will be mainly from imported sources.

HOME BUILDERS' ENERGY UPDATE
Summer 1990

PREVENTING AIR LEAKS AT FIRE STOPS

Fire stops are a vital part of all combustible construction. A fire stop cuts off concealed draft openings through which a fire could pass. The state building code requires that fire stops be installed in conformance with the Uniform Building Code, section 2516 (f).

Fire stops can be made either of wood or other solid blocking material meeting certain specifications, or they can be made of mineral fiber insulation. Unfortunately, fire stops made of mineral fiber or fiberglass do not completely seal the opening. Energy audits conducted in hundreds of Minnesota single and multi-family buildings over the past 15 years have provided countless examples of fiberglass and mineral fiber fire stops that are laden with dirt (Figure 1). The dirt is deposited when air passes through the fiberglass fire stop, just as dirt is collected by a furnace filter. The soiled fiberglass is a sure sign that air is leaving or entering the building through the fire stop.

Air loss through fire stops causes problems. Many of the residences audited (some of them new homes) report frost in attics and other problems caused by air flow from the living space into the attic. Unless solid blocking materials are used, fire stops don't block air flow. This edition of the *Update* focuses on why fire stops should also be air stops, and describes measures for making them air stops.

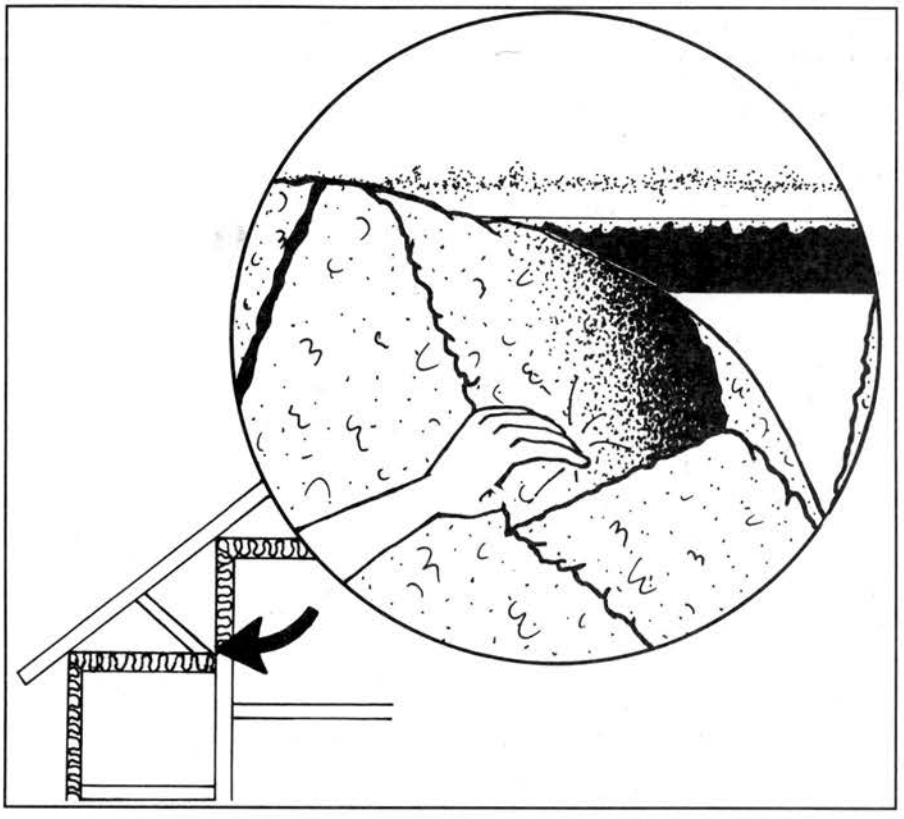


Figure 1 — Dirt is filtered out of air passing through the fire stop at a mid-wall/ceiling intersection in a split-level home.

Problems caused by non-air sealed fire stops

Ice dams. Warm air entering the attic through unsealed fire stops is a major contributor to ice dams. (The Spring 1987 edition of *Update* covers this topic in some detail.) The warm air not only melts snow next to the roof, but the moisture it carries condenses in the attic insulation and reduces the insulation's effectiveness as a barrier against roof snow melt.

Roof sheathing damage. Much

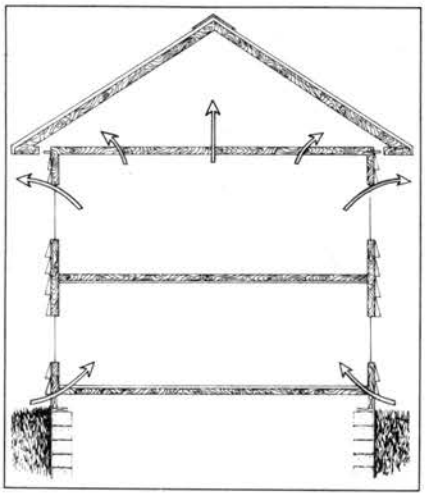


Figure 2 — Results of the stack effect can be observed by walking down the street in winter and looking at windows: warm, moist air exhausting at the second story causes much more frost to form on second floor windows than on first floor windows.

of the moisture that forms frost on the under side of roof sheathing comes from air leaking up from the living space below. Sun or warmer weather melts the frost accumulation, resulting in wet insulation and sometimes in ceiling stains. On occasion contractors have tried to solve attic frost accumulation by adding ventilation. An easier and less expensive solution might be to address the *source* of the moisture causing the damage. Air sealing at all fire stops eliminates a major source of moisture in the attic.

Back drafting. Unsealed fire stops are passageways for warm air to leak up into the attic (as shown in Figure 2.) The stack effect is greatest in windy and colder weather and may even draw up air needed for the combustion appliances in the house. Thus, an unsealed fire stop could contribute to back drafting of a furnace, water heater, or fireplace.

Energy loss. In the mid 1970s, many attics were insulated and ventilated in the interest of saving energy. Unfortunately, the air leaks from the house into the attic were generally not sealed, and as a result many of the houses had higher energy use after they were insulated! The attic ventilation allowed increased air flow through unsealed fire stops, thereby increasing energy loss.

The lesson learned in the 70s was that air flow into the attic significantly affects energy use. Houses use less energy if fire stops are air sealed.

Air leaks through fire stops

During the winter, warm air inside a house causes the house to act like a big chimney, drawing air in at the lower parts of the house. (This is called the "stack effect," see Figure 2.) As a result, warm moist house air leaks out wherever there is an opening in the wall or ceiling and escapes up into the unheated attic. Unsealed fire stops are a source of these air leaks. Unfortunately, these air passageways into the attic (sometimes called "attic bypasses") are hidden from sight once construction is completed, and their effects are usually not noticeable until major problems develop.

Solutions

Fire stops often do not block air flow, but they should. The best time to seal fire stops against air leaks is during construction.

Following are descriptions and suggested solutions for some common fire stops that leak air into the attic. Other common unsealed openings that leak air into the attic include electrical penetrations and knee walls of story-and-a-half homes.

Metal chimneys. The fire stop between metal chimneys and wood framing is sometimes dismally inadequate. If the metal chimney metal collar is loose or does not cover the entire framing, the "fire stop" will not even function as a fire stop!

One way to correct this is to cut a piece of 24-gauge or thinner sheet metal to fit tightly to the

Figure 3 — The chimney collar is sealed to sheet metal and the sheet metal is fastened to the framing to construct an air tight fire stop.

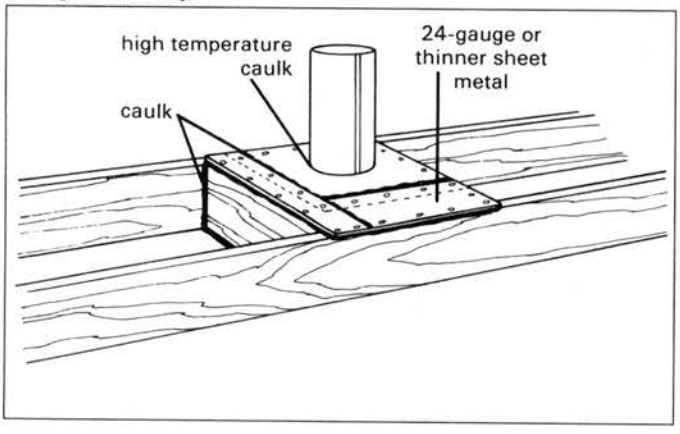
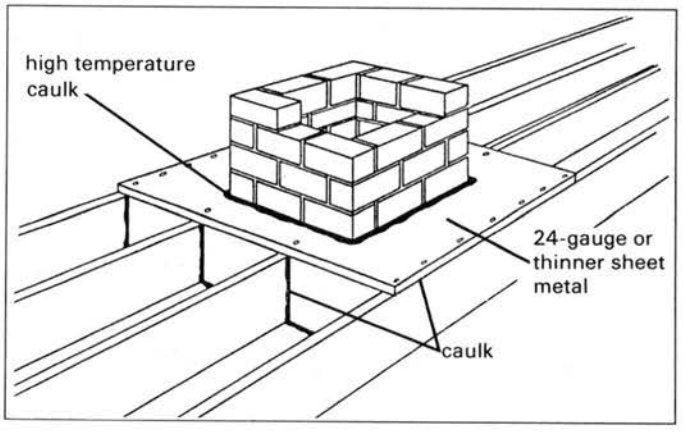


Figure 4 — Metal flashing is added to a brick chimney and air-sealed to the framing to create a fire stop.



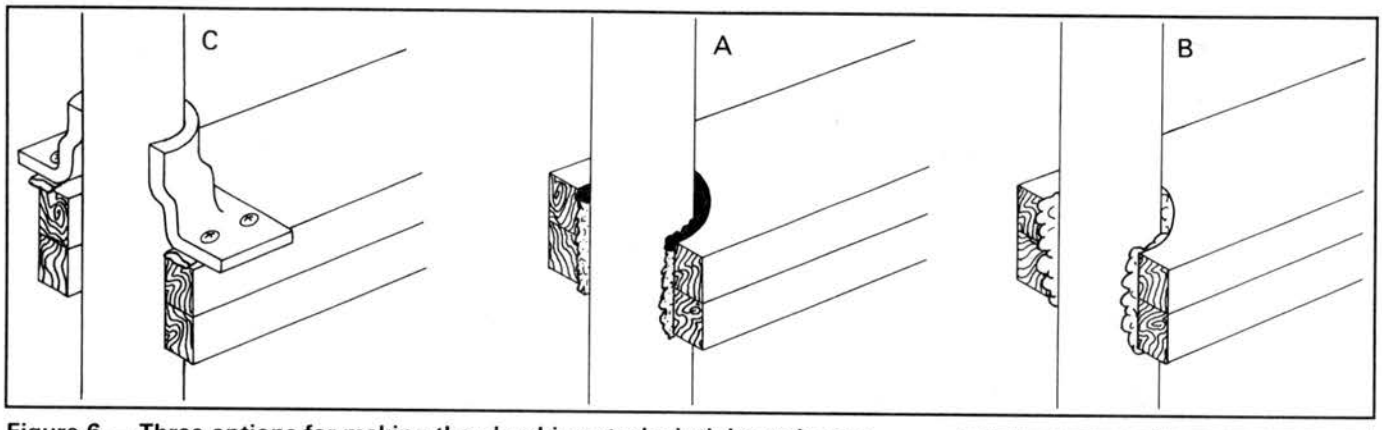


Figure 6 — Three options for making the plumbing stack air tight at the top plate: A uses fiberglass and flexible caulk, B uses foam sealant, and C uses a rubber roof boot.

chimney collar and the framing and use screws and a long-life, flexible caulk to seal the sheet metal to the framing. Seal the collar to the chimney with high temperature caulk, as recommended by the chimney manufacturer. Also caulk the corners of the wood blocking so an air-tight box is created below the sheet metal (Figure 3).

Brick chimneys. A fireplace brick chimney must also have a fire stop at the ceiling framing. Seal this stop the same way as the metal chimney stop. Cut the sheet metal into two halves to fit the chimney and seal in place (Figure 4). Better yet, have the masonry contractor insert the sheet metal (not so far as to weaken the joint) when the chimney is being built.

Do not tightly pack fiberglass insulation to stop this air leak because the fiberglass could transfer too much heat to the framing, posing a possible fire hazard. To keep heat transfer low, stick with narrow gauge (24-gauge or thinner) sheet metal.

Soffits. Soffits in kitchens or elsewhere must have a fire stop, and the stop should not permit air leakage. Sometimes the soffit is framed at the same time as the walls, and later a piece of gypsum board is installed within the soffit frame to provide the required fire stop. Unfortunately, this often results in several air leaks into the attic where the vapor barrier is cut to fit the framing or where there are gaps in the piece of gypsum.

A better idea would be to postpone the soffit framing until *after* the ceiling is sheetrocked. Although this requires a carpenter to return for a day to frame the soffit and install the gypsum board, it also has advantages: the ceiling gypsum will be easier to install and the fire stop will not leak.

Wall/attic intersections. These intersections are a challenging detail of the split-level house design, or in houses with knee walls. In these locations, the fire stop requirement typically is met by filling the wall cavity with batt insulation (see Figure 1). House air easily enters the wall cavity through electrical penetrations and at the baseboard. Heat and moisture are readily carried into the attic with the rising air.

An easy way to stop the airflow is to install solid blocking between the studs at the level of the plate. If you want to do a thorough job, caulk the blocking into place.

Plumbing vent stacks. The soil stack is another major source of air leakage into the attic. Three options to make the plumbing stack air tight at the top plate are illustrated in Figure 6. In the first approach (Fig. 6-A), fiberglass is packed into the rough opening, then flexible caulk is applied to prevent air leakage. In the second approach (Fig. 6-B), foam sealant fills the gap between the framing and vent stack (this approach will not allow as much movement between the stack and framing as other approaches). Another approach is to use a rubber roof boot (Fig. 6-C) sealed to the plate with caulk and stapled in place.

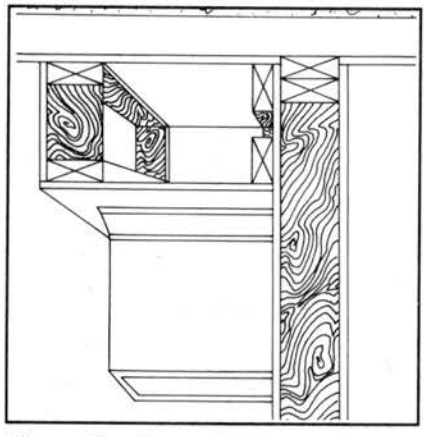


Figure 5 — Gypsum board is installed on the ceiling before the soffit is framed to create an air tight fire stop.

Brochure available

The brochure "Improved Fire Safety" describes fire stopping and draft stopping in more detail. It is available from the National Forest Products Association, 1250 Connecticut Ave. NW, Washington, DC 20036, phone (202) 463-2766. A single copy is free, additional copies are 50 cents each.

Back issues available

Previous editions of the **Update** are available free from the Energy Information Center.

Fall 1985	**Household Ventilation**
Winter 1986	**Water Heating**
Spring 1986	**Energy Calculations**
Winter 1987	**Heating Systems**
Spring 1987	**Ice Dam Causes**
Summer 1987	**Effective Sealing Methods: Interior Partition Walls**
Winter 1988	**Indoor Moisture a Problem for Homeowner, Home Builder Alike**
Summer 1988	**Moisture Problems in Bathroom Exterior Walls**
Winter 1989	**Cold Ceiling Corner Mystery Examined**
Summer 1989	**Band Joist is Hidden Problem Area**
Winter 1990	**Exterior Foundation Wall Insulation**

To receive past editions, or to be put on the mailing list to receive future editions of **Home Builders' Energy Update**, call the Energy Information Center at 296-5175, or Minnesota toll-free, 800-652-9747 and ask for "Energy."

Minnesota Department of Public Service, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101

Energy
INFORMATION CENTER
Twin Cities: 296-5175
MN toll free: 800-652-9747
Ask for "Energy"

Forwarding and Address Correction Requested

Celebrate MINNESOTA 1990

Bulk Rate
U.S. Postage
PAID
Permit No. 171
St. Paul, MN

Printed on recycled paper

TABLE 3.5-1 (Continued)
BASE LPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY SPECIFIC BUILDINGS	1989 LPD	1989 NOTE	1995 LPD	1995 NOTE
Airport, Bus and Rail Station				
Baggage Area	0.8		0.75	
Concourse/Main Thruway	0.9		0.45	
Ticket Counter	2.5		1.3	
Waiting & Lounge Area	1.2		0.6	
Bank				
Customer Area	1.8		0.8	
Banking Activity Area	2.8		2.2	
Barber & Beauty Parlor	2.8		1.6	
Church, Synagogue, Chapel				
Worship/Congregational	2.3		1.3	
Preaching & Sermon/Choir	2.7		1.8	
Dormitory				
Bedroom	1.8		0.6	
Bedroom with Study	1.3		1.3	
Study Hall	1.8		0.9	
Fire & Police Department				
Fire Engine Room	0.7		0.7	
Jail Cell	0.8		0.4	
Hospital/Nursing Home				
Corridor	1.3	(a)	0.9	(a)
Dental Suite/Exam/Treat	1.6		1.4	
Emergency	2.3		2.0	
Laboratory	1.9		1.7	
Lounge/Waiting Room	0.9		0.6	
Medical Supplies	2.4		2.4	
Nursery	2.8		1.6	
Nurse Station	2.1		1.8	
Occu./Physical Therapy	1.6		1.4	
Patient Room	1.4		0.9	
Pharmacy	1.7		1.5	
Radiology	2.1		1.8	
Surgical & O.R. Suites				
General Area	2.1		1.8	
Operating Room	7.8		6.8	
Recovery	3.8		2.8	
Hotel/Conference Center				
Banquet Room/Multipurpose	2.4	(d)	1.4	(d)
Bathroom/Powder Room	1.2		0.6	
Guest Room	1.4		0.7	
Public Area	1.1		0.8	
Exhibition Hall	2.6		1.3	
Conference/Meeting	1.8	(d)	1.5	(d)
Lobby	1.9		1.3	
Reception Desk	2.4		2.4	
Laundry				
Washing	0.9		0.6	
Ironing & Sorting	1.3		1.3	
Museum & Gallery				
General Exhibition	1.9		1.2	
Inspection/Restoration	3.9		3.0	
Storage (Artifacts)				
Inactive	0.6		0.25	
Active	0.7		0.5	
Post Office				
Lobby	1.1		0.8	
Sorting & Mailing	2.1		2.1	
Service Station/Auto Repair	1.0		0.8	
Theater				
Performance Area	1.5		1.1	
Motion Picture	1.0		0.75	
Lobby	1.5		1.0	
Retail Establishments				
(Merchandising & Circulation Areas)				
Applicable to all lighting, including accent and display lighting, installed in merchandising and circulation areas				
Type A	5.6	(c)	6.8	(c)
Type B	3.2	(c)	2.9	(c)
Type C	3.3	(c)	2.7	(c)
Type D	3.0	(c)	2.5	(c)
Type E	2.8	(c)	2.4	(c)
Type F	2.7	(c)	2.6	(c)
Mall Concourse	1.4		0.6	
Retail Support Area				
Tailoring	2.1		2.1	
Dressing/Fitting Rooms	1.4		1.1	

TABLE 3.5-1 (Continued)
BASE LPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY INDOOR ATHLETIC AREAS	1989 LPD	1989 NOTE (b)	1995 LPD	1995 NOTE (b)
Boxing Area, All Sports	0.4		0.4	
Badminton				
Club	0.5		0.5	
Tournament	0.8		0.8	
Basketball/Volleyball				
Intramural	0.8		0.8	
College	1.3		1.3	
Professional	1.9		1.9	
Bowling				
Approach Area	0.5		0.5	
Lanes	1.1		1.1	
Boxing or Wrestling (platform)				
Amateur	2.4		2.4	
Professional	4.8		4.8	
Gymnasium				
General Exercising & Recreation Only	1.0		1.0	
Handball/Racquetball/Squash				
Club	1.3		1.3	
Tournament	2.6		2.6	
Hockey, Ice				
Amateur	1.3		1.3	
College or Professional	2.6		2.6	
Skating Rink				
Recreational	0.6		0.6	
Exhibition/Professional	2.6		2.6	
Swimming				
Recreational	0.9		0.9	
Exhibition	1.5		1.5	
Underwater	1.0		1.0	
Tennis				
Recreational (Class III)	1.3		1.3	
Club/College (Class II)	1.9		1.9	
Professional (Class I)	2.6		2.6	
Tennis, Table				
Club	1.0		1.0	
Tournament	1.6		1.6	

NOTES:
(a) Area Factor of 1.0 shall be used for these spaces.
(b) Area Factor of 1.0 shall be used for all indoor athletic spaces.
(c) Base LPD includes lighting power required for clean-up purposes.
(d) A 1.5 adjustment factor is applicable for multi-functional spaces
(e) See Section 11.0 - Definitions for Classification of Retail Facilities
(f) These Standards do not prescribe LPD for dwelling units.
(g) Area factor shall not exceed 1.35.
(h) Minimum of 90% of all work stations shall be enclosed with partitions of the height prescribed.

Table 3.4-1
Prescriptive Unit Lighting Power Allowance (ULPA), W/ft^2

BUILDING TYPE/AREA FUNCTION	Gross Lighted Area Ranges						Effective Date
	0 to 2,000 ft^2	2,001 to 10,000 ft^2	10,001 to 25,000 ft^2	25,001 to 50,000 ft^2	50,001 to 250,000 ft^2	> 250,000 ft^2	
Food Service							
Fast Food/Cafeteria	1.50	1.38	1.36	1.32	1.31	1.30	1988
	0.92	0.85	0.82	0.81	0.81	0.80	1993
Leisure Dining/Bar	2.20	1.91	1.71	1.56	1.46	1.40	1988
	1.60	1.56	1.52	1.48	1.44	1.40	1993
Offices	1.90	1.81	1.72	1.65	1.57	1.50	1988
	1.48	1.34	1.27	1.22	1.16	1.11	1993
Retail[1]							
Retail General	3.30	3.08	2.83	2.50	2.28	2.10	1988
	2.78	2.52	2.32	2.05	1.87	1.72	1993
Mall Concourse							
Multi-Store Service	1.60	1.58	1.52	1.46	1.43	1.40	1988
	0.69	0.68	0.65	0.63	0.61	0.60	1993
Service Establishment	2.70	2.37	2.08	1.92	1.80	1.70	1988
	2.01	2.05	1.78	1.65	1.54	1.46	1993
Garages	0.30	0.28	0.26	0.22	0.21	0.20	1988
	0.25	0.24	0.23	0.22	0.21	0.20	1993
Schools							
Pre-elementary	1.80	1.80	1.72	1.65	1.57	1.50	1988
	1.33	1.33	1.27	1.22	1.16	1.11	1993
Jr. High/High School	1.90	1.90	1.88	1.83	1.76	1.70	1988
	1.40	1.40	1.39	1.35	1.30	1.26	1993
Technical/Vocational	2.40	2.33	2.17	2.01	1.84	1.70	1988
	1.77	1.72	1.60	1.49	1.36	1.26	1993
Warehouse/Storage	0.80	0.66	0.56	0.48	0.43	0.40	1988
	0.60	0.50	0.42	0.36	0.32	0.30	1993

Notes:
1. Includes general, merchandising and display lighting.

