NBSIR 75-795

Recommended Criteria for Retrofit Materials and Products Eligible for Tax Credit

Edited by
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Materials and Composites Section
Structures, Materials and Safety Division
National Bureau of Standards
Washington, D. C. 20234

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Final

Prepared for
Federal Energy Administration
12th & Pennsylvania Avenue, N. W.
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TABLE OF CONTENTS

ACKNOWLEDGMENT

The editors wish to thank the researchers in the Center for Building Technology at the National Bureau of Standards who participated in preparing this report. Mr. Bradley A. Peavy, Jr. of the Thermal Engineering Section provided the criteria and information for thermal insulation and vapor barriers. Mr. Jenkins Washington and Mr. John S. Stroik of the Architectural Research Section provided the criteria and information for storm windows and doors. Mr. Arthur Hockman and Dr. Walter J. Rossiter of the Materials and Composites Section furnished the criteria and information for caulks and sealants, and weatherstripping and clock thermostats, respectively. Mr. Bertram M. Vogel of the Office of Building Standards and Codes Services reviewed the relationship between retrofitting and model building codes. Mr. Daniel Gross and Mr. Gregory A. Harrison of the Center for Fire Research provided the requirements for fire and health safety.

The editors also express their appreciation to those industrial representatives who provided many useful comments and submitted pertinent product standards and specifications.

SI CONVERSION UNITS

In view of present accepted practice in this country in this technological area, common U.S. units of measurement have been used throughout this paper. In recognition of the position of the USA as a signatory to the General Conference on Weights and Measures, which gave official status to the metric SI system of units in 1960, we assist readers interested in making use of the coherent system of SI units by giving conversion factors applicable to U.S. units used in this paper.

Length

1 in = 0.0254 meter* (m)
1 ft = 0.3048 meter* (m)

Area

1 in^2 = 0.000645 square meter (m^2)
1 ft^2 = 0.0929 square meter (m^2)

Volume

1 in^3 = 0.0000164 cubic meter (m^3)
1 ft^3 = 0.0283 cubic meter (m^3)

Mass

1 lb = 0.453 kilogram (kg)

Mass/Volume (Density)

1 lb/ft^3 = 16.02 $kilogram/meter^3$ (kg/m^3)

Temperature

degree Celcius (°C) = 5/9 (°F - 32)

Pressure

1 psi = 6895 $newton/meter^2$ (N/m^2)

Mass/Time (Flow)

1 perm (23°C) = 5.745×10^{-11} $kilogram/pascal\ second\ meter^2$ ($kg/Pa.s.m$)

Volume/Time (Flow)

1 cfm = 0.000472 $meter^3/second$ (m^3/s)

Velocity

1 mph = 0.447 meter/second (m/s)

Quantity of Heat

1 Btu = 1055.87 joule (J)

Thermal Resistance

1 °F h ft^2/Btu = 0.176 square meter degree Celcius/Watt ($m^2.°C/W$)

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* exactly

ABSTRACT

The Federal Energy Administration requested the National Bureau of Standards to develop criteria for retrofitting for possible use by the Internal Revenue Service in implementing the Presidential initiative authorizing tax credit to homeowners. Criteria are recommended for materials and products considered eligible for proposed tax credit for retrofitting one and two family residences to conserve energy. The materials considered include insulation and vapor barriers, storm windows and doors, caulking and weatherstripping, and clock thermostats. A list of these retrofit materials was compiled by generic type and recommendations made on their installation.

In addition to recommended criteria for materials and products eligible for tax credit, desired levels of performance for the retrofit materials are presented as a guide to homeowners to achieve maximum benefits in energy conservation through retrofitting.

1. INTRODUCTION

1.1 BACKGROUND

In the past homes were usually built to minimize first cost. Energy costs were low and little attention was paid to effective use of energy in homes. Many existing dwellings are inadequately insulated in the ceilings, walls and floors, are without storm windows (double glazing) and doors, and are in need of caulking and weatherstripping around windows and doors. It is estimated that more than 40 million single family residences are inadequate in one or more of these ways and should be considered for retrofitting [1]*. Effective retrofitting of residences could save nearly 20 percent of the energy used for residential heating and cooling in the United States [2]. The term retrofitting, as used here, is the process whereby materials and products are added to existing homes to reduce permanently heating and cooling energy consumption.

The savings in both dollars and energy from effective retrofitting have been discussed in the literature [1-9]. Examples of savings cited from the literature are given in Appendix A. The reports cited show in general that a sound economic basis for retrofitting exists.

1.2 TAX CREDIT FOR RETROFITTING

As an incentive for homeowners to retrofit their homes to conserve energy, the President of the United States proposed legislation to Congress that would allow a tax credit on retrofitting. The original proposal called for a credit of 15% of the purchase and installation cost, with a maximum credit of $150.00. To be prepared for the passage of such legislation, the Federal Energy Administration (FEA) requested the National Bureau of Standards (NBS) to recommend the criteria to be used by the Internal Revenue Service (IRS) for considering materials and products eligible for tax credit. Although Congress deleted retrofit tax credit from earlier legislation, it is still possible that this provision may be included in a future federal energy bill.

1.3 OBJECTIVES

The objectives of this report are to recommend criteria for retrofit materials and products which may be eligible for proposed tax credit to homeowners; to compile a list of retrofit materials and products by generic type and to indicate areas where they can be used; and to suggest levels of performance for retrofit materials to achieve maximum benefits in energy conservation.

1.4 SCOPE OF THE PROJECT

An interdisciplinary team from the National Bureau of Standards, Center for Building Technology, was assembled to conduct the program. The team members included materials specialists, thermal engineers, architects, and fire, safety and building code experts. They identified materials and products which might be suitable for retrofitting. As requested by FEA, the categories of materials and products were limited to insulation, vapor barriers, storm windows and storm doors, caulks and sealants, weatherstripping and clock thermostats. These items are discussed in this report. Other commercially available materials and products which may be suitable for retrofitting are not included in the recommended criteria for tax credit given in Section 2. A list of such products is given in Appendix B. If necessary, criteria for tax credit eligibility could be established in the future for other materials and products that are effective in conserving energy in residences. This report can be updated to include additional items.

A number of industrial trade and manufacturer's associations, as well as individual manufacturers, were asked to participate in the program by NBS. On March 14, 1975, a meeting was held at NBS, Gaithersburg, to explain the purpose of the program to industry representatives. The representatives were requested to aid NBS in compiling the retrofit criteria by submitting relevant literature, standards and specifications. The information

*Figures in brackets indicate references listed in Section 6.

they submitted was considered in developing the recommended criteria and in preparing the list of additional materials and products which may be suitable for retrofitting (Appendix B).

1.5 ORGANIZATION OF THIS REPORT

Section 1 gives background information and the objectives and scope of the project.

Section 2 presents the recommended criteria for determining the eligibility of retrofit materials and products for tax credit.

Section 3 gives desired levels of performance for retrofit materials and products. Although not necessary for tax credit, nor likely to be able to be made a requirement, these levels of performance would assure maximum benefit from retrofitting.

Section 4 outlines precautions which must be taken to assure proper installation of the retrofit items.

Section 5 shows the relationship between the retrofitting process and model building codes, and the constraints which the codes impose upon retrofitting.

2. RECOMMENDED CRITERIA FOR MATERIALS AND PRODUCTS TO BE ELIGIBLE FOR PROPOSED TAX CREDIT

The materials and products considered eligible for proposed tax credit are insulation, storm windows and doors, caulks and sealants, weatherstripping, vapor barriers and clock thermostats, when used for retrofitting residential housing to save energy. This section gives recommended criteria by which the eligibility of these materials and products can be determined.

These recommended criteria are based on factors such as thermal performance, fire safety, health safety, structural integrity, durability, quality, conformance to building codes, use and ease of installation. FOR ALL ITEMS WHICH MEET THE CRITERIA, TAX CREDIT SHOULD ONLY BE ALLOWABLE IF THE MATERIALS, PRODUCTS AND INSTALLATION TECHNIQUES DO NOT VIOLATE APPLICABLE EXISTING LOCAL BUILDING RELATED CODES.

Existing materials specifications and standards were reviewed for their suitability as a basis for the criteria. For some items, conformance to existing specifications or standards is recommended as the criterion for tax credit eligibility. For others, for which there are no available specifications or standards, but which produce important energy savings when retrofitted to existing housing, the recommended criterion is that materials be purchased and properly installed. These items are recommended eligible for proposed tax credit, since they have been proven effective for conserving energy in heating and cooling residences [3, 5, 6 and 8].

The intent of the proposed tax credit is to conserve energy through the encouragement of retrofitting. Early action should not be hindered by requiring that new standards or specifications be written for retrofit items in cases where no applicable ones exist. Also, the problem of enforcing conformance to the criteria in evaluating the validity of claims for tax credits was kept in mind. Complicated technical criteria could make enforcement difficult, if not practically impossible.

All the materials and products considered eligible for proposed tax credit and recommended criteria for determining their eligibility are summarized in Table 1. All the specifications and standards cited in this report are listed in Appendix D.

