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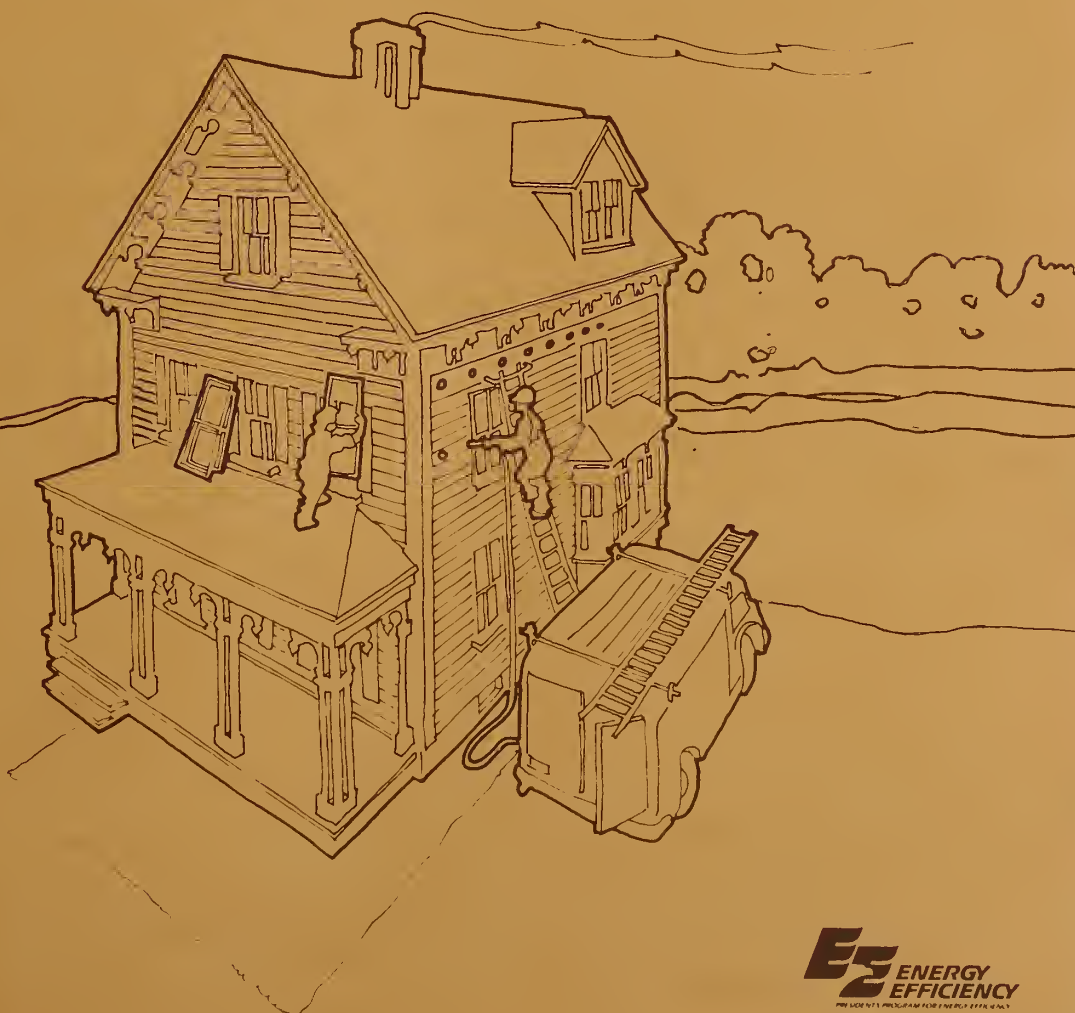
Criteria for the Installation of Energy Conservation Measures



ENERGY EFFICIENCY

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Criteria for the Installation of Energy Conservation Measures

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The development of the installation practices was an interagency, interdisciplinary effort conducted over a period of more than 3 years and involving many individuals. The efforts of several persons were so considerable that they require special mention.

In resolving technical issues, the authors drew most heavily on recent research by P. Reece Achenbach and Douglas Burch on moisture control; Burch on attic ventilation; Lawrence Galowin and Thomas Faison on electrical wiring; and Michael Fulcomer on surface and recessed lighting fixtures. Richard Grot's support in developing the section on diagnostic tools was invaluable, and Maureen Breitenberg assisted in preparing the section on product certification and laboratory accreditation.

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The standards in draft and proposed form were published in September 1978 and March 1979. A total of over 400 comments were received and considered in the preparation of the final document. Although the large number of comments prevents us from mentioning individuals and organizations, the valuable help and assistance provided by those commenting have greatly enhanced the quality and utility of the installation practices.

The authors wish to acknowledge the great help received from all the above and to express their most sincere thanks to all of them. However, full responsibility for all the content of this publication rests with the authors.

CRITERIA FOR THE INSTALLATION OF ENERGY CONSERVATION MEASURES

Heinz R. Trechsel* and Shelia J. Launey

ABSTRACT

Standard installation practices were developed to assist in assuring the effectiveness and safety of energy conservation measures installed under the Residential Conservation Service (RCS). They serve as mandatory standards under RCS but are recommended guides for all installations of the covered materials and products. The criteria are being used by DoE to develop training manuals for installers, inspectors, and energy auditors.

Part I provides information on the intended use of the practices, outlines the RCS program, and discusses specific major technical and related issues that were considered in the development of the standards: moisture and building retrofit, attic ventilation, electrical wiring, recessed and surface-mounted fixtures, the use of diagnostic tools (infrared thermography, air change rate, and window air leakage measurements), and product certification.

Part II provides the actual practices together with commentary and additional recommendations. The products covered are loose-fill, batts and blankets, rigid foam boards, UF foam and reflective insulations, window devices, caulks and sealants, water heater insulation, oil burner replacements, and vent dampers.

Key words: automatic ignition devices; caulks; effectiveness; energy conservation; energy conservation measures; installation; insulation; oil burners; practices; safety; sealants: standards; storm doors; storm windows; vent dampers; water heaters; windows.

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1. INTRODUCTION

Building construction as practiced today was developed over many centuries. Construction methods that proved unsafe or caused early deterioration were discredited and discontinued. Practices pertaining to the health and safety of building occupants and that have withstood "the test of time" were continued, and many of them were finally incorporated into building codes. Construction methods are sets of a great many practices and materials acting individually and in concert. Changes in one material, or in one individual practice, can have unforeseen impact on many other parts of the total building. For example, the addition of insulation to walls can alter the migration and condensation patterns of water vapor in a way that adversely affects certain building materials. The enclosure of electrical wiring in thermal insulation prevents the natural cooling of wires, thus leading to elevated wire temperatures. Were energy conservation retrofits installed gradually, that is, in a few buildings at a time, undesirable side effects would occur on a limited number of houses, the practice could be changed, and the defects in the few affected houses could be corrected. However, because of both high energy cost and the various government programs such as the U.S. Department of Energy (DoE) Residential Conservation Service (RCS) which are designed to stimulate retrofitting, a gradual installation pattern and "the test of time" cannot be relied upon to unveil major problems. Therefore, a concerted effort must be made through the development of training and inspection programs, feedback mechanisms, and quality assurance programs so that undesirable side effects can be controlled, if not eliminated. This effort must have as its centerpiece the establishment and continual upgrading of material standards and standard installation practices.

Material Standards: These attempt to present reliable data concerning critical properties of products so that effective, durable, and safe installations can be made. The American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) are two of the major voluntary standards organizations. Technical committees within ASTM and ANSI have addressed properties of energy conservation materials has the Consumer Products Safety Commission (CPSC) which develops standards it deems necessary to protect the public. Federal Specifications used in the purchasing process by the Federal Government also address this subject. For the RCS Program, DoE has established material standards to assist in assuring that the energy conservation measures installed meet minimum requirements for effectiveness and safety. DoE standards, mandated by Congress, were published in the RCS Rule, Federal Register notice of November 7, 1979 [1].[1]

Standard Practices: Even the highest quality material may not perform properly if installed incorrectly. Improper installation also can seriously affect the durability and general performance of adjacent materials and components. The National Energy Conservation and Policy Act (NECPA) [2] therefore requires that DoE also establish standard installation practices for the RCS Program. It is these practices that this publication addresses, often simply by the term "practices." What precisely is a standard practice? It is, in short, and with respect to energy:

> A description of critical requirements for the installation of an energy conservation measure (material or product) which must be followed so that the measure performs after installation as effectively and safely as intended, and which helps to assure that the installation will not adversely affect, in whole or in part, the recipient building.