TABLE 3.5-1
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY COMMON ACTIVITY AREAS	1989 UPD	1989 NOTE	1993 UPD	1993 NOTE
Auditorium	1.6	(d)	1.4	(d)
Corridor	0.8	(a)	0.8	(a)
Classroom/Lecture Hall	2.0		1.8	
Elec/Mech Equipment Room				
General	0.7	(a)	0.7	(a)
Control Rooms	1.5	(a)	1.5	(a)
Food Service				
Fast Food/Cafeteria	1.3		0.8	
Leisure Dining	2.5	(c)	1.4	(c)
Bar/Lounge	2.5	(c)	1.3	(c)
Kitchen	1.4		1.4	
Recreation/Lounge	0.7		0.5	
Stairs				
Active Traffic	0.6		0.6	
Emergency Exit	0.4		0.4	
Toilet & Washroom	0.8		0.5	
Garage				
Auto/Pedestrian Circulation	0.3		0.25	
Parking Area	0.2		0.2	
Laboratory	2.3		2.2	
Library				
Audio Visual	1.1		1.1	
Stack Area	1.5		1.5	
Card File & Cataloging	1.6		0.8	
Reading Area	1.9		1.0	
Lobby (General)				
Reception & Waiting	1.0		0.55	
Elevator Lobbies	0.8		0.4	
Atrium (Multi-Story)				
First 3 Floors	0.7		0.4	
Each Additional Floor	0.2		0.15	
Locker Room & Shower	0.8		0.6	

AREA/ACTIVITY COMMON ACTIVITY AREAS	1989 UPD	1989 NOTE	1993 UPD	1993 NOTE
Offices				
Enclosed offices of less than 900 ft^2 and all open plan offices w/out partitions or w/partitions lower than 4.5 ft below ceiling.		(b)		(b)
Reading, Typing and Filing	1.8	(g)	1.3	(g)
Drafting	2.6	(g)	2.2	(g)
Accounting	2.1	(g)	1.8	(g)
Open plan offices, 900 ft^2 or larger, w/medium height partitions 3.5 to 4.5 ft below ceiling.		(h)		(h)
Reading, Typing and Filing	1.9	(a)	1.5	(a)
Drafting	2.9	(a)	2.6	(a)
Accounting	2.4	(a)	2.1	(a)
Open plan offices, 900 ft^2 or larger, w/partitions higher higher than 3.5 ft below ceiling.		(h)		(h)
Reading, Typing and Filing	2.2	(a)	1.7	(a)
Drafting	3.4	(a)	3.0	(a)
Accounting	2.7	(a)	2.4	(a)
Common Activity Areas				
Conference/Meeting Room	1.8	(d)	1.3	(d)
Computer/Office Equipment	2.1		2.1	
Filing, Inactive	1.0		1.0	
Mail Room	1.8		1.8	
Shop (Non-Industrial)				
Machinery	2.5		2.5	
Electrical/Electronic	2.5		2.5	
Painting	1.6		1.6	
Carpentry	2.3		2.3	
Welding	1.2		1.2	
Storage & Warehouse				
Inactive Storage	0.3		0.2	
Active Storage, Bulky	0.5		0.3	
Active Storage, Fine	1.0		0.9	
Material Handling	1.0		1.0	
Unlisted Space	0.2		0.2	

ATTACHMENT 15

Date: 07/19/90 RENA Analysis

SYLVANIA INFORMATION ANALYSIS

FIRST BANK TOWER/IBM

JOEL JOHNSON

SYLVIA Relight Energy Analysis (RENA) Analysis

Description Ballast Number of Lamps	Present F40WW ENERGY SAVING 39,918	Proposal 1 FO32/31K ELECTRONIC 39,918	Proposal 2
Annual Savings-Lighting			
Total Present System Lighting Load (KW)		1,808.29	
Total New System Lighting Load (KW)		1,117.70	
Load Reduction Due To Lighting (KW)		690.59	
Load Reduction For 3,000 Hrs/Yr		2,071,770	
Savings at $ .050 per KWH		$103,588.50	
Demand Charge Savings at $6.00 /KW		$49,722.48	
Annual Savings-Air Conditioning			
Reduced A/C Load per Year (Therms)			
Reduced A/C Capacity Required (Tons)		196.42	
Savings on Reduced A/C Load		x 2500	
Annual Expense Heating			
Heat Load Reduction (BTU/Hr)		2,356,984	
Total Heat Load Reduction per Yr (Therms)		70,709.52	
Add'l Fuel Req./Yr of			
Annual Cost for Add'l Fuel			
Annual Savings Summary			
Total Lighting Energy Savings		$153,310.98	
Plus Annual Savings in A/C Costs			
Less Annual Add'l Fuel Cost			
Total Annual Energy Savings		$153,310.98	
Return On Investment			
Total Energy Savings Over Life		$1,022,073.20	
Less Total Investment for New Lamps/Sys			
Net Return on Investment		$1,022,073.20	
Annual Net Return		$153,310.98	
Return On Investment (%)			
Pay Back Period of Proposal (Months)			

The calculations are believed appropriate for most lighting installations.

Form: SYLZR31 GTE Sylvania - Danvers, MA

S Y L V A N I A I N F O R M A T I O N A N A L Y S I S

FIRST BANK TOWER/IBM

JOEL JOHNSON

SYLVIA Relight Energy Analysis (RENA) Analysis
Input Recap

Common System Data	
Burning Hours per Year:	3,000
Average Energy Cost/KWH:	$.050
Average Monthly Demand:	$6.00
Heating Fuel Code:	
Fuel Description	
Unit Description	
Fuel Content (BTU)	
Net Cost of Fuel:	
Pct of Heating per Year:	
Pct of Air Cond per Year:	

Lamp Data	Present	Proposal 1	Proposal 2
Lamp Type Code:	24435	21825	
Description	F40WW	FO32/31K	
Wattage	45.3	28.0	
Rated Lamp Life	20,000	20,000	
Thrift/Mate:			
Description			
Luminaire Data			
No. Lamps per Luminaire:	3	3	
No. Luminaires:	13,306	13,306	
Net Cost per Luminaire:		133000	

ATTACHMENT 16

IS ASHRAE/IES STANDARD 90.1P BEING FOLLOWED?

Pre-code construction is studied for efficiency

Steven M. Nadel and Fred Davis

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) and the IESNA have been working together for several years to develop *ASHRAE/IES Standard 90.1P Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*. The proposed standard that emerged from this work promises to reduce lighting energy use by an average of 14–30 percent compared to the old ASHRAE 90A-1980 standard.* Because of these projected savings, Massachusetts formally incorporated 90.1P into the state building code, effective October 1, 1988.

A persistent concern about the proposed standards has been how the current lighting design practice compares with the proposed standards? On the one hand, if current practice is far from meeting the standards, the standards may be too stringent. Conversely, if construction already conforms to the standards, no net energy savings will result.

The New England Power Company (NEP) is a wholesale power generation company that sells power to retail subsidiaries in Massachusetts, Rhode Island, and New Hampshire. NEP recently began offering an energy conservation program designed to help developers and design professionals meet and exceed the newly revised Massachusetts building code. In order to determine whether meeting or exceeding the new building code was feasible, NEP commissioned a study to determine how current lighting design practices in new commercial buildings measured up to the new building code. The results of this study are the subject of this paper.

**The savings estimates were made by Batelle Pacific Northwest Laboratories based on computer modelling of several prototypical buildings across a range of systems and climates.*

Methodology

The study was jointly conducted by NEP and the Fred Davis Corporation (FDC), an independent firm that consults on and sells energy-efficient lighting products. For the project, NEP selected a representative sample of 18 office and retail buildings in its service territory that were completed and occupied between August 1987 and November 1988. Projects selected provide an even mix of owner-occupied and speculative buildings. Buildings of less than 15,000 ft², between 15,000 and 50,000 ft², and over 50,000 ft² were includ-

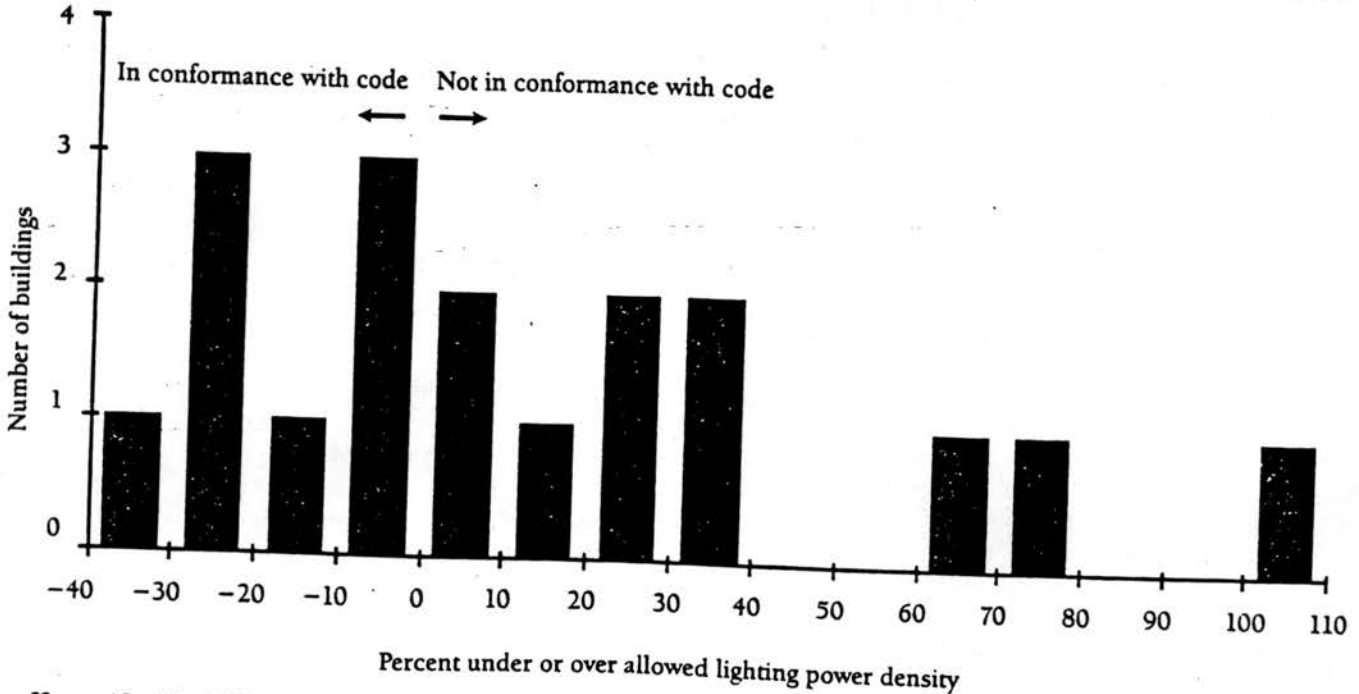


Figure 1—Distribution of buildings by percent under/over allowed lighting power density



The main concourse in building 18 account for 31 percent of the adjusted lighting power. Though well-daylit and automatically controlled, most lighting is incandescent, and therefore ineligible for the power adjustment factor.



Building 4 was a small spec-built office building used by a counselling center.



In this room in building 4, there are 325 W of incandescent and 190 W of fluorescent load. While this facility had the highest proportion of task lighting, it still was in conformance with the code.

ed. FDC visited each site and collected information on building use, floor area, installed lighting type and load, and illuminance in a limited sample of spaces.

Based on these data, NEP and FDC calculated the actual lighting power desnsity for each building and the maximum lighting power density allowed by the new building code. None of the buildings surveyed had any legal reason to be in compliance with the new code, because all of the buildings surveyed predated its effective date. All calculations were based on the prescriptive criteria specified in the Massachusetts building code which is based on the second public review draft of 90.1P. The prescriptive criteria were used rather than the system performance criteria, because less data collection was required to use the prescriptive criteria. While we would have also liked to use the system performance criteria, it was not possible to collect all the necessary data within the time and budget constraints of the project.

Buildings surveyed

The 18 buildings surveyed included 14 in Massachusetts and four in Rhode Island. Eleven of the buildings were offices; seven were retail facilities. Eight of the buildings were owner-occupied; the remaining ten were speculative (renter-occupied). Buildings ranged in size from 4157 ft^2 to 257,790 ft^2 with an average size of 43,770 ft^2. Based on the size definitions discussed above, eight of the buildings were small, six medium, and four large.

Results

Eleven buildings used F40 fluorescent fixtures as their dominant lighting system. One building used F96 fluorescents and one used F32T8 fluorescents as their major lighting system. The remaining five buildings had more than one type of lighting installed. Of the fluorescent lighting systems installed, approximately 40 percent used energy-saving lamps (e.g., 34-W 4-ft lamps) and two-thirds used energy-saving ballasts (one set of which was electronic). Only one building had any type of automatic lighting controls that qualify for power adjustment factor credits.* This building had time controls installed in a limited portion of the building.

Approximately half of the office buildings and all of the retail buildings did not make use of task lights. The other office buildings, for the most part, used task lights in a limited manner. In these office buildings task lights accounted for 1–6 percent of the connected lighting load. One office building had task lights on nearly every desk. In this building task lights accounted for 15 percent of the total connected lighting load.

Conformance

Eight of the buildings surveyed conformed with the prescriptive criteria of the Massachusetts building code; 10

**Under 90.1P, buildings with qualifying automatic lighting controls are allowed increased lighting power densities through the application of a power adjustment factor.*

Appendix A: Summary Data on Buildings Included in Sample

Building Number	State	Floor Area (ft^2)	Owner-Occupied or Speculative	Office or Retail	Predominant Lighting	Actual LPD (W/ft^2)	Percent LPD in Task Lighting	Automatic Controls
1	MA	4157	spec	office (limited retail)	4L F40ES/ES ballasts	1.73	0.0	No
2	MA	7280	own	office	2&4L F40ES/ES ballasts	1.18	0.0	No
3	MA	9960	spec	office & workshop	2L F96/ES ballasts, 400-W metal halide	1.30	3.7	No
4	MA	11,316	spec	office	4L F40/std ballasts	1.77	15.0	No
5	RI	14,856	own	office	4L F40/std ballasts, 75-W floods in high hats	2.40	2.4	No
6	MA	18,544	own	office & warehouse	4L F40ES, 2L F96ES/ all ES ballasts	1.00	0.0	No
7	RI	22,934	spec	office	2&4L F40/ES ballasts	1.75	1.2	No
8	MA	29,875	own	office, garage, warehouse, & workshop	2L F96HO, 1L F96, 4L F40/ all ES ballasts	0.79	0.0	No
9	MA	71,272	spec	office	3L F40ES/ES ballasts	2.49	0.3	No
10	MA	82,500	own	office	4L F32T8/electronic ballasts,	1.07	4.1	No
11	MA	156,981	spec	office (limited retail)	3&4L F40/std ballasts, 100-W incand	2.19	6.3	No
12	MA	6000	own	retail	2L F96/std ballasts	1.86	0.0	No
13	RI	9774	spec	retail	4L F40/ES ballasts	3.06	0.0	No
14	MA	10,540	spec	retail	4L F40/std ballasts	2.46	0.3	No
15	MA	15,522	spec	retail	4L F40/ES ballasts	1.15	0	No
16	MA	25,185	own	retail	2&3L F40ES, 1&2L F96ES/ all ES ballasts	2.38	0.0	No
17	RI	33,365	own	retail	1L 400-W metal halide, 2L F40ES/std ballasts	3.26	2.3	No
18	MA	257,790	spec	retail	500-W PAR, 2&4L F40/ES ballasts, 90-W PAR38(halogen), 11-W S14	3.41	0.0	Programmable timers in concourse

LPD = lighting power density; ES = energy saving; L = lamp

Code Allowed LPD (W/ft^2)	Actual/ Allowed LPD	Average fc in Spaces Measured	Steps to Bring into Compliance with Code
.88	0.92		
1.51	0.78	47	
1.36	0.95	118 (offices)	
1.79	0.99		
1.80	1.33	141	ES lamps and ballasts in F40 fixtures, replace each flood with 2 PL7s
1.19	0.84		
1.66	1.06		Change half of F40 to F40ES,
0.70	1.12		use ES lamps where not currently used
1.50	1.66		Use electronic ballasts throughout, convert most incand to PLs Alternatively, add automatic controls
1.50	0.71	88	
1.60	1.37	100 (office) 95 (retail)	Use electronic ballasts where appropriate, ES ballasts elsewhere; use F40ES lamps; convert most incand to PLs. Alternatively add automatic controls
2.95	0.63	110	
2.35	1.30	62	Install electronic ballasts in F40 fixtures
2.37	1.04	71	Replace a third of F40 lamps or ballasts with ES equivalents
1.45	0.79		
1.95	1.22		Electronic ballasts in all 4 & 8-ft fluorescent fixtures
1.84	1.78	106	Electronic ballasts in F40 fixtures, switch to 175-W metal halide (this will reduce light levels)
1.65	2.06	highly variable	Requires significant modifications to lighting design

did not. The most efficient building surveyed used 37 percent fewer watts than allowed by the prescriptive criteria. The code allowed this small retail space relatively high lighting power density. The least-efficient building surveyed used 106 percent more watts than the prescriptive criteria allowed. This building was a large mall that made extensive use of incandescent lights for area lighting and for decorative purposes. The median building surveyed used 5 percent more watts than allowed by the prescriptive criteria. The percentage by which each building was over or under its allowed lighting power density is summarized in Figure 1.

Of the buildings in Massachusetts, 57 percent were in conformance with the prescriptive criteria of the Massachusetts building code. None of the buildings in Rhode Island were. This discrepancy may be caused by the effects of stronger building code standards in Massachusetts: For years the Massachusetts building code has had lower lighting power limits than the Rhode Island code. The impact of the Massachusetts Ballast Efficiency Law also contributed to the difference. Since January 1988 Massachusetts has required energy-efficient ballasts, but a similar Rhode Island law did not take effect until July 1989.

Office buildings, small buildings, and owner-occupied buildings were found to conform with the prescriptive criteria more often than retail buildings, large buildings, and speculative buildings. Fifty-five percent of the office buildings conformed with the prescriptive criteria; only 29 percent of the retail buildings did. Sixty-two percent of the small buildings conformed, compared to 30 percent of the medium and large buildings. Fifty percent of the owner-occupied buildings conformed, compared to 40 percent of the speculative buildings. All of these differences are statistically significant at a .05 level.*

Light levels

During half of the site visits illuminances were measured at desktop or display level in a representative sample of spaces. Measurements were made using a Minolta Illuminance Meter model T-1. The measurements were made for illustrative purposes, not to produce a definitive and reproducible light level estimate for each building. Among the five offices measured the average of individual illuminance measurements in each building ranged between 47 and 141 fc. The median illuminance level of general areas was 100fc, a level in excess of IESNA recommendations for most office tasks. Many of the offices surveyed were overlit. Of the five retail buildings measured average illuminances in each building ranged from 62–110 fc.

Bringing buildings into conformance

As part of this study, steps were investigated to bring the buildings surveyed into conformance with the Massachusetts building code. This was done in order to see how easy or difficult it would be to make these representative buildings conform. As was previously noted, all of these buildings predate the new building code and are not required to comply with

*Statistical significance was determined using a T-test.

the new code.

Perhaps the simplest method for bringing the nonconforming buildings into conformance with the new code is to use the system performance criteria instead of the prescriptive criteria. For example, the actual lighting power density in building 16, a medium-sized clothing store, was 22 percent greater than the lighting power density allowed by the prescriptive criteria. But it was 4 percent less than the lighting power density allowed by the system performance criteria. Sufficient data were not available to determine whether other buildings would conform using the system performance criteria.

In cases in which a building does not conform with the system performance criteria, or in which use of the system performance criteria is too cumbersome, changes to the lighting system are needed to bring the building into conformance. Of the 10 buildings in the survey that do not currently meet the prescriptive requirements of the new Massachusetts building code, three can be brought into conformance through the use of energy-efficient magnetic ballasts or energy-saving fluorescent lamps. An additional six buildings can be brought into conformance through the use of electronic ballasts or compact fluorescent lamps. Alternatively, automatic lighting controls can be used in place of electronic ballasts. One building required a redesign of the lighting system to bring the building into conformance.

Conclusions

Based on the findings of the survey, the authors conclude that standards such as 90.1P are not unduly strict and will save significant amounts of energy. Furthermore, those buildings in our study that exceeded the requirements of 90.1P indicate that additional energy savings is possible in many cases. As standards such as 90.1P are incorporated into building codes, designers will find that incorporating simple energy saving measures into their designs will be enough to ensure compliance in most cases. Adoption of 90.1P will be a significant step toward improving lighting energy efficiency without causing undue hardship on the practice of lighting design.



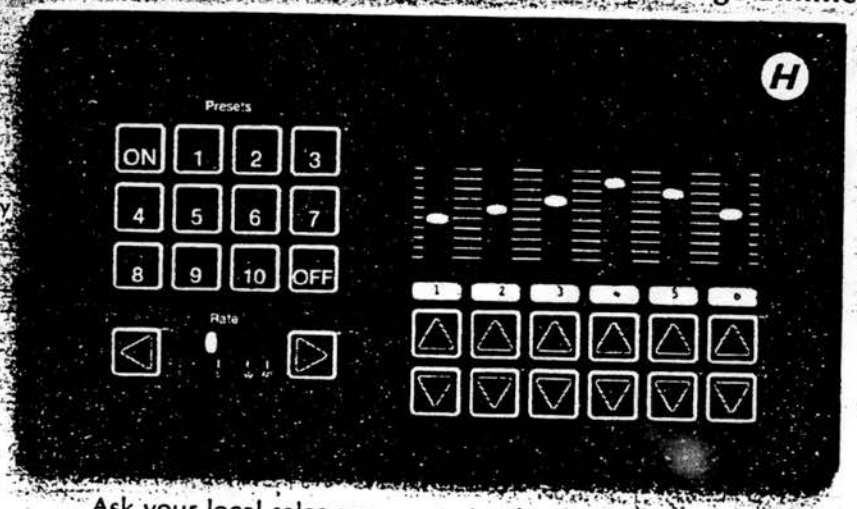
The author: Steven Nadel is a senior associate with the American Council for an Energy-Efficient Economy. At the time of the survey he was employed by an affiliate of the New England Power Company.



The author: Fred Davis is president of the Fred Davis Corporation, energy and lighting specialists.