Table 1. Summary of Recommended Criteria

Material or Product	Recommended Criteria for Tax Credit Eligiblity[1]
Insulation-Mineral Fiber	
Blanket/Batt	Conformance to F.S.[2] HH-I-521E and ASTM C665-70
Board	Conformance to F.S. HH-I-526C and ASTM C612-70 or C726-72
Duct Material	Conformance to F.S. HH-I-545B
Loose-fill	Conformance to F.S. HH-I-1030B and ASTM C764-73
Insulation-Mineral Cellular	
Aggregate Board	Conformance to F.S. HH-I-529B
Cellular Glass	Conformance to F.S. HH-I-551E and ASTM C552-73
Perlite	Conformance to F.S. HH-I-574A and ASTM C549-73
Vermiculite	Conformance to F.S. HH-I-585B and ASTM C516-67
Insulation-Organic Fiber	
Cellulose-Classes 25 and 75	Conformance to F.S. HH-I-515B and ASTM C739-73 (Loose-fill)
Cellulose-Class 200	Conformance to F.S. HH-I-515B and ASTM C739-73 (Loose-fill) and fire safety requirements[3]
Vegetable	Conformance to F.S. HH-I-528B and fire safety requirements
Board and Block	Conformance to F.S. LLL-I-535A and ASTM C208-72 and fire safety requirements
Insulation-Organic Cellular	
Polystyrene Board	Conformance to F.S. HH-I-524B and ASTM C578-69 and fire safety requirements
Urethane Board	Conformance to F.S. HH-I-530A and ASTM C591-69 and fire safety requirements
Flexible Unicellular	Conformance to F.S. HH-I-573B and ASTM C534-70 and fire safety requirements

Table 1. Summary of Recommended Criteria (continued)

Material or Product	Recommended Criteria for Tax Credit Eligibility(1)
Insulation-Air Spaces	
Reflective	Conformance to F.S. HH-I-1252A
Storm Windows	
Aluminum Frame	Equivalent to ANSI A134.3-1972
Wood Frame	Conformance to Section 3 of NWMA Industry Standard I.S.2-73
Rigid Vinyl Frame	Conformance to NBS Product Standard PS26-70 and performance guarantee
Frameless Plastic Glazing	Required Minimum Thickness, 6 mil (0.006 in)
Storm Doors	
Aluminum	Equivalent to ANSI A134.4-1972
Wood	
Pine	Conformance to Section 3 of NWMA I.S.5-73
Fir, Hemlock, Spruce	Conformance to Section 3 of FHDA/5-75
Hardwood veneered	Conformance to Section E of NWMA I.S.1-73
Rigid Vinyl	Conformance to NBS Product Standard PS26-70 and performance guarantee
Caulks and Sealants	Commercial Availability
Weatherstripping	Commercial Availability
Vapor Barriers	Conformance to ASTM C755-73
Clock Thermostats	Commercial Availability

(1) For all items, tax credit should be allowed only if the items are installed as stated in Section 2 and installation does not violate any existing applicable building-related code.

(2) F.S. - federal specification.

(3) For fire safety requirements, see Section 2.1.3.1.

2.1 INSULATION

2.1.1 Definition. Thermal insulation is a material or assembly of materials used primarily to provide resistance to heat flow.

2.1.2 Materials. The materials listed below are those considered acceptable for use in residential housing to provide increased thermal resistance through retrofitting.

2.1.2.1 Types. Insulation is available as the following types:

°Mineral fibrous materials such as glass, rock or slag wool.

°Mineral cellular materials such as perlite and vermiculite.

°Organic fibrous materials such as cotton, wood, paper, animal hair or synthetic fibers.

°Organic cellular materials such as polystyrene or polyurethane.

°Air spaces with either non-reflective or metallic or metallized organic reflective surfaces.

2.1.2.2 Physical Forms. Insulation is available in the following physical forms:

°Loose-fill. Loose-fill insulation consists of fibers, granules or nodules which are usually poured or blown into walls, attics or other enclosed spaces.

°Flexible and Semirigid. These are materials with varying degrees of compressibility and flexibility, generally blanket, batt or felt insulation. They are available in sheets or rolls of many types and varieties, both organic and inorganic. Coverings and fastenings may be fastened to one or both sides to serve as reinforcing, vapor barriers, reflective surfaces or surface finishes. Thickness and shape of insulation may be of any dimension conveniently handled, although standard sizes are generally used.

°Rigid. These materials are available in rectangular dimensions called block, board or sheet, and preformed during manufacture to standard lengths, widths and thicknesses.

2.1.3 Criterion. Materials used for thermal insulation should meet minimum requirements for heat flow resistance, fire safety and quality. Federal specifications and ASTM designations are available which set the requirements for heat flow resistance and quality of the insulations, but which are, in some cases, incomplete in regards to fire safety. For fire safety, addition of thermal insulation should be accomplished in such a manner so as not to decrease the overall fire safety of the residence. This involves considerations of (a) installation, (b) burning characteristics, and (c) flame resistance permanency.

Materials conforming to the federal specifications and ASTM designations listed in Table 2 and properly installed as designated in Section 2.1.4 are considered to meet the minimum requirements for heat flow resistance, fire safety and quality. As such, they should be eligible. Each insulation should be labeled as meeting the applicable specification.

Materials conforming to the federal specifications and ASTM designations listed in Table 3 are considered to meet only the requirements for heat flow resistance and quality. They may not meet the requirement for fire safety. As such, they should be eligible only if they are certified as conforming to the fire safety requirements listed in Section 2.1.3.1, in addition to conforming to the other requirements of the federal specifications, and are properly installed as designated in Section 2.1.4. Each insulation should be labeled as conforming to both the fire safety requirement and the federal specification.

2.1.3.1 Fire Safety Requirements.

° Surface Burning Characteristics. The flame spread classification index for all insulation materials shall not exceed the following values:

plastic foam	25*
all other insulation material	150.

The ASTM E84-70 flame spread test method shall be the basis for evaluating the surface burning characteristics of the residential insulation material. Where fibrous blankets with facings are to be used, the surface burning characteristics of the complete faced insulation blanket shall be measured.

° Flame Resistance Permanency. Chemical retardant insulations shall retain their flame resistance throughout their service lifetime. The procedures and equipment specified in ASTM C739-73, Section 10.4, "Flame Resistance Permanency" shall be used in judging the effect of aging on the permanence of any flame retardants used during manufacture.

2.1.4 Areas of Application. Materials used for thermal insulation may be applied in residential housing to the following areas: walls, roofs, ceilings, floors, pipes, ducts, vessels and equipment exposed to the external environment.

Exposed plastic foam (untreated or fire-retardant treated) and non-fire-retardant treated cellulosic loose-fill insulation shall not be permitted in habitable areas. These materials should be protected by a layer of gypsum board of 1/2 inch thickness or greater, or an equivalent fire barrier.

Installed insulation shall not make contact with recessed light fixtures, motors, fans, blowers, heaters, flues, and chimneys. Thermal insulation should not be installed within 24 inches of the top or within 3 inches of the side of a recessed electrical fixture enclosure, wiring compartment or ballast unless labeled for the purpose. To retain loose-fill insulation from making contact with other energy-dissipating objects, a minimum of 2 inches of air space should be provided and assured by the use of blocking.

2.1.5 Commentary. Although a degree of material combustibility is allowed, the intent is to allow insulating materials which are not more combustible (or flammable) than existing construction and insulation materials, and to preclude any increased fire hazard due to the retention of heat from energy-dissipating objects.

In areas where occupants are likely to be engaged in normal activities, the insulation should perform its intended function without the increased risk of ignition, rapid flame spread, and heat and smoke generation. Insulation in concealed spaces may be a particular fire problem due to its susceptibility to smoldering and its inaccessibility for firefighting.

*No single test is sufficient to provide a full estimate of performance of a product in a fire. Plastic foams are difficult to evaluate in ASTM E84-70. The requirement of flame spread classification of 25 maximum for these foams will provide as much safety assurance as is possible with current test methods. Such a classification (or any other numerical classification) shall not be construed as the equivalent of "noncombustible". Insulation materials, including those consisting of cellulose, plastic foam and fibrous glass (containing organic binder) are combustible materials which will burn and release heat, especially when exposed to continuous large fire sources.

Table 2. Thermal Insulating Materials Which Are Eligible*

Type of Insulation	Federal Specification Number	Federal Specification Title	ASTM Designation
Mineral Fiber	HH-I-521E	Insulation Blankets, Thermal (Mineral Fiber, for Ambient Temperatures)	C665-70
	HH-I-526C	Insulation Board, Thermal (Mineral Fiber)	C612-70 C726-72
	HH-I-545B	Insulation, Thermal and Acoustical (Mineral Fiber, Duct Material)	--
	HH-I-1030B	Insulation, Thermal (Mineral Fiber for Pneumatic or Poured Application)	C764-73
Mineral Cellular	HH-I-529B	Insulation Board, Thermal (Mineral Aggregate)	--
	HH-I-551E	Insulation, Block and Board, Thermal (Cellular Glass)	C552-73
	HH-I-574A	Insulation, Thermal (Perlite)	C549-73
	HH-I-585B	Insulation, Thermal (Vermiculite)	C516-67
Organic Fiber	HH-I-515B Class 25 Class 75	Insulation Blanket, Thermal; and Insulation, Thermal (Loose-fill for Pneumatic or Poured Application) Cellulose, Vegetable and Wood Fiber	C739-73 (Loose-fill) Type I Type II
Air Spaces	HH-I-1252A	Insulation, Thermal, Reflective (Aluminum Foil)	--

*Products listed under the categories Batts and Blankets (40U8.3) and Loose Fill Material (40U8.11) in the Underwriters' Laboratories Building Materials Directory comply with the flame spread limitations given in Section 2.1.3.1.

Table 3. Thermal Insulating Materials Which May Be Eligible*

Type of Insulation	Federal Specification		ASTM
	Number	Title	Designation
Organic Fiber	HH-I-515B Class 200	Insulation Blanket, Thermal; and Insulation, Thermal (Loose-fill for Pneumatic or Poured Application) Cellulose, Vegetable and Wood Fiber	C739-73 (Loose-fill) Type III
	HH-I-528B	Insulation Batts and Blankets, Thermal (Vegetable Fiber)	--
	LLL-I-535A	Insulation Board, Thermal and Insulation Block, Thermal	C208-72
Organic Cellular	HH-I-524B	Insulation Board, Thermal (Polystyrene)	C578-69
	HH-I-530A	Insulation Board, Thermal (Urethane)	C591-69
	HH-I-573B	Insulation, Thermal (Flexible Unicellular Sheet and Pipe Covering)	C534-70

*They must be certified as conforming to the fire safety requirements in Section 2.1.3.1.

The urethane plastic foam industry recommends that urethane foam used in all interior and/or ceiling construction should be covered with at least 1/2 inch of cement plaster or fire-rated gypsum wallboard or an equivalent barrier providing a finish fire rating of 15 minutes or more [10]. This recommendation has been incorporated in building codes and Federal regulations for various types of buildings.