The need for practices in energy conservation retrofit is particularly pronounced in light of the fact that high and rising energy costs can be expected to induce most homeowners to seek relief from burdensome heating and cooling bills. While the RCS practices are mandatory only for the RCS Program, it is hoped that they will serve as a quality yardstick for energy conservation installations in general. The standard practices offer the following:

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1 Numbers in brackets indicate references listed at the end of Part I.

- To the homeowner, they provide assurance that the products bought will actually perform after installation at or near the level assumed on purchase;

- To the material producer, they give assurance that his/her product is installed in such a way as to provide safely the performance level of service for which it was designed, thus producing a satisfied customer and reducing call-backs;

- To the auditor, they indicate the precautions that need to be taken to assure a safe and effective installation, to permit an estimate of the cost of installing the conservation measures, and to identify cost-effective energy conservation measures;

- To the installer, they provide guidance on correct installation, a common basis for the bidding process to guard against unfair competition, and protection from unreasonable liability; and

- To the inspector, they give guidance on what constitutes "good practice" for the safe and effective installation of the energy-conserving product involved.

This publication was prepared as a source document and technical backup for those who need to know (1) what the RCS standard practices are, (2) their technical background and why major provisions were chosen, and (3) the principal issues considered in their development. This document will assist those developing RCS State plans; those conducting training programs for RCS installers, auditors, and inspectors, and all others concerned with the implementation of the RCS Program; and homeowners who want to know more about the installation of energy conservation measures. Specifically, DoE has prepared training manuals for installers [3] and inspectors [4] based on the technical content of this publication. It is also hoped that this publication represents a contribution to the development of standards, and the voluntary standards organizations are invited to adopt, through their consensus process, those practices they consider appropriate.

The recently published Office of Management and Budget (OMB) Circular A-119 [5] establishes as Federal policy the use of voluntary standards in procurement whenever feasible and consistent with the provisions of the laws and regulations of the agency. DoE has expanded on this policy in the RCS Program, preferring as a general rule to adopt existing voluntary standards rather than to develop new ones. Voluntary standards, however, cannot be incorporated into the Rules without careful review by DoE to ascertain that the standards do not unduly restrict trade and that they are consistent with the agency's mandate [6,7]. The standard practices will be used as one element in determining whether future voluntary standards address the concerns of the RCS; DoE encourages the conversion to voluntary standards of those practices generated specifically for the RCS Program.

Part I of this publication consists of an introduction, a brief description of the RCS Program, discussions of the major technical issues considered in developing the practices, an outline of examples of diagnostic tools that can be used to determine whether a particular installation meets the criteria of the practices, and a discussion of product certification and laboratory accreditation.

Part II describes the individual practices. Mandatory provisions are set apart from recommendations. Where desirable, a commentary outlines the reason or rationale for the provision, along with the requirement's significance and the potential consequences of ignoring or violating it. The recommendations cover precautions that might be taken in addition to the mandatory requirements. Although the recommendations are not mandatory under the RCS Program, their use should be considered on a specific, house-by-house basis.

One final word. Only through careful installation of appropriate materials can the concern for the national goal for energy conservation effectiveness be balanced with the concern for safety and durability of every individual house retrofitted. Such proper balance will both reduce energy use in residential buildings and increase the value of the Nation's housing stock. The standard practices contained in Part II will assist in finding the proper balance.

2. THE RESIDENTIAL CONSERVATION SERVICE

2.1 GENERAL PROGRAM PROVISIONS

The National Energy Conservation Policy Act (NECPA) [2] requires DoE to establish a national residential energy conservation program to assist homeowners in saving both energy and money. The RCS Program requires large utilities and participating heating oil suppliers to offer services to their residential customers which will encourage the installation of energy conservation and renewable resource measures. Although the RCS is a national program, each State may develop and implement its own State plan. The purpose of the program is to provide residential energy users with information on the cost-effectiveness of energy conservation measures and techniques, to give assistance to homeowners in having measures installed and in securing financing, and to protect the consumer from unsafe installations and unfair business practices.

Utility customers who are occupants of residential buildings of up to four dwelling units can take advantage of the services offered by their utilities and will gain several benefits, including:

- Information about estimated savings in energy cost for selected energy conservation and renewable resource measures;
- Information about precautions needed to assure a safe installation;
- Energy audits upon request to identify specific measures that would be cost effective when installed in the customer's residence. During the audit, the home will be inspected for energy inefficiencies and potential safety problems that may result from retrofit;
- Arranging services for the purchase, installation, financing, and billing of program measures;
- Safe and effective installations by contractors who are qualified to perform the work, are bonded, and have agreed to follow the installation practices;
- Special procedures for consumer protection, including grievance procedures, warranties, and post-installation inspections to verify the safe and effective installation of measures.

Suppliers and installation contractors who participate will get:

- More business opportunities. Energy conservation is an expanding market area. As a result of the RCS Program, an estimated $6.7 billion will be invested in the purchase and installation of energy conservation products and materials;
- A marketing advantage. DoE standards require that the products and materials installed are dependable and of consistently high quality, and that they are labeled as meeting DoE standards;
- Reputation for quality installation. Procedures outlined in the RCS regulations are Government-required minimums for installing conservation products and materials. Where contractors follow these practices, their customers will be assured of safe and effective installations.

Installation contractors are required to meet the following requirements to conduct business under the RCS Program:

- Comply with the standard practices applicable to a given installation;
- Comply with all applicable local, State, and Federal (apart from RCS) regulations and codes;

- Install only materials which comply with DoE material standards and are so labeled;
- Install only measures covered by the RCS warranty;
- Furnish the customer with a written contract;
- Agree to consumer conciliation procedures, and agree to correct any violation of the RCS standard practices without cost to the customer;
- Comply with bonding and liability insurance provisions;

Suppliers and lenders have to agree to supply measures that meet the DoE Standards and carry the measures warranty, to meet appropriate requirements relating to product certification, and to participate in conciliation procedures in order to conduct business under RCS.

Lenders have to agree to comply with specific provisions relating to security in real property used as principal residence, to allow rebate on unearned finance charges and to participate in conciliation procedures.

2.2 MATERIAL STANDARDS

The RCS Program has promulgated standards for safety and effectiveness for most products and materials covered by the Program. These standards expand on and incorporate features of existing standards developed by nationally recognized organizations. When appropriate, the DoE standards provide references to relevant existing standards. All products installed under RCS must be labeled by manufacturers as complying with the DoE Material Standards; installers must agree to use only products so labeled. To date DoE Material Standards have been issued for the following materials and products:

Energy conservation measures

- Loose-fill cellulosic or wood-fiber thermal insulation;
- Loose-fill mineral-fiber thermal insulation;
- Mineral-fiber blanket-and-batt thermal insulation;
- Vermiculite thermal insulation;
- Perlite thermal insulation;
- Polystyrene thermal insulation board;
- Polyurethane and polyisocyanurate thermal insulation board;
- Urea-formaldehyde foamed-in-place insulation (interim standard);
- Aluminum foil reflective thermal insulation;
- Caulks and sealants;
- Water heater insulation;
- Heating and air conditioning duct insulation;
- Pipe insulation;
- Storm and thermal windows, multiglazing, storm and thermal doors;

- Furnace efficiency modifications, including vent dampers and automatic intermittent pilot ignition devices for gas-fired furnaces and replacement oil burners, replacement heating systems with the same fuel type;
- Replacement central air conditioners;
- Load management devices.

The DoE Material Standards were published as part of the Rule for the Residential Conservation Service [1].

Renewable resource measures

- Solar domestic hot water and active solar space heating systems;
- Thermosyphon hot water systems;
- Swimming pool heaters;
- Wind energy devices.