DIGITAL MEMORY CONTROL
ARCHITECTURAL LIGHTING

Controls all incandescent, fluorescent & low voltage dimmers



Digital/Multiplex
4 low voltage wires
Battery backed memory
No moving parts
Standard back box
Membrane switches
Lighted displays
Time of day clock

12 Presets
Up to 36 channels
1-60 sec. time fade
Playback stations
On/Off stations
Wireless remote
Central processor
Security code

Ask your local sales representative for a demonstration.

HUB ELECTRIC CO., INC.
6207 Commercial Rd., Crystal Lake, IL 60014 (312) 530-6860

Circle 14 on Reader Information Card.

DEPARTMENT OF PUBLIC SERVICE
ENERGY DIVISION

Proposed Permanent Rules Amending the Minnesota State Building Code Regarding Heat Loss, Illumination and Climate Control

Notice of Intent to Amend a Rule Without a Public Hearing and Notice of Intent to Adopt a Rule With a Public Hearing if Twenty-Five or More Persons Request a Hearing

(1) **Notice is hereby given** that the Minnesota Department of Public Service intends to adopt amendments to Minnesota Rules Chapter 7670, without a public hearing. The Commissioner has determined that the proposed amendment of these rules will be noncontroversial in nature and has elected to follow the procedures set forth in the Minnesota Statutes, sections 14.22 to 14.28. Authority for the adoption of these rules is contained in Minnesota Statutes, section 216C.19, subdivision 8.

(2) All persons have 30 days in which to submit comment in support of or in opposition to any part or subpart of the proposed amendments. Comment is encouraged. (3) Each comment should identify the proposed amendment addressed, the reason for the comment, and any change proposed.

All persons may make a written request for a public hearing on the proposed amendments within the 30-day comment period. (4) If 25 or more persons submit a written request for a public hearing within the 30-day comment period, a public hearing will be held unless a sufficient number withdraw their requests in writing. (6) Any person requesting a public hearing must state his or her name and address and is encouraged to identify the portion of the proposed amendment addressed, the reason for the request, and any change proposed. (7) If a public hearing is required, the agency will proceed pursuant to Minnesota Statutes, sections 14.131 to 14.20.

PLEASE NOTE: that if twenty five or more persons submit written requests for a public hearing within the 30 day comment period, a public hearing will be held on November 5, 1990 unless a sufficient number withdraw their requests in accordance with the notice of hearing on these rules published in the STATE REGISTER and mailed to persons registered with the Department of Public Service. To verify whether a hearing will be held, please call the Department of Public Service, Energy Information Center on October 31, 1990 between the hours on 8:00 a.m. and 4:15 p.m. at 296-5175 or Minnesota toll free 800-652-9747 (ask for "Energy").

(5) Comments or written requests for a public hearing must be submitted to:

Bruce Nelson, Senior Engineer
Department of Public Service, Energy Division
790 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101
phone (612) 297-2313 fax (612) 297-1959.

Comments or requests for a public hearing must be received no later than 4:30 p.m. on October 30, 1990.

(8) The proposed amendments may be modified if the modifications are supported by the data and views submitted to the Department and do not result in a substantial change in the proposed amendments as noticed.

A Copy of the proposed rule amendment is attached to this notice.

(12) **A Statement of Need and Reasonableness** that describes the need for and reasonableness of each provision of the proposed amendments and identifies the data and information relied upon to support the proposed amendments has been prepared and is available by requesting a copy from Mr. Nelson at the address listed above.

(13) The adoption of these rules will not result in additional spending by local bodies of government in excess of $100,000 per year in either of the first two years following their adoption.

(9) If no hearing is required, upon adoption of the rule, the rule and the required supporting documents will be submitted to the Attorney General for review as to legality and form to the extent that form relates to legality. Any person may request notification of the date of submission to the Attorney General. Persons who wish to be advised of the submission of this material to the Attorney General, or who wish to receive a copy of the adopted rules, must submit a written request for such to Mr. Nelson at the address listed above.

Tony Perpich, Commissioner
Department of Public Service

Sept 14-1990
Dated

Notice of Hearing and Notice of Intent to Cancel Hearing if Fewer than Twenty-Five Persons Request a Hearing in Response to Notice of Intent to Adopt Rules without a Public Hearing

Notice is hereby given that a public hearing on the above-entitled matter will be held on November 5, 1990 in Conference Room 4, 9th floor of the American Center Building, 150 East Kellogg Boulevard, St. Paul, Minnesota commencing at 9:00 a.m. and continuing until all interested or affected persons have an opportunity to participate. The proposed rules may be modified as a result of the hearing process. Therefore, if you are affected in any manner by the proposed rule, you are urged to participate in the rule hearing process.

PLEASE NOTE, HOWEVER, that the hearing will be cancelled if fewer than twenty-five persons request a hearing in response to the notice of intent to adopt these same rules without a public hearing published in this State

Register and mailed to persons registered with the Department of Public Service, Energy Division. To verify whether a hearing will be held, please call the Department of Public Service, Energy Information Center on October 31, 1990 between the hours of 8:00 a.m. and 4:15 p.m. at 296-5175 or Minnesota toll free 800-652-9747 (ask for "Energy").

Following the agency's presentation at the hearing, all interested or affected persons will have an opportunity to participate. Such persons may present their views either orally at the hearing or in writing at any time prior to the close of the hearing. All evidence presented should be pertinent to the matter at hand. Written material not submitted at the time of the hearing which is to be included in the hearing may be mailed to Bruce D. Campbell, Administrative Law Judge, Office of Administrative Hearings, 310 Fourth Avenue South, Minneapolis, Minnesota 55415; telephone 612/341-7602, either before the hearing or within five working days after the public hearing ends. The Administrative Law Judge may at the hearing, order the record to be kept open for a longer period not to exceed 20 calendar days. The comments received during the comment period shall be available for review at the Office of Administrative Hearings. Following the close of the comment period the agency and all interested persons have three business days to respond in writing to any new information submitted during the comment period. During the three day period, the agency may indicate, in writing, whether there are amendments suggested by other persons which the agency is willing to adopt. No additional evidence may be admitted during the three day period. The written responses shall be added to the rulemaking record. Upon the close of the record the Administrative Law Judge will write a report as provided for in Minnesota Statutes, Sections 14.15 to 14.50. The rule hearing is governed by Minnesota Statutes, section 14.14 to 14.20 and by Minnesota Rules, parts 1400.0200 to 1400.1200. Questions about procedure may be directed to the Administrative Law Judge.

Authority for the adoption of these rules is contained in Minnesota Statutes, section 216C.19, subdivision 8.

The adoption of these rules will not result in additional spending by local bodies of government in excess of $100,000 per year in either of the first two years following their adoption.

A Copy of the proposed rule amendment is attached to this notice.

NOTICE: Any person may request notification of the date on which the Administrative Law Judge's report will be available, after which date the agency may not take final action on the rules for a period of five working days. If you desire to be notified, you may so indicate at the hearing. After the hearing, you may request notification by sending a written request to the Administrative Law Judge. Any person may request notification of the date on which the rules were adopted and filed with the secretary of state, The notice must be mailed on the same day the rules are filed. If you want to be so notified you may so indicate at the hearing or send a request in writing to the agency at any time prior to filing the rules with the secretary of state.

NOTICE IS HEARBY GIVEN that a Statement of Need and Reasonableness is now available for review at the Agency and at the Office of Administrative Hearings. The Statement of Need and Reasonableness includes a summary of all the evidence and argument which the agency anticipates presenting at the hearing justifying both the need for and reasonableness of the proposed rules. Copies of the Statement of Need and Reasonableness may be reviewed at the agency or the Office of Administrative Hearings and may be obtained from the Office of Administrative Hearings at the cost of reproduction.

Copies of the Statement of Need and Reasonableness are also available by submitting a request to:

Bruce Nelson, Senior Engineer
Department of Public Service, Energy Division
790 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101
phone (612) 297-2313 fax (612) 297-1959.

Minnesota Statutes, Chapter 10A requires each lobbyist to register with the State Ethical Practices Board within five days after he or she commences lobbying. A lobbyist is defined in Minnesota Statutes, section 10A.01, subdivision 11 as any individual:

(a) engaged for pay or other consideration, or authorized by another individual or association to spend money, who spends more than five hours in any month or more than $250.00, not including travel expenses and membership dues, in any year, for the purpose of attempting to influence legislative or administrative action by communication or urging others to communicate with public officials;

(b) who spends more than $250.00, not including his own traveling expenses and membership dues, in any year, for the purpose of attempting to influence legislative or administrative action by communicating or urging others to communicate with public officials.

The statute provides certain exceptions. Questions should be directed to the Ethical Practices Board, 625 North Robert Street, St. Paul, Minnesota 55101, telephone 612-296-5148.

Tony Perpich, Commissioner
Department of Public Service

Sept 4, 1990
Dated

Department of Public Service

Proposed Permanent Rules Relating to Minnesota Energy Code

Rules as Proposed

GENERAL

7670.0100 AUTHORITY; SCOPE; CONFLICTS.

Subpart 1. **Authority.** This chapter is adopted pursuant to Minnesota Statutes, section 216C.19, subdivision 8 ~~and constitute amendments to~~.

Subp. 2. **Scope.** Under Minnesota Statutes, section 216C.19, subdivision 8, this chapter is a part of the State Building Code, adopted in accordance with Minnesota Statutes, sections 16B.59 to 16B.73.

Subp. 3. **Conflicts.** In cases of conflict with other parts of the State Building Code, this chapter governs in all cases not affecting safety and health requirements.

~~Additionally, this chapter is intended to serve as standards for conducting maxi-audits of existing buildings owned by the state, the University of Minnesota, cities, counties, and school districts as specified in Minnesota Statutes, section 216C.20.~~

7670.0120 EFFECTIVE DATE.

The effective date of this chapter is ~~January~~ February 1, ~~1984~~ 1991.

7670.0125 LEGISLATIVE MANDATES CONCERNING THE MINNESOTA ENERGY CODE.

An enclosed structure or portion of an enclosed structure constructed after January 1, 1978, and used primarily as a commercial parking facility for three or more motor vehicles may not be heated. Incidental heating resulting from building exhaust air passing through a parking facility is not prohibited if substantially all useful heat previously has been removed from the air.

Approved by Revisor

EXCEPTION: Parking facilities that are appurtenant to dwelling unit occupancies.

7670.0130 ~~ADOPTION~~ INCORPORATIONS BY REFERENCE ~~OF THE MODEL ENERGY CODE WITH AMENDMENTS~~.

Subpart 1. **Incorporated items.** The following standards and references are incorporated by reference:

A. The Model Energy Code, ~~1983~~ 1989 Edition, as published by the Council of American Building Officials (Falls Church, Virginia), ~~is incorporated by reference and made a part of the State Building Code, subject to the amendments in this chapter~~ as amended by parts 7670.0330 to 7670.1000.

B. Code of Federal Regulations, title 10, part 435, Energy Conservation Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; subpart 103, Lighting and subpart 105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in sheet metal construction.

C. ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality as published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (Atlanta, GA).

D. ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings.

E. AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.

F. ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box.

G. ASTM C 976-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box.

H. WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory.

Subp. 2. **Availability.** All standards and documents

Approved by Revisor _____

incorporated by reference are available for public inspection at the Minnesota State Law Library and through the Minitex interlibrary loan system. In addition:

A. ASHRAE and ANSI/ASHRAE documents and standards are available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers - Publication Sales, 1791 Tullie Circle NE, Atlanta, GA 30329;

B. AAMA standards are available from the American Architectural Manufacturers Association, 2700 River Road, Des Planes, IL 60018;

C. ASTM standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103; and

D. The WINDOW computer program is available from Bostik Construction Products, P.O. Box 8, Huntington Valley, PA 19006.

7670.0250 APPLICABILITY.

Buildings covered by this chapter must comply with the Model Energy Code as amended by parts 7670.0325 to 7670.1000. This part also applies to remodeled elements of buildings covered by the State Building Code. This chapter governs in case of conflict with the Model Energy Code.

EXCEPTION: Relocated residential buildings need not comply with this chapter, except that, where available, an energy audit must be conducted on the relocated building.

7670.0325 AMENDMENTS TO SECTION 201: DEFINITIONS.

Subpart 1. Thermal transmittance (U). In section 201 of the Model Energy Code, the definition of "Thermal transmittance (U)" is amended to read:

THERMAL TRANSMITTANCE (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature differential between the warm side and cold side air films (Btu/h ft^2 F).

A. Thermal transmittance of opaque wall components (U_w) and roof/ceiling components (U_r) must be calculated using one of the following methods appropriate for the application:

Approved by Revisor

(1) Parallel heat flow method:

Reference: Model Energy Code, chapter 5, equation 1.

Applications: Wood frame and masonry with surface applied thermal insulation.

(2) Series-parallel method:

Reference: RS-1, page 22.4.

Applications: Masonry blocks with insulation inserts or filled cores, nonmetal surface with metal framing.

(3) Thermal bridges in sheet metal construction method:

Reference: Code of Federal Regulations, title 10, part 435.105, section 5.3.3.2.1(d).

Applications: Metal framing bonded on one or both sides to a metal skin or covering.

(4) Zone method:

Reference: RS-1, page 22.10.

Applications: Metal surface with nonmetal framing.

B. Thermal transmittance of window area (U_g) and skylight elements (U_s) must be determined in accordance with one of the following methods:

(1) Reference RS-1, representative U-values for fenestration products, pages 27.16 to 27.18;

(2) AAMA Standard 1503.1;

(3) ASTM C 236 or ASTM C 976, using design conditions specified in footnote (a) of table 13, chapter 27 of reference RS-1; or

(4) WINDOW computer program.

Subp. 2. **Vapor retarder.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

VAPOR RETARDER. A material to retard air and water vapor passage designed to meet a maximum perm rating of 1.0 grain per hour per ft^2 per inch Hg pressure differential. Polyethylene material that is not cross laminated which is used to meet the requirements of this paragraph must be designed to have a minimum thickness of four mills.

Subp. 3. **Wind wash.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WIND WASH. Wind wash is the passage of unconditioned air

Approved by Revisor _____

through thermal insulation of the building envelope.

Subp. 4. **Window area.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WINDOW AREA. Window area, or glazing area, is either the area of glazing and sash, or the area used by the manufacturer to determine the window thermal transmittance.

7670.0400 AMENDMENT TO ~~302.1~~ SECTION 302: ~~FOOTNOTE 1~~ DESIGN CONDITIONS.

~~On page 12 of the code,~~ Footnote 1 ~~to~~ of section 302.1 of the Model Energy Code is amended to read:

[1]~~The~~ Outdoor design ~~temperature shall~~ conditions must be ~~selected from the columns of 99 percent values for winter and one percent values for summer from tables in~~ Standard RS-1. Heating design temperatures must be no lower than the temperature listed in the 99 percent column. Cooling design temperatures must be no greater than the temperature listed in the 2.5 percent column.

EXCEPTION: Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the median of annual extremes for heating and one percent column for cooling may be used.

Heating degree days ~~heating shall~~ must be selected from Standard RS-22. Adjustments may be made as determined by the building official to reflect local climates which differ from the tabulated temperatures or local weather experience ~~as determined by the building official~~.

7670.0450 AMENDMENT TO SECTION 303: VENTILATION.

Section 303.1 of the Model Energy Code is amended to read:

303.1 Ventilation. Ventilation systems must be designed to conform with ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality.

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE.

Section 502.2.1 of the Model Energy Code is amended by

Approved by Revisor

adding a new section to read:

502.2.1.7 Alternative compliance. Alternative methods of compliance with section 502.2.1 for one- and two-family residential buildings.

Minimum performance for Type A-1 (one- and two-family) buildings:

Ceilings	Walls	Floors	Windows	Doors
R-38	R-19[1]	R-19[1]	Maximum U-0.49[2]	R-3

(1) For the insulation within the cavity of opaque walls and rim joists.

(2) Maximum window area must not exceed 12 percent of the area of exterior walls, not including foundation walls.

Site-built fixed glazing must be installed in either an aluminum or steel frame having a minimum 0.25 inch low conductance thermal break or in wood or vinyl framing. The glazing must be either double-glazed with a dead air space between panes of nominal one-half inch spacing or triple-glazed with a dead air space between panes of not less than one-fourth inch.

Foundation walls must comply with part 7670.0510, slab-on-grade floors must comply with section 502.2.1.4 and crawl space walls must comply with section 502.2.1.5.

7670.0480 AMENDMENT TO SECTION 502: EFFECTIVENESS OF REQUIRED THERMAL INSULATION.

Section 502.2 of the Model Energy Code is amended by adding paragraphs to read:

Subpart 1. **Thermal insulation.** Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards.

Subp. 2. **Cold weather vapor condensation.** Building assemblies are required to maintain the thermal performance of required insulation and the integrity of building materials against cold weather water vapor condensation.

A. A vapor retarder must be installed between the interior surface and the winter design condition dew point

Approved by Revisor _____

location within each building envelope surface. Joints in the vapor retarder must be sealed between solid blocking.

EXCEPTION: A vapor barrier need not be installed on the rim joist insulation.

B. A barrier against air leakage must be installed to prevent the leakage of moisture-laden air from the house into the building envelope. An air barrier must be continuous at all plumbing and heating penetrations of interior surface of the building exterior envelope. If a tub or shower is located on an exterior wall, an air barrier must be provided at the interior surface of the building exterior envelope behind the tub or shower.

Subp. 3. **Preventing wind wash.** A barrier must be provided at the following locations to mitigate wind wash:

A. the exterior edge of attic insulation; and

B. cantilevered floors and bay windows, including corners with adjoining vertical walls above and below.

7670.0500 AMENDMENT TO ~~502.2.1.4~~ 502: SLAB ON GRADE FLOORS.

~~On page 19 of the code,~~ Section 502.2.1.4 of the Model Energy Code is amended to read:

502.2.1.4 Slab on grade floors. For slab on grade floors, the thermal resistance of the insulation around the perimeter of the floor must be not less than the value given in Table No. 5-~~1~~ 502.2.1. The insulation must extend downward from the top of the slab to the design frost line or downward to the bottom of the slab then horizontally beneath the slab for an equivalent distance, and must be an approved type.

7670.0510 AMENDMENT TO ~~502.2.1~~ SECTION 502: FOUNDATION WALLS.

~~On page 19~~ Section 502.2.1.6 of the Model Energy Code, ~~502.2.1~~ is amended ~~by adding a paragraph~~ to read:

Subpart 1. 502.2.1.6 Foundation walls. Foundation walls enclosing heated or conditioned spaces must be insulated.

Either the thermal resistance (R) of the insulation on the entire opaque foundation wall must be not less than R-5, or the thermal resistance (R) of the insulation on the opaque

Approved by Revisor _____

foundation wall must be not less than R-10 from the top of the wall down to the design frost line. If the top of the footing is at or above the design frost line, the thermal resistance (R) of the insulation on the wall must not be less than R-5 from the top of the wall to the top of the footing.

Subp. 2. **Intended use; installation.** All insulation used in or on foundation walls must be approved for the intended use. The insulation must be installed in accordance with the approved manufacturer's specifications.

Subp. 3. **Exterior insulation.** If the foundation wall insulation is on the exterior, the portion from the top of the foundation wall to six inches below grade must be covered by an approved protective coating finish to protect the insulation from deterioration due to sunlight and physical abuse.

7670.0550 AMENDMENT TO ~~502.4.3~~ SECTION 502: AIR LEAKAGE.

~~On page 23 of the code,~~ Section 502.4.3 of the Model Energy Code is amended to read as follows:

Subpart 1. ~~502.4.3.1~~ 502.4.3 Exterior joints in the building envelope that are sources of air leakage~~, such as around window and door frames,~~ must be caulked, gasketed, or otherwise sealed in an approved manner. These air leak sources include, but are not limited to, areas between wall cavities and window or door frames, between walls and foundations, between walls and roofs or ceilings and between wall panels, ~~openings~~ and at penetrations of utility services ~~through walls, floors, and roofs, and all other similar openings in the building envelope must be caulked, gasketed, or otherwise sealed in an approved manner. A continuous air barrier must be provided at all electrical, mechanical, and plumbing penetrations~~.

Subp. 2. **Alternative.** As an alternative to the prescriptive requirements of subpart 1 for detached single-family residential buildings, air tightness must comply with air leakage class A, B, C, or D of ANSI/ASHRAE Standard 119. In addition, this alternative requires that the ventilation system must provide a ventilation rate of not less

Approved by Revisor _____

than 0.35 air changes per hour (determined in accordance with ASHRAE Standard 62, Table 2.3) or 15 cfm per person, whichever is greater. This ventilation rate must be verified by measurement.

Subp. 3. **Fire stops.** Fire stops must be installed in accordance with the State Building Code. When mineral fiber or glass fiber materials are used as fire stop construction at ceilings and wall cavities separating conditioned and nonconditioned spaces, the fire stop must be installed to block air movement.

EXCEPTIONS: A fire stop need not block air movement if its installation would conflict with any other part of the State Building Code.

7670.0610 ~~AMENDMENT~~ AMENDMENTS TO ~~503.2~~ SECTION 503: BUILDING MECHANICAL SYSTEMS.

Subpart 1. **Calculation procedures.** ~~On page 24~~ Section 503.2.1 of the Model Energy Code~~, 503.2~~ is amended ~~by adding a paragraph~~ to read:

~~503.2.3 System design heating and cooling capacity. The rated capacity of the heating and cooling system at design conditions may not be greater than 115 percent for heating, 100 percent for cooling at design output load calculated in accordance with 503.2, whenever appropriate equipment is available.~~

~~Exceptions: 1. Equipment designed for standby purposes.~~
~~2. Cooling capacity of heat pumps.~~
~~3. Systems designed for pick up after automatic temperature setback when a registered professional engineer shows that the extra system design heating and cooling capacity is needed for pick up.~~

503.2.1 Calculation procedures. Heating and cooling system design loads for the purpose of sizing systems and equipment must be determined in accordance with the procedures described in Standard RS-1. For those design parameters addressed in part 7670.0400, the values specified must be used.

503.2.1.1 Safety factor. Design loads may at the designer's option be increased by as much as ten percent to account for unexpected loads or changes in space usage.

Approved by Revisor _____

503.2.1.2 Pick-up loads. Transient loads such as warm-up or cool-down loads that occur after off-hour setback or shutoff may be calculated from principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be up to 30 percent for heating and ten percent for cooling of the steady-state design loads. The steady-state load may include a safety factor in accordance with section 503.2.1.1.

Subp. 2. **System and equipment sizing.** Section 503.2 of the Model Energy Code is amended by adding a paragraph to read:

503.2.3 System and equipment sizing. HVAC systems and equipment must be sized to provide no more than the space and system loads calculated in accordance with 503.2.1.

Exceptions:

(a) Equipment capacity may exceed the design load if the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Equipment whose capacity exceeds the design load may be specified if oversizing the equipment can be shown to not increase the overall annual energy costs.