Although the primary fire safety properties of insulation relate to ignitability and rate of heat release, at the present time standard test methods for these properties do not exist. ASTM E84-70 is the current standard used to judge the fire performance.

No general test method exists for evaluating the flame resistance permanency of all chemical retardant insulations. ASTM C739-73, Section 10.4, was specifically developed for cellulosic insulations. This test method is an accelerated aging procedure designed to determine the permanency of the chemicals used as fire retardants. Aging is performed by cycling at high relative humidities and temperature. The intent is to simulate conditions in which flame retardants may be leached from the insulation.

2.2 STORM WINDOWS

2.2.1 Definition. A storm window is an extra window, normally installed to the exterior of the primary or ordinary window to increase resistance to heat flow and to decrease air infiltration. Less commonly, storm windows are installed on the interior of the primary window.

2.2.2 Materials. Storm windows may be constructed of aluminum, wood or rigid vinyl [poly(vinyl chloride)] frames, with glass or plastic glazing. Flexible and rigid plastic sheeting may also be used.

2.2.3 Criterion. Storm windows for retrofitting should conform to the standards or special provisions listed below, and be installed as stated in Section 2.2.4.

2.2.3.1 Aluminum Combination and Frame Storm Windows. Aluminum combination storm windows should be equal to those conforming to the American National Standard Institute (ANSI) A134.3-1972 "Specifications for Aluminum Combination Vertically-Sliding or Horizontally-Operating Storm Windows for External Applications". Aluminum frame storm windows should conform to Sections C1.2, C1.3, C1.4 and C1.6 of ANSI A134.3-1972.

2.2.3.2 Wood Frame Storm Windows. Wood frame storm windows should conform to Section 3 of the National Woodwork Manufacturers Association (NWMA) Industry Standard I.S.2-73 for Wood Window Units.

2.2.3.3 Rigid Vinyl Frame Storm Windows. Rigid vinyl frame storm windows should be constructed with vinyl profile extrusions which conform to NBS Voluntary Product Standard PS 26-70, "Rigid Poly(Vinyl Chloride) (PVC) Profile Extrusions". These windows should be equal in quality to aluminum and wood frame storm windows. The manufacturer should assure their quality and guarantee that they will perform as well as aluminum and wood frame storm windows.

2.2.3.4 Frameless Plastic Glazing. Plastic glazing used as frameless storm windows should consist of either flexible or rigid sheets, a minimum of 6 mil thick.

2.2.4 Areas of Application. Storm windows used for retrofitting may be installed on residential housing to any existing primary windows. Installation should not violate any applicable existing local building related code. A minimum of 1/2 inch of air space should be provided between the primary and storm windows.

2.2.5 Commentary. Some storm windows are installed in a fixed position which may create a ventilation problem. Also, fixed position storm windows may hinder or prevent egress in case of emergency. Local building codes should be consulted to see if this type of retrofitting is permitted.

2.2.5.1 Aluminum Combination and Frame Storm Windows. The intent of the criterion is to assure the quality of storm windows which are used for energy conservation. It is not the intent to impose expensive testing upon the storm window manufacturer to show conformance to the standard. Thus, it is only required that storm windows be manufactured to meet the provisions of ANSI A134.3-1972. They should be labeled as being manufactured to those provisions. It is not required that they be certified by independent laboratory testing as meeting the standard.

2.2.5.2 Wood Frame Storm Windows. NWMA Standard I.S.2-73 was not developed for storm windows, but rather for primary windows. Section 3 of the standard is used as the criterion in retrofitting to assure the quality of the materials and the quality of the construction of the windows. They should be labeled as being manufactured to the provisions of Section 3 of NWMA Standard I.S.2-73.

2.2.5.3 Rigid Vinyl Frame Storm Windows. NBS Voluntary Product Standard PS 26-70 is concerned with the quality of vinyl profile extrusions, and not completed windows. Since there are no standards to assure the quality of these windows, the manufacturer should guarantee that they perform as well as aluminum and wood frame storm windows described in Sections 2.2.3.1 and 2.2.3.2.

2.2.5.4 Frameless Plastic Glazing. Flexible and rigid plastic sheeting can be effective in reducing heat flow and are acceptable for use as storm windows. Flexible sheeting offers an economical method for retrofitting but has a short life, usually lasting one season. In the installation of these types of windows, consideration should be given to the fact that interior installation is easier and provides greater protection to the plastic. Condensation on the interior of the primary window may appear and may be difficult to remove. Outside installation is more difficult (e.g. 2 story houses) and damage to the plastic is more likely from the elements. In the case of outside installation condensation which occurs on the plastic glazing can in general be removed from the inside by opening the windows.

2.3 STORM DOORS

2.3.1 Definition. A storm door is an extra door, installed to the exterior of the primary or ordinary door, to provide greater resistance to heat flow and to reduce air infiltration.

2.3.2 Materials. Storm doors may be constructed of aluminum, wood or rigid vinyl frames with glazing, or of solid wood.

2.3.3 Criterion. Storm doors installed for retrofitting should conform to the standards listed below, and be installed as stated in Section 2.3.4.

2.3.3.1 Aluminum Frame Storm Doors. Aluminum frame storm doors should be equal to those conforming to ANSI Standard A134.4-1972 entitled "Specifications for Aluminum Storm Doors".

2.3.3.2 Wood or Wood Frame Storm Doors.

°Pine storm doors should conform to the requirements for exterior doors listed in Section 3 of NWMA I.S.5-73 entitled "Ponderosa Pine Doors".

°Fir, hemlock and spruce storm doors should conform to the requirements for exterior doors listed in Section 3 of the Fir and Hemlock Door Association Industry Standard FHDA/5-75 entitled "Industry Standard for Douglas Fir, Western Hemlock, and Sitka Spruce Doors and Blinds".

°Hardwood veneered flush doors should conform to the general requirements for exterior doors listed in Section 3 of NWMA I.S.1-75 entitled "Hardwood Flush Doors".

2.3.3.3 Rigid Vinyl Frame Storm Doors. Rigid vinyl frame storm doors should be constructed with vinyl profile extrusions which conform to NBS Voluntary Product Standard PS 26-70, "Rigid Poly(Vinyl Chloride) (PVC) Profile Extrusions". These doors should be equal in quality to aluminum and wood frame storm doors. The manufacturer should assure their quality and guarantee that they will perform as well as aluminum and wood frame storm doors described in Sections 2.3.3.1 and 2.3.3.2.

2.3.4 Areas of Application. Storm doors used for retrofitting may be installed on residential housing to any existing exterior door. Installation should not violate any applicable existing local building related code.

2.3.5 Commentary.

2.3.5.1 Aluminum Frame Storm Doors. The intent of the criterion is to assure the quality of the storm doors necessary for satisfactory performance and that energy savings will be realized through their use. It is not the intent to impose expensive testing upon the storm door manufacturers to show conformance to the standard. Thus, it is only required that aluminum storm doors be manufactured to meet the provisions of ANSI A134.4-1972. They should be labeled as being manufactured to those provisions. It is not required that they be certified by independent laboratory testing as meeting the standard.

2.3.5.2 Wood Frame Storm Doors. The standards NWMA I.S.5-73 "Ponderosa Pine Doors", FHDA/5-75 "Industry Standard for Douglas Fir, Western Hemlock, and Sitka Spruce Doors and Blinds" and NWMA I.S.1-73 "Hardwood Flush Doors" were not developed for storm doors, but rather for primary wood doors. Section 3 of each standard is used for criteria in retrofitting because there are no existing standards or specifications that have been developed specifically for wood storm doors.

Conformance to the requirements given in Section 3 of each standard assures the quality of the materials and construction of the storm doors. They should be labeled as being manufactured to the provisions of Section 3 of the applicable standard.

If woods other than those listed in Section 2.3.3.2 are used to construct storm doors, the quality of these doors shall be equal to the quality of the doors listed in Section 2.3.3.2.

2.3.5.3 Vinyl Frame Storm Doors. NBS Voluntary Product Standard PS26-70 is concerned with the quality of vinyl profile extrusions, and not completed doors. Since there are no standards to assure the quality of these doors, the manufacturer should guarantee that they perform as well as aluminum and wood frame storm doors described in Sections 2.3.3.1 and 2.3.3.2.

2.4 CAULKS AND SEALANTS

2.4.1 Definition. Caulks and sealants are non-rigid materials placed in joints of buildings to prevent the passage of heat, air, moisture and dust. The terms caulk and sealant are often used interchangeably. On the other hand, many formulators and contractors refer to the lower performance materials as caulks, and to the better performance materials as sealants.

2.4.2 Materials. Materials used as caulks and sealants are grouped in three classifications according to their performance. The materials in each class are listed below. Information relevant to properties, performance and use of the materials is given in Appendix C.

2.4.2.1 Basic Performance

°Oil and Resin Base Caulks

°Polybutene Compound

2.4.2.2 Intermediate Performance

°Latex Caulks

°Acrylic (Solvent Type) Caulks

°Butyl Rubber Sealant (or Caulk)

°Chlorosulfonated Polyethylene

2.4.2.3 High Performance

°Polysulfide

°Polyurethane

°Silicone

2.4.2.4 Putty and Glazing Compounds. There are two types of compounds generally used for sealing relatively small glass panes. The two types are putty and glazing compounds. For larger glass windows (e.g., picture windows) sealants from the intermediate and high performance classes are used.

2.4.3 Criterion. All of the materials listed in Section 2.4.2 and marketed as caulks and sealants are eligible without conformance to any specification or special provision. It is sufficient that the material be commercially available, and marketed as a caulk or sealant.

2.4.4 Areas of Application. Caulks and sealants used for retrofitting should be installed in joints of residential housing such as those associated with the following:

°Window frames

°Door frames

°Window glazing

°Wall to slab joints

°Siding joints

°Skylights

°Ducts and vents

°Air conditioners to window joints

°Attic floor/chimney/siding gaps

°Fuel-oil pipe and other similar designed breaks in the exterior surface

°Window frame/storm window joint.