2.3 STANDARD INSTALLATION PRACTICES

The RCS Program has promulgated standard practices to help ensure the safe and effective installation of conservation and renewable resource measures. These cover the following materials and products:

Energy conservation measures

- Loose fill insulation;
- Mineral fiber blanket and batt insulation (including duct insulation);
- Organic cellular rigid board insulation;
- Reflective insulation;
- Urea-formaldehyde foamed-in-place insulation (interim standard);
- Water heater insulation;
- Storm windows, thermal windows, multi-glazing, storm doors, thermal doors;
- Caulks and sealants;
- Replacement oil burners;
- Vent dampers;
- Automatic intermittent pilot ignition devices (interim standard).

Renewable resources measures

- Solar domestic hot water and active solar space heating systems;
- Thermosyphon hot water heaters;
- Swimming pool heaters;
- Wind energy devices.

This publication addresses only the practices for the energy conservation measures.

2.4 FURTHER INFORMATION

The RCS program is administered by a lead agency in each State. For detailed information on the various aspects or the State plan and its implementation, the State lead agency should be contacted. Although the exact name of the agencies differ from State to State, the responsible agency is in most cases either a State energy office or a State public utility commission.

3. METHOD OF INSTALLATION PRACTICES DEVELOPMENT AND TECHNICAL BASIS FOR PROVISIONS

The standard practices included in this publication were developed jointly by DoE and the National Bureau of Standards (NBS), with substantial assistance from other Federal agencies and private consultants. The effort was coordinated through the DoE/RCS "Installation Standards Committee" which drew on experts as required and which undertook the preparation of the practices in a variety of ways. Some practices, such as that for water heater insulation, were prepared by a consultant and reviewed and revised by the Committee. Others were more directly written by the Standards Committee, individual members contributing specific chapters, sections, or provisions. The practice for window devices was developed jointly with ASTM Subcommittee E06.51, Performance of Windows, Doors, and Curtain Walls. (This practice was adopted by ASTM as E737-80, in March 1980) [8].

A first draft of some of the practices was published in November 1978 in a DoE report [9], and through posting of an appropriate notice in the Federal Register [10] interested persons were requested to comment. Based on the comments, Proposed Installation Standards were included in the March 19, 1979, Federal Register Notice as part of the Proposed Rule for the RCS Program [11]. Over 400 written comments were received in response to the publication, and many more were received in oral testimonies during RCS public hearings held in seven cities. Extensive improvements based on the public comments were included in the final practices published on November 7, 1979 (amended on August 11, 1980 [12]). Some practices were published as proposed on December 21, 1979 [13], and as final on September 24 and 25, 1980 [14,15].

Early in the development of the practices, it was decided to base their provisions wherever possible on existing standards. Thus, provisions of the HUD Minimum Property Standards (MPS), Federal Specifications, ASHRAE Guidelines, and ASTM Standards were reviewed. Where appropriate, individual provisions (such as the MPS requirements for attic ventilation) were adopted. However, in existing buildings (to which the RCS Program is directed) some of the provisions included in codes and standards for new buildings would be difficult or expensive to implement. This applied, for example, to the requirements for vapor barriers in wall constructions. For this type of situation, the installation committee initiated research or fact-finding activities to assist in preparing appropriate provisions. In the above-mentioned vapor barrier issue, a panel of experts under contract to NBS assisted in formulating the provisions discussed under "Moisture and Building Retrofit" and in the individual practices. In other cases, such as attic ventilation and electrical hazards, DoE sponsored research activities to develop a technical basis for appropriate provisions. Since some of this research requires several years to complete or at least involves observation and tests over a full annual cycle, not all results are yet available. Thus, the provisions included in the practices are based on the best available data to date, and future revisions may be needed.

Where no applicable standards existed, the guiding principle was that the overall level of safety of the building should not be decreased by the installation of the energy conservation measure. Where trade-offs between potential hazards and effective installation were unavoidable, DoE adopted provisions as conservative as judged compatible with the overall purpose of RCS -- to assist homeowners in saving energy.

Many local, State, and Federal agencies regulate aspects of building constructions and their operations. Whenever possible, those requirements which affect the installation of energy conservation measures (or are affected by them) were identified and are specifically included in the standard practices. Thus, the Federal requirement for safety glazing in doors is referenced in the standard practice for window and door devices. However, it would have been an impossible task to review all local, State, and Federal regulations possibly relating to the installation of energy conservation measures. Accordingly, the RCS Rule includes a general statement that the standards are not intended to supersede local, State and other Federal codes and standards [16]. The most significant application of this principle is in the provisions for electrical wiring discussed in detail under "Technical Issues."

4. TECHNICAL ISSUES

In the course of developing the standard practices, a great many technical issues were considered. Where appropriate, these are mentioned in the "Commentary" accompanying individual provisions of the practices in Part II. Brief descriptions of the most significant, or most difficult, technical issues follow.

4.1 MOISTURE AND BUILDING RETROFIT

"Except for structural errors, about 90 percent of all building construction problems are associated with water in some way," states the 1980 ASTM Book of Standards [17]. Construction measures which control moisture adequately will deliver safe and effective performance over a long period of time. Structures that do not control moisture will experience early deterioration through fungus growth in wooden structures, paint peeling, staining of interior surfaces, warping and resultant air leakage, spalling in masonry walls, and corrosion of metal building components. Besides causing damage to the structure, moisture also may sometimes reduce the effectiveness of thermal insulation [18].

Moisture can enter building elements primarily by two means: by penetration of water from the outside of the house, such as rainwater leakage or a burst pipe, and by vapor diffusion and air penetration into cavities from the inside of the house. In either case, the most serious problems arise when moisture accumulates for extended periods of time.

The control of moisture needs to be considered in energy conservation retrofit for several reasons:

- Insulation placed in walls reduces the temperature at the plane of condensation, thus raising the water vapor pressure difference between the inside of the house and the cold surface, increasing the amount of condensed water [19,20].

- Installation of weatherstripping, caulking, thermal windows, and vent dampers reduces air infiltration [21] and raises the indoor relative humidity. Higher indoor moisture levels increase vapor transfer through the building envelope and thereby increase the amount of interstitial moisture accumulation.

- Some insulations contain considerable amounts of moisture when installed. This moisture must be vented to the outdoors to prevent the deterioration of the structure. This venting is particularly important when insulation is installed during cold weather.

For the above reasons, a house free of moisture problems prior to retrofit could develop such problems after the installation of energy conservation measures. It is possible that the first sign of such a problem (maybe slight peeling of paint) will show up shortly after the retrofit, allowing for timely corrective action. But in some cases no such telltale signs will signal the major trouble that may lie several years ahead. In a house with no signs of prior water leakage or condensation, the likelihood of a moisture problem can be reduced by conscientiously following the installation practices given in this book. Addition information, suggestions for identifying special types of previous moisture damage, means of preventing their recurrence, and evaluative tests that the homeowner can perform to determine whether additional precautions may be justified are given below.

4.1.1 Previous Moisture Problems

As has been noted, the installation of insulation increases the risk of moisture accumulation within constructions. It is therefore important that any already existing problems be corrected and the causes of leaks or condensation be minimized or eliminated. What follows are brief descriptions of the more likely causes of previous problems. Also presented is information on how each problem can be recognized, how to determine whether it still is a problem, and how the problem can be corrected and its cause eliminated.

Rainwater leakage is generally recognizable by pronounced streaks emanating from one or more clearly identifiable locations. If the sources of leakage are small cracks or openings, caulking or patching in good condition should be assumed to have corrected the leakage unless actual moisture is present. If not previously corrected, small leaks around openings and flashings should be sealed with appropriate caulking compound (see DoE Material Standards), using techniques prescribed by the manufacturer and in the material standards and installation practices. Roof leaks generally will require the replacement of the roofing material or repairs using supplemental waterproof membranes.

Leaking or burst pipe is recognizable by pronounced streaks or actual spraying or dripping emanating from a water pipe or from a space containing a pipe. Check for actual moisture present while pipe is under normal operating pressure for at least 15 minutes. If leak is apparent, repair piping in accordance with good plumbing practice. Where local code requires, repairs are to be made only by approved personnel.