(c) Stand-by equipment may be installed if controls and devices are provided that allow stand-by equipment to operate automatically only when the primary equipment is not operating.

(d) Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on load.

(e) For a single piece of equipment that has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function must be, within available equipment options, the smallest size necessary to meet the load.

7670.0660 AMENDMENT TO ~~TABLE NO. 5-7~~ SECTION 503: EQUIPMENT

Approved by Revisor _____

EFFICIENCY.

Subpart 1. Table No. 503.4.3. Table No. 503.4.3 of the Model Energy Code "HVAC System Heating Equipment - Gas- and Oil-Fired Minimum Steady State Combustion Efficiency" is amended by changing the requirement for forced-air furnaces and low-pressure steam or hot-water boilers for all other commercial or industrial furnaces and boilers to 80 percent.

~~On page 29~~ Subp. 2. Table No. 503.4.8. Section 503 of the Model Energy Code~~, Table No. 5-7~~ is amended by adding a table to read:

Table No. ~~5-7~~ 503.4.8 -- Minimum EER and COP for Electrically Driven ~~HVAC System Components~~ Water Source Hydronic Heat Pumps[1]

~~Component~~	~~Type of Compressor~~	~~Condensing Means: Air EER~~	~~Air COP~~	~~Water EER~~	~~Water COP~~	~~Evaporative EER~~	~~Evaporative COP~~
~~Self-contained water-chillers~~	~~Centrifugal~~	~~8.00~~	~~2.34~~	~~13.00~~	~~4.04~~		
	~~Positive displacement~~	~~8.40~~	~~2.46~~	~~12.00~~	~~3.51~~		
~~Condenserless water-chillers~~	~~Positive displacement~~	~~9.90~~	~~2.9~~	~~12.00~~	~~3.51~~		
~~Compressor and condenser units 65,000 Btu/h (19,050 watts) and over[2]~~	~~Positive displacement~~	~~9.50~~	~~2.78~~	~~12.50~~	~~3.66~~	~~12.50~~	~~3.66~~

~~Water-Source Hydronic Heat Pump~~	Size	under 19 kW (65,000 Btu/h)		19 kW (65,000 Btu/h) and over	
		~~EER~~	~~COP~~	~~EER~~	~~COP~~
	~~Centrifugal~~	~~9.0~~	~~2.64~~	~~9.4~~	~~2.75~~
	EER	9.0		9.4	
	COP	2.64		2.75	

[1]When tested at the standard rating conditions specified in Table No. ~~5-10C~~ 503.4.6a.

~~[2]Ratings in accordance with Standard RS-14 as applicable. COP based on condensing unit standard rating capacity and energy input to the unit, all at sea level.~~

7670.0670 AMENDMENT TO ~~503.10.2~~ SECTION 503.10: DUCT CONSTRUCTION.

Approved by Revisor _____

~~On page 33 of the code,~~ Section 503.10.2 of the Model Energy Code is amended to read:

503.10.2. For low pressure supply and return air ducts located outside of the conditioned space, all transverse joints must be sealed using mastic, tape, or mastic ~~plus~~ and tape. For fibrous glass ductwork, pressure sensitive tape may be used.

7670.0710 ~~DELETION OF 504.5.3~~ AMENDMENTS TO SECTION 504: SERVICE WATER HEATING.

Subpart 1. **Time clocks.** ~~On page 38~~ Section 504.5 of the Model Energy Code~~,~~ is amended by deleting section 504.5.3 ~~is deleted~~.

Subp. 2. **Pipe insulation.** Section 504.7 of the Model Energy Code is amended by deleting the exception.

Subp. 3. **Devices to limit temperature.** Section 504.8.2 of the Model Energy Code is amended by deleting section 504.8.2.2.

7670.0800 ~~AMENDMENT OF 505.2~~ AMENDMENTS TO SECTION 505: ELECTRIC POWER AND LIGHTING.

Subpart 1. **Electric energy determination.** The exception to section 505.2 of the Model Energy

~~On page 39 of the~~ Code~~,~~ ~~505.2~~ is amended to read:

~~505.2 Electric energy determination.~~

~~In any multi-tenant residential building, provisions shall be made to separately determine the electric energy consumed by each tenant. Electrical service to individual dwelling units in buildings containing two or more units shall be separately metered, with individual metering readily accessible to the individual occupants.~~

EXCEPTION: Motels, hotels, college dormitories, other transient facilities, and buildings intended for occupancy primarily by persons who are 62 years of age or older or handicapped, or which contain a majority of units not equipped with complete kitchen facilities.

Subp. 2. **Lighting power budget.** The lighting requirements of sections 505.3 and 505.4 of the Model Energy code are amended to read:

Approved by Revisor _____

The lighting power budget must be the upper limit of the power to provide the lighting needs in accordance with the 1988 and 1989 criteria and calculation procedure specified in Code of Federal Regulations, title 10, part 435.103 (excluding section 3.2).

EXCEPTION: One- and two-family detached dwellings and the dwelling portion of multifamily buildings.

7670.0850 AMENDMENT TO SECTION 600: DESIGN BY ACCEPTABLE PRACTICE.

Section 601.1 of the Model Energy Code is amended by adding a paragraph to read:

Buildings constructed in accordance with this section must also comply with parts 7670.0480 to 7670.0800.

7670.1000 ~~AMENDMENT~~ AMENDMENTS TO ~~701.1~~ SECTION 701: REFERENCES.

~~On page 54 of the code,~~ Section 701.1~~, Code Standard No. RS-4,~~ of the Model Energy Code is amended by replacing the following code standard numbers to read:

RS-1	1989 ASHRAE Handbook of Fundamentals.
RS-3	ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality.
RS-4	ASHRAE Standard 55-1981 Thermal Environment Conditions for Human Occupancy.
RS-17 & RS-18	SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985.
RS-23	Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80 Minnesota. National Oceanic and Atmospheric Administration September 1982.

REPEALER. Minnesota Rules, parts 7670.0110; 7670.0200; 7670.0210; 7670.0220; 7670.0300; 7670.0310; 7670.0320; 7670.0330; 7670.0340; 7670.0520; 7670.0540; 7670.0600; 7670.0620; 7670.0630; 7670.0640; 7670.0650; 7670.0700; 7670.0720; 7670.0730; 7670.0900; 7670.0910; 7670.0920; 7670.0930; 7670.0940; 7670.0950; 7670.0960; 7670.0970; 7670.1010; 7670.1020; 7670.1030; 7670.1100; and 7670.1110 are repealed.

Approved by Revisor _____

Office of the Revisor of Statutes

Administrative Rules

TITLE: Proposed Permanent Rules Relating to Minnesota Energy Code

AGENCY: Department of Public Service

MINNESOTA RULES: Chapter 7670

INCORPORATIONS BY REFERENCE:

Part 7670.0130: Model Energy Code, 1989 Edition, published by Council of American Building Officials, Falls Church, Virginia, as amended by parts 7670.0330 to 7670.1000; ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, published by American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, Georgia; ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings; AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections; ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box; ASTM C 979-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box; WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory. Available at Minnesota State Law Library and through Minitex interlibrary loan system.

The attached rules are approved for publication in the State Register

Paul M. Marinac
Assistant Deputy Revisor

STATE OF MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

In the Matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service Amending the State Building Code Regarding Heat Loss, Illumination and Climate Control, Minn. Rules Ch. 7670

AFFIDAVIT OF MAILING THE NOTICE OF INTENT TO ADOPT A RULE WITHOUT A PUBLIC HEARING AND NOTICE OF INTENT TO ADOPT A RULE WITH A PUBLIC HEARING IF TWENTY-FIVE OR MORE PERSONS REQUEST A HEARING

STATE OF MINNESOTA)
) ss.
COUNTY OF RAMSEY)

MARLENE ODEEN, being first duly sworn deposes and says:

I hereby certify that on the 25th day of September, 1990, at the City of St. Paul, County of Ramsey, State of Minnesota, I mailed the attached Notice of Intent to Adopt a Rule Without a Public Hearing and Notice of Intent to Adopt a Rule with a Public Hearing if Twenty-five or More Persons Request a Hearing by depositing in the State of Minnesota Central Mail System, a copy thereof, with postage prepaid, to all persons and associations who have requested, pursuant to Minnesota Statutes, sections 14.14, subdivision 1a and 14.22 or 14.30, that their names be placed on the state Department of Public Service, Energy Division, rulemaking mailing list.

Marlene Odeen
(name)

Secretary
(title)

Subscribed and sworn to before me
this 25th day of September, 1990.

Dennis M. Devereaux
Notary Public

DENNIS M. DEVEREAUX
NOTARY PUBLIC-MINNESOTA
RAMSEY COUNTY
My Comm. Expires Apr. 1, 1994

STATE OF MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

In the Matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service Amending the State Building Code Regarding Heat Loss, Illumination and Climate Control, (Minn. Rules Ch. 7670)

AFFIDAVIT OF CERTIFICATION OF MAILING LIST FOR NOTICE OF INTENT TO ADOPT A RULE WITHOUT A PUBLIC HEARING AND NOTICE OF INTENT TO ADOPT A RULE WITH A PUBLIC HEARING IF TWENTY-FIVE OR MORE PERSONS REQUEST A HEARING

STATE OF MINNESOTA)
) ss.
COUNTY OF RAMSEY)

Judy Schmidt, being first duly sworn deposes and says:

I hereby certify that the list of persons and associations who have requested, pursuant to Minnesota Statutes, sections 14.14, subdivision 1a and 14.22 or 14.30, that their names be placed on the state Department of Public Service, Energy Division, rulemaking mailing list is accurate, complete, and current as of this 24 day of Sept, 1990.

Judy Schmidt
(name)

Data Proc. Coord
(title)

Subscribed and sworn to before me this 24th day of September, 1990.

Elizabeth A. Woodhouse
Notary Public

ELIZABETH A. WOODHOUSE
NOTARY PUBLIC-MINNESOTA
RAMSEY COUNTY
MY COMMISSION EXPIRES FEBRUARY 28, 1993

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
RUDY BOSCHWITZ	HART STATE OFFICE BLDG-RM SH506 WASHINGTON, DC 20510	MCD
DAVID DURENBERGER	RUSSELL BLDG-RM 154 WASHINGTON, DC 20510	MCD
WILLIAM FRENZEL	LONGWORTH OFFICE BLDG-RM 1026 WASHINGTON, DC 20515	MCD
MICHAEL JOHNSON	117 FIFTH ST W - BOX 95 BLUE EARTH, MN 56013	RULES
RALPH T KEYES	2240 MIDLAND GRV RD ST PAUL, MN 55113	RULES
JAMES L OBERSTAR	RAYBURN OFFICE BLDG-RM 2351 WASHINGTON, DC 20515	MCD
RONALD E OLSON	5416 70TH ST W EDINA, MN 55435	RULES
TIMOTHY PENNY	CANNON OFFICE BLDG-RM 436 WASHINGTON, DC 20515	MCD
ALFRED J ROSS	6356 WARE RD LINO LAKES, MN 55014	RULES
MARTIN O SABO	RAYBURN OFFICE BLDG. - RM 2201 WASHINGTON, DC 20515	MCD
ARLAN STANGELAND	RAYBURN OFFICE BLDG. - RM 2245 WASHINGTON, DC 20515	MCD
BRUCE F VENTO	RAYBURN OFFICE BLDG. - RM 2304 WASHINGTON, DC 20515	MCD
VIN WEBER	CANNON OFFICE BLDG. - RM 106 WASHINGTON, DC 20515	MCD
ADMIN HEARING OFFICE SAM RUHLE	310 FOURTH AVE - RM 400 MINNEAPOLIS, MN 55415	RULES
ALABAMA DEPT OF ENERGY	3465 NORMAN BRIDGE RD MONTGOMERY, AL 36105	SEO
ALASKA ENERGY OFFICE	949 E. 36TH AVE - RM 400 ANCHORAGE, AK 99508	SEO

‹‹‹‹ R U L E S ››››

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
ARIZONA ENERGY OFFICE MARK GINSBERG	1700 WASHINGTON ST W PHOENIX, AZ 85007	SEO
ARKANSAS ENERGY OFFICE-ECON PLAN	1 CAPITOL MALL-RM 2C 105 LITTLE ROCK, AR 72201	SEO
BEMIDJI CHAMBER OF COMMERCE	BOX 850 BEMIDJI, MN 56601	RULES
BRAINERD WATER & LIGHT DEPT WALTER C SJOLUND	501 LAUREL ST-BOX 373 BRAINERD, MN 56401	RULES
BROEKER GEER LMTD. JOHN M BROEKER	8500 NORMANDALE LK BLVD #1510 MINNEAPOLIS, MN 55437	RULES
CALIFORNIA ENERGY COMMISSION	1516 NINTH ST SACRAMENTO, CA 95814	SEO
CARLTON COUNTY HUMAN SERVICES WILLIAM K. PINSONNAULT	BOX 316, 1215 AVENUE C CLOQUET, MN 55720	RULES
CITY OF BELLE PLAINE DAVID J UNMACHT	420 MAIN ST E BELLE PLAINE, MN 56011	RULES
CITY OF CIRCLE PINES JAMES KEINATH	200 CIVIC HEIGHTS CIRCLE CIRCLE PINES, MN 55014	RULES
CLOQUET CITY OF WILLIAM SCHLENVOGT	508 CLOQUET AVE CLOQUET, MN 55720	RULES
COLORADA OFFICE OF ENERGY CONSERV ROLAND RIVERA	112 14TH AVE E DENVER, CO 80203	SEO
COLUMBIA DIST OF ENERGY UNIT	613 G ST. N.W. WASHINGTON, DC 20001	SEO
CONNECTICUT ENERGY DIVISION BRADFORD S. CHASE	80 WASHINGTON ST HARTFORD, CT 06106	SEO
COOPERATIVE POWER ASSN ROBERT P AMBROSE	14615 LONE OAK RD EDEN PRAIRIE, MN 55344	RULES
COOPERATIVE POWER ASSN ADE MUSSELL	14615 LONE OAK ROAD EDEN PRAIRE, MN 55344	RULES
COTTONWOOD CO OFFICES FARLEY GRUNIG	COURTHOUSE WINDOM, MN 56101	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
DAIRYLAND POWER COOPERATIVE ALBERT D DIAL	BOX 817 LACROSSE, WI 54602	RULES
DELAWARE ENERGY OFFICE	FEDERAL ST-BOX 1401 DOVER, DE 19903	SEO
DORSEY AND WHITNEY BECKY A COMSTOCK	220 SIXTH ST S-RM 2300 MINNEAPOLIS, MN 55402	RULES
DORSEY AND WHITNEY WILLIAM J. KEPPEL	2200 FIRST BANK PL E MINNEAPOLIS, MN 55402	RULES
E W A INC	133 FIRST AVE NORTH MINNEAPOLIS, MN 55401	RULES
FARIBAULT AREA CHAMBER OF COMMERCE ELAINE KENOW	228 CENTRAL AVE -- P. O. BOX 434 FARIBAULT, MN 55021	RULES
FLORIDA ENERGY OFFICE	BRYANT BLDG-RM 301 TALLAHASEE, FL 32301	SEO
FRIDLEY CITY OF JIM ROBINSON	6431 UNIVERSITY AVE NE FRIDLEY, MN 55432	RULES
GEO. A. HORMEL & CO DOUGLAS D. HAHN, P.E.	BOX 800 AUSTIN, MN 55912	RULES
GEORGIA OFFICE OF ENERGY RESOURCES	270 WASHINGTON ST SW-STE 615 ATLANTA, GA 30334	SEO
GUAM ENERGY OFFICE	BOX 2950 AGANA, GM 96910	SEO
HASTINGS CITY OF THOMAS HARMENING	100 SIBLEY ST HASTINGS, MN 55033	RULES
HAWAII ENERGY OFFICE	335 MERCHANT ST. RM 110 HONOLULU, HI 96813	SEO
HENN CNTY ENVIRONMENT & ENERGY OFF BEN KERMMOADE	822 SOUTH 3RD ST. SUITE 300 MINNEAPOLIS, MN 55415	RULES
HENN CNTY ENVIRONMENT & ENERGY OFF LUTHER D. NELSON	822 SOUTH 3RD ST. SUITE 300 MINNEAPOLIS, MN 55415	RULES
HENNEPIN CO PROPERTY MANAGEMENT JOHN G MCMILLAN	HENN CNTY GOVT CNTR, BLDG OFC-A LEVL MINNEAPOLIS, MN 55487	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
Hessian, McKaby and Soderberg Jerome M. Soderberg	4700 IDS Center Minneapolis, MN 55402	RULES
HONEYWELL INC W C VIITALA	HONEYWELL PLAZA-BOX 524 MINNEAPOLIS, MN 55440	RULES
HOYT HEATING CO. ERIC M. LANNES	PO BOX 60129 RENO/STEAD, NV 89506	RULES
IDAHO OFFICE OF ENERGY	450 STATE ST. W BOISE, ID 83720	SEO
ILLINOIS INST OF NAT RESOURCES	325 ADAMS ST W-RM 300 SPRINGFIELD, IL 62704	SEO
INDIANA ENERGY OFFICE	1 CAPITOL ST N-STE 700 INDIANAPOLIS, IN 46204	SEO
IOWA DEPT OF NATURAL RESOURCES ENERGY BUREAU	WALLACE STATE OFFICE BLDG DES MOINES, IA 50319	SEO
KANSAS CORP COMM-RESEARCH & ENERGY	STATE OFFICE BLDG-FOURTH FLR TOPEKA, KS 66612	SEO
KENTUCKY ENERGY CABINET LANA ROGERS	P.O. BOX 3249 FRANKFORT, KY 40603	SEO
LAKE SUPERIOR INDUSTRIAL BUREAU ALFRED E FRANCE	306 SUPERIOR ST W-#1408 ALWORTH DULUTH, MN 55802	RULES
LEFEVERE AND LEFLER JOHN E DRAWZ	2000 FIRST BANK PLACE WEST MINNEAPOLIS, MN 55402	RULES
LEHMANN & ASSOC INC ERNEST K LEHMANN	430 FIRST AVE N. - RM 790 MINNEAPOLIS, MN 55401	RULES
LEVANDER GILLEN MILLER & MAGNUSON ROGER C MILLER	633 CONCORD ST-RM 402-BOX 298 S ST PAUL, MN 55075	RULES
LINDBERG ASSOCIATES CLARENCE P LINDBERG	750 PLAZA DR S MENDOTA HTS, MN 55120	RULES
LOUISIANA DEPT OF NAT RESOURCES	BOX 94396 BATON ROUGE, LA 70804	SEO
LUVERNE CITY OF STEVEN L. PERKINS	203 MAIN ST E - BOX 348 LUVERNE, MN 56156	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
LYMAN LUMBER CO JUDITH A. JANICKE	300 MORSE AVE - BOX 40 EXCELSIOR, MN 55331	RULES
MAINE OFFICE OF ENERGY RESOURCES	STATE HOUSE-STN 53 AUGUSTA, ME 04333	SEO
MANKATO AREA CHAMBER OF COMMERCE	BOX 999 MANKATO, MN 56002	RULES
MARYLAND ENERGY OFFICE JAN SHOREY	45 CALVERT ST. ANNAPOLIS, MD 21401	SEO
MASSACHUSETTS ENERGY POLICY OFFICE	100 CAMBRIDGE ST-RM 1500 BOSTON, MA 02202	SEO
MICHIGAN ENERGY ADMINISTRATION	BOX 30228 LANSING, MI 48909	SEO
MINN ASSN OF TOWNSHIPS DAVID FRICKE	BOX 267 - 705 CENTRAL AVE. E. ST MICHAEL, MN 55376	RULES
MINN ATTORNEY GEN OFC-ANTITRUST DIV THOMAS F PURSELL	117 UNIV AVE - SECOND FLR ST PAUL, MN 55155	RULES
MINN AUTO DEALERS ASSN LOUIS W CLAESON JR	277 UNIVERSITY AVE ST PAUL, MN 55103	RULES
MINN COOPERATIVES ASSN OF ALLEN GERBER	480 CEDAR ST - RM 580 ST PAUL, MN 55101	RULES
MINN GOVERMENT REPORT JEAN DAWSON	STATE CAPITAL BLDG - PRESS RM B2 ST PAUL, MN 55155	RULES
MINN HOUSING FINANCE AGENCY HEIDE E. WHITNEY	400 SIBLEY ST - STE 300 ST PAUL, MN 55101	RULES
MINN LEGIS COMM TO REVIEW ADMIN RUL MARYANNE V HRUBY	STATE OFFICE BLDG - RM 55 ST PAUL, MN 55155	RULES
MINN MULTI HOUSING ASSN JOHN HORNER	4740 PARK GLEN RD MINNEAPOLIS, MN 55416	RULES
MINN PETROLEUM COUNCIL DARREL BUNGE	350 ST. PETER ST. - RM 1025 ST PAUL, MN 55102	RULES
MINN POLLUTION CONTROL AGENCY Gerald Willet	520 LAFAYETTE RD. N. ST. PAUL, MN 55155	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
MINN POWER CO ELAINE DEBEIR	30 SUPERIOR ST W DULUTH, MN 55802	RULES
MINN POWER CO JAMES A ROBERTS	30 SUPERIOR ST W DULUTH, MN 55802	RULES
MINN STATE UNIV SYSTEM MARY E STANTON	555 PARK ST-STE 230 ST PAUL, MN 55105	RULES
MINNEGASCO TRACY BRIDGE	201 SEVENTH ST S MINNEAPOLIS, MN 55402	RULES
MINNEGASCO INC. GEORGE H. LOFGREN	P.O. BOX 1165 MINNEAPOLIS, MN 55440	RULES
MINNESOTA SENATE DONALD J FRANK	STATE CAPITOL BLDG-RM G10 ST PAUL, MN 55155	RULES
MISSISSIPPI DEPT OF ENERGY	510 GEORGE ST-STE 300 JACKSON, MS 39202	SEO
MISSOURI DIV OF ENERGY	BOX 176 JEFFERSON CITY, MO 65102	SEO
MONTANA ENERGY DIV	1520 E. 6TH AVE HELENA, MT 59620	SEO
MONTEVIDEO CITY OF A.J. JOHNSON	BOX 676 MONTEVIDEO, MN 56265	RULES
MONTICELLO CITY OF	250 BROADWAY ST E MONTICELLO, MN 55362	RULES
MOSS AND BARNETT MICHAEL J AHERN	200 SIXTH ST S-1200 PILLSBURY CNTR MINNEAPOLIS, MN 55402	RULES
MPLS BLDG OWNERS & MGRS ASSN INC. ARTHUR W OLOFSON	927 SOO LINE BLDG-105 5TH ST S. MINNEAPOLIS, MN 55402	RULES
NEBRASKA ENERGY OFFICE ANN BROCKHOFF	BOX 95085 LINCOLN, NB 68509	SEO
NEVADA COMM SERVICES-ENERGY OFFICE	1100 WILLIAM ST E RM 117 CARSON CITY, NV 89710	SEO
NEW HAMPSHIRE GOV COUNCIL ON ENERGY MALTZIE SCOTT	2 1/2 BEACON ST CONCORD, NH 03301	SEO