2.4.5 Commentary. Federal or other specifications do not exist for all caulks and sealants which are commercially available to the homeowner. Many of the caulks and sealants for which no specifications exist perform adequately to conserve energy. Moreover, even a low quality caulk or sealant will save energy by reducing air infiltration if properly applied. On this basis, no criterion, other than commercial availability and labeling as a caulk or sealant is required for these materials to be eligible.

For the prudent homeowner who wants to assure himself of buying and installing caulks and sealants which meet requirements for quality, there are specifications (listed in Table 4) for some products. These materials are usually marked on the container or cartridge as conforming to the applicable specification.

Table 4. Specifications for Caulks and Sealants

Performance Classification	Caulk or Sealant	Federal Specification	ASTM Designation
Basic	Oil and Resin Base	TT-C-00598C	C570-72
Intermediate	Acrylic (Solvent Type)	TT-S-00230C	--
	Butyl Rubber	TT-S-001657	--
	Chlorosulfonated Polyethylene	TT-S-00230C	--
High	Polysulfide		
	single component	TT-S-00230C	--
	multi-component	TT-S-00227E	--
	Polyurethane	TT-S-00230C TT-S-00227E	--
	Silicone	TT-S-001543A TT-S-00230C	--
--	Putty	TT-P-00791B	--
	Glazing Compound	TT-G-410E	--

In general, the level of performance of the sealant is related to the cost of the product. A more expensive product will in general last longer. Thus, a high initial investment may more than pay for itself by eliminating additional expense at a later date because of re-installation costs.

2.5 WEATHERSTRIPPING

2.5.1 Definition. Weatherstripping consists of narrow strips of material placed over or in moveable joints of windows and doors to reduce the passage of air and moisture.

2.5.2 Materials. Various types of weatherstripping are available for retrofitting. In general most can be applied to both windows and doors. However, others are made specifically for doors. Examples of weatherstripping include the following:

2.5.2.1 Weatherstripping for both Windows and Doors

spring bronze strips

felt strips

adhesive backed foam strips

adhesive backed vinyl foam strips

adhesive backed sponge rubber strips

hollow vinyl cord

sponge rubber gasket

metal wrapped vinyl strips

metal wrapped felt strips

2.5.2.2 Weatherstripping for Doors

door bottom strips

door bottom sweeps

door shoes

vinyl bulb threshold

interlocking threshold

2.5.3 Criterion. Any commercially available material which is marketed as weatherstripping is eligible. It is not required that the weatherstripping conform to any specification or special provision.

2.5.4 Areas of Application. Materials used as weatherstripping may be applied to all windows and exterior doors in residential housing.

2.5.5 Commentary. This report is concerned with weatherstripping normally sold in building supply houses, hardware stores and home improvement centers. Weatherstripping is one of the easiest retrofit materials or products to install. There are no standards or specifications pertaining to these materials. The only requirement for tax credit eligibility is that the material be commercially available and be labeled as weatherstripping.

There is a range of quality among the various weatherstrippings that the homeowner may purchase. In general, the foam plastics are inferior to the metal strips or vinyl cord [11]. Even an inferior quality product will save energy by reducing air infiltration at windows and doors. Such materials are, therefore, eligible. The homeowner should be aware that inferior quality weatherstripping may not perform as well as better quality products and may have to be replaced more frequently. Better quality products are more durable and tend to retain their ability to reduce air infiltration for a longer period of time.

2.6 VAPOR BARRIERS

2.6.1 Definition. A vapor barrier is a material which provides a high resistance to the transmission (flow) of water vapor through building and insulating materials due to water vapor pressure difference. The principal purpose of water vapor barriers is to preclude or appreciably reduce the possibility of condensation of water vapor within insulation and other building materials.

2.6.2 Materials. The materials listed below, when installed as recommended, provide water vapor barriers. Vapor barrier materials should be water resistant, puncture resistant, abrasion resistant, tear resistant, fire resistant, noncorrosive, rot and mildew resistant, and of sufficient tensile strength, in addition to a high resistance to water vapor transmission.

2.6.2.1 Membrane barriers are flexible and non-load bearing, and are supplied in roll form or as an integral part of thermal insulation. These include metal foils, coated felts and papers, laminated foil and treated papers, and plastic films and sheets. Accessory items, such as tape and adhesives, are required for sealing joints.

2.6.2.2 Mastic, coating and paint barriers are field applied semi-liquid compositions having high resistance to water vapor transmission after curing, the ingredients of these barriers include bitumens (asphalts), resins or polymers, pigments, fillers, and volatile solvent or water. Paints which have been used as vapor barriers include alkyds including aluminum pigmented alkyds, polyurethanes, epoxies and rubber based paints. Paints used as vapor barriers should be labeled as having a water vapor permeance not greater than 1 perm (see Section 3.6).

2.6.2.3 Structural barriers may be formed from rigid or semi-rigid materials of low permeability which form a part of a structure. They include reinforced plastics, aluminum, stainless steel and insulating materials which are relatively impervious to water vapor flow due to their physical structure and composition. They require careful sealing of joints and seams. These materials are generally not used as vapor barriers in residential housing.

2.6.3 Criterion. The materials used for water vapor barriers should conform to provisions cited in ASTM C755-73, "Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulation", and be installed in areas listed in Section 2.6.4.

2.6.4 Areas of Application. Materials used for water vapor barriers may be applied in residential housing to the following areas: (1) warm (winter) side of opaque walls, (2) warm (winter) side of flat roofs and ceilings under ventilated attic spaces, and (3) over ground or soil in crawl spaces.

2.6.5 Commentary. Increased insulation in the walls, roofs or ceilings and floors to reduce heat flow from residences requires attention to the increased possibility of excessive accumulation of condensed water vapor (moisture) in these elements. This may be prevented by one or more of the following measures:

- providing a vapor barrier to limit vapor entrance
- ventilating the residence to reduce vapor pressure
- making the cold side of walls, roofs or ceilings, and floors more permeable to the egress of water vapor.

The deleterious effects of moisture condensation in building and insulating materials include:

°deterioration of materials by chemical, physical and biological changes and by freeze-thaw breakdown of materials.

°water in liquid form, accumulated in thermal insulating materials, reduces their resistance to heat flow and their effectiveness as insulation.

°significant dimensional changes occur in many building materials with changes in moisture content.

2.7 CLOCK THERMOSTATS

2.7.1 Definition. A clock thermostat is a temperature control device for interior spaces incorporating two temperature control points and a clock for switching from one control point to the other. Only one control point regulates the interior space temperature at one time.

2.7.2 Products. Clock thermostats and clock thermostat systems may be classified as follows:

2.7.2.1 A clock and two individual thermostats. In this system, two thermostats are connected through a time clock to the heating system. The clock automatically switches from the normal temperature controlled by one thermostat to the setback (lower) temperature controlled by the other. The duration of the setback is determined by the clock. This system has the advantage that more than one setback period may be chosen in a 24 hour period. Also, different types of clocks may be used to control switching. For example, 24 hour and 7 day clocks are commercially available. By using a 7 day clock, the setback time can be programmed for a whole week. The system may be used with central air conditioning.

2.7.2.2 Fully automatic clock thermostat. This is a thermostat which combines the two temperature controls and the clock in one unit. After the setback period is fixed, the thermostat automatically switches between the normal and setback temperatures once every 24 hours. This unit may also be used with central air conditioning systems.

2.7.2.3 Semi-automatic clock thermostat. This is a thermostat which combines the two temperature controls and a wind-up timer in one unit. With this unit, the setback is manually activated by setting the timer. The duration of setback is also fixed manually each time the setback is activated. The thermostat automatically switches from setback to normal temperature. This device may be activated more than once every 24 hours.

2.7.3 Criterion. Any commercially available product marketed as a clock thermostat or clock thermostat system as listed in Section 2.7.2 is eligible when used for retrofitting residential housing. It is not required that the clock thermostat or related system conform to any specification or special provision.

2.7.4 Areas of Application. Clock thermostats and related systems may be applied in residential housing as replacements of or additions to existing thermostats which control interior space temperatures.

2.7.5 Commentary. There are no specifications or standards presently available for clock thermostats. Because there is a substantial energy savings to be gained through their use [5, 6] clock thermostats are recommended without conformance to specifications or standards.

3. DESIRED LEVELS OF PERFORMANCE FOR MATERIALS AND PRODUCTS USED FOR RETROFITTING

Section 2 of this report gives recommended criteria for assessing the eligibility of materials and products for tax credit. While these criteria cover materials and products which are effective in conserving energy, they do not in general directly address the question of the performance of the retrofit materials and products. This section presents desired levels of performance for the retrofit items recommended for tax credit eligibility in Section 2. The purpose is to provide the homeowner with guidlines to assist him in gaining maximum benefit from energy conservation.

It would be desirable to have performance criteria for assessment of the tax credit eligibility of retrofit materials and products. However, performance criteria are in general not available for the immediate need and their development would take a long time. The time required to develop performance criteria would significantly delay the implementation of the tax credit program since many needed performance tests are not available. For the purpose of determining tax credit eligibility performance criteria may be difficult to apply because of required testing and certification.

3.1 INSULATION

3.1.1 Performance Need

Heat Flow. Materials used for thermal insulation should not allow more than the prescribed rates of heat flow into or from the building.

3.1.1.1 Level of Performance

Heat Flow Resistance. The addition of thermal insulation for retrofitting purposes should increase the total thermal resistance, R_t, to the values listed below.

° Walls, Roofs, Ceilings and Floors. For the various geographical locations as designated by heating degree-days, the minimum total thermal resistance, R_t, resulting from retrofitting thermal insulation to opaque portions of walls, roofs, ceilings and floors should lie within the ranges of values given in Table 5.

° Slab-On-Ground Floors. For the geographical locations as designated by heating degree-days, the retrofitting of insulation at the edges of slab floors to reduce slab edge heat loss should give resultant minimum thermal resistances, R-values, and total depths of insulation at the slab edges as listed in Table 6.

° Thermal Resistance of Ducts, Plenums, Pipes and Other Equipment. Air ducts and other surfaces installed in nonheated spaces (e.g., attics, unheated garages, crawl spaces, etc.) should be thermally insulated to provide a metal surface to outside surface thermal resistance of not less than $R = \Delta T/20$, where ΔT is the maximum temperature difference (°F) between the duct (or other enclosure) and the surrounding air, or shall be insulated to a value of $R = 4$ whichever is greater.