Flooding is indicated by distinct horizontal markings showing the highest water level. Frequency and time of last occurrence determines most reliably whether the cause of the flooding has previously been eliminated. If flooding occurs only at intervals of more than five years, the potential for damaging the added insulation or for deterioration of the structure due to the water retention of insulation is minimal. Remedial action depends on the type of flooding. This may be due to sewer backup, or to seepage of groundwater through the wall or floor (see below). Since the success of the wall treatment cannot be determined by visual inspection during dry weather, it is necessary to await wet weather to evaluate whether flooding has stopped.

Seepage through walls below grade is generally marked by large discolored areas with clearly defined edges on basement or crawl space walls. Determine frequency of occurrence. If occurrence is at intervals of five years or more, or if seepage has not occurred since the application of remedial action, the risk for potentially serious damage to insulation or structure can be discounted. Minor seepage through masonry walls can often be stopped by the application of sealer on the interior surface of the wall. Major seepage is difficult to stop and professional advice is required. The only effective remedial action may be to excavate the ground around the location of the seepage, to apply a waterproof membrane on the outside surface of the wall, and to provide drainage at the bottom of the wall. To prevent future moisture problems, the ground around the building should always be sloped away from the wall.

Condensation should be suspected whenever no other cause of a prior moisture problem is apparent and is most likely to occur in walls and attics of high moisture areas such as in bathrooms and unvented kitchens and laundries. It may also be suspected where the outside sheathing and finish of the exterior wall are of vapor-impervious materials, such as oil-base painted wood siding over plywood sheathing and asphalt impregnated felt or construction paper and where a vapor barrier is not provided on the interior surfaces of exterior walls. It is also to be suspected in ceilings without adequate attic ventilation. It should also be suspected whenever there is paint peeling on exterior surfaces. Remedial actions are discussed below in section on "Control of Condensation." If it is determined that remedial action is not feasible, too costly, or not desired by the homeowner, no insulation should be installed in the immediate area (such as within the stud or joist space) of the moisture damage. The energy conservation impact of leaving such spaces uninsulated is proportional to the ratio of insulated to uninsulated areas. For example, if a single stud space among 100 total stud spaces were left uninsulated, the loss of effectiveness of the insulation job would be one percent.

4.1.2 Control of Condensation in Walls

The ASHRAE Guide states that "a typical family of four may produce as much as 11 kg (25 lbs) per day of water vapor, or more, if humidifiers, automatic washers, and clothes dryers are used" [22]. More recent data indicate that a range of 8 to 9 kg (18 to 20 lbs) per day may be a better estimate because of less floor scrubbing, cooking, and indoor clothes drying, and fewer daily hours of house occupancy for modern families as compared to the situation 30 years ago [23]. The principal sources of moisture in houses are respiration, perspiration, cooking, bathing, laundering, and of course, humidification.

Some of these moisture-generating processes take place throughout a house but the moisture release in bathrooms, kitchens, and laundry rooms is typically much higher than for other rooms.

The moisture generated in a house is dissipated in one or more of the following three ways: by exfiltration or ventilation, by diffusion or mass transport through the envelope materials, and by condensation on windows or other cold surfaces. These processes may all occur simultaneously, and there may be interactions among them. During cold winter months, water vapor that permeates through an exterior wall from inhabited space may condense and accumulate in the outer parts of the wall. The amount of such moisture accumulation depends on climate, relative humidity of the indoor air and relative permeance of the interior and exterior wall surfaces.

The principal methods available for controlling winter condensation within existing walls when installing insulation are [24]: sealing of openings on the inside surface of the exterior walls to prevent leakage of room air into wall cavities; installation of a vapor barrier on the warm side of the wall, venting the wall cavity to the outside; maintaining low indoor humidity in cold weather; and allowing intermittent condensation in limited amounts to occur. Many experts in moisture control agree that air leakage through interior wall surfaces (such as at electrical outlets, pipe penetrations and cracks) is a more significant moisture transfer mechanism than diffusion through the wall coverings. Therefore, sealing air leaks that allow air to enter the wall construction should have first priority for controlling condensation.

Little field data are available on actual moisture damage in insulated walls and ceilings of occupied houses. In two recent field studies conducted independently on insulated side-walls in Portland, Oregon for the Oregon Department of Energy [25] and in various locations of the midwest, northeast and middle atlantic states for the National Bureau of Standards [26], no adverse effects were found to have been caused by the installation of thermal insulation, even though in some of the walls inspected vapor barriers either were totally missing or were found to be installed on the exterior of the insulation in violation of accepted "good practice."

Existing "good practice" recommendations and standards (ASHRAE Guide [27] and HUD MPS [28]) require vapor barriers on the interior of walls and ceilings in all three condensation zones of figure 1.[2] Because such requirements are expensive to implement in existing buildings, and because the need for such stringent precautions has not been shown conclusively, the moisture control provisions of the practices in this publication and in the DoE Standards differ from the new building requirements:

- Vapor barriers are required in condensation zones 1 and 2 where the installation of a vapor barrier is no more difficult and costly to install than in new buildings. In all cases, a vapor barrier is required in condensation zone 1 in high humidity rooms such as bathrooms and unvented kitchen and laundry rooms;

- The sealing of cracks on the interior side of exterior walls and ceilings of high humidity rooms is required in condensation zone 1.

- For condensation zone 2, the same precautions in high humidity rooms are recommended, but not mandatory.

- In zone 1 and 2, in attics which have existing insulation, a vapor barrier (paint) is recommended.

The requirements depend somewhat on insulation material type. For detailed information consult the specific standard practice in Part II.

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[2] Figures are shown at end of Part I.

The above and the standard practices provide minimum requirements to prevent long-term moisture damage. Additional precautions may need to be taken in homes with the potential for high indoor relative humidity, such as:

- Homes with an area of less than 75 m^2 (800 ft^2);
- Homes with less than 23 m^2 (250 ft^2) per occupant;
- Homes with tight wall and ceiling construction and weatherstripped windows and doors;
- Electrically heated homes or homes with a heating system which uses outside combustion air; and
- Homes that are humidified during the winter.

To determine whether houses with one or more of the above characteristics need additional precautions, the indoor relative humidity is a fairly good indicator of the potential for moisture condensation occurring inside building walls. For any given outdoor climate and a particular insulated wall construction, there is an indoor relative humidity level below which no condensation will occur at any position inside the wall. Likewise, for any given rate of moisture generation in a house, there is a minimum ventilation or infiltration rate which will prevent that indoor relative humidity level and therefore prevent condensation. A relative humidity indicator can thus give a good measure of whether in the particular house such precautions as caulking of cracks and added vapor barriers are needed to reduce the potential for serious condensation problems. Below are recommendations for the use of the humidity indicators and the steps that can be taken to reduce the likelihood of any serious problems:

Install the relative humidity indicator near the thermostat. Inexpensive color-change relative humidity indicators as shown on figure 2 are available that are of sufficient accuracy for the purpose. During the heating seasons, compare the readings of the relative humidity indicator with the values shown in table 1[3] for the applicable Climate Zone and month.

If the relative humidity as measured in the house is consistently higher than the values shown in table 1 for the particular climate zone and month, the following steps should be considered to assure that no serious deteriorative moisture problems occur:

- Caulk or seal openings at the <u>interior surface</u> of the exterior walls and in the ceiling[4] that permit convection of room air into the wall cavity or through the ceiling (zones 1 and 2). The more important openings are:

    a. Joints around window and door frames

    b. Electrical switches and service outlets and the power cord to electric range (preformed foam gaskets are available for this purpose)

    c. Wall-mounted and ceiling-mounted[4] light fixtures

    d. Duct openings (between grille and wall) in exterior walls and ceiling[4]

    e. Plumbing penetrations: floor, wall, and ceiling[4]

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[3] Tables are shown at end of Part I.

[4] Joints around utility penetrations of ceilings do not require sealing when the amounts of attic ventilation specified in the standard practices are provided.

f. Joint between wall and floor at the top of the baseboard and also at the bottom of the baseboard if carpeting does not prevent it

g. Joint between wall and ceiling

h. Built-in cabinets not tightly fitted into exterior walls.

- Apply low permeability paint or wallpaper to all untiled interior surfaces of exterior walls unless they are already covered with such materials. Low permeability paints and wallpapers have a permeance of less than one perm as defined in ASTM C755-73.

- Do not caulk or seal exterior surfaces of outside walls around window and door frames and at the joint between foundation and wall except as required to prevent rain leakage into the wall.