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
NEW JERSEY DEPT OF COMM & ECON DEV ROBERT J. GOLDEN JR.	101 COMMERCE ST RM 204 NEWARK, NJ 07102	SEO
NEW MEXICO DEPT OF ENERGY &MINERALS	525 CAMINO DE LOS MARQUEZ SANTA FE, NM 87501	SEO
NEW YORK STATE ENERGY OFFICE CHARLES STUBER	2 ROCKEFELLER PLAZA-10TH FLR ALBANY, NY 12223	SEO
NORTH CAROLINA ENERGY DIV	BOX 25249 RALEIGH, NC 27611	SEO
NORTH CENTRAL PUBLIC SERVICE CO. JAMES A SMITH	1080 MONTREAL AVE ST PAUL, MN 55116	RULES
NORTH DAKOTA OFFICE OF ENERGY	STATE CAPITOL BLDG-14TH FL BISMARCK, ND 58505	SEO
NORTH MARIANA ISLANDS ENERGY PLANNR	P.O. BOX 340 SAIPAN, MR 96950	SEO
NORTHERN PRODUCTS LOG HOMES, INC. Allison T. Beaulieu	P.O. BOX 616 BANGOR, ME 04401	RULES
NORTHERN STATES POWER C. GARY ANDERSON	414 NICOLLET MALL MINNEAPOLIS, MN 55401	RULES
NORTHERN STATES POWER - LAW DEPT. JOSEPH D. BIZZANO JR.	414 NICOLLET MALL MINNEAPOLIS, MN 55401	RULES
NORTHERN STATES POWER CO KEITH H WIETECKI	414 NICOLLET MALL MINNEAPOLIS, MN 55401	RULES
NORTHERN SUN ALLIANCE JOAN VANHALA	1519 FRANKLIN AVE E MINNEAPOLIS, MN 55404	RULES
OHIO DEPT OF ENERGY	30 BROAD ST E-24TH FLOOR COLUMBUS, OH 43266	SEO
OKLAHOMA DEPT OF ENERGY	2101 N. LINCOLN BLVD. OKLAHOMA CITY, OK 73105	SEO
OREGON DEPT OF ENERGY	625 MARION ST NE SALEM, OR 97310	SEO
OWATONNA PUBLIC UTILITIES DAVID M. MARTIN	P.O. BOX 800 OWATONNA, MN 55060	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
PENNSYLVANIA GOVERNORS ENERGY CNCL	BOX 8010 HARRISBURG, PA 17105	SEO
PEPIN DAYTON HERMAN JOHN H HERMAN	150 FIFTH ST-STE 2300 MINNEAPOLIS, MN 55402	RULES
PHILLIPS LEGISLATIVE SERVICE INC WILLIAM L PHILLIPS	459 RICE ST - 3RD FLOOR ST PAUL, MN 55103	RULES
POPHAM HAIK LAW FIRM ROBERT S BURK	3300 PIPER JAFFERY TOWER MINNEAPOLIS, MN 55402	RULES
PUERTO RICO ENERGY OFFICE	MANILLAS STATION-BOX 41089 SANTRUCE, PR 00940	SEO
Q S S INC CHARLES KROEGER	BOX 838 FARIBAULT, MN 55021	RULES
REGION FIVE REG DEVEL COMM DAVE WEIRENS	611 IOWA AVE STAPLES, MN 56479	RULES
RHODE ISLAND ENERGY OFFICE	275 WESTMINISTER MALL PROVIDENCE, RI 02903	SEO
RICHFIELD CITY OF BRUCE NORDQUIST	6700 PORTLAND AVE S RICHFIELD, MN 55423	RULES
SAAG CHRISTOPHER K. SANDBERG	BREMER TOWER-RM 1100 ST PAUL, MN 55101	RULES
SAMOA ENERGY OFFICE MATT Le'i	TERRITORIAL ENERGY OFFICE PAGO PAGO, SM 96799	SEO
SIERRA CLUB	1313 - 5TH ST. S.E. RM 323 MINNEAPOLIS, MN 55414	RULES
SMITH ARCHITECTURE & PLANNING RALPH SMITH	117 GLENWOOD AVE SUITE #204 RALEIGH, NC 27603	
SOUTH CAROLINA ENERGY OFFICE	1201 MAIN ST #1710 COLUMBIA, SC 29201	SEO
SOUTH DAKOTA OFFICE-ENERGY POLICY STEVE WEGMAN	217 1/2 W. MISSOURI PIERRE, SD 57501	SEO
ST CLOUD AREA CHAMBER OF COMMERCE THOMAS MOORE	26 N. SIXTH AVE ST CLOUD, MN 56302	RULES

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
ST LOUIS CO PLANNING & ZONING OFF MARK JOHNSON	COURTHOUSE DULUTH, MN 55802	RULES
ST PAUL CITY OF JAN GAFTERLAND	445 CITY HALL ST PAUL, MN 55102	RULES
STATE GOVERNMENT AFFAIRS 3M CO WILLIAM J. LANGLOIS	BLDG 225-5N-04 3M CENTER ST PAUL, MN 55144	RULES
TENNESSEE ENERGY OFFICE	320 - 6TH AVE. N. NASHVILLE, TN 37219	SEO
TEXAS ENERGY OFFICE	1700 NO. CONGRESS AVE SUITE 640 AUSTIN, TX 78701	SEO
TRI COUNTY COMM ACTION PROG MARK G SEXTON	404 SECOND AVE NE LITTLE FALLS, MN 56345	RULES
U OF M ROBERT W SNYDER	1994 BUFORD AVE-RM 248COB ST PAUL, MN 55108	RULES
U S DEPT OF INTERIOR-FISH &WILDLIFE ROBERT F. WELFORD	400 SIBLEY ST-STE 50 ST PAUL, MN 55101	RULES
U.S. HOUSE OF REPRESENTATIVES GERRY SIKORSKI	CANNON OFFICE BLDG-RM 414 WASHINGTON, DC 20515	MCD
UNITED POWER ASSN BRUCE HAUSCHULZ	HIGHWAY 10 ELK RIVER, MN 55330	RULES
UNITED POWER ASSN REYNOLD S RAHKO	HWY 10 E ELK RIVER, MN 55330	RULES
UNOCAL CORP DAVE HENDERSON	1650 GOLF RD E SCHAUMBURG, IL 60196	RULES
UPPER MINN VALLEY REG DEVEL COMM OTTO SCHMID	323 SCHLIEMAN AVE W APPLETON, MN 56208	RULES
UTAH ENERGY OFFICE - 3 TRAID CENTER MICHAEL JOHNSON	355 WEST NORTH TEMPLE - Room 450 SALT LAKE CITY, UT 84180	SEO
VERMONT STATE ENERGY OFFICE	STATE OFFICE BLDG MONTPELIER, VT 05602	SEO
VIRGIN ISLANDS ENERGY OFFICE	BOX 2996 ST THOMAS, VI 00801	SEO

<<<< R U L E S >>>>

People receiving information on rule changes

Company / Person	Street / City, State, Zip	Code
VIRGINIA ENERGY OFFICE JENNIFER SNEAD	2201 W. BROAD ST. RICHMOND, VA 23220	SEO
WALDORF CORP GARY KAZUIKEWICA	2250 WABASHA ST ST PAUL, MN 55114	RULES
WASHINGTON CO HRA SAM GRIFFITH	455 BROADWAY AVE ST PAUL PK, MN 55071	RULES
WASHINGTON STATE ENERGY OFFICE	400 UNION ST E-FIRST FL OLYMPIA, WA 98504	SEO
WINTHROP AND WEINSTINE JOHN A KNAPP	444 CEDAR ST-STE 1800 ST PAUL, MN 55101	RULES
WISCONSIN STATE PLANNING&ENERGY DIV	BOX 7868 MADISON, WI 53707	SEO
WYOMING ENERGY CONSERVATION OFFICE	2301 CENTRAL AVE CHEYENNE, WY 82002	SEO
YAGGY, COLBY ASSOCIATES	717 THIRD AVE SE BOX 7038 ROCHESTER, MN 55903	RULES
ZENK, READ, TYPSTAD & ASSOC. LARRY A READ	BOX 689-OLD HIGHWAY 65 N. ALBERT LEA, MN 56007	RULES

STATE OF MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

In the Matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service Amending the State Building Code Regarding Heat Loss, Illumination and Climate Control, Minn. Rules Ch. 7670

AFFIDAVIT OF ADDITIONAL DISCRETIONARY NOTICE

STATE OF MINNESOTA)
) SS.
COUNTY OF RAMSEY)

MARLENE ODEEN, being duly sworn, deposes and says:

1. That in addition to giving the statutorily required rulemaking notice in the above-captioned matter, the Department of Public Service provided additional discretionary notice to the persons on the attached mailing list. The persons on the mailing list include architects, engineers, home builders, building officials and window manufacturers, some of whom are small businesses within the meaning of Minn. Stat. Subd. 14.115 (1988). The Department has given this notice in accordance with Minn. Stat. Subd. 14.115, subp. 4 (1988) in order to provide an opportunity for small businesses to participate in the rulemaking process.

2. This additional discretionary notice was given on the 25th day of September, 1990, when the Department of Public Service served its "Notice of Intent to Adopt a Rule Without a Public Hearing and Notice of Intent to Adopt a Rule With a Public Hearing if Twenty-five or More Persons Request a Hearing" on the persons on the mailing list referred to in paragraph 1 above by depositing in the State of Minnesota Central Mail system or in the United States mail for first class mailing at said City of St. Paul, a copy thereof, properly enveloped, with postage prepaid, and addressed to said persons.

Marlene Odeen
(name)

Secretary
(title)

Subscribed and sworn to before me this 25th day of September 1990.

DENNIS M. DEVEREAUX
NOTARY PUBLIC-MINNESOTA
RAMSEY COUNTY
My Comm. Expires Apr. 1, 1994

Dennis M. Devereaux
Notary Public

LIST OF PERSONS RECEIVING NOTICE IN THE MATTER OF PROPOSED AMENDMENTS TO RULES OF THE MINNESOTA DEPARTMENT OF PUBLIC SERVICE AMENDING THE STATE BUILDING CODE REGARDING HEAT LOSS, ILLUMINATION AND CLIMATE CONTROL
September, 1990

Dick Lambert
R.C. Lambert & Associates
800 Brenner Avenue
Roseville, MN 55113

Wayne Larson
CEC Code Committee
3524 Labore Road
White Bear Lake, MN 55110

Don Hassenstab
MN Society of Professional Engineer
Suite 130
555 Park St.
St. Paul, MN 55103

Deanna Christensen
MSAIA Professional Dev't.
275 Market St., Suite 54
Minneapolis, MN 55405

Lance LaVine
U of M Daylighting Center
110 Architecture Building
89 Church St. SE
Minneapolis, MN 55455

Joan Archer
Builders Association of MN
2469 University Avenue
St. Paul, MN 55114

Vicki Sullivan
Elk River Area Builders Assn
729 Main Street
Elk River, MN 55330

Vicki Marthaler
Lake Area Builders Assn.
P.O. Box 145
Detroit Lakes, MN 56501

Connie Gerard
Mid-Minnesota Bldrs. Assn.
715 Charles Street
Brainerd, MN 56401

Alex Sleiman
ASHRAE Energy & Tech. Comm.
76 W. Kellogg Blvd.
St. Paul, MN 55102-1611

Dave Oxley
Consulting Engineers Council
5407 Excelsior Boulevard, Suite A
Minneapolis, MN 55416

Bill Snyder
MSAIA Codes Committee
4901 Olson Memorial Hwy.
Minneapolis, MN 55422

Glenn Strand
MSAIA Professional Dev't.
W. R. Grace & Co.
1365 Pierce Butler Route
St. Paul, MN 55104

Rachel Manley
Arrowhead Builders Assn.
405 East Superior Street
Duluth, MN 55802

Bonnie Moeller
Central Minn. Area Home Bldr
26 - 6th Avenue #360
St. Cloud, MN 56301

Steve Inkel
Headwaters Builders Assn.
1210 East Avenue
Bemidji, MN 56601

Robert Hanson
Metro East Builders Assn.
1410 Energy Park Drive Suite 6
St. Paul, MN 55108

Vi Anne Marie Traynor
Mpls. Builders Association
2905 N.W. Boulevard #50
Minneapolis, MN 55441

Dawn Yoshimura
Rochester Builders Assn
1915 N. Hwy. 52 - #103
Rochester, MN 55901

Bob Brown
Arrowhead Chapter ICBO
City Hall - City Clerk Office
Hibbing, MN 55746

John Southerland
East Central Bldg. Officials
Isanti County Building Inspections
221 2nd Ave SW
Cambridge, MN 55008

Tom Sly
Minnesota Chapter of IAPMO
City of Bloomington
2215 West Old Shakopee Road
Bloomington, MN 55431

Ken Norquist
NW Area Metro Bldg Officials
City of Bloomington
2215 W. Old Shakopee Road
Bloomington, MN 55431

LeRoy Kicker
Northwest Chapter ICBO
P.O. Box 647
Detroit Lakes, MN 56501

Don Nelson
Southwest Chapter of ICBO
City of Windom
P.O. Box 38
Windom, MN 56101

Al Kleinback
State Building Codes Div.
408 Metro Square Bldg.
St. Paul, MN 55101

Steve Klossner
Advanced Certified Thermography
672 Quixote Ave.
Lakeland, MN 55043

Gil Mamer
South Central Home Bldr Assn
1132 Hawthorne Avenue
Owatonna, MN 55060

Herb Meyer
Bloomington Bldg. Inspection
2215 W. Old Shakopee Rd.
Bloomington, MN 55431

Jim Manteufel
Lake County Chapter ICBO
4172 Summit Lane
White Bear Lake, MN 55110

Russ Wahl
N. Dakota Co. Bldg Officials
125 3rd Avenue North
South St. Paul, MN 55075

Tom Anderson
North Star Chapter of ICBO
1010 1st Street S.
Hopkins, MN 55343

Bob Peterson
SE MN Conf Bld-Fire Officals
500 4th Avenue N.E.
Austin, MN 55912

Duane Grace
4375 McMenemy St.
Vadnais Heights, MN 55127

Joe Fischer
Quality Insulation
3715 Oregon Ave. S
Minneapolis, MN 55426-4338

Judy Cook
405 Sibley #150
St. Paul, MN 55101

Mark Emond
Emond Insulation
P.O. Box 1136
Lakeville, MN 55044

Jon Childers
Farmers Home Administration
316 North Robert St.
St. Paul, MN 55101

Stephen Braun
Mineral Insulation Mfgr's. Assoc.
1420 King St.
Alexandria, VA 22314

Carolyn Fitch
NCSBCS
505 Hutman Park Rd. #210
Herndon, VA 22070

Lloyd West
West Materials, Inc.
1103 Burnsville Parkway
Burnsville, MN 55337

Joel Johnson
Designers Lighting Forum
Sylvania - GTE
5330 Industrial Blvd. NE
Fridley, MN 55421

Steve Nelson
North Central Elect. Engrs.
Setter, Leach & Lindstrom, Inc.
1011 Nicollet Mall
Minneapolis, MN 55403

David Grimsrud
Cold Climate Hsg. Research
86 Pleasant Street SE 330 Welling
Minneapolis, MN 55455

Bruce Baumann
MN Concrete Products Assn.
5959 Baker Road, Suite 370
Minnetonka, MN 55345

Gerald Ramsdell
SMARCA, Inc.
1405 Lilac Drive North, #100
Minneapolis, MN 55422-4598

Martha Hewett
Ctr. for Energy & Urban Environment
510 First Ave. N # 500
Minneapolis, MN 55403

John Pates
Insulation Supplies
11430 K-Tel Drive
Minnetonka, MN 55343-8844

Roger Peterson
Minnesota Energy Council
P.O. Box 76070
St. Paul, MN 55175

Mark LaLiberte
Shelter Supply
1325 East 79th Street
Minneapolis, MN 55420

Ruben Zaback
7625 Joyce Road
Carver, MN 55315

Pat Hunt
North Central Elect. Engrs.
Setter, Leach & Lindstrom, Inc.
1011 Nicollet Mall
Minneapolis, MN 55403

Stan Wrzeski
Cold Climate Housing Info. Ctr.
266 McNeal Hall
1985 Buford Ave.
St. Paul, MN 55108

Don Sullivan
MN Assn. Plumbing Heating Cooling
2801 Wayzata Blvd.
Minneapolis, MN 55405

Bob King
Minnesota Masonry Institute
5959 Bake Road - Suite 320
Minnetonka, MN 55345

Steve Peterson
Twin City Piping
766 Transfer Road
St. Paul, MN 55114

Dale Sullivan
NSP Electric Marketing
414 Nicollet Mall
Minneapolis, MN 55401

Steve Schlesing
Battelle Pacific NW Labs
Battelle Boulevard
Richland, WA 99352

Jay Jacobson
Cannan Energy
7200 Hemlock Lane #323
Maple Grove, MN 55369

Michael Hoy
United Power Association
Elk River, MN 55330-0800

Kate Talmage
Oregon Departoment of Energy
625 Marian St. NE
Salem, OR 97310

Mark Losure
A H Bennett
900 Glenwood Avenue
Minneapolis, MN 55405

Ross Dahlin
Anderson Corp.
Bayport, MN 55003

Jim Larson
Cardinal Glass
12301 White Water Dr.
Minnetonka, MN 55343

F.E. Sewell
Cole Sewell
2288 University Ave
St. Paul, MN 55114

Philip Cole
Duratherm Windows
3216 Maryland Ave N.
Crystal, MN 55427

Jim
Gordon Millwork Co.
12 Suburban Square
Hopkins, MN 55343

Hurd Millwork Co.
520 S. Whelon Ave.
Medford, WI 54451

Tom Higgins
Allied Aluminum Mfgs.
7341 NE Commerce Lane
Fridley, MN 55432

Steve Girrard
Anderson Corp.
Bayport, MN 55003

John McDermott
CertainTeed
PO Box 860
Valley Forge, PA 19482

Mark Halverson
Cullan Corp.
7435 Washington Ave S.
Edina, MN 55435

Craig Nelson
Eagle Window of the TC
9280 Wellington Lane N
Maple Grove, MN 55374

Richard Rouhoff
Hayfield Window & Door Co.
P.O. Box 25
Hayfield, MN 55940

Denman Weis
Hurd Windows
P.O. Box 655
Wayzata, MN 55391

John Wheidt
J. Wheidt & Assoc.
110 West 2nd St.
Chaska, MN 55318

Jim Krahn
Marvin Windows
P.O. Box 100
Warroad, MN 55763

Dave Leitner
Minnesota Wood Specialties
P.O. Drawer M
St. Paul Park, MN 55071

Mike Cyr
Nawco Minnesota, Inc.
P.O. Box 206
Monticello, MN 55362

Don Hahn
Norco Windows, Inc.
P.O. Box 140
Hawkins, WI 54530

Jim Johnson
Pella Window Store
668 Kasota Avenue
Minneapolis, MN 55414

Doug McDougall
Peach Tree Doors, Inc.
PO Box 5700
Norcross, GA 30091

Gene Gulan
SNE Enterprises
P.O. Box 8007
Wausau, WI 54402-8007

Phil Sommerfeld
SealRite Windows
P.O. Box 4468
Lincoln, NE 68504

Al Mazig
Twin City Testing
662 Cromwell Ave.
St. Paul, MN 55114

Jim Euler
Kolbe & Kolbe Millwork Co.
1323 S. Eleventh Ave.
Wausau, WI 54401

Tom Yehl
Metro Millworks
7460 Oxford St.
St. Louis Park, MN 55426

John Bower
Mon-Ray Windows Inc.
2720 Nevada Avenue N
Minneapolis, MN 55427

James C. Benney
Nt'l Wood Window & Door Assoc
1400 E Touhy Ave. # G-54
Des Plaines, IL 60018

Andrew Johnson
Patio Doors, Inc.
8975 Zacahry Lane
Maple Grove, MN 55369

Jesse Stevens
Rolscreen Company
100 Main Street
Pella, IA 50219

Phil Bowman
Roto Frank Skylights
P.O. Box 310
Sun Prairie, WI 53590

Gary Erickson
SNE Enterprises
P.O. Box 8007
Wausau, WI 54402-8007

John Lawler
Twin City Storm Sash Co.
1608 Como Ave., Suite 101
St. Paul, MN 55108

Steve Wanberg
Vinal Sash
10730 Nesbitt Ave. So.
Bloomington, MN 554377

Ralph Hardgrove
Vinyl Sash
P.O. Box 91
Waconia, MN 55487

Jerry Viegut
Weather Shield Mfg.
12180 Dogwood St. NW
Coon Rapids, MN 55433

Dan Corbin
Window Warehouse Inc.
1907 S. Robert St.
West St. Paul, MN 55118

Randy Bergstrom
Window Warehouse Inc.
8040 University Ave NE
Fridley, MN 55432

Phil Jenson
Windsor Wood Windows
900 South 19th Street
West Des Moines, IA 50265

Jim Dressely
Vinyl Therm Inc.
8300 Grand Ave S.
Bloomington, MN 55420

Don Krueger
Weather Shield Mfg.
P.O. Box 309
Medford, WI 54451

Gary Dash
Window Warehouse Inc.
8567 Lyndale Ave. So.
Bloomington, MN 55420

Tim Duncan
Window Warehouse Inc.
I-694 & White Bear Ave
Maplewood, MN 55110

Rc 12-11-90

STATE OF MINNESOTA

OFFICE OF THE ATTORNEY GENERAL

December 5, 1990

HUBERT H. HUMPHREY, III
ATTORNEY GENERAL

BUSINESS REGULATION SECTION
1100 BREMER TOWER
SEVENTH PLACE & MINNESOTA ST.
ST. PAUL, MN 55101
TELEPHONE: (612) 296-9412
FACSIMILE: (612) 296-7438

645.15

Patricia Nolte
Legal Assistant
Public Finance Division
404 Capitol Office Building
525 Park Street
St. Paul, MN 55103

Re: In the matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service Amending the State Building Code regarding Heat Loss, Illumination, and Climate Control (Minn. Rules ch. 7670)

Dear Ms. Nolte:

On November 29, 1990, the Minnesota Department of Public Service adopted the above-captioned rules governing thermal insulation standards. Enclosed for your review are the following:

1. Rule as adopted (original and three copies).

2. Findings of Fact, Conclusions, and Order Adopting Rule Amendments (two copies).

3. Notice of Intent to Solicit Outside Opinion (13 S.R. 2991, June 19, 1989).

4. All written comments received pursuant to Notice of Intent to Solicit Outside Opinion.

5. Notice of Intent to Amend Rules Without a Public Hearing and Rules as Proposed (15 S.R. 828, 1 October, 1990).

6. Comments received pursuant to notice of intent to adopt rule amendments without a public hearing.

7. Notice of Intent to Amend Rules Without a Public Hearing, and Notice of Intent to Adopt a Rule With a Public Hearing if Twenty-Five or More Persons Request a Hearing as mailed.