Table 5. Minimum Total Thermal Resistance of Walls, Roofs, Ceilings and Floors, R_t [1]

Heating Degree-Days [2]	0 - 4500	4501 - 8000	8001 or more
Flat roof deck	7-20	11-25	12-25
Ceilings	12-20	18-25	22-30
Masonry wall construction	9-11	10-12	11-17
Frame wall construction	12-14	14-17	14-20
Floors [3]	5-8	7-11	11-14

[1] Values of total thermal resistance are given in units °F h ft^2 Btu^{-1}. To obtain thermal transmittance, $U = 1/R_t$.

[2] Values of degree-days for many geographical locations are given in Chapter 43 of the ASHRAE Systems Handbook [12].

[3] Total resistance values for floors over basements, unheated garages or crawl spaces with no positive heat supply.

Table 6. Minimum Total Thermal Resistance of Slab-On-Ground Floors

Heating Degree-Days	R [1]	Depth of Insulation [2]
2500 - 4500	2.5 - 4.0	18
4501 - 8000	3.8 - 5.0	24
8001 or more	5.0 - 7.0	24

[1] Values of total thermal resistance are given in units °F h ft^2 Btu^{-1}.

[2] Inches.

Evaluation.

The thermal resistance of building and insulating materials may be obtained or calculated from values given in Table 3 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13]. Where calculation is necessary, the thermal resistance is the thickness of a material divided by its thermal conductivity in consistent units. The thermal resistances of air spaces may be obtained from Table 2 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13] for various orientations and effective emissivities of the air space.

The thermal resistance of surfaces exposed to still (inside) and moving (outside) air and various positions and directions of heat flow must be used in calculations for total thermal resistance. R-values are given in Table 1 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13].

The total thermal resistance to heat flow through a flat wall, roof, ceiling or floor is equal numerically to the sum of the individual resistances in series of the components comprising the opaque portions of the walls, roofs, ceilings or floors, and the resistances of the air films on the inside and outside surfaces of the wall, roof, ceiling or floor. Table 4 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13] gives examples for computation of total thermal resistance, R_t.

Commentary.

Proper retrofitting requires the installation of adequate amounts of insulation to reach prescribed levels of heat flow resistance. The prudent homeowner who retrofits should upgrade his home to these levels. The homeowner should realize that heating and cooling costs vary with energy prices. The amount of insulation that is economically justified based on energy costs increases with fuel prices [3].

3.2 STORM WINDOWS

3.2.1 Performance Need

Heat Flow. Storm windows should not allow more than the prescribed rate of heat flow into or from the building.

3.2.1.1 Level of Performance

Heat Flow Resistance. Addition of a storm window to a primary window should give a resultant total thermal resistance of the primary window-storm window assembly which is at least 80% greater than the thermal resistance of the primary window alone.

Evaluation.

The thermal resistance of storm windows may be obtained from values given in Table 8 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13]. This table gives coefficients of thermal transmittance for windows. The thermal resistance is the reciprocal of the thermal transmittance.

Commentary.

Addition of storm windows is a major means of reducing heating energy consumption of residential housing and in some instances conserves cooling energy. Approximately one-half of the heat loss through single-glazed primary windows can be saved by the addition of storm windows.

3.2.2 Performance Need

Air and Water Infiltration. Storm windows should not allow more than the prescribed levels of air infiltration and water penetration into the building.

3.2.2.1 Level of Performance

Air Infiltration. Allowable air infiltration should be at least 1.0 cfm but not be more than 4.0 cfm per linear foot of net sash crack perimeter at a static air pressure of 1.56 psf. (This is the equivalent of a 25 mph wind blowing against the window.)

Evaluation.

The test is conducted in accordance with ASTM E283-73 with the sash closed and latched.

Commentary.

Air infiltration provides natural ventilation. Natural ventilation for habitable rooms is required under some building codes (see Section 5, paragraph 6).

Also, some air infiltration is necessary to prevent excessive moisture condensation on the storm window.

3.2.2.2 Level of Performance

Water Penetration. Adequate drainage should be provided to prevent water from running over the interior edge of the sloped sill of the primary window.

Evaluation.

The water drainage test is conducted in accordance with ASTM E331-70 except that the pressure drop shall be zero and test duration shall be three minutes.

Commentary.

ASTM E331-70 was specifically developed for primary window units. This test was adapted for aluminum storm windows by ANSI A134.3-1972. The test conditions listed above are those given in ANSI Standard. These test conditions for water penetration are now cited for all storm windows.

3.2.3 Performance Need

Safety. The installed storm windows should not endanger the safety of the occupants of the dwellings.

3.2.3.1 Level of Performance

Egress. The installed storm windows should not appreciably obstruct or restrict the existing capacity and access required for occupant egress via windows.

Evaluation.

Evaluation is accomplished by inspection of the installed unit.

Commentary. It is normally expected that one (or more) bedroom and living room windows can serve as emergency means of exit and will be easily openable and of suitable size (5 sq ft).

3.3 STORM DOORS

3.3.1 Performance Need

Heat Flow. Storm doors should not allow more than the prescribed rate of heat flow into or from the building.

3.3.1.1 Level of Performance

Heat Flow Resistance. Addition of a storm door to a primary door should give a resultant total thermal resistance of the primary door - storm door assembly which is at least 30% greater than the thermal resistance of the primary door alone.

Evaluation. The thermal resistances of storm doors are obtained from values given in Table 9 of Chapter 20 of the ASHRAE Handbook of Fundamentals [13]. This table gives coefficients of thermal transmission through doors. The thermal resistance is the reciprocal of the thermal transmission.

Commentary. Addition of storm doors is a means of reducing heating and cooling energy consumption of residential housing by increasing the thermal resistance of primary doors. The increase in thermal resistance is dependent upon the design and composition of the door. For example, as the percentage of glass in a wood storm door increases, the thermal resistance decreases.

3.3.2 Performance Need

Air and Water Infiltration. Storm doors should not allow more than the prescribed levels of air infiltration and water penetration into the building.

3.3.2.1 Level of Performance

Air Infiltration. Allowable air infiltration should not exceed 5.0 cfm per square foot of rough opening at a static air pressure of 1.56 psf. (This is the equivalent of a 25 mph wind blowing against the door.)

Evaluation. The door should be closed and locked and the test should be conducted according to ASTM E283-73.

Commentary. Usually a low level of air infiltration does not cause a problem with moisture condensation because a door is opened and closed. If a storm door is installed on a primary door that is infrequently used, condensation may occur.

3.3.2.2 Level of Performance

Water Penetration. Adequate drainage should be provided to prevent water from running over the interior edge of the sloped threshold.

Evaluation. The door should be closed and locked and the test should be conducted according to ASTM E331-70.

Commentary. This test was developed for primary doors, but has been applied to storm doors.

3.3.3 Performance Need

Safety. An installed storm door should not endanger the safety of the occupants of the dwelling.

3.3.3.1 Level of Performance

Egress. An installed storm door should not appreciably reduce or restrict the existing capacity and access required for occupant egress.

Evaluation.

Evaluation is accomplished by inspection of the installed unit.

Commentary.

Doors are the normal means of exit from a residence. Storm doors which cannot be opened should not be installed, even on infrequently used doors.

3.3.3.2 Level of Performance

Safety Glazing. Safety glazing should be installed in all storm doors which contain glazing.

Evaluation.

Glazing materials should conform to ANSI Z97.1-1972 entitled "Performance Specification and Methods of Test for Transparent Safety Glazing Materials Used in Buildings".

Commentary.

Many existing local codes require that safety glazing be used in storm doors. Safety glazing greatly reduces the risk of bodily injury due to accidental impact with the glass.

3.4 CAULKS AND SEALANTS

3.4.1 Performance Need

Air, Water and Dust Infiltration. Joint caulks and sealants should prevent the passage of air, water and dust through the joints of a building, throughout their service lifetime.

3.4.1.1 Level of Performance

Adhesion and Cohesion of Elastomeric Sealants. A sealant should maintain adhesion and cohesion throughout its expected service lifetime.

Evaluation.

A cyclic movement test involving extension and compression of the sealant within a joint evaluates the adhesive and cohesive properties. The test involves 7 days water immersion, followed by 7 days of continuous compression beyond the nominal width at 158°F, followed by 10 additional cycles of compression-extension at 158°F and -15°F respectively.

The test method is described in the following federal specifications:

TT-S-00227E - Section 4.3.9

TT-S-00230C - Section 4.3.9

TT-S-001543A - Section 4.3.9.

A slightly modified test method is given in TT-S-001657 Section 4.3.10.

Commentary.

The most critical properties of a sealant are its adhesive (bond) strength and its cohesive strength (ability to hold itself together). These two properties must be maintained during the service life of the sealant.

The cyclic movement test is the most significant laboratory evaluation for predicting the durability of a caulk or a sealant in a joint. The test has good correlation with service in buildings provided there is correct joint design and application technique. The amount of acceptable bond (adhesion) and cohesion loss during testing varies according to the type of caulk or sealant.

3.4.1.2 Level of Performance

Shrinkage. A sealant should not shrink more than 25% by volume.

Evaluation.

A sealant layer, 1/8 inch thick and 2 5/8 inches in diameter, is applied to a glass plate and allowed to remain at room temperature for 14 days, after which time the height and diameter are measured to compute volume loss.

Commentary.

Excessive shrinkage obtained by laboratory testing indicates a high probability of early sealant failure in a joint. The shrinkage causes stresses on the sealant bonding area, hastening adhesion loss to the substrate.

3.5 WEATHERSTRIPPING

3.5.1 Performance Need

Air Infiltration. Weatherstripping should limit the amount of air infiltration around windows and doors.

3.5.1.1 Level of Performance

The installation of weatherstripping should appreciably reduce drafts or air flow through the joints of windows and doors.

Evaluation.

Performance of weatherstripping should be demonstrated by its performance under service conditions.

Commentary.