- Vent clothes dryer to outdoors (zones 1 and 2).

- Do not dry laundry indoors unless additional natural ventilation is provided by opening windows or an exhaust fan is running.

- If the exterior of a house being retrofitted has a low-permeability finish (e.g., metal, plastic, or heavily painted wood) steps should be taken to open up the siding construction in ways that would increase outdoor venting of the wall without increasing rain penetration.

If the suggested steps above are not taken, it is strongly recommended that the house be carefully observed after installing insulation, caulking, weatherstripping, or thermal windows. Should early signs of moisture problems appear, particularly paint blistering or excessive condensation on windows, immediate correction action should be taken. Such action could include as a temporary measure the opening of one or more windows by a fraction of an inch and operating kitchen and bathroom fans to reduce indoor humidity. However, these later actions should be taken only as a last resort and only to the extent required inasmuch as they are energy consuming. The extensive use of fans to ventilate the house's interior can also affect the operation and safety of fossil fuel heating systems located within the building envelope. The negative pressure resulting from fan operation can draw such poisonous combustion products as carbon monoxide into the living space.

4.1.3 Attic Ventilation

A portion of the up to 11 kg (25 lbs) of water per day released in the average home reaches the attic space either by diffusion through ceiling materials or by being carried through mass transport in air that penetrates cracks, access doors, and other openings in the ceiling. Unless the vapor is vented from the attic to the outdoors, it may condense during cold weather on the cold surfaces of the underside of the roof. A thick layer of frost resulting from such condensation on the underside of roof sheathing is shown in figure 3. During warm periods the ice melts, wetting insulation on the attic floor, rendering the insulation ineffective and causing the deterioration of ceiling materials, structural members, or electrical systems. Also, the roof sheathing may absorb the condensed moisture, promoting fungus growth. Installing attic and ceiling insulation, or increasing it, will cause attics to be colder in winter, thus increasing the potential for moisture problems in attic spaces.

Both ASHRAE recommendations and HUD Minimum Property Standards call for attic ventilation. The requirements that follow were established by the HUD MPS and are adopted for the RCS program.

a. 0.1 m^2 (1 ft^2) minimum of free ventilation area per 15 m^2 (150 ft^2) of attic floor area, if no vapor barrier exists in the attic

b. $0.1\ m^2$ ($1\ ft^2$) minimum of free ventilation area per $30\ m^2$ ($300\ ft^2$) of attic floor area if a vapor barrier does exist

c. $0.1\ m^2$ ($1\ ft^2$) minimum of free ventilation area per $30\ m^2$ ($300\ ft^2$) of attic floor space if at least 50 percent of the required ventilating area is provided with fixed ventilation located in the upper portion of the space to be ventilated (at least 900 mm (3 ft) above eave or soffit vents) with the remainder of the required ventilation provided by eave or soffit vents, if no vapor barrier exists.

It should be noted that the requirements for attic ventilation are primarily related to the prevention of moisture condensation in the attic space during cold weather. Attic ventilation also lowers the attic temperature in summer. In uninsulated attics, the lowering of these temperatures in the summer may increase the thermal comfort in the habitable space below, but comfort is more effectively improved by the installation of attic insulation.

In insulated attics, the increased summer comfort, or in the case of air conditioned houses, the amount of cooling energy savings resulting from increased attic ventilation, were found to be negligible [29]. Accordingly, the requirements for attic ventilation are governed by the need to prevent the condensation of water vapor penetrating from habitable spaces into the attic during cold weather.

While the given requirements have proven generally adequate in the past, they have been questioned as to their validity in retrofit. Some of the questionable aspects are:

- If a house already has attic insulation, but slightly less than the above "minimum" requirements, is the expense of providing a minimal additional amount of ventilation justified?
- Is it possible that a single requirement for attic ventilation can cover all types of climates--hot, cold, dry, and moist?
- Does the use of increased attic insulation and the corresponding lowering of attic temperatures require increased attic ventilation?
- Does caulking of walls and weatherstripping of windows cause more moisture to migrate from the habitable space to the attic, increasing the potential for condensation and moisture damage in the attic?

While experts on attic moisture problems agree that insufficient attic ventilation can lead to problems, they disagree on the amount of attic ventilation required for their prevention.

In an effort to resolve these differences, NBS has developed a mathematical model for predicting the required attic ventilation rate for preventing condensation or frost accumulation on the underside of roof sheathing. This mathematical model indicates that the ASHRAE/ HUD MPS requirements are generally valid for ASHRAE Condensation Zone I, provided the house is not humidified [30]. Under DoE sponsorship, the model is currently being improved upon, expanded to other zones, and will be experimentally validated. If, based on the experimental work, any changes in the DoE/RCS practices are indicated, such changes will be incorporated in later issues of the installation practices.

4.2 ELECTRICAL SERVICES

All electrical systems, while being operated, generate heat. When properly designed for the imposed loading conditions and environment, such generated heat will dissipate harmlessly. However if the loading conditions are changed, for example, by overlamping of fixtures (meaning installing lamps of higher wattage than the fixtures were designed for), or if the environment is changed, for example, by electrical wiring surrounded by thermal insulation, harmless heat dissipation may no longer be possible. There are three electrical service components that are of primary importance as they relate to the installation of insulation in walls and ceilings: wires and fuses, surface-mounted lighting fixtures, and recessed lighting fixtures.

4.2.1 Wiring

The National Electrical Code (NEC) [31] stipulates the temperatures that electrical wires may safely operate under (See Part III). This temperature for most residential wiring is 60°C (140°F) for polyvinyl insulation and 50°C (122°F) for "code rubber" wire used generally before 1940. According to the Fire Protection Handbook, "it is generally agreed that 100°C (212°F) is the highest temperature to which wood can be continuously exposed without risk of ignition," [32]. Schaffer [33] cites several sources which indicate that "safe" levels of long term exposure are between 100°C (212°F) and 150°C (302°F). Ignition temperature for wood (short-term exposure) is most commonly quoted as 200°C (392°F) [32]. The melting point on polyvinyl chloride (PVC) insulation commonly used for electrical insulation is 115°C (239°F) [34]. To assure that the allowed ampacity in the wire is not exceeded, the NEC also requires that all branch circuits be protected by overcurrent protection devices, either fuses [35] or circuit breakers [36]. These devices are designed to interrupt the current upon sensing a surge of current or after a steady draw of 135 percent of rated current for one hour.

The NEC requirements apply to wires installed in open air at an ambient temperature of not more than 30°C (86°F). If ambient air exceeds 30°C (86°F), the circuit must be derated. Thus, when wires and protection devices are properly matched, even an excessive load on the circuit cannot cause an overheating of the wire installed in an open air space. In actual service and in open air, the wire temperatures are normally substantially below the 60°C (140°F) limit. However, if the wires are surrounded by thermal insulation, thus reducing the heat dissipation, temperatures near or above those stipulated have been observed in laboratory tests. Figure 4 shows a summary of exploratory tests conducted at NBS [37].

More recent tests at NBS have confirmed the tendency toward elevated temperatures on electrical wiring surrounded by thermal insulation, and similar results were obtained by Hill [38] and by Drucker [39]. In tests conducted by the Stevens Institute of Technology [40], the 60°C (140°F) NEC temperature limit was exceeded when three adjacent cables carried full rated load simultaneously, and when a single cable carrying full rated load was sandwiched between layers of thermal insulation. These tests also showed that gypsum board ceilings in contact with electrical cables provided an effective heat sink. Wood joists in contact with cables provided a lesser heat sink effect. The experimental results have been confirmed in analytical work by Evans [41].

There still remains a question as to what degree high amperage and elevated temperatures actually occur in service. To get at least some preliminary data on field conditions, DoE and NBS are conducting a study in which utility companies in various parts of the country have installed temperature sensors on branch circuit wiring in attics, particularly on wires buried in thermal insulation. Preliminary results based on sensors installed over a two- to six-month period (generally Fall, Winter and Spring months) indicate that of approximately 2000 circuits monitored, approximately 5 percent reached temperatures of 68°C (155°F) or higher, that is temperatures in excess of the limits stipulated in NEC [42]. This experiment indicates only the highest temperature reached within the range of the sensor, 50°-88°C (122°-190°F). The length of time the wire was exposed to the elevated temperature could not be obtained with the type indicator used. Nevertheless, the experiment does indicate that in-service temperatures of electrical wiring encapsulated in thermal insulation can, and approximately 5 percent of the cases did, exceed the NEC limits. These findings provide substantial agreement with laboratory and analytical investigations for in-service conditions. One of the most serious concerns is that of long-term degradation of the dielectric and physical properties of the insulating material on the electrical conductors.