8. Mailing list, Certificate of Mailing List and Affidavit of Mailing.

Equal Opportunity Employer

Printed on Recycled Paper

9. Affidavit of Additional Discretionary Notice.

10. Rules as proposed.

11. Statement of Need and Reasonableness.

12. Declaration of Counsel.

Very truly yours,

ERIC F. SWANSON
Special Assistant
Attorney General

Telephone: (612) 296-8703

ES:li.ak5

cc: Bruce Nelson

56,977-57,877	4,749-4,823	1,000	6,000
57,878-58,778	4,824-4,898	1,066	6,396
58,779-59,679	4,899-4,973	1,134	6,804
59,680-60,851	4,974-5,070	1,203	7,218

This fee schedule is based on the Minnesota State Median Income of $36,746 for a four-person household in federal fiscal year 1989. The Bureau of the Census developed the median income estimates for each state from three sources of data: the March 1987 Current Population Survey; the 1980 Census of Population; and 1986 per capita income estimates from the Bureau of Economic Analysis. These median income estimates were published in the *Federal Register*, Volume 53, No. 64/Monday, April 4, 1988, pages 10947 and 10948.

The department shall adjust the fee schedule annually, and publish the adjustments in the *State Register* on the last Monday in June. The adjustments shall be based on the most recent annual state median income as published in the *Federal Register* by the Department of Health and Human Services.

Department of Human Services

Health Care Programs Division

Notice of Solicitation of Outside Information or Opinions Regarding Proposed Amendments to Rules Governing Preadmission Screening and Alternative Care Grants

NOTICE IS HEREBY GIVEN that the State Department of Human Services is seeking information or opinions from sources outside the agency in preparing to propose amendments to the rules governing the standards and procedures applicable to alternative care grants under the medical assistance program, *Minnesota Rules*, parts 9505.2455, subparts 5 and 8; 9505.2465, subpart 4; and 9505.2490, subparts 1 and 2.

The adoption of the rule is authorized by *Minnesota Statutes*, section 256B.091, subdivisions 8 and 9, which require the agency to establish procedures for employing or contracting for services and for determining the use of grants for payment of costs of providing care-related supplies, the limits on rates for payment of approved services, and the limits on the total cost of an alternative care grant to an alternative care grant client.

The State Department of Human Services requests information and opinions concerning the subject matter of the rule. Interested persons or groups may submit data or views on the subject matter of concern in writing or orally. Written statements should be addressed to:

Eleanor Weber
Rules Division
Minnesota Department of Human Services
444 Lafayette Road
St. Paul, MN 55101

Oral statements will be received during regular business hours over the telephone at (612) 297-4301 by Eleanor Weber and in person at the above address.

All statements of information and opinions shall be accepted until further notice. Any written material received by the State Department of Human Services shall become part of the rulemaking record to be submitted to the attorney general or administrative law judge in the event that the rule is adopted.

Department of Public Service

Energy Division

Notice of Solicitation of Outside Information or Opinions Regarding the Minnesota Energy Code

NOTICE IS HEREBY GIVEN that the Department of Public Service is seeking information or opinions from sources outside the agency in preparing to propose the amendment *Minnesota Rules* Chapter 4215 governing energy matters within the State Building Code. The adoption of the rule is authorized by *Minnesota Statutes*, section 216C.19 subdivision 8, to establish energy standards for building design and construction.

The Department requests information and opinions concerning the subject matter of the rule, including but not limited to, ventilation and other issues related to both residential and nonresidential requirements of the Energy Code. Interested persons or groups may submit data or views on the subject matter of concern in writing or orally. Written statements should be addressed to:

Bruce Nelson, Senior Engineer, Department of Public Service, Energy Division, 900 American Center Building, 150 East Kellogg Boulevard, St. Paul, Minnesota 55101, (612) 297-2313.

Oral statements will be received during regular business hours over the telephone and in person at the above address.

All statements of information and opinions shall be accepted until October 1, 1989. Any written material received by the State Department of Public Service shall become part of the rulemaking record to be submitted to the attorney general or administrative law judge in the event that the rule is adopted.

Dated: 12 June 1989

Burl W. Haar
Deputy Commissioner

Minnesota Public Utilities Commission

Notice of Intent to Solicit Outside Information Regarding Proposed Rule Governing Construction Plans for Major Utility Facilities, Docket No. G,E-999/R-89-386.

NOTICE IS HEREBY GIVEN that the Minnesota Public Utilities Commission (Commission) is seeking information or opinions from outside sources in preparing to propose the adoption of rules governing construction plans for major utility facilities. The adoption of the rule is authorized by *Minnesota Statutes* § 216B.08 (1988), which allows the Commission to adopt rules, and *Minnesota Statutes* § 216B.24 (1988), which allows the Commission to review utility plans for contemplated construction of major utility facilities.

The Commission requests information and opinions concerning the subject matter of the rule. Interested persons or groups may submit data or views in writing or orally. Written statements or comments should be directed to:

Caroline Heil
Minnesota Public Utilities Commission
780 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101

Oral statements or comments should be directed to David Jacobson of the Commission Staff at (612) 297-4562. Oral statements or comments will be received during regular business hours, 8:00 a.m. to 4:30 pm., Monday through Friday.

All statements of information and opinion will be accepted until 4:30 p.m. on July 21, 1989. Any written materials received by the Commission shall become part of the rulemaking record in the event that the rule is adopted.

Mary Ellen Hennen
Executive Secretary

Draft Rules Governing Construction Plans for Major Utility Facilities

7841.0100 DEFINITIONS.

Subpart 1. **Scope.** The terms used in this chapter have the meanings given them in this part.

Subp. 2. **Commission.** "Commission" means the Minnesota Public Utilities Commission.

Subp. 3. **Construction.** "Construction" means significant physical alteration of a site to install or enlarge a major utility facility, but does not include activities incident to preliminary engineering or environmental studies.

Subp. 4. **Major utility facility.** "Major utility facility" has the meaning given the term in *Minnesota Statutes*, section 216B.24, subdivision 1.

Subp. 5. **Public utility.** "Public utility" has the meaning given the term in *Minnesota Statutes*, section 216B.02, subdivision 4.

7841.0200 PURPOSE AND SCOPE.

Subpart 1. **Purpose.** The purpose of parts 7841.0100 to 7841.0500 is to prescribe the contents of and procedures for Commission review of construction plans for major utility facilities.

Department of Public Service

Adopted Permanent Rules Relating to Minnesota Energy Code

Rules as Adopted

GENERAL

7670.0100 AUTHORITY; SCOPE~~,-CONFLICTS~~.

Subpart 1. **Authority.** This chapter is adopted pursuant to Minnesota Statutes, section 216C.19, subdivision 8.

Subp. 2. **Scope.** Under Minnesota Statutes, section 216C.19, subdivision 8, this chapter is a part of the State Building Code, adopted in accordance with Minnesota Statutes, sections 16B.59 to 16B.73.

~~Subp.-3.--Conflicts.--In-cases-of-conflict-with-other-parts of-the-State-Building-Code,-this-chapter-governs-in-all-cases not-affecting-safety-and-health-requirements.~~

7670.0120 EFFECTIVE DATE.

The effective date of this chapter is February 1, 1991.

7670.0125 LEGISLATIVE MANDATES CONCERNING THE MINNESOTA ENERGY CODE.

An enclosed structure or portion of an enclosed structure constructed after January 1, 1978, and used primarily as a commercial parking facility for three or more motor vehicles may not be heated. Incidental heating resulting from building exhaust air passing through a parking facility is not prohibited if substantially all useful heat previously has been removed from the air.

EXCEPTION: Parking facilities that are appurtenant to dwelling unit occupancies.

7670.0130 INCORPORATIONS BY REFERENCE.

Subpart 1. **Incorporated items.** The following standards and references are incorporated by reference:

A. The Model Energy Code, 1989 Edition, as published by the Council of American Building Officials (Falls Church,

Approved by Revisor

Virginia), as amended by parts 7670.0330 to 7670.1000.

B. Code of Federal Regulations, title 10, part 435, Energy Conservation Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; subpart 103, Lighting and subpart 105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in sheet metal construction.

C. ~~ASHRAE-Standard-62-1989,-Ventilation-for Acceptable-Indoor-Air-Quality-as-published-by-the-American Society-of-Heating,-Refrigerating-and-Air-Conditioning-Engineers (Atlanta,-GA)~~ LTGSTD, lighting prescriptive and system performance compliance calculation program, a computer program developed by Battelle Pacific Northwest Laboratories.

D. ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings.

E. AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.

F. ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box.

G. ASTM C 976-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box.

H. WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory.

Subp. 2. **Availability.** All standards and documents incorporated by reference are available for public inspection at the Minnesota State Law Library and through the Minitex interlibrary loan system. In addition:

A. ASHRAE and ANSI/ASHRAE documents and standards are available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers - Publication Sales, 1791 Tullie Circle NE, Atlanta, GA 30329;

B. AAMA standards are available from the American Architectural Manufacturers Association, 2700 River Road, Des

Approved by Revisor _____

Planes, IL 60018;

C. ASTM standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103; and

D. The WINDOW computer program is available from Bostik Construction Products, ~~P.O. Box 8~~ 1740 County Line, Huntington Valley, PA 19006.

7670.0250 APPLICABILITY.

Buildings covered by this chapter must comply with the Model Energy Code as amended by parts 7670.0325 to 7670.1000. This part also applies to remodeled elements of buildings covered by the State Building Code. This chapter governs in case of conflict with the Model Energy Code.

EXCEPTION: Relocated residential buildings need not comply with this chapter, except that, where available, an energy audit must be conducted on the relocated building.

7670.0260 MATERIALS AND EQUIPMENT.

Section 102 of the Model Energy Code is amended by adding a paragraph to read:

102.3 Thermal Insulation. Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards, adopted by the Department of Public Service.

7670.0325 AMENDMENTS TO SECTION 201: DEFINITIONS.

Subpart 1. **Thermal transmittance (U).** In section 201 of the Model Energy Code, the definition of "Thermal transmittance (U)" is amended to read:

THERMAL TRANSMITTANCE (U). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature differential between the warm side and cold side air films (Btu/h ft^2 F).

~~A.~~ Thermal transmittance of opaque wall components (U_w) and roof/ceiling components (U_r) ~~must be calculated using one of the following~~ calculation methods ~~appropriate for the application~~ are defined in the references indicated:

Approved by Revisor _____

(1) Parallel heat flow method:

~~Reference:~~ Model Energy Code, chapter 5, ~~equation~~ equations 1 and 2.

~~Applications:--Wood-frame-and-masonry-with-surface-applied thermal-insulation.~~

(2) Series-parallel method:

~~Reference:~~ page 22.4 of Standard ~~RS-1,-page-22.4~~ listed in chapter 7.

~~Applications:--Masonry-blocks-with-insulation-inserts-or filled-cores,-nonmetal-surface-with-metal-framing.~~

(3) Thermal bridges in sheet metal construction method:

~~Reference:--Code-of-Federal-Regulations,-title-10,-part 435.105,-section-5.3.3.2.1(d).~~

~~Applications:--Metal-framing-bonded-on-one-or-both-sides-to a-metal-skin-or-covering.~~ Standard RS-25 listed in chapter 7.

(4) Zone method:

~~Reference:~~ page 22.10 of Standard ~~RS-1,-page-22.10~~ listed in chapter 7.

~~Applications:--Metal-surface-with-nonmetal-framing.~~

~~B.--Thermal-transmittance-of-window-area-(U_g)-and skylight-elements-(U_s)-must-be-determined-in-accordance-with-one of-the-following-methods:~~

~~(1)-Reference-RS-1,-representative-U-values-for fenestration-products,-pages-27.16-to-27.18;~~

~~(2)-AAMA-Standard-1503.1;~~

~~(3)-ASTM-C-236-or-ASTM-C-976,-using-design conditions-specified-in-footnote-(a)-of-table-13,-chapter-27-of reference-RS-1,-or~~

~~(4)-WINDOW-computer-program.~~

Subp. 2. **Vapor retarder.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

VAPOR RETARDER. A material to retard air and water vapor passage designed to meet a maximum perm rating of 1.0 grain per hour per ft^2 per inch Hg pressure differential. Polyethylene material that is not cross laminated which is used to meet the requirements of this paragraph must be designed to have a minimum thickness of four mills.

Subp. 3. **Wind wash.** Section 201 of the Model Energy Code

Approved by Revisor _____

is amended by adding a new definition to read:

WIND WASH. Wind wash is the passage of unconditioned air through thermal insulation of the building envelope.

Subp. 4. **Window area.** Section 201 of the Model Energy Code is amended by adding a new definition to read:

WINDOW AREA. Window area, or glazing area, is either the area of glazing and sash, or the area used by the manufacturer to determine the window thermal transmittance.

7670.0400 AMENDMENT TO SECTION 302: DESIGN CONDITIONS.

Footnote 1 of section 302.1 of the Model Energy Code is amended to read:

[1]~~Outdoor~~ The exterior design ~~conditions~~ temperature must be selected from ~~Standard RS-1.--Heating design temperatures must be no lower than the temperature listed in the 99 percent column.--Cooling design temperatures must be no greater than the temperature listed in the 2.5 percent column~~ the "Design Conditions" columns shown in Table 302.1.

EXCEPTION: Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the ~~median of annual extremes for heating and one percent column for cooling~~ values listed in Table 302.1 under "extreme conditions" may be used.

TABLE 302.1 Exterior Design Temperatures

CITY	DESIGN CONDITIONS SUMMER DB/WB	DESIGN CONDITIONS WINTER DB	EXTREME CONDITIONS SUMMER DB/WB	EXTREME CONDITIONS WINTER DB
Albert Lea	87/72	-17	90/74	
Alexandria	88/72	-22	90/72	-28.0
Bemidji	85/69	-31	88/69	-36.9
Brainerd	87/71	-20	90/73	
Duluth	82/68	-21	85/70	-27.4
Faribault	88/72	-17	91/74	-24.3
Fergus Falls	88/72	-21	91/72	-27.8
International Falls	83/68	-29	85/68	-36.5
Mankato	88/72	-17	91/72	
Minneapolis	89/73	-16	92/75	-22.0
Rochester	87/72	-17	90/74	
St. Cloud	88/72	-15	91/74	
St. Paul	89/73	-16	92/75	-22.0
Virginia	83/68	-25	85/69	-33.0
Willmar	88/72	-15	91/74	-24.3
Winona	88/73	-14	91/75	

"DB" = dry bulb temperature, degrees Fahrenheit

"WB" = wet bulb temperature, degrees Fahrenheit

Approved by Revisor _____

Heating degree days must be selected from Standard ~~RS-22~~ RS-23 listed in chapter 7. Adjustments may be made as determined by the building official to reflect local climates which differ from the tabulated temperatures or local weather experience.

7670.0450 AMENDMENT TO SECTION 303: VENTILATION.

Section 303.1 of the Model Energy Code is amended to read:

303.1 Ventilation. Ventilation systems must be designed to conform with ~~ASHRAE~~ Standard ~~62,-Ventilation-for-Acceptable-Indoor-Air-Quality~~ RS-3 listed in chapter 7.

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE.

Subpart 1. Section 502.1 of the Model Energy Code is amended by adding a paragraph to read:

502.1.4 Thermal transmittance of opaque wall components and roof/ceiling components. Thermal transmittance of opaque wall components and roof/ceiling components must be calculated using the following methods:

(1) Wood frame and masonry with surface applied thermal insulation: Parallel heat flow method.

(2) Masonry blocks with insulation inserts or filled cores and nonmetal surface with metal framing: Series-parallel method.

(3) Metal framing bonded on one or both sides to a metal skin or covering: Thermal bridges in sheet metal construction method.

(4) Metal surface with nonmetal framing: Zone method.

Subp. 2. Section 502.1 of the Model Energy Code is amended by adding a paragraph to read:

502.1.5 Thermal transmittance of window area and skylight elements. Thermal transmittance of window area (U_g) and skylight elements (U_s) must be determined in accordance with one of the following methods:

(1) Representative U-values for fenestration products, pages 27.16 to 27.18 of Standard RS-1 listed in Chapter 7;

(2) Standard RS-26 listed in chapter 7;

Approved by Revisor _____

(3) Standard RS-27 or RS-28 listed in chapter 7 using design conditions specified in footnote (a) of table 13, chapter 27 of Standard RS-1; or

(4) Standard RS-29 listed in chapter 7 using design conditions specified in footnote (a) of table 13, chapter 27 of Standard RS-1.

Subp. 3. Section 502.2.1 of the Model Energy Code is amended by adding a new section to read:

502.2.1.7 Alternative compliance. Alternative methods of compliance with ~~section 502.2.1~~ sections 502.2.1.1, 502.2.1.2, and 502.2.1.3 for one- and two-family residential buildings.

Minimum performance for Type A-1 (one- and two-family) buildings:

Ceilings	Walls	Floors	Windows	Doors
R-38	~~R-19~~[1] R-20[1]	~~R-19~~[1] R-20[1]	Maximum U-0.49[2]	R-3

(1) For the ~~insulation within the~~ insulated cavity of opaque walls and rim joists.

(2) Maximum window area must not exceed 12 percent of the area of exterior walls, not including foundation walls.

Site-built fixed glazing must be installed in either an aluminum or steel frame having a minimum 0.25 inch low conductance thermal break or in wood or vinyl framing. The glazing must be either double-glazed with a dead air space between panes of nominal one-half inch spacing or triple-glazed with a dead air space between panes of not less than one-fourth inch.

~~Foundation walls must comply with part 7670.0510, slab on grade floors must comply with section 502.2.1.4 and crawl space walls must comply with section 502.2.1.5.~~

7670.0480 AMENDMENT TO SECTION 502: EFFECTIVENESS OF REQUIRED THERMAL INSULATION.

Section 502.2 of the Model Energy Code is amended by adding paragraphs to read:

~~Subpart 1. Thermal insulation. Thermal insulation used in residential buildings three stories or less in height must~~

Approved by Revisor _____

~~conform to chapter 7640, Minnesota Thermal Insulation Standards.~~

~~Subp. 2.~~ 502.2.1.8 Cold weather vapor condensation. Building assemblies are required to maintain the thermal performance of required insulation and the integrity of building materials against cold weather water vapor condensation.

~~A.~~ 502.2.1.8.1 Vapor retarder. A vapor retarder must be installed between the interior surface and the winter design condition dew point location within each building envelope surface. The vapor retarder must be continuous and joints in the vapor retarder must be sealed between solid blocking.

EXCEPTION: A vapor barrier need not be installed on the rim joist insulation.

~~B.~~ 502.2.1.8.2 Air leakage barrier. A barrier against air leakage must be installed to prevent the leakage of moisture-laden air from the house into the building envelope. An air barrier must be continuous at all plumbing and heating penetrations of interior surface of the building exterior envelope. If a tub or shower is located on an exterior wall, an air barrier must be provided at the interior surface of the building exterior envelope behind the tub or shower.

~~Subp. 3.~~ 502.2.1.9 Preventing wind wash. A barrier must be provided at the following locations to mitigate wind wash:

A. the exterior edge of attic insulation; and

B. cantilevered floors and bay windows, including corners with adjoining vertical walls above and below.

7670.0500 AMENDMENT TO SECTION 502: SLAB ON GRADE FLOORS.

Section 502.2.1.4 of the Model Energy Code is amended to read:

502.2.1.4 Slab on grade floors. For slab on grade floors, the thermal resistance of the insulation around the perimeter of the floor must be not less than the value given in Table No. 502.2.1. The insulation must extend downward from the top of the slab to the design frost line or downward to the bottom of the slab then horizontally beneath the slab for an equivalent distance, and must be an approved type.

Approved
by Revisor _____

7670.0510 AMENDMENT TO SECTION 502: FOUNDATION WALLS.

Section 502.2.1.6 of the Model Energy Code is amended to read:

~~Subpart 1.~~ 502.2.1.6 Foundation walls. Foundation walls enclosing heated or conditioned spaces must be insulated.

Either the thermal resistance (R) of the insulation on the entire opaque foundation wall must be not less than R-5, or the thermal resistance (R) of the insulation on the opaque foundation wall must be not less than R-10 from the top of the wall down to the design frost line. If the top of the footing is at or above the design frost line, the thermal resistance (R) of the insulation on the wall must not be less than R-5 from the top of the wall to the top of the footing.

~~Subp. 2. Intended use; installation.~~ All insulation used in or on foundation walls must be approved for the intended use. The insulation must be installed in accordance with the approved manufacturer's specifications.

~~Subp. 3. Exterior insulation.~~ If the foundation wall insulation is on the exterior, the portion from the top of the foundation wall to six inches below grade must be covered by an approved protective coating finish to protect the insulation from deterioration due to sunlight and physical abuse.

7670.0550 AMENDMENT TO SECTION 502: AIR LEAKAGE.

Subpart 1. **Alternative.** Section 502.4.3 of the Model Energy Code is amended ~~to read~~ by adding an exception as follows:

~~Subpart 1. 502.4.3 Exterior joints in the building envelope that are sources of air leakage must be caulked, gasketed, or otherwise sealed in an approved manner. These air leak sources include, but are not limited to, areas between wall cavities and window or door frames, between walls and foundations, between walls and roofs or ceilings and between wall panels, and at penetrations of utility services.~~

~~Subp. 2.~~ EXCEPTION: ~~**Alternative.**~~ As an alternative to the prescriptive requirements of ~~subpart 1~~ section 502.4.3 for detached single-family residential buildings, air tightness must

Approved
by Revisor _____

comply with air leakage class A, B, C, or D of ~~ANSI/ASHRAE~~ Standard ~~119~~ RS-26 listed in chapter 7. In addition, this alternative requires that the ventilation system must provide a ventilation rate of not less than 0.35 air changes per hour (determined in accordance with ~~ASHRAE~~ Standard ~~62~~ RS-3, Table 2.3) or 15 cfm per person, whichever is greater. This ventilation rate must be verified by measurement. If this alternative is not chosen, this ventilation rate requirement applies only if required by Standard RS-3.

Subp. ~~3.~~ 2. **Fire stops.** Section 502 is amended by adding a section as follows:

502.4.4 Fire stops. Fire stops must be installed in accordance with the State Building Code. When mineral fiber or glass fiber materials are used as fire stop construction at ceilings and wall cavities separating conditioned and nonconditioned spaces, the fire stop must be installed to block air movement.

EXCEPTIONS: A fire stop need not block air movement if its installation would conflict with any other part of the State Building Code.