There are no test methods for demonstrating the efficiency of weatherstripping used for retrofitting. The amount of reduction of air flow will depend upon the tightness of the door or window being weatherstripped. Certain weatherstripping may not be suitable for all doors and windows because of the gap size of the joint.

3.6 VAPOR BARRIERS

3.6.1 Performance Need

Materials used for water vapor barriers should appreciably reduce the flow of water vapor into building and insulating materials.

3.6.1.1 Level of Performance

Permeance. Vapor barrier materials installed for retrofitting purposes should have a permeance not greater than 1 perm.

Evaluation. Permeance values for typical vapor barrier materials are given in Table 1 of Chapter 18 of the ASHRAE Handbook of Fundamentals [13]. (A perm unit is grain h^{-1} ft^{-2} in^{-1} of mercury vapor pressure difference.)

Commentary. Exact values for permeance should be obtained from the manufacturer of the material under consideration or secured as a result of laboratory tests. Tests for determining permeance of vapor barrier materials are found in ASTM E96-66(72), "Standard Method of Test for Water Vapor Transmission of Materials in Sheet Form", and in ASTM C355-64(73), "Standard Method of Test for Water Vapor Transmission of Thick Materials".

3.7 CLOCK THERMOSTATS

3.7.1 Performance Need. The clock thermostat should offer the user ease and reliability of temperature setback.

3.7.1.1 Level of Performance. The clock thermostat should be fully automatic.

Evaluation. The manufacturer should state on the clock thermostat and its packaging that the clock thermostat is fully automatic.

Commentary. Substantial energy savings can be achieved through temperature setback at night. Temperature setback of a thermostat can be accomplished manually. There is no technical reason for requiring automatic control. However, there is the human reason that people often fail to use manual setback. For example, they may forget at night or may not want to rise in a cool house in the morning. Automatic control of the setback eliminates the human element and assures regular night setback with its resulting energy savings. Although some fully automatic clock thermostats may only function on one cycle (setback) a day, they may be nevertheless set back manually at other times whenever the need arises.

4. INSTALLATION PRECAUTIONS

This report is not intended to be a manual for installing retrofit materials and products. Among such manuals which already exist are: The U. S. Department of Housing and Urban Development report "In the Bank. . .Or Up the Chimney?" [4] and the NAHB Research Foundation's "Insulation Manual - Homes/Apartments" [9] which discusses all aspects of insulation including proper installation. The NBS report "Retrofitting Existing Housing for Energy Conservation: An Economic Analysis" [3] gives the levels of retrofitting which are cost effective for the homeowner. In addition, many manufacturers and trade associations have available pamphlets describing the correct installation of their products.

The preceding sections presented recommended criteria for tax credit and desired levels of performance to assure the quality of the materials and products used for retrofitting. Proper retrofitting requires more than quality materials and products. Proper installation of retrofit materials and products is a necessity. A superior material will be less effective in saving energy if improperly installed.

This section points out certain precautions that must be taken in the installation of retrofit materials and products. Following these precautions will assist the homeowner in correctly installing the material.

4.1 INSULATION

°When a vapor barrier is attached to the insulation, and the insulation is being applied to an uninsulated wall or ceiling, the vapor barrier must be applied towards the warm (winter) side of the wall or ceiling.

°When adding insulation on top of existing ceilings insulation, do not use a vapor barrier.

°For air conditioning applications, duct insulation should contain a vapor barrier on the outside (warm-side) surface to prevent condensation on the duct and in the insulation.

°When insulating attics, do not cover air vents in soffits and gables. Insulated attics should be vented. In general, the net ventilation area for attics should be 1/300 of the ceiling area. Net ventilation area refers to the total of all openings free from obstructions.

°When insulating floors over unheated crawl spaces where earth is damp and uncovered, provision must be made for a high rate of ventilation. Less ventilation is required if the earth is covered with a vapor barrier or concrete slab.

°Retrofitting walls with loose-fill insulation may cause significant moisture to accumulate in the siding and sheathing, particularly in cold climates [14]. Water vapor permeation through the exterior wall may cause blistering and peeling of exterior paints. Application of a vapor barrier paint on the inside wall surface may alleviate this problem.

°Loose-fill insulation added to ceilings and walls should be of the proper fill density. Blown or poured-in-place loose-fill insulation should not contain excess voids or air spaces. The fill density of cellulose insulation should be 2-3 lb/ft^3 for ceilings and 3-4 lb/ft^3 for walls; for glass fiber insulation 0.8 and 2 lb/ft^3 for ceilings and walls respectively. These values can be used to calculate needed amounts of these insulations.

°For fire safety, installed insulation should not contact recessed light fixtures, motors, fans, blowers, heaters, flues and chimneys. Thermal insulation should not be installed within 24 inches of the top or within 3 inches of the side of a recessed electrical fixture enclosure, wiring compartment or ballast unless labeled for the purpose. To retain loose-fill insulation from making contact with other energy dissipating objects, a minimum of 2 inches of air space should be provided and assured by use of blocking.

4.2 STORM WINDOWS

°Storm windows must be fastened in place straight, plumb, level and without distortion to assure satisfactory contact to the primary window frame.

°Storm windows should be sealed in place according to the manufacturer's instructions.

°Weep holes in the storm window frame should not be closed.

4.3 STORM DOORS

°Storm doors must be fastened in place straight, plumb, level, without distortion to assure satisfactory contact to the primary door frame.

°Storm doors should be installed in place according to the manufacturer's instructions.

4.4 CAULKS AND SEALANTS

°Follow manufacturer's directions as indicated on label of the cartridge or can or in a brochure. Pay particular attention to precautions given for safety in handling the material.

°Remove from the joint to be caulked all dust, dirt particles, oil, grease, loose caulking and loose paint before placing the new compound into the joint.

°Manufacturers often recommend a primer or surface conditioner for certain surfaces. This is done to produce a strong bond of the sealant to the surface. Use only the recommended primer.

°Whenever possible, do not caulk joints at temperatures below 40°F because condensed moisture formed on the building at this temperature may cause poor adhesion of the sealant.

°Do not apply sealant on wet or damp surfaces.

°If the joint is 1/4 inch wide or more, use a back up or filler material, if possible. The filler may be any foam or sponge type non-staining material which is squeezed into the joint leaving at least 1/4 inch space for the sealant.

°Tool the sealant with a spatula or smooth wooden stick to force the sealant against the sides of the joint.

°The placing of paper masking tape on each side of the joint before the caulking operation will leave a neat looking joint. Peel the tape off as soon as each section of work is finished.

°Do not add any liquid or powder to a sealant to change its handling property unless specific instructions are given by the manufacturer.

°Do not heat the sealant unless there are printed instructions to do so.

4.5 WEATHERSTRIPPING

°Follow manufacturer's directions as printed on the package or in a brochure.

°Assure that the surface is level and smooth by removing old weatherstripping, dirt particles, loose paint, etc.

°Apply adhesive backed weatherstripping to clean and dry surfaces only.

°Apply weatherstripping in one continuous strip along each joint of the door or window.

4.6 VAPOR BARRIERS

°Apply vapor barriers on the warm (winter) side of ceilings and walls.

°Do not puncture, rip or tear vapor barriers.

°Punctured, ripped or torn vapor barriers must be repaired with kraft paper tape, aluminum faced tape or other suitable material.

4.7 CLOCK THERMOSTATS

°Follow the manufacturer's instructions for installation.

°Do not wire the clock into the temperature limit control circuit of the furnace. Whenever the limit control is activated, the clock will stop and loose time. An inaccurate clock may discourage the homeowner from using the clock thermostat.

5. RETROFITTING AND MODEL BUILDING CODES

To determine the relationship between retrofitting residential homes to conserve energy and the model building codes, the Standard Building Code, Basic Building Code, the One- and Two-Family Dwelling Code and the Uniform Building Code were examined. Conversations were held with the Technical Director of each model code generating organization. The study produced the following information:

1. None of the model codes, per se, are retroactive unless substantial repairs or alterations are performed on existing buildings; this is especially the case with existing single family dwellings and therefore building permits are generally not required for retrofitting.

2. In their adoption of model codes by reference, local jurisdictions at times change certain aspects of the requirements of the model code to conform to specific local conditions, and therefore may require building permits for retrofitting.

3. Local jurisdictions may have contractor licensing laws which require the issuance of building permits for all work performed on single family dwellings.

4. Since the model codes in general do not require the issuance of building permits, inspections of the installation of insulation, weatherstripping and/or storm windows and doors in existing single family dwellings accordingly are not required. Again, local regulations may require permits and inspections.

5. All three of the model codes have requirements which prohibit certain types of foam plastic insulations unless certain encapsulation conditions are satisfied. This poses a problem wherein the installer can be in violation of a law although no permit or inspection is required.

6. The question of the installation of storm windows over openings necessary for required natural ventilation or emergency exits in existing single family dwellings will not arise in the case of model codes, per se, but may be a problem in specific local jurisdictions.

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APPENDIX A. SELECTED CITATIONS FROM THE LITERATURE ON RETROFITTING

This appendix is a limited survey of the literature. It is included in this report to show that a sound basis for retrofitting exists. The reports cited demonstrate that retrofitting existing housing not only conserves energy, but is also economically desirable for the homeowner.

The National Mineral Wool Insulation Association (NMWIA) conducted a study to determine the extent to which the requirements for improved thermal performance of living units could alleviate the shortage of energy for heating and cooling in the decade 1973 - 1982 [1]. The study considered two techniques for retrofitting existing housing. These were the upgrading of existing ceiling insulation, and the installation of storm windows and storm doors. It was estimated that there were 42.6 million single family units built before 1973 to consider for retrofitting. For the computations an "average" home* was defined. If the ceiling insulation of these "average" homes was upgraded with an R-11 insulation, the potential energy savings per year in the U.S. would be 562 trillion Btu. For the year 1982, this would amount to a savings of 1,124 million dollars. The 1972 estimated cost of the ceiling insulation retrofit was $144 per dwelling. The recovery of this investment would take 5.45 years.