Single Cables

In the NBS laboratory tests at rated ampacity, the temperature in a 3-wire single cable surrounded by thermal insulation exceeded the NEC provisions in less than 1 hour, and at

135 percent of rated ampacity the temperature was exceeded in less than 20 minutes and reached 98°C (208°F) within 1 hour. Thus under the laboratory test conditions the wire temperatures exceeded those stipulated by NEC, and if experienced in a building would constitute a violation of NEC. However, the recorded temperatures (assuming properly matched overcurrent protection devices were installed) should last for only a limited time.

No tests are reported on circuits with overcurrents above the 135 percent limit set by proper overcurrent protection. Such higher currents could flow through wires if the overcurrent protection device is mismatched to the wire. For example, in a circuit designed for 15 ampere and wired with #14 wire, the 15-ampere fuse might be replaced with a 30-ampere fuse. This fuse would now permit a continuing load of 30 amp and a 1-hour load of 40.5 ampere. Other tests conducted at NBS on electrical wiring covered with cellulosic insulation showed that smoldering fires were initiated at overloads corresponding to 190 to 200 percent of rated current [43].

The consideration of circuits with improperly matched overcurrent protection devices might be assumed an academic exercise, were it not for a recent survey which indicated that some 45 percent of all houses in a sample of low income homes in some 14 localities of the United States had at least one improperly matched circuit [44]. In the DoE/NBS conducted study with utility companies, preliminary data showed that 37 percent of the houses had at least one improperly matched overcurrent protection device. The survey data do not indicate a reason for the mismatched overcurrent protection. In circuits with fuses, such mismatch can result from "blown" fuses being replaced by the homeowner with fuses of incorrect rating. Where this is done on a random basis, all circuits in a house could eventually be mismatched (the higher rated fuses would never "blow"). However, unless the circuits actually carry a higher load for extended periods, no increased hazard would result. The mismatch could also be deliberate, in that a fuse which "blows" frequently is replaced with one of a higher rating to mistakenly "cure" the problem. In this case, it would be precisely those circuits which have shown a history of carrying excessive currents that are incorrectly protected. An NBS staff member recently discussed with eight homeowners the reasons for improperly matched overcurrent protection devices. One of the owners indicated that he deliberately "cured" his fuse-blowing problem by replacing the blown fuses with a higher rated fuse [45].

Parallel (Multiple) Cables

For comparison, figure 4 also shows the temperatures reached by three parallel cables in contact with each other. When all three cables each carried full load (20 amps) the temperatures were similar to those observed when the single cable carried 27 amps (135%). When the three cables each carried 27 amps (135%), the temperature rose within 1 hour to 148°C (298°F). Although the temperatures reached by parallel wires during laboratory tests were high, the frequency of several parallel wires in close proximity each carrying simultaneously full or excessive loads is not known. It appears unlikely that this occurs with any significant frequency.

Significance

Excessive temperatures of wires surrounded with thermal insulation can impact three building elements: the electrical cable itself, the thermal insulation, and adjacent building elements.

The temperature levels and their duration observed for residential branch circuits with properly matched overcurrent protection devices do not seem to constitute significant hazards. Ignition of the electrical insulation, thermal insulation, or adjacent structure is unlikely. The electrical insulation could experience a long-term degradation and reduced service life, but the available data do not support a more definitive statement.

Few data exist regarding the duration of load and temperature levels possible on wires in circuits with incorrectly matched overcurrent protection devices. However, it appears that elevated temperatures could exist for sufficient duration to cause melting and possible ignition of the electrical insulation on encapsulated cabels in improperly protected circuits. The temperature of wiring and duration of exposure should not lead to the ignition of approved (labeled as meeting DoE standards) insulation. However, if a wire in an improperly protected circuit under loaded conditions were sandwiched between existing combustible insulation (such as untreated paper or wood shavings), and new insulation (regardless of the new insulation's properties), initiation of smoldering of the old insulation could occur. If adjacent wood construction were in contact with electrical wires in circuits with mismatched overcurrent protection devices, long-term exposure to elevated wire temperatures could result in chemical change, charcoal formation, and eventual initiation of smoldering. From the above, it appears that hazards from surrounding electrical wiring with thermal insulation are closely related to the issue of circuits that are incorrectly protected against overcurrent. Fact Sheet No. 18 on Home Electrical Systems of the Consumer Product Safety Commission [46] warns against overfusing. It also recommends as a precaution against overfusing that all Edison-based fuses (which allow higher rated fuses) be replaced by "S" type non-interchangeable fuses (figure 5).

The same fact sheet also recommends that houses showing signs that their electrical systems are beginning to fail be inspected by a licensed electrician or by the local power company (if it makes inspections). The signs are: light dimming, fuses blowing or circuit breakers tripping frequently, overheated or glowing receptacles, and flickering lights.

Remaining Questions

Several questions remain unanswered regarding potential hazards associated with electrical wiring surrounded with thermal insulation:

° How frequently and for what length of time do cables in residences actually carry the overcurrents that could cause a hazard? Actual currents and their duration in typical or in overfused residential circuits have never been measured.

° What effect, if any, does a temperature slightly higher than the NEC limits, both short-term and prolonged, have on electrical wiring or on surrounding materials?

° How widespread is the practice of installing parallel (or "bunched") wires in residential applications, and with what frequency do such parallel wires carry near full ampacity at the same time?

° To what degree do gypsum wallboard or ceilings, wood joists or studs and siding serve as heat sinks, and what effects do these have on the temperature of wires?

° Why have we apparently not experienced a rash of fires or at least electrical breakdowns in the many millions of homes retrofitted to date?

Code Rubber Wiring

A further potential hazard exists with houses that have so-called "Code Rubber" wiring. The temperature limits for that wire were set by NEC at 50°C (120°F). Laboratory tests show that this temperature will be exceeded by a wire carrying the full rated load for less than half an hour when the wire is surrounded by thermal insulation. Unless circuits consisting of code rubber wire are derated, no insulation should be placed over them. Code rubber was regularly installed until about 1940. Since, to begin with, such houses frequently do not have adequate electrical circuits for today's heavy loads, (particularly for window air conditioners, color television sets, and portable electric room heaters), the potential for overloaded circuits is all the greater. Because there is a lack of data on the performance and safety of circuits with code rubber type wiring, it is recommended that houses with such wiring be inspected by an approved electrician and that upgrading of the electrical service or derating of circuits be done prior to installing thermal insulation in contact with this electrical wiring [47].

Insulation in Electrical Boxes

An additional potential hazard can result from the penetration of loose fill or foamed-in-place insulation into electrical boxes [48]. Insulation in junction, switch, and outlet boxes can cause galvanic corrosion of the boxes and their components and can lead to short circuits and arcing with corresponding fire risk (see figure 6). Therefore, after the installation of loose fill or foamed in place insulation, electrical boxes, need to be inspected and any insulation that has lodged in the boxes must be cleaned out. <u>Prior to this inspection and cleaning-out operation, electrical current in the particular circuit must be shut off</u>.

Conclusions and Recommendations

Test results and analytical studies show a potential violation of NEC provisions when overloaded residential branch circuits are surrounded by thermal insulation. However, such overload appears only possible if the circuits are improperly protected. Since the installation of electrical circuits and related safety features are the subject of NEC and are under the jurisdiction of local and State agencies, the RCS installation practices do not contain mandatory provisions regarding the encapsulation of electrial wiring with thermal insulation. DoE believes that the general statement in the RCS Rule to the effect that existing local and State codes and standards are not superseded by the standard practices sufficiently addresses the potential violations of the National Electrical Code. DoE is closely monitoring the results of ongoing research and should evidence appear that a significant hazard is likely to result from surrounding wiring with insulation, the installation practices will be amended accordingly.