7670.0610 AMENDMENTS TO SECTION 503: BUILDING MECHANICAL SYSTEMS.

Subpart 1. **Calculation procedures.** Section 503.2.1 of the Model Energy Code is amended to read:

503.2.1 Calculation procedures. Heating and cooling system design loads for the purpose of sizing systems and equipment must be determined in accordance with the procedures described in Standard RS-1. For those design parameters addressed in part 7670.0400, the values specified must be used.

503.2.1.1 Safety factor. Design loads may at the designer's option be increased by as much as ten percent to account for unexpected loads or changes in space usage.

503.2.1.2 Pick-up loads. Transient loads such as warm-up or cool-down loads that occur after off-hour setback or shutoff may be calculated from principles based on the heat capacity of

Approved by Revisor _____

the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be up to 30 percent for heating and ten percent for cooling of the steady-state design loads. The steady-state load may include a safety factor in accordance with section 503.2.1.1.

Subp. 2. **System and equipment sizing.** Section 503.2 of the Model Energy Code is amended by adding a paragraph to read:

503.2.3 System and equipment sizing. HVAC systems and equipment must be sized to provide no more than the space and system loads calculated in accordance with 503.2.1.

Exceptions:

(a) Equipment capacity may exceed the design load if the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Equipment whose capacity exceeds the design load may be specified if oversizing the equipment can be shown to not increase the overall annual energy costs.

(c) Stand-by equipment may be installed if controls and devices are provided that allow stand-by equipment to operate automatically only when the primary equipment is not operating.

(d) Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on load.

(e) For a single piece of equipment that has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function must be, within available equipment options, the smallest size necessary to meet the load.

7670.0660 AMENDMENT TO SECTION 503: EQUIPMENT EFFICIENCY.

Subpart 1. **Table No. 503.4.3.** Table No. 503.4.3 of the Model Energy Code "HVAC System Heating Equipment - Gas- and Oil-Fired Minimum Steady State Combustion Efficiency" is amended

Approved by Revisor _____

by changing the requirement for forced-air furnaces and low-pressure steam or hot-water boilers for all other commercial or industrial furnaces and boilers to 80 percent.

Subp. 2. **Table No. 503.4.8.** Section 503 of the Model Energy Code is amended by adding a table to read:

Table No. 503.4.8 -- Minimum EER and COP for Electrically Driven Water Source Hydronic Heat Pumps[1]

Size	under 19 kW (65,000 Btu/h)	19 kW (65,000 Btu/h) and over
EER	9.0	9.4
COP	2.64	2.75

[1]When tested at the standard rating conditions specified in Table No. 503.4.6a.

7670.0670 AMENDMENT TO SECTION 503.10: DUCT CONSTRUCTION.

Section 503.10.2 of the Model Energy Code is amended to read:

503.10.2. For low pressure supply and return air ducts located outside of the conditioned space, all transverse joints must be sealed using mastic, tape, or mastic and tape. For fibrous glass ductwork, pressure sensitive tape may be used.

7670.0710 AMENDMENTS TO SECTION 504: SERVICE WATER HEATING.

Subpart 1. **Time clocks.** Section 504.5 of the Model Energy Code is amended by deleting section 504.5.3.

Subp. 2. **Pipe insulation.** Section 504.7 of the Model Energy Code is amended by deleting the exception.

Subp. 3. **Devices to limit temperature.** Section 504.8.2 of the Model Energy Code is amended by deleting section 504.8.2.2.

7670.0800 AMENDMENTS TO SECTION 505: ELECTRIC POWER AND LIGHTING.

Subpart 1. **Electric energy determination.** The exception to section 505.2 of the Model Energy Code is amended to read:

EXCEPTION: Motels, hotels, college dormitories, other transient facilities, and buildings intended for occupancy primarily by persons who are 62 years of age or older or handicapped, or which contain a majority of units not equipped

Approved by Revisor _____

with complete kitchen facilities.

Subp. 2. **Lighting power budget.** The lighting requirements of sections 505.3 and 505.4 of the Model Energy code are amended to read:

The lighting power budget must be the upper limit of the power to provide the lighting needs in accordance with the 1988 and 1989 criteria and calculation procedure specified in ~~Code of Federal Regulations, title 10, part 435.103~~ Standard RS-24 listed in chapter 7 (excluding section 3.2, referencing equation 3.4-1 in section 3.1.6.2, and correcting the units of Interior Lighting Power Allowance in equation 3.5-3 to Watts), or using Standard RS-26 listed in chapter 7.

EXCEPTION: One- and two-family detached dwellings and the dwelling portion of multifamily buildings.

7670.0850 AMENDMENT TO SECTION 600: DESIGN BY ACCEPTABLE PRACTICE.

Section 601.1 of the Model Energy Code is amended by adding a paragraph to read:

Buildings constructed in accordance with this section must also comply with parts ~~7670.0480~~ 7670.0470 to 7670.0800~~.~~ as indicated below:

Model Energy Code	Minnesota Rules Part
602.2	7670.0470, 7670.0480
602.2.4	7670.0500
602.2.6	7670.0510
602.3.2	7670.0550
603.1	7670.0610
603.2.1	7670.0660
603.4	7670.0670
604	7670.0710
605	7670.0800

7670.1000 AMENDMENTS TO SECTION 701: ~~REFERENCES~~ STANDARDS.

Section 701.1 of the Model Energy Code is amended by replacing and adding the following code standard numbers to read:

RS-1	1989 ASHRAE Handbook of Fundamentals.
RS-3	ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality.
RS-4	ASHRAE Standard 55-1981 Thermal Environment Conditions for Human Occupancy.
RS-17 & RS-18	SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985.
RS-23	Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80 Minnesota.

Approved by Revisor _____

National Oceanic and Atmospheric Administration September 1982.

RS-24 Code of Federal Regulations, title 10, part 435.103, lighting.

RS-25 Code of Federal Regulations, title 10, part 435.105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in Sheet Metal Construction.

RS-26 LTGSTD, lighting prescriptive and system performance compliance calculation program.

RS-26 ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings.

RS-26 AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation of Windows, Doors and Glazed Wall Sections.

RS-27 ASTM C 236-87, Standard Test Method for Steady State Performance of Building Assemblies by means of a Guarded Hot Box.

RS-28 ASTM C 2976-82, Standard Test Method for Steady State Performance of Building Assemblies by means of a Calibrated Hot Box.

RS-29 WINDOW computer program.

REPEALER. Minnesota Rules, parts 7670.0110; 7670.0200; 7670.0210; 7670.0220; 7670.0300; 7670.0310; 7670.0320; 7670.0330; 7670.0340; 7670.0520; 7670.0540; 7670.0600; 7670.0620; 7670.0630; 7670.0640; 7670.0650; 7670.0700; 7670.0720; 7670.0730; 7670.0900; 7670.0910; 7670.0920; 7670.0930; 7670.0940; 7670.0950; 7670.0960; 7670.0970; 7670.1010; 7670.1020; 7670.1030; 7670.1100; and 7670.1110 are repealed.

Approved by Revisor _____

Office of the Revisor of Statutes

Administrative Rules

TITLE: Adopted Permanent Rules Relating to Minnesota Energy Code

AGENCY: Department of Public Service

MINNESOTA RULES: Chapter 7670

INCORPORATIONS BY REFERENCE:

Part 7670.0130: Model Energy Code, 1989 Edition, published by Council of American Building Officials, Falls Church, Virginia, as amended by parts 7670.0330 to 7670.1000; LTGSTD, lighting prescriptive and system performance compliance calculation program, a computer program developed by Battelle Pacific Northwest Laboratories; ANSI/ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-Family Residential Buildings; AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections; ASTM C 236-87, Standard Test Method for Steady State Thermal Performance of Building Assemblies by means of a Guarded Hot Box; ASTM C 979-82, Standard Test Method for Thermal Performance of Building Assemblies by means of a Calibrated Hot Box; WINDOW, a computer program developed by the Windows and Daylighting Group at Lawrence Berkeley Laboratory. Available at Minnesota State Law Library and through Minitex interlibrary loan system.

The attached rules are approved for filing
with the Secretary of State

Craig E. Lindeke
Senior Assistant Revisor

STATE OF MINNESOTA

DEPARTMENT OF PUBLIC SERVICE

In the matter of the Proposed Amendments to Rules of the Minnesota Department of Public Service Amending the State Building Code regarding Heat Loss, Illumination, and Climate Control (Minn. Rules ch. 7670)	**FINDINGS OF FACT, CONCLUSIONS AND ORDER ADOPTING RULE WITHOUT PUBLIC HEARING**

The above entitled matter came before Tony Perpich, Commissioner of the Department of Public Service, on November 29, 1990. In accordance with statutory requirements regarding adoption of noncontroversial rules, after considering the Statement of Need and Reasonableness, after considering all of the evidence in the rulemaking record, the Commissioner hereby adopts the following Findings of Fact, Conclusions and Order:

FINDINGS OF FACT

(1) 1. Notice of the Department of Public Service's intent to adopt the above-entitled rule amendments without a public hearing was published in the State Register on 1 October, 1990 (15 S.R. 828), and was sent by United States mail to all persons on the list maintained by the Department pursuant to Minn. Stat. §§ 14.14, subd. 1a and § 14.22 (1988) on 25 September, 1990. In accordance with Minn. Stat. § 14.115 (1988), additional discretionary notice was mailed to architects, engineers, home builders, building officials and window manufacturers in order to provide an opportunity for small businesses to participate in the rulemaking process.

(2) 2. The Statement of Need and Reasonableness was prepared prior to mailing and publication of the notice and was made available to the public.

(4) 3. All persons were given the opportunity to submit comment on the rule amendments for 30 days after notice of proposed rulemaking. The 30 day comment

period, as set out in the notice, expired on October 30, 1990.

4. During the comment period, agency received 19 requests for a public hearing. Therefore, the agency did not receive requests for a public hearing from 25 or more persons which were not withdrawn.

5. No requests for notice of submission to the Attorney General were received by the Department.

6. The Department received 25 written comments following publication of the proposed rules. In addition, oral comments were received during the comment period from Bostik Construction Products, Alvin Kleinbeck of the Department of Administration Building Codes Division, Merwyn Larson of the Minneapolis Department of Inspections, and Tate Halvorson of the St. Paul Building Inspection and Design Division. The Department finds that the following modifications to the proposed rule amendments are justified by the record in this proceeding:

a. **Part 7670.0100 AUTHORITY; SCOPE; CONFLICTS**

The Department proposed to amend this part by identifying subpart 3 as "conflicts," and prescribing that "in cases of conflict with other parts of the State Building Code, this chapter governs in all cases not affecting safety and health requirements." The Department received comments from Mr. Merwyn Larson and Mr. Alvin Kleinbeck that this subpart itself conflicts with the State Building Code (incorporated 1988 edition of the Uniform Building Code, section 103) which states:

> Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

The comments recommended that the proposed subpart 3 be replaced with the language from the Uniform Building Code, section 103. The Department agrees that

subpart 3 is itself in conflict with the State Building Code, and that the subpart 3 as proposed does not clarify the intent of the rule. Therefore, the Department has modified part 7670.0100 to delete subpart 3 in its entirety, since the Uniform Building Code section 103 already exists as part of the State Building Code.

The Department finds that the deletion is needed because it eliminates a potential conflict between chapter 7670 and other parts of the State Building Code. It is reasonable because section 103 of the 1988 Edition of the Uniform Building Code sufficiently addresses this matter for the purposes of interpreting the State Building Code.

The modification does not constitute a substantial change of the rule because the State Building Code continues to address the issue of conflicts in the State Building Code. Because the modification merely deletes a portion of the proposed rule that is in conflict with an adopted portion of the State Building Code, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

b. Part 7670.0130, Incorporations by Reference, subp. 1, Incorporated Items, Item C

The Department proposed to add to the list of incorporated items the ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality." The Department received comments from Mr. Merwyn Larson and Mr. Alvin Kleinbeck that this incorporation was unnecessary, since the document is referenced in part 7670.1000 as RS-3. The Department agrees with this suggestion and has modified item C of subp. 1 of part 7670.0130 to exclude this item. Item C is modified as follows:

C. ~~ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air~~

~~Quality as published by the American Society of Heating, Refrigerating and Air Conditioning Engineers (Atlanta, GA).~~

LTGSTD, lighting prescriptive and system performance compliance calculation program, a computer program developed by Battelle Pacific Northwest Laboratories.

The Department finds that the deletion is needed because it eliminates a duplication of the reference to a single item in the rule. It is reasonable because the document is fully referenced in part 7670.1000.

The addition of reference to the LTGSTD computer program is needed because designers of lighting systems in buildings may use the LTGSTD computer program to demonstrate compliance with the provisions of 10CFR part 435.103. The reference is reasonable because the LTGSTD computer program is an equivalent method of determining lighting prescriptive and system performance compliance.

The modification to delete the incorporation of ASHRAE Standard 62-1989 by reference does not constitute a substantial change of the rule because part 7670.1000 references the same document. Because the modification is merely elimination of a duplicate reference, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

The modification to add the LTGSTD computer program as an incorporation by reference does not constitute a substantial change of the rule because it merely cites an equivalent means of complying with the lighting power requirements of the energy code. Because the modification is only adding reference to an equivalent calculation tool, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

c. Part 7670.0130 Incorporations by Reference, subp. 2, Availability, Item D.

The Department had proposed in this item that the WINDOW computer program was available from Bostik Construction Products, P.O. Box 8, Huntington Valley, PA 19006. Upon checking this source, Department staff discovered that Bostik Construction Products had recently discontinued their P.O. box, and is asking that requests for the WINDOW computer program be sent to their street address, as indicated in the rule modification below. The Department wishes that requests for the WINDOW computer program be made to the correct address, and therefore has modified item D to read:

D. The WINDOW computer program is available from Bostik Construction Products, ~~P.O. Box 8~~1740 County Line, Huntington Valley, PA 19006.

This modification is needed to assure that requests for the WINDOW computer program are made to the correct address. It is reasonable because the modified address of Bostik Construction Products is correct.

The modification does not constitute a substantial change of the rule because the rule as modified cites the same source for the WINDOW computer program as did the rule as proposed. Because the modification does not change the source, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

d. Part 7670.0260, Materials and Equipment

The Department proposed add to part 7670.0480 (Effectiveness of Required Thermal Insulation) subpart 1 dealing with thermal insulation materials used in residential buildings three stories or less. The Department received comments from Mr. Merwyn Larson and Mr. Alvin Kleinbeck that this item would be more appropriately located as an amendment to the "Materials and Equipment" section of

the Model Energy Code. In addition, the Department received comment from Mr. Tate Halvorson that the rule should notify building officials of the agency administering chapter 7640. The Department agrees with these suggestions and has deleted subpt. 1 of 7670.0480, and included the language in a new part 7670.0260, and added a phrase indicating that chapter 7640 is adopted by the Department of Public Service. The numbering of the two subparts remaining in part 7670.0480 have been renumbered to account for deletion of subpt. 1 as proposed.

7670.0260 MATERIALS AND EQUIPMENT.

Section 102 of the Model Energy Code is amended by adding a paragraph to read:

102.3 Thermal Insulation. Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards, adopted by the Department of Public Service.

The modification to move this paragraph is needed to place the amendment in the proper location of the Model Energy Code, thereby avoiding disruption of the organization of the Model Energy Code. The addition of the phrase indicating that chapter 7640 is adopted by the Department of Public Service is needed to inform users of chapter 7670 of the origin of the State thermal insulation standards. These changes are reasonable because the intent of the rule is clarified while no substantive change is made.

The modifications do not constitute a substantial change of the rule because the rule as modified is only to a different location and expanded to indicate the origin of chapter 7640. Because the modification is merely moving the language to a new location and adding the source of another chapter of Minn. rules, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

e. Part 7670.0325 Definitions, Subp. 1, Thermal Transmittance, item A, subitems 1-4

The Department proposed to add definitions of four methods of determining the thermal transmittance of opaque wall components and roof/ceiling components. The definitions proposed included both a "reference" identifying where an explanation of the method could be found, and a list of "applications" for each method. The Department received comments from Mr. Merwyn Larson and Mr. Alvin Kleinbeck that the "applications" listed did not belong in the definitions, but would be more appropriately located under building envelope requirements. In addition, Mr. Kleinbeck indicates that the entire subpart on window U-values be relocated under building envelope requirements of the code for the same reason given for moving the "applications" language. The Department agrees with these suggestions and deleted the "applications" listed for each of the subitems, and moved them to a new subpart 1 under part 7670.0470, "Envelope Thermal Transmittance" (see item 6 h.). In addition, the entire item B describing window U-values have been deleted from this location and moved to the envelope thermal transmittance section (see items 6h and 6i of this document). The following modifications are made to subp. 1 of part 7670.0325:

Subpart 1. Thermal transmittance (U). In section 201 of the Model Energy Code, the definition of "Thermal transmittance (U)" is amended to read:

THERMAL TRANSMITTANCE (U). The coefficient of heat transfer (air to air). It is the time rate of heat transfer between the warm side and cold side air films (Btu/h ft^2 F).

~~A.~~ Thermal transmittance of opaque wall components (U_w) and roof/ceiling components (U_r) ~~must be calculated using one of the following~~ calculation methods ~~appropriate for the application~~ are defined in the references indicated:

(1) Parallel heat flow method: ~~Reference:~~ Model Energy Code, chapter 5, ~~equation~~ equations 1 and 2.
~~Applications: Wood frame and masonry with surface applied thermal insulation.~~

(2) Series-parallel method: ~~Reference:~~ Page 22.4 of Standard RS-1~~, page 22.4~~ listed in Chapter 7.
~~Applications: Masonry blocks with insulation inserts or filled cores and nonmetal surface with metal framing.~~

(3) Thermal bridges in sheet metal construction method:

~~Reference:~~Standard RS-25 listed in Chapter 7.
~~Applications:Metal framing bonded on one or both sides to a metal skin or covering.~~

(4) Zone method: ~~Reference:~~ page 22.10 of Standard RS-1~~, page 22.10~~ listed in Chapter 7.
~~Applications: Metal surface with nonmetal framing.~~

~~B. Thermal transmittance of window area (U_g) and skylight elements (U_s) must be determined in accordance with one of the following methods:~~
~~(1) Reference RS-1, representative U values for fenestration products, pages 27.16 to 27.18;~~
~~(2) AAMA Standard 1503.1;~~
~~(3) ASTM C 236 or ASTM C 976, using design conditions specified in footnote (a) of table 13, chapter 27 of reference RS-1; or~~
~~(4) WINDOW computer program.~~

The Department finds that this modifications are needed because "definitions" is an inappropriate location for prescribing when a particular method of calculation must be used. It is reasonable because the prescription of which method to use is simply moved to an appropriate location in part 7670.0470 dealing with envelope thermal transmittance requirements.

These modifications do not constitute substantial changes to the rule because the rule as modified contains the same language as proposed, only in a different location. Because the modification is merely moving the language to a new location, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

f. Part 7670.0400 Design Conditions

The Department had proposed to amend the Model Energy Code to identify design conditions by a cite to specific columns in a table in reference standard RS-1. The Department received comments from Mr. Merwyn Larson, Mr. Tate Halvorson and Mr. Alvin Kleinbeck who stated, first, for the convenience of users of the rule, that the amendment be worded as close as possible to the language of the Model Energy Code section 302.1 and second, include a table giving the design

conditions as printed in the referenced document. The Department agrees with these suggestions and has modified the language as follows to be as close as possible to that of the Model Energy Code section 302.1, and added a table of design conditions taken from the previously referenced document. In addition, Mr. Tate Halvorson pointed out that the standard containing heating degree days is in fact RS-23. Part 7670.0400 has been changed as follows:

7670.0400 AMENDMENT TO SECTION 302: DESIGN CONDITIONS.

Footnote 1 of section 302.1 of the Model Energy Code is amended to read:

[1]The exterior ~~outdoor~~ design ~~conditions~~ temperature must be selected from ~~Standard RS-1 Heating design temperatures must be no lower than the temperature listed in the 99 percent column. Cooling design temperatures must be no greater than the temperature listed in the 2.5 percent column~~ the "Design Conditions" columns shown in Table 302.1.

EXCEPTION: Where necessary to assure prevention of damage to the building or to the material and equipment within the building, the ~~median of annual extremes for heating and one percent columns for cooling~~ values listed in Table 302.1 under "extreme conditions" may be used.

TABLE 302.1 Exterior Design Temperatures

	DESIGN CONDITIONS		EXTREME CONDITIONS	
CITY	SUMMER DB/WB	WINTER DB	SUMMER DB/WB	WINTER DB
Albert Lea	87/72	-17	90/74	
Alexandria	88/72	-22	90/72	-28.0
Bemidji	85/69	-31	88/69	-36.9
Brainerd	87/71	-20	90/73	
Duluth	82/68	-21	85/70	-27.4
Faribault	88/72	-17	91/74	-24.3
Fergus Falls	88/72	-21	91/72	-27.8
International Falls	83/68	-29	85/68	-36.5
Mankato	88/72	-17	91/72	
Minneapolis	89/73	-16	92/75	-22.0
Rochester	87/72	-17	90/74	
St.Cloud	88/72	-15	91/74	
St.Paul	89/73	-16	92/75	-22.0
Virginia	83/68	-25	85/69	-33.0
Willmar	88/72	-15	91/74	-24.3
Winona	88/73	-14	91/75	

"DB" = dry bulb temperature, degrees Fahrenheit

"WB" = wet bulb temperature, degrees Fahrenheit

Heating degree days must be selected from Standard ~~RS-22~~ RS-23 listed in Chapter 7. Adjustments may be made as determined by the building official to reflect local climates which differ from the tabulated temperatures or local weather experience.

The Department finds that adding the table of design temperatures rather than the referenced standard is needed for the convenience of users of this chapter. The addition of this table is reasonable because all the values in the table are taken from appropriate columns of the document previously referenced (i.e., RS-1).

The modification to change the reference standard cited is needed and reasonable because the rule as proposed cited the wrong reference standard.

These modifications do not constitute substantial changes of the rule because the rule as modified has exactly the same meaning and requirements as the rule as proposed. Because the modifications are presenting the same data in a more useful manner, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

g. Part 7670.0450 Ventilation

The Department had proposed to amend the Model Energy Code to require ventilation systems to be designed to conform to ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality." The Department received comment from Mr. Alvin Kleinbeck that, for the convenience of users of the rule, whenever standards are referenced by chapter 7670, they be worded as close as possible to language of the Model Energy Code. Whenever the Model Energy Code references a standard it does not state the name of the standard, but rather uses the words "Standard RS-__ listed in Chapter 7." The Department agrees with this suggestion and has modified the language as follows to be as close as possible to

that of the Model Energy Code section 303.1. Similar modifications are made to the rule as proposed in items 6e, 6f, 6i, 6l and 6m of this document. Part 7670.0450 is modified to accomodate this change as follows:

7640.0450 AMENDMENT TO SECTION 303: VENTILATION.

303.1 Ventilation. Ventilation systems must be designed to conform with ~~ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality~~ RS-3 listed in Chapter 7.