Retrofitting storm doors and storm windows alone was considered for 21.3 million single family residences by the National Mineral Wool Insulation Association. In this case, the total energy savings would be 818 trillion Btu per year, and the dollar savings, 1,635 million per year. The 1972 cost of installing storm doors and windows was $240 per dwelling. The NMWIA reported that the recovery of the investment would require 3.1 years.

According to NMWIA the total energy savings achieved by the retrofitting of ceiling insulation to the 42.6 million units and of storm doors and windows to 21.3 million units would be 1380 trillion Btu per year.

The National Bureau of Standards (NBS) has recently published a report which considered the economic aspects of retrofitting existing housing for energy conservation [3]. The study identified economically optimal combinations of selected energy conservation techniques for reducing heating, ventilating and air conditioning (HVAC) costs. The study maximized potential dollar savings achieved with certain retrofitting techniques by comparing total savings versus total costs. Climatic, architectural and economic variables were used in the analysis. The retrofitting techniques considered were:

1) attic insulation

2) wall insulation

3) floor insulation over an unheated space

4) duct insulation in unheated space

5) storm windows

6) storm doors

7) weatherstripping.

The optimal combination of each of these techniques varies with fuel costs and climatic conditions. The optimal level of retrofitting increases as the cost of fuel increases and the climatic conditions become more severe. Levels of retrofitting are greater for homes that are both heated and air conditioned than for homes with heating only. Some general results of the NBS study follow.

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*floor area, 1200 ft^2; doors, 40 ft^2; windows 160 ft^2; location, in degree day range of 4700 - 5000; assumed level of ceiling insulation, U = 0.10 Btu/h ft^2 °F.

The NBS report showed that even in areas of low fuel costs and mild climates, it is economically desirable to add insulation to attics where none previously existed. Moreover, in areas of high fuel costs and severe climates, it is economically desirable to add more than the currently recommended six inches of attic insulation. For example, about 10 to 12 inches is optimal for oil heated homes and about 12 inches for electrically heated and cooled residences in certain climates. The figures vary slightly depending on the type of insulation.

It is also cost effective to blow insulation into existing walls and to wrap exposed heating and cooling ducts in most climatic conditions regardless of the cost of fuel. Insulating over unheated spaces becomes cost effective in mild climates where fuel costs are high. It is cost effective in all other climates regardless of the price of fuel.

The economic desirability of retrofitting with storm windows depends upon window size as well as fuel costs and climatic conditions, according to NBS. In general, it is economically advantageous to add storm windows in most climates. The exceptions are mild climates where fuel costs are low. Even here, the addition of storm windows over large windows (minimum size 4 x 5 ft) becomes cost effective. On the other hand, the addition of storm doors is only cost effective in areas of high fuel costs and severe climates, assuming that a screen door must be replaced.

Weatherstripping of doors and windows to reduce air infiltration was shown in the NBS report to be cost effective in all cases. The effect of sealing and caulking around doors and windows was not examined.

The U. S. Department of Housing and Urban Development (HUD) has also recently prepared a report on the economics of retrofitting existing homes to reduce energy consumption [4]. This report is intended to help the homeowner calculate how much money he can expect to save by spending money to retrofit. The report states that if each homeowner spent $400 to retrofit his home, he would, in most cases, recover that money in less than 5 years.

The retrofit techniques discussed in the HUD report include those in the NBS report. In addition, the HUD report takes into account other energy saving techniques such as caulking, servicing of furnaces and air-conditioners and thermostat setback.

Lowering the thermostat setting to reduce interior house temperature and thus heating fuel consumption is called setback. A lower thermostat setting during the sleeping hours than during the daytime is called night setback. The Oak Ridge National Laboratory has recently examined the potential energy savings that may be achieved through thermostat setback [5]. It was concluded that, if temperatures of homes were reduced from a typical 72°F to 68°F during the day and further reduced to 55°F during the night, the total U. S. energy budget for residential heating could be reduced by 14%. The reduction in energy consumption is dependent upon the climate. The percentage of energy savings is greater in mild climates than in severe climates. The absolute energy savings are greater in the more severe climates. For a home maintained at 68°F and located in an area of 4000 degree days, a night setback to 55°F could produce an energy savings of 22%. Savings from night setback for homes located in other areas can be estimated from the method given in the report.

The energy savings gained from night setback had been previously reported [6]. This paper showed that a night setback of 5°F produced an energy savings of 5 to 12% depending upon the location. For a setback of 10°F, the percentage savings was 9 to 16%. As in the Oak Ridge report, the more severe climates give a smaller percentage, but a greater absolute savings.

Another example of energy saved by retrofitting is given by the Consumers Power Company of Jackson, Michigan [7]. They estimate that there are in their service area 665,000 gas heated residences which have inadequate ceiling insulation. If all these customers were to install 6 inches or the equivalent of R-19 of ceiling insulation, natural gas consumption would be reduced by an estimated 14,725,000 Mcf per year. That is enough gas to heat 125,850 homes in their area, for one year.

The NAHB Research Foundation recently prepared a business guide for retrofitting homes [8]. The basic retrofitting techniques considered in the guide were insulation, storm windows and doors, sealants, weatherstripping, clock thermostats, heating and air-conditioning tune-ups, and lower hot water heater temperatures. Additional techniques such as exhaust fans, awnings and replacement heating systems were listed as optional, depending on the homeowner's preference to install them.

APPENDIX B. ADDITIONAL MATERIALS AND PRODUCTS SUGGESTED FOR RETROFITTING

While compiling the criteria for insulation, storm windows and doors, sealants, weatherstripping, vapor barriers and clock thermostats, additional materials and products were suggested to NBS as means for reducing the energy consumption of residential housing. As such, it was suggested that they should be eligible for proposed tax credit when used for retrofitting. Manufacturers and trade associations were the primary source of these suggestions. Other suggestions resulted from conversations between NBS personnel and outside researchers who were familiar with the energy conservation problem.

A list of the suggested additional retrofit items is included in this appendix along with a brief comment as to why each item was suggested. NBS has not examined these items in regards to eligibility for proposed tax credit and criteria for tax credit eligibility have not been recommended. If the additional items are effective in conserving energy in residences, criteria will be needed for considering their eligibility for tax credit. The criteria should be based on the factors given in Section 2 including fire and health safety. The appendix has been included in this report to present the retrofit items that have been suggested.

1. Window Shades. Drawn window shades may prevent or reduce solar radiation shining into the house. In the summer this lowers the temperature of the residence and less energy is consumed in cooling the residence.

2. Window Draperies. As with window shades, drawn window draperies may prevent or reduce the passage of solar radiation through windows so that less energy is consumed in cooling the residence. In the winter drawn draperies may reduce drafts and may lower heat loses through windows.

3. Insulated Siding. Insulated siding has a higher thermal resistance than normal siding. When added to the exterior walls of the house, it increases the total thermal resistance of the walls to a greater extent than normal siding.

4. Urea Formaldehyde Foam Insulation. This organic cellular material is an effective insulation. As foamed-in-place insulation, this material initially contains relatively large amounts of water. Care must be exercised to permit the water to permeate outward and escape from the building.

5. Replacement Windows. A replacement window, as defined for retrofitting, is a thermal insulating, double glazed window. It is used to replace an existing primary window in lieu of adding a storm window. The thermal resistance may be equal to or greater than that of a primary window-storm window assembly. Some types of primary windows may not readily accept storm windows. In these cases, replacement windows may be the only means of reducing heat flow through the windows. These replacement windows must also be capable of limiting air infiltration.

6. Replacement Doors. A replacement door, as defined for retrofitting, is a thermal insulation door. It is used to replace an existing primary door in lieu of adding a storm door. The thermal resistance should be equal to or greater than that of the primary door-storm door assembly. These replacement doors must also be capable of limiting air infiltration.

7. Replacement Fuel Burners. Some fuel burners in residential homes are not properly sized to the home. These burners operate inefficiently, needlessly consuming excess fuel. Replacement of these burners with more efficient burners would result in less fuel consumption in heating the residence.

8. Regular Maintenance of Fuel Burners and Air Conditioners. Regular maintenance will increase the operating efficiency and result in less fuel consumption in heating and cooling residences.

9. Replacement Filters for Furnaces and Air-Conditioners. Dirty or clogged filters on furnaces and air conditioners reduce the operating efficiency. Replacement of such filters with clean filters would result in less fuel consumption in heating or cooling the residence.

10. Clogged Furnace Filter Alarms. A clogged furnace filter alarm is a device which measures the pressure drop across the furnace filter. When the filter is clogged, the pressure drop is great. The alarm signals that the filter needs to be replaced.

11. Load Matching on Hydronic Systems. A system whereby the temperature of a heating boiler is maintained in relation to the outdoor temperature. The water in the boiler is not heated as hot on warm days as on cold days, thus reducing energy consumption.

12. Gas Pilot Pressure Regulator. This is a device for regulating the gas pressure at the pilot of a gas burner, and thereby reducing consumption of gas by the pilot.

13. Heat Reflective Glass and Reflective Coatings or Films on Glass for Windows. The reflective glass or coating on the glass rejects the radiation of the sun which normally penetrates into the home. The interior remains cooler. Less energy is consumed in air conditioning the residence.

14. Automatic Gas Igniters. Continuously burning gas pilot lights on furnaces are replaced with automatic gas igniters, conserving the gas that the pilot light consumes as it continuously burns.

15. Automatic Furnace Flue Dampers. This device allows the furnace flue to be automatically shut when the furnace is not operating, reducing heat loss and air infiltration through the flue.

16. Awnings. Awnings lowered in place shade the windows of a residence, reducing or preventing the penetration of sun rays into the interior.

17. Solar Screens. This device placed on the exterior of windows allows the penetration of sun rays into the interior during winter time and prevents their penetration during summer time.

APPENDIX C. CAULKS AND SEALANTS AVAILABLE FOR RETROFITTING

A. Basic Performance

1. Oil and Resin Base Caulks - General purpose caulking compounds formulated to seal exterior or interior non-moving or very slightly moving joints between various building materials; form a skin which can be painted to prolong performance; may function for several years if applied properly; available in cartridges for use in caulking guns, in flexible tubes and sometimes in cans for putty knife application.