However, in recognition of the fact that placing thermal insulation over and around electrical circuits may aggravate such potential hazards as may already exist in circuits with incorrectly matched overcurrent protection devices, it appears prudent to take the following precautions prior to installing thermal insulation so as to surround or encapsulate electrical wiring:

- Conventional Edison-base fuses should be replaced with S-type fuse adaptors (S-type fuse adaptors only accept correct fuses);

- Oversized circuit breakers should be replaced with correctly rated ones;

- In houses in which signs of beginning failure in electrical systems are apparent, an inspection should be performed prior to the installation of thermal insulation, by either a licensed electrician or the local power company;

- Houses with code rubber wiring (generally those built prior to 1940) should be inspected by an approved electrician prior to the installation of thermal insulation which will encapsulate the wiring.

These recommendations are in general agreement with the practices followed by the DoE Weatherization Assistance Program and with similar recommendations provided by CSA in their efforts to advise low income families. These recommendations are also in agreement with the conclusions reached by Drucker: "House wiring embedded in good thermal insulating material is dangerous under conditions of electrical overloading of the circuits", but he continues: "there appears to be no cause for alarm in houses where circuits are all correctly protected."

4.2.2 Recessed Lighting Fixtures

The National Electric Code for 1981 specifies that "thermal insulation shall not be installed within three inches of the recessed fixture enclosure, wiring compartment or ballast and shall not be so installed above the fixture as to entrap heat and prevent the free circulation of air unless the fixture is otherwise approved for this purpose," [49]. To conform with this NEC requirement, the RCS standard practices for thermal insulations include a similar statement.

NBS has conducted an investigation to determine the effectiveness of various protective barriers in maintaining the requisite 3-inch spacing and in preventing over-temperature conditions when loose-fill insulation is installed around recessed lighting fixtures [50].

For the devices tested, the results indicate that properly installed open-top barriers are sufficient to allow the fixture and associated branch circuit wiring to operate within specified ratings. However, a barrier closed at the top by any method can cause branch circuit wiring, the external surface of the barrier and/or parts of the fixture to operate at temperatures above those designated as "safe".

The tests were conducted on three fixture types, A, B and C, as shown on figure 7. Types A and B were each tested with three barriers, X, Y, and Z (rectangular). Type C fixture was tested with the same barriers but with two shapes of Barrier Z (rectangular and square).

The four barriers tested were:

Barrier X consisted of asbestos sides and metal clip connectors. It measured 304 x 406 x 3.2 mm (12 x 16 x 1/8 inch).

Barrier Y is cut from a 356 mm (14 inch) by 7300 mm (24 foot) long roll of 0.25 mm 30 gage aluminum with fold-out tabs for stapling or taping in place.

Barrier Z is a 0.55 mm (26 gage) galvanized steel sheet box which is available in two sizes:

- 280 mm (11 inches) high and 370 mm (14 1/2 inches) square
- 280 mm (11 inches) high and 370 mm (14 1/2 inches) wide by 510 mm (20 inches) long.

Table 2 shows selected temperatures as measured during the tests. The results can be summarized as follows:

- Properly installed open-topped barriers are effective in maintaining the 75 mm (3-in) spacing between thermal insulation and the light fixture enclosure.

- The 75 mm (3-in) clearance requirements of the NEC, as provided by the open-topped barriers, are sufficient to allow these fixtures and associated branch circuit wiring to operate within their specified temperature rating.

- Barriers in which the air flow is restricted by covering the top can cause branch circuit wiring, and in some cases, fixture wiring to operate above their rated "safe" temperatures.

- The branch circuit wiring was always the first item to exceed its rating.

- When a barrier is closed on top by a layer of insulation, temperatures on the exterior surface of the barrier can exceed the 90°C (194°F) limit specified by the National Electric Code, and temperatures on various parts of the fixture itself can exceed the 150°C (302°F) limit required by Underwriter's Laboratory Standard for Safety for Electric Lighting Fixtures (UL-57).

- Significantly lower maximum temperatures are observed as the volume of the enclosed barrier is increased.

- Fixtures rated for and operated with lower wattage lamps provide wider margin of safety than do fixtures rated for and operated with high wattage lamps.

4.2.3 Surface-Mounted Lighting Fixtures[5]

While the hazards associated with covering recessed lighting fixtures are generally acknowledged, well documented, and addressed in the RCS installation standards, hazards associated with installing insulation on ceilings over surface-mounted incandescent fixtures have not been widely recognized. However, recent CPSC-sponsored research at NBS [51] has shown that such practice can lead to electrical component temperatures (wires and junction boxes) well above those permitted by the National Electrical Code [31]. Table 3 shows some representative temperatures observed in the NBS tests conducted with the fixtures shown in figures 8 through 11.

As can be seen from the table, some temperatures of electrical system components above surface-mounted (both flush and semi-flush) incandescent lighting fixtures were found to be running above the NEC code requirements even before the addition of thermal insulation. While this shows that a potential hazard is present even without thermal insulation, the table also shows that the temperature increase with the addition of thermal insulation is in the range of 20°C (68°F) to 30°C (86°F) for fixtures with more than one lamp and 10°C (50°F) to 15°C (59°F) for single-lamp fixtures. This temperature increase results in an increased potential hazard. It is further seen that "over-lamping" can cause additional significant temperature rises.

While these results indicate the potential for violations of NEC, (covered under local and State codes), the level of hazard has not been determined and DoE did not therefore include mandatory installation standards provisions for precautions to be taken by the installer to reduce the hazard. However, it is recommended that prior to the installation of insulation above ceiling-mounted fixtures, the following precautions be taken for fixtures not specifically approved for installation under insulated ceilings:

- Assure that the lamps used in the fixture are of no greater wattage than the fixture was designed for. For example, a fixture designed to carry two 60-watt bulbs should never carry two 100-watt bulbs (or one 60 and one 100-watt bulb). If the fixture does not carry a marking stating the maximum allowable wattage (or a recommended wattage), assume that 60 watt per bulb is the maximum allowable.

- Install a barrier around the ceiling box so as to provide a 75 mm (3 inch) air space around the box and at least as high as the intended level of attic insulation. This barrier is to be of the same type as that required for recessed lighting fixtures. No insulation material should be placed inside the barrier or on top so as to restrict free air circulation.

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5 A surface-mounted fixture is one that is mounted directly to the underside of a ceiling and either is fully enclosed with a cover ("flush") or provided with an air gap of only 38 mm (1 1/2 inch) or less between the enclosure and the ceiling ("semi-flush"). Not included as surface mounted fixtures are hanging or pendant fixtures in which the lamp is substantially below the ceiling.

5. DIAGNOSTIC TOOLS

Several diagnostic tools are available for the detection of energy losses in buildings. Their use during energy audits is useful to assure that significant cost-effective energy conservation opportunities are not missed (audit test). The same or similar tools are also useful for evaluating the level of compliance with the standard practices (inspections) and for the quality assurance programs of installation contractors (post installation test). Selected commonly used tools are described below. As the interest in energy audits, quality assurance and inspection grows, many more, less costly, but also more accurate diagnostic tools will be developed.

5.1 INFRARED REMOTE SENSING (THERMOGRAPHY)

The installation standards include a general requirement that insulation be installed in such a way as not to leave any gaps or voids. Where the installation is open for visual inspection, it is easy for the contractor, inspector, or homeowner to assure himself that this installation requirement has been met. However, where insulation is installed in enclosed cavities, or where insulation is covered by a finish material (as is required for plastic foam boards), visual inspection is not possible. Similarly, an auditor may not be able to determine visually whether a house already has sufficient wall insulation, or whether existing wall insulation was installed without leaving major gaps or unfilled spaces.

The only practical means for determining whether insulation in cavities or behind finish material was installed in accordance with the DoE installation practices, is by infrared remote sensing devices: thermographic imaging systems, line scanners, or spot radiometers. With the use of this equipment, the auditor can determine whether a house was previously insulated and the degree of voids left. The contractor can assure himself that his installation crews have performed a credible job. The inspector can determine compliance with the installation standards. The homeowner finally can have a record (hardcopy/photograph) of the quality of the installation useful at time of resale. Thermographic imaging systems and line scanners have been used successfully by specialized auditing firms in residential energy surveys. New home builders [53] sometimes use this equipment as do insulation contractors for existing buildings. The major drawbacks of using infrared remote sensing devices are the cost of the equipment, time for survey and evaluation, and the necessity for training operators and evaluators. Also, infrared sensing can only be done under indoor-to-outdoor temperature differences of at least 10°C (18°F). For practical purposes, this limits its use to the colder season and to the northern part of the country.