The Department finds that this modification is needed to have this part consistent with the style of the Model Energy Code. It is reasonable because these changes clarify the intent of the rule without making a substantive change.

The modification does not constitute a substantial change of the rule because the rule as modified contains only grammatical changes. Because the modification is merely grammatical, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

h. Part 7670.0470 Envelope Thermal Transmittance, subp. 1, U-value Calculations

The Department proposed to add definitions of four methods of determining the thermal transmittance of opaque wall components and roof/ceiling components. The definitions proposed included both a "reference" identifying where an explanation of the method could be found, and a list of "applications" for each method. The Department received comments from Mr. Merwyn Larson, Mr. Tate Halvorson and Mr. Alvin Kleinbeck that the "applications" listed did not belong in the definitions, but would be more appropriately located under building envelope requirements. The Department agrees with this suggestion and deleted the "applications" listed for each of the subitems, and moved them to a new subpart 1 under part 7670.0470, "Envelope Thermal Transmittance." To accommodate this move, part 7670.0470 is

modified by adding subpart 1 as follows:

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE

Subpart 1. Section 502.1 of the Model Energy Code is amended by adding a paragraph to read:

502.1.4. Thermal transmittance of opaque wall components and roof/ceiling components must be calculated using the following methods:

(1) Wood frame and masonry with surface applied thermal insulation: Parallel heat flow method.

(2) Masonry blocks with insulation inserts or filled cores and nonmetal surface with metal framing: Series-parallel method.

(3) Metal framing bonded on one or both sides to a metal skin or covering: Thermal bridges in sheet metal construction method.

(4) Metal surface with nonmetal framing: Zone method.

The Department finds that this modification is needed because "thermal envelope transmission requirements" is an appropriate location for prescribing when a particular method of calculation must be used. It is reasonable because the prescription of which method to use is moved to this appropriate location from part 7670.00325 dealing with definitions.

The modification does not constitute a substantial change of the rule because the rule as modified contains the same language as proposed, only in a different location. Because the modification is merely moving the language to a new location, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

i. Part 7670.0470 Envelope Thermal Transmittance, subp. 2, U-value Calculations

The Department proposed to add definitions of four methods of determining the thermal transmittance of window and skylights. The Department received comments from Mr. Merwyn Larson, Mr. Tate Halvorson and Mr. Alvin Kleinbeck that the "applications" listed did not belong in the definitions, but would be more appropriately located under building envelope requirements. The Department

agrees with this suggestion and deleted the "applications" listed for each of the subitems, and moved them to a new subpart 2 under part 7670.0470, "Envelope Thermal Transmittance."

In addition, the Department received comment form Mr. James C. Benney of the National Wood Window and Door Association recommending that the reference to the WINDOW computer program be amended to require ASHRAE winter design conditions. The Department agrees with this suggestion, and has added a reference to the ASHRAE winter design conditions. To accommodate these revisions, part 7670.0470 is modified by adding subpart 2 as follows:

Subp. 2. Section 502.1 of the Model Energy Code is amended by adding a paragraph to read:

502.1.5. Thermal transmittance of window area (U_g) and skylight elements (U_s) must be determined in accordance with one of the following methods:

(1) Representative U-values for fenestration products, pages 27.16 to 27.18 of Standard RS-1 listed in Chapter 7;

(2) Standard RS-26 listed in Chapter 7;

(3) Standard RS-27 or RS-28 listed in Chapter 7 using design conditions specified in footnote (a) of table 13, chapter 27 of standard RS-1; or

(4) Standard RS-29 listed in Chapter 7 using design conditions specified in footnote (a) of table 13, chapter 27 of Standard RS-1.

The Department finds that this modification is needed because "thermal envelope transmission requirements" is an appropriate location for prescribing when a particular method of calculation must be used. It is reasonable because the proscription of which method to use is moved to this appropriate location from part 7670.00325 dealing with definitions.

In addition, the proscription of winter design conditions when using the WINDOW computer program is needed because if other design conditions are used, the resulting calculated U-value would be different. It is reasonable because the design conditions specified are the default values in the WINDOW computer program.

The modification does not constitute a substantial change of the rule because

the rule as modified contains the same language as proposed, only in a different location. Because the modification is merely moving the language to a new location, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

j. Part 7670.0470, Envelope Thermal Transmittance, subp. 3, Alternative Compliance

The Department proposed to amend the R-value of floor and wall components. The Department received comments from Mr. Tate Halvorson and Mr. Phil Hendrickson, DOW Chemical USA, recommending that the existing rule language for these R-values and accompanying footnote is superior. The Department agrees with this suggestion and restored the R-values and footnote 1 to the existing rule language. In addition, Department staff noted that since this alternative compliance method applies only to walls and roof/ceilings, the rule could be clarified by referencing sections 502.2.1.1 (titled "Walls" in the Model Energy Code), 502.2.1.2 (titled "Roof/ceiling" in the Model Energy code), and 502.2.1.3 (titled "Floors over unheated spaces" in the Model Energy Code) instead of the broader section 502.2.1 (titled "Heating and cooling criteria" in the Model Energy Code). This change of reference would shorten this subpart by eliminating the need for the last paragraph that indicated the other sub-sections of section 502.2.1 that must be complied with. Because subparts 1 and 2 have been added to this part (see items 6h and 6i above), the alternative compliance is assigned subpart 3, and modified as follows:

7670.0470 AMENDMENT TO SECTION 502: ENVELOPE THERMAL TRANSMITTANCE

Subp. 3. Section 502.2.1 of the Model Energy Code is amended by adding a new section to read:
502.2.1.7 Alternative compliance. Alternative methods of compliance to ~~section 502.2.1~~ sections 502.2.1.1, 502.2.1.2 and 502.2.1.3 for one- and two-family residential buildings.

Minimum performance for Type A-1 (one- and two-family) buildings:

Ceilings	Walls	Floors	Windows	Doors
R-38	~~R-19~~[1] R-20[1]	~~R-19~~[1] R-20[1]	Maximum U-0.49[2]	R-3

(1) For the ~~insulation within the~~ insulated cavity of opaque walls and rim joists.
(2) Maximum window area must not exceed 12 percent of the area of exterior walls, not including foundation walls.

Site-built fixed glazing must be installed in either an aluminum or steel frame having a minimum 0.25 inch low conductance thermal break or in wood or vinyl framing. The glazing must be either double-glazed with a dead air space between panes of nominal one-half inch spacing or triple-glazed with a dead air space between panes of not less than one-forth inch.

~~Foundation walls must comply with part 7670.0510, slab on grade floors must comply with section 502.2.1.4 and crawl space walls must comply with section 502.2.1.5.~~

The Department finds that the modification to reference sections 502.2.1.1, 502.2.1.2 and 502.2.1.3 instead of section 502.2.1 and deletion of the last paragraph is needed to clarify the rule. It is reasonable because the alternative compliance method pertains only to walls, roof/ceilings and floors, and the only sub-sections of section 502.2.1 to reference walls, roof/ceilings and floors are 502.2.1.1, 502.2.1.2 and 502.2.1.3, respectively. The modification to restore the R-values and footnote 1 to the existing rule is needed because the proposed change would have made enforcement difficult. The modification is reasonable because the language would be unchanged from the existing rule. In addition, the restoration of the wall and floor R-values and footnote 1 to the existing rule language has no effect on the amendment to the window U-value nor other modifications to this or any other part of chapter 7670 as proposed.

The modification to referenced sections of the Model Energy Code and deletion of the last paragraph of this subpart do not a constitute substantial change because the rule is merely clarified. These modifications to the R-values and

footnote 1 do not constitute a substantial change of the rule because the rule is restored. Because the modifications are restoring the language as now exists and clarifying the rule, the modifications do not introduce new subject matter into the rule nor do they make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

k. Part 7670.0480, Effectiveness of Required Thermal Insulation

The Department had proposed revisions to this paragraph (existing part 7670.0520), including deleting the sentence "The vapor barrier (retarder) must be continuous and uninterrupted." The Department received oral comments from Mr. Merwyn Larson that the requirement for the vapor retarder to be continuous should not be deleted because the proposed change in the definition of the vapor retarder (at part 7670.0325, subp.2) raises the perm rating from 0.1 to 1.0 perms. In order to maintain its effectiveness with this higher perm rating, Mr. Larson argued, the requirement that the vapor retarder be continuous is essential. The Department agrees that this requirement for a continuous vapor retarder should not be deleted, and has modified part 7670.0480 to read as follows. In addition, this part, and part 7670.0510, are modified to conform to style requirements of the Revisor.

7670.0480 AMENDMENT TO SECTION 502: EFFECTIVENESS OF REQUIRED THERMAL INSULATION.

Section 502.2 of the Model Energy Code is amended by adding paragraphs to read:

~~Subpart 1. Thermal Insulation. Thermal insulation used in residential buildings three stories or less in height must conform to chapter 7640, Minnesota Thermal Insulation Standards.~~

~~Subp. 2.~~ 502.2.1.8 Building assemblies are required to maintain the thermal performance of required insulation and the integrity of building materials against cold weather vapor condensation.

~~A.~~ 502.2.1.8.1 A vapor retarder must be installed between the interior surface and the winter design condition due point location within each building envelope surface. The vapor retarder must be continuous and joints in the vapor retarder must be sealed between solid blocking.

EXCEPTION: A vapor retarder need not be installed on the rim joist insulation.

~~B.~~ 502.2.1.8.2 A barrier against air leakage must be installed to prevent the leakage of moisture-laden air from the house into the building envelope. An air barrier must be continuous at all plumbing and heating penetrations of the interior surface of the building exterior envelope. If a tub or shower is located on an exterior wall, an air barrier must be provided at the interior surface of the building exterior envelope behind the tub or shower.

Subp. ~~3.~~ 2. Preventing wind wash. Section 502 of the Model Energy Code is amended by adding a paragraph to read:

502.2.1.9 A barrier must be provided at the following locations to mitigate wind wash:

A. the exterior edge of attic insulation; and

B. cantilevered floors and bay windows, including corners with adjoining walls above and below.

The Department finds that the modification is needed because the change in perm rating in the definition of vapor retarder to a higher value adds importance to the vapor retarder being continuous. The modification is reasonable because the language would be unchanged from the existing rule. The style modifications are needed and reasonable to conform to Revisor's style requirements.

The modifications do not constitute a substantial change of the rule because the rule is restored. Because the modification is merely restoring the language as now exists and changed to conform to style requirements, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

1. **Part 7670.0550, Air Leakage**

The Department proposed to amend the Model Energy Code part 502.4.3, exterior joints, add subpart 2, alternative and subpart 3, fire stops. The Department received comments from Mr. Alvin Kleinbeck that the amendment to the Model Energy Code paragraph 502.4.3 was only grammatical, and thus the proposed amendment was superfluous. In addition, Mr. Kleinbeck suggested that subp. 2 "Alternative" be stated as an exception to 502.4.3. Additional comment was received from Mr. Tate

Halvorson that the rule should clarily indicate that if this alternative is not chosen, then the portion of the alternative prescribing a ventilation rate does not apply (unless required by other parts of chapter 7670). The Department agrees with these suggestions, and has amended this part follows. Subpart 2 (subp. 3 of the rules as proposed) is modified to conform to style without substantive change from the rule as proposed.

7670.0550 AMENDMENT TO SECTION 502: AIR LEAKAGE.

Subpart 1. Alternative. Section 502.4.3 of the Model Energy Code is amended ~~to read~~ by adding an exception as follows:

~~Subpart 1. 502.4.3 Exterior joints in the building envelope that are sources of air leakage must be caulked, gasketed, or otherwise sealed in an approved manner. These air leak sources include, but are not limited to, areas between wall cavities and window or door frames, between walls and foundations, between walls and roofs or ceilings and between wall panels, and at penetrations of utility services.~~

~~Subpart 2.~~ EXCEPTION: ~~Alternative.~~ As an alternative to the prescriptive requirements of ~~subpart 1~~ section 502.4.3 for detached single-family residential buildings, air tightness must comply with air leakage class A, B, C, or D of ~~ANSI/ASHRAE Standard 119~~ Standard RS-26 listed in Chapter 7. In addition, this alternative requires that the ventilation system must provide a ventilation rate of not less than 0.35 air changes per hour (determined in accordance with ~~ASHRAE~~ Standard ~~62~~ RS-3, Table 2.3) or 15 cfm per person, whichever is greater. This ventilation rate must be verified by measurement. If this alternative is not chosen, this ventilation rate requirement applies only if required by Standard RS-3.

Subp. ~~3~~2. Section 502.4 of the Model Energy Code is amended by adding a paragraph to read as follows:

502.4.4 Fire stops. Fire stops must be installed in accordance with the State Building Code. When mineral fiber or glass fiber materials are used as fire stop construction at ceilings and wall cavities separating conditioned and unconditioned spaces, the fire stop must be installed to block air movement.

EXCEPTIONS: A fire stop need not block air movement if its installation would conflict with any other part of the State Building Code.

The Department finds that the elimination of the first paragraph (subp. 1 of the rule as proposed) is needed and reasonable because the proposed amendment would have made enforcement more difficult, and the paragraph as it exists in the

Model Energy Code is equivalent in content and meaning.

The addition of the sentence clarifying that if this alternative is not chosen then the specific ventilation rate prescribed by the alternative does not apply (unless required by Standard RS-3) is needed to clarify that the builder is not required to follow a portion of this alternative if the alternative is not chosen. The additional sentence is reasonable because whether or not this alternative is chosen, compliance with Standard RS-3 is required.

The modifications to the subp. 2 are needed and reasonable to conform to the style of the Model Energy Code and style requirements of the Revisor.

These modifications do not constitute a substantial change of the rule because the rule as modified contains the same meaning as proposed. Because the modifications are only for organization and clarification, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

m. Part 7670.0800 Electric Power and Lighting, subp. 2, Lighting power budget

The Department proposed to amend the Model Energy Code to require a lighting power budget as specified in the Code of Federal Regulations, title 10, part 435.103 (excluding section 3.2). Following publication of the notice, Department staff noted two typographical errors in 10 CFR part 435.103. In part 3.1.6.2, reference is made to equation 3.3-1 to calculate Exterior Lighting Power Allowance (ELPA). The equation by which ELPA is calculated is 3.4-1. In equation 3.5-3, the dimensional units for Interior Lighting Power Allowance are incorrectly identified as "watts per square foot." The correct units are "watts." Comments were received from J. Steven Schliesing of Battelle Pacific

Northwest Laboratories about the availability of a computer program developed to assist users of 10 CFR part 435.103 (lighting standards). The LTGSTD program (for LighIinG STanDards) provides users with an easy-to-use way of determining compliance with 10 CFR part 435.103. Department staff noted that since the LTGSTD computer program would often be used by lighting designers to demonstrate compliance with the lighting power budget requirements, it should be referenced in chapter 7670. To correct the typographical errors and add a reference to the LTGSTD computer program, the Department has modified subp. 2 of part 7670.0800 as follows:

> Subp. 2. Lighting power budget. The lighting requirements of sections 505.3 and 505.4 of the Model Energy Code are amended to read:
>
> The lighting power budget must be the upper limit of the power to provide lighting needs in accordance with the 1988 and 1989 criteria and calculation procedure specified in ~~Code of Federal Regulations, title 10, part 435.103~~ Standard RS-24 listed in Chapter 7 (excluding section 3.2, referencing equation 3.4-1 in section 3.1.6.2, and correcting the units for ILPA in equation 3.5-3 to Watts), or using Standard RS-26 listed in Chapter 7.
>
> Exception: One- and two family detached dwellings and the dwelling portion of multifamily buildings.

The Department finds that the modification to include corrections to typographical errors in the Code of Federal Regulations is needed and reasonable because users of this part may be confused if not alerted to the existence to the typographical errors.

The addition of the reference to RS-26 (LTGSTG computer program) is needed to acknowledge the acceptability of the use of this tool to show compliance with this part. The reference to the LTGSTD computer program is reasonable because its use gives the same results as following the written provisions of 10 CFR part 435.103.

These modifications do not constitute a substantial changes of the rule because the rule as modified contains the same meaning as proposed. Because the

modifications address grammatical issues and the addition of an equivalent method of demonstrating compliance, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

n. Part 7670.0850 Design by Acceptable Practice

The Department proposed to amend the "Design by Acceptable Practice" section of the Model Energy Code by indicating that "Buildings constructed in accordance with this section must also comply with parts 7670.0480 to 7670.0800." The Department received comments from Mr. Tate Halvorson, Mr. Merwyn Larson, and Mr. Alvin Kleinbeck that the proposed rule language would be inconvenient to users, since they would have to identify which sections of the Model Energy Code section 600 were modified by which parts and subparts of Minnesota rules. The Department agrees with this observation, and in response has modified part 7670.0800 to provide a cross-reference table indicating which sections of the Model Energy Code section 600 were modified by which parts and subparts of Minnesota rules. In addition, part 7670.0470 has been modified (see items 6h and 6i) to include requirements (for U-value calculations) that had been in definitions (part 7670.0325, subp. 1) in the rules as proposed. To assure that the requirements for U-value calculations are still included in the Design by Acceptable Practice section, this part must be modified to include a reference to part 7670.0470. The rule is modified as follows:

7670.1000 AMENDMENTS TO SECTION 600: DESIGN BY ACCEPTABEL PRACTICE

Section 601.1 of the Model Energy Code is amended by adding a paragraph to read:

Buildings constructed in accordance with this section must also comply with parts ~~7670.0480~~ 7670.0470 to 7670.0800 as indicated below:

Model Energy Code	Minn. Rules Part

602.2	7670.0470, 7670.0480
602.2.4	7670.0500
602.2.6	7670.0510
602.3.2	7670.0550
603.1	7670.0610
603.2.1	7670.0660
603.4	7670.0670
604	7670.0710
605	7670.0800

The Department finds that the modification to add a table indicating which parts of the Model Energy Code section 600 are modified by chapter 7670 is needed because users of the Design by Acceptable Practices section of the Model Energy Code should be able to conveniently identify which sections of the Model Energy Code are amended by Minn. Rules ch. 7670. The modification to add the reference to part 7670.0470 is needed to assure that requirements that were previously in part 7670.0325 still apply to the use of this section. The modification is reasonable because only those sections indicated in part 7670.1000 as modified are amended by the respective parts of Minnesota rules as indicated.

The modification does not constitute a substantial change of the rule because the rule as modified contains the same meaning as proposed. Because the modification only clarifies the rule, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

o. Part 7670.1000, Chapter 7, Referenced standards

The Department had proposed to amend section 701 of the Model Energy Code to update several standard references. The recommendation was received from Mr. Alvin Kleinbeck and Mr. Merwyn Larson that to conform to the style of the Model Energy Code, all references cited part 7670.0130 be assigned "RS" numbers and be listed as an amendment to section 701. Additionally, it was recommended that to

further conform to the style of the Model Energy Code, throughout chapter 7670, whenever a reference is made to a standard, the "RS" number be cited. These recommendations were made in the interest of clarifying the rule for the convenience of the users of this chapter. The Department agrees that, for the convenience of users of this chapter, "RS" numbers should be assigned to all references, and that the "RS" numbers should be used whenever a reference standard is cited. The rule has been modified as indicated below, and throughout chapter 7670 the "RS" numbers have been substituted whenever reference standards are cited.

7670.1000 AMENDMENTS TO SECTION 701: ~~REFERENCES~~ STANDARDS.

Section 701.1 of the Model Energy Code is amended by replacing and adding the following code standard numbers to read:

RS-1 1989 ASHRAE Handbook of Fundamentals.
RS-3 ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality.
RS-4 ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy.
RS-17 & RS-18 SMACNA HVAC Duct Construction Standards: Metal and Flexible, First Edition, 1985.
RS-23 Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-1980 Minnesota. National Oceanic and Atmospheric Administration, September, 1982.
RS-24 Code of Federal Regulations, title 10, part 435.103, lighting.
RS-25 Code of Federal Regulations, title 10, part 435.105, section 5.3.3.2.1(d), Calculation procedures for thermal bridges in Sheet Metal Construction.
RS-26 LTGSTD, lighting prescriptive and system performance compliance calculation program.
RS-26 ASHRAE Standard 119-1988, Air Leakage Performance for Detached Single-family Residential Buildings.
RS-26 AAMA Standard 1503.1-88, Voluntary Test Method for Thermal Transmittance and Condensation of Windows, Doors and Glazed Wall Sections.
RS-27 ASTM C 236-87, Standard Test Method for Steady State Performance of Building Assemblies by means of a Guarded Hot Box.
RS-28 ASTM C 2976-82, Standard Test Method for Steady State Performance of Building Assemblies by means of a Calibrated Hot Box.
RS-29 WINDOW computer program.

The Department finds that this modification is needed because users of this

chapter will able to more conveniently identify reference standards. The modification is reasonable since no changes are made in the references in the rule as proposed.

The modification does not constitute a substantial change of the rule because the rule as modified contains the same meaning as proposed. Because the modification only clarifies the rule, the modification does not introduce new subject matter into the rule nor does it make a major substantive change that was not raised by the proposed rule as originally noticed in such a way as to invite reaction.

7. The Department adopts the Statement of Need and Reasonableness, in its entirety, as the factual basis for the proposed rules. The Department hearby incorporates the Statement of Need and Reasonableness into these findings.

8. The above-captioned rule amendments, as modified, are needed and reasonable. (8)

CONCLUSIONS

1. The Minnesota Department of Public Service duly acquired and has jurisdiction over this proceeding.

2. The Department published and served due, timely, and adequate notice of the intent to adopt the rules without a public hearing.

3. All relevant legal and procedural requirements of statute and rule have been complied with.

4. The modifications to the proposed rule amendments are supported by the record and do not result in a substantial change in the proposed rules.

ORDER

NOW, THEREFORE, IT IS ORDERED that the attached amendments to rules amending the State building code regarding heat loss, illumination and climate control are adopted this 29 day of Nov, 1990, pursuant to authority vested in me by Minn. Stat. § 216C.19, subd. 8(9)

Tony Perpich

Tony Perpich, Commissioner
Department of Public Service

STATE OF MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

In the matter of the Proposed
Amendments to Rules of the
Minnesota Department of Public
Service Amending the State Building
Code regarding Heat Loss,
Illumination, and Climate Control
(Minn. Rules ch. 7670)

DECLARATION OF COUNSEL

I, Eric F. Swanson, Special Assistant Attorney General, do hereby declare that I have examined the above-captioned rule, and the supporting rulemaking record, and that, based on my examination, the Administrative Procedure Act and Minnesota Rules, chapter 2010 have been followed. Any exceptions are listed below. For Attorney General billing purposes, the four digit docket client code is 0730.

ERIC F. SWANSON
Special Assistant
Attorney General

Dated: 12/5/90