2. Polybutene Compound - Available in preformed shapes such as rope, cord or tape; excellent for temporary seals around window air conditioners and storm windows, for example; performance is extended when used in areas where it is protected from the elements.

B. Intermediate Performance

1. Latex Caulk - General purpose sealant designed for exterior or interior joints; responds to small joint movements; flexes with the joint to provide a resilient seal; extrudes smoothly from a gun, can be painted almost immediately after application; available in standard cartridges and in cans.

2. Acrylic (solvent type) Caulk - For general purpose caulking in joints with moderate movement; excellent adhesion to most building materials without the use of a primer; estimated service life up to 20 years; strong odor restricts use to exterior joints; available in cartridges and cans and in numerous colors.

3. Butyl Rubber Sealant (or Caulk) - An all-purpose sealant with greater service life and performance than the oil base caulks and about equal in overall quality to the latex acrylic types; forms a skin which can be painted; responds to joint movements up to about 10 percent of the original width; adheres to all building surfaces and retains a high degree of flexibility; available in cartridges and cans in numerous colors.

4. Chlorosulfonated Polyethylene - An all-purpose sealant with a relatively slow cure to a rubbery compound; provides good durability, flexibility and adhesion as well as easy application; responds to somewhat larger joint movements than the butyl or latex caulks; for use on exterior joints only; available in cartridges and cans in standard colors.

C. High Performance

1. Polysulfide - A sealant which cures to a rubbery compound with exceptional flexibility, recovery and adhesion to most building surfaces. The sealant has the ability to respond to joint movements up to plus and minus 25 percent of the installed width. When properly installed, the service life can be 20 years or more. It is available as a one-component material which is packaged in standard cartridges for caulking guns; also available in a multi-component type which is mixed on the job just before application; also available in a pourable type for deck joints. The cured sealant has practically no shrinkage. Primers are used when recommended by the producer. Several colors are available. Joint design and preparation are of great importance for durability.

2. Polyurethane - The characteristics and performance properties of this class of sealant are essentially the same as those of the polysulfides when properly installed in accordance with the producer's instructions. The sealant is particularly known for high abrasion resistance and tear strength and is often used for joints in plazas and decks with heavy foot traffic. It is available in single and multi-component types, the latter in both non-sag and pourable grades.

3. Silicone - A class of single component sealants known for its versatility as a joint filler with exceptional performance under very high and low temperatures. It has exceptionally strong adhesion to glass as well as to other building materials. Ease of extrusion from the caulking gun is unaffected by cold temperature. It forms a skin in less than a hour and cures in a few days to an elastic compound. It is available in cartridges and cans in several colors including clear. One variety is used for joints with exceptionally large movements.

D. Compounds for Sealing Glass Panes

1. Putty - This name is usually applied to a soft dough-like, knife applied compound formulated by blending oils and pigments. It is used for face glazing (application around the edges of a pane of glass, and for the bedding application to the inner side of the sash). After the putty is set, painting extends its performance life. It is available for wood or metal sash. Putties harden and crack with age and need replacement periodically.

2. Glazing Compound - Different from putty in that the formulation is modified to enable the compound to remain plastic over a long period. It performs well as an effective seal between the glass and the framing. Several types are available for specific purposes. A general purpose glazing compound will bed and face glaze glass to both wood and metal frames. It is available in standard cartridges and cans.

APPENDIX D. SPECIFICATIONS AND STANDARDS CITED IN THIS REPORT

1. Federal Specifications

Specifications Sales (3FRSBS)
Building 197
Washington Naval Yard
General Services Administration
Washington, D.C. 20407

HH-I-515B - Insulation Blanket, Thermal; And Insulation (Loose-Fill for Pneumatic or Poured Application): Cellulose Vegetable and Wood Fiber (9-25-72)

HH-I-521E - Insulation Blankets, Thermal (Mineral Fiber, for Ambient Temperatures) (7-24-72)

HH-I-524B - Insulation Board, Thermal (Polystyrene) (11-6-72)

HH-I-526C - Insulation Board, Thermal (Mineral Fiber) (10-17-68)

HH-I-528B - Insulation Batts and Blankets, Thermal (Vegetable Fiber) (5-26-66)

HH-I-529B - Insulation Board, Thermal (Mineral Aggregate) (2-12-71)

HH-I-530A - Insulation Board, Thermal (Urethane) (11-22-71)

HH-I-545B - Insulation, Thermal and Acoustical (Mineral Fiber, Duct Lining Material) (3-4-71)

HH-I-551E - Insulation Block and Boards, Thermal (Cellular Glass) (3-11-74)

HH-I-573B - Insulation, Thermal (Flexible Unicellular Sheet and Pipe Covering) (2-20-68)

HH-I-574A - Insulation, Thermal (Perlite) (5-31-66)

HH-I-585C - Insulation, Thermal (Vermiculite) (10-17-74)

HH-I-1030A - Insulation, Thermal (Mineral Fiber, for Pneumatic or Poured Application) (2-23-73)

HH-I-1252A - Insulation, Thermal, Reflective (Aluminum Foil) (3-4-71)

LLL-I-535A - Insulation Board, Thermal and Insulation Block, Thermal (1-19-70)

TT-C-00598C - Caulking Compound, Oil and Resin Base Type (for Building Construction) (6-23-70)

TT-G-410E - Glazing Compound, Sash (Metal) for Back Bedding and Face Glazing (Not for Channel or Stop Glazing) (4-21-69)

TT-P-00791B - Putty: Linseed-Oil Type, (For Wood - Sash- Glazing) (10-16-69)

TT-S-00227E - Sealing Compound: Elastomeric Type, Multi-Component (For Caulking, Sealing, and Glazing in Buildings and Other Structures) (11-4-69)

TT-S-00230C - Sealing Compound: Elastomeric Type, Single Component (For Caulking, Sealing, and Glazing in Buildings and Other Structures) (2-2-70)

TT-S-001543A - Sealing Compound: Silicone Rubber Base (For Caulking, Sealing, and Glazing in Buildings and Other Structures) (6-9-71)

TT-S-001657 - Sealing Compound -- Single Component, Butyl Rubber Based, Solvent Release Type (for Buildings and Other Types of Construction) (10-8-70)

2. NBS Voluntary Product Standards

National Bureau of Standards
Washington, D.C. 20234

NBS Voluntary Product Standard PS26-70 Rigid Poly(Vinyl Chloride) (PVC) Profile Extrusions (4-1-70)

3. ASTM

American Society for Testing and Materials
1916 Race Street
Philadelphia, Pennsylvania 19103

C208-72 - Insulating Board (Cellulosic Fiber), Structural and Decorative

C355-64(73) - Water Vapor Transmission of Thick Materials

C516-67 - Vermiculite Loose Fill Insulation

C534-70 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C549-73 - Perlite Loose-fill Insulation

C552-73 - Cellular Glass Block and Pipe Thermal Insulation

C570-72 - Oil and Resin-Base Caulking Compound for Building Construction

C578-69 - Preformed, Block-Type Cellular Polystyrene Thermal Insulation

C591-69 - Rigid Preformed Cellular Urethane Thermal Insulation

C612-70 - Mineral Fiber Block and Board Thermal Insulation

C665-70 - Mineral Fiber Blanket Thermal Insulation for Wood Frame and Light Construction Buildings

C726-72 - Mineral Fiber Roof Insulation Board

C739-73 - Cellulosic Fiber (Wood-Base) Loose-Fill Thermal Insulation

C755-73 - Selection of Vapor Barriers for Thermal Insulations

C764-73 - Mineral Fiber Loose-Fill Thermal Insulation

E84-70 - Surface Burning Characteristics of Building Materials

E96-66(72) - Water Vapor Transmission of Materials in Sheet Form

E283-73 - Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors

E331-70 - Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

4. ANSI

American National Standards Institute
1430 Broadway
New York, New York 10018

ANSI A134.3-1972 - Aluminum Combination Vertically-Sliding or Horizontally-Operating Storm Windows for External Application

ANSI A134.4-1972 - Aluminum Storm Doors

ANSI Z97.1-1972 - Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings

5. NWMA

National Woodwork Manufacturers Association
400 West Madison Street
Chicago, Illinois 60606

NWMA Industry Standard I.S.1-73 - Wood Flush Doors

NWMA Industry Standard I.S.2-73 - Wood Windows

NWMA Industry Standard I.S.5-73 - Ponderosa Pine Doors

6. FHDA

Fir & Hemlock Door Association
Yeon Building
Portland, Oregon 97240

Industry Standard FHDA/5-75 - Douglas Fir, Western Hemlock, and Sitka Spruce Doors and Blinds

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 75-795	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

Recommended Criteria for Retrofit Materials and Products Eligible for Tax Credit

5. Publication Date

November 1975

6. Performing Organization Code

7. AUTHOR(S)

Walter J. Rossiter and Robert G. Mathey

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Complete Address (Street, City, State, ZIP)

Federal Energy Administration
12th & Pennsylvania Avenue, N.W.
Washington, DC 20461

13. Type of Report & Period Covered

Final

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The Federal Energy Administration requested the National Bureau of Standards to develop criteria for retrofitting for possible use by the Internal Revenue Service in implementing the Presidential initiative authorizing tax credit to homeowners. Criteria are recommended for materials and products considered eligible for proposed tax credit for retrofitting one and two family residences to conserve energy. The materials considered include insulation and vapor barriers, storm windows and doors, caulking and weatherstripping, and clock thermostats. A list of these retrofit materials was compiled by generic type and recommendations made on their installation.

In addition to recommended criteria for materials and products eligible for tax credit, desired levels of performance for the retrofit materials are presented as a guide to homeowners to achieve maximum benefits in energy conservation through retrofitting.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Caulks and sealants; clock thermostats; energy conservation; insulation; retrofitting; storm doors; storm windows; tax credit; vapor barriers; weatherstripping.

18. AVAILABILITY

[XX] Unlimited

[ ] For Official Distribution. Do Not Release to NTIS

[ ] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13

[XX] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151

19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
UNCLASSIFIED	44
20. SECURITY CLASS (THIS PAGE)	**22. Price**
UNCLASSIFIED	$4.00