The information below is given to assist those involved in home retrofit, specifically administrators, auditors, contractors, and inspectors working under RCS to evaluate the usefulness of thermographic surveys in their own particular situation. Those interested in more detail on thermography will find the references and bibliography helpful.

In addition to its use for detecting missing insulation, thermography can also be used to locate major air leaks in a building. This can be done under natural atmospheric conditions, but is more effective if done in conjunction with fan pressurization test (see below). This method is particularly well suited to detect air leakage bypasses in attics at flues, chimneys, interior and exterior walls, and at windows in walls. Since stopping of bypasses, once located, is often easy and inexpensive, this method is particularly well suited in cases where a "low cost-no cost" energy retrofit is combined with the audit.

5.1.1 Need for Thermographic Surveys

Since equipment, operators, training, and time for thermographic surveys are relatively expensive, DoE has sponsored joint research at NBS and the New England Innovation Group to evaluate the cost effectiveness of such surveys [52]. The study found that: (1) typical insulating jobs in wall cavities often leave substantial portions of walls uninsulated, and (2) that infrared thermography, used and evaluated by trained personnel, can detect faulty installations. Specifically, the following deficiencies were found in 65 homes in eight cities: 20 percent of the homes had over 10 percent of the wall area insulation missing. For these homes the price of the missing insulation was usually more than the cost of a thermographic survey by private contractors. Approximately 30 percent of the homes had insulation missing in 5 to 10 percent of the insulated wall. For most homes this is still more than 4.65 m^2 (50 ft^2) of missing insulation. About 50 percent of the homes inspected had less than 5 percent of the wall area uninsulated. Thus, more than half of the installations in the sample houses would not have been in compliance with the DoE Installation Standards. Shrinkage and fissures occurred in about two-thirds of the inspected homes, and about one-third had defective ceiling insulation. Improperly installed weatherstripping around the doors was noted in about half of the homes, and heat losses around the doors and windows were observed in 31 percent and 72 percent of the dwellings, respectively. Joint heat losses occurred at the wall-to-wall joints in 74 percent of the dwellings, at the wall-to-ceiling joint in 51 percent of the dwellings and at the wall to floor joint (baseboard) in 23 percent of the dwellings. Abnormal heat losses from the attic, as revealed by exterior inspections of the loss from the living areas or basement into the attic, were observed in 32 percent of the dwellings. Excessive heat loss from the basement or crawl space was observed in about 15 percent of the dwelling. Air penetration into interior ceilings between floors or under insulation was noted in 44 percent of the dwellings. As the above data indicate, serious defects still existed in over two-thirds of the thermographically inspected dwellings after weatherization by professional installers. Some of these defects result from poor quality workmanship--missing insulation, air leakage at doors, and shrinkage or fissures, for example. Others, such as frame heat loss, excessive heat loss from basements/crawl spaces, air penetration into ceilings, and excessive heat loss from attics at soffits and eaves can be corrected, but are usually not considered normal weatherization measures. Finally, other thermal defects such as joint heat losses and thermal bridges cannot be corrected unless interior or exterior insulation is applied to the dwelling.

Based on the work to date, it can be assumed that if major expenditures are being made for the installation of energy conservation measures in homes, a quality control inspection using thermography may be necessary to provide confidence that the building will actually accrue the full savings expected from the measures. However, at present the thermographic inspection services being provided by private inspection contractors vary greatly in consistency, and few if any services to date specialize in residential insulation void detection. Unless done by qualified personnel, such inspections are of little value. The significance of the findings described above for the RCS Program is that auditors, installation contractors, quality assurance personnel, and inspectors would be well advised to use infrared thermography in their work, even if it is only on a spot-check basis. Such use would be cost effective for the homeowner, would add to customer satisfaction and would promote more effective installation of energy conservation measures, particularly insulation. However, it also indicates the need for adequate training of RCS, (auditors, inspectors) and installer's personnel in operating the equipment, in techniques of inspecting buildings, and in analyzing the results of thermographic survey data.

5.1.2 Types of Equipment

There are three basic types of thermographic equipment that may be suited for use in conjunction with residential building retrofit: thermographic imaging systems, line scanners, and spot radiometers. Each of the three types has its own advantages and drawbacks, as summarized below. A more detailed description of individual systems and lists of manufacturers are provided in "Status of Thermal Imaging Technology as Applied to Conservation" [53] and in "Thermographic Instruments and Systems" [54]. For a brief introduction, see also the DoE Fact Sheet, "Infrared - An Energy Tool" [55].

Thermographic Systems: With this equipment, a two-dimensional thermal image of the surveyed body or area is produced on a TV-like screen and hardcopy "thermograms" can be produced for the record. The image shows surface temperatures in shades of black, gray and white (black and white equipment) or in color (color equipment). Figure 12 shows an example of a thermogram of a room wall interior with defects noted, and figure 13 shows the same wall as a photograph. Figures 14 and 15 show photographs of typical systems.

The equipment provides thermal resolutions down to 0.2°C (0.36°F) and spatial resolutions to 100 m^2 (1080 ft^2). The available resolutions permit the distinction between wall areas insulated with R-5 and R-15 (thus distinguishing between noninsulated and insulated wall areas); and under more favorable conditions, between R-10 and R-15. The equipment is portable and for higher resolution systems consists of a camera, control and display units.

Some lower-resolution systems are hand-held. The cost for systems suitable for on-ground work in conjunction with residential energy conservation audits and inspections is in the range of $8,000 to $40,000. The majority of specialized infrared survey firms appear to be using the more expensive models, but equipment at the lower end of the cost range has been used successfully in residential conservation work under reasonably favorable conditions and with proper care.

Line Scanners: Unlike imaging equipment which produce a two-dimensional display, line scanners only produce a one-dimensional measure of the apparent radiant temperatures along a line in the optically viewed scene. In order to obtain meaningful results, the area to be surveyed has to be "scanned" and if hard copy is required for the record, it is necessary to take a number of photographs. Each of the photographs may show a visual image and a line indicating the apparent temperature variations along the scale line. Figure 16 gives an example of a line display. Figure 17 shows a photograph of a typical system.

According to manufacturer's literature, the equipment provides thermal resolutions similar to those for imaging systems. The equipment is a hand-held, one-piece unit. The cost for the equipment is in the $8,000 range.

Spot Radiometers: While imaging equipment produces a two-dimensional display and line scanners a one-dimensional representation of the apparent temperature along a line, the spot radiometer measures the apparent temperature of a small area (hence "spot") on the surface surveyed. The equipment is thus not well suited for conducting a complete survey of a house, but can be used to determine whether a wall is insulated at all, and can be used as a spot check to identify voids; for example, at the top of cavities filled with loose-fill insulations. Figure 18 shows a photograph of a typical spot radiometer. The read-out is a numerical meter indicating the apparent temperature of the surface target. Through appropriate instrument adjustments and calculations, radiometer readings can be corrected to measure actual surface temperatures.

According to manufacturer's literature, thermal resolutions are similar to those of the imaging and line scanning equipment. The unit is relative small and lightweight. The cost is in the $300 to $1200 range.

5.1.3 Use of Thermography

A complete thermographic survey of a house may take as little as 45 minutes or as much as three hours of a trained and experienced operator's time, and commercial thermographic survey firms charge between $45 and $200 for residential surveys [53]. The cost of surveys as part of audits, installation and inspection should be lower since separate travel to and from the site is not required. Also, it may be possible to develop individual survey techniques specifically suited to each of the three potential uses in RCS Program retrofit. Thermography is a powerful tool for auditing, quality control, and inspections. However, the usefulness of this technique depends on several factors:

- Most importantly, thermography is not for use by untrained and inexperienced personnel. Unreliable results must be anticipated if used without proper training.

- Although individual equipment may have different requirements, the following are some general guidelines and limitations:

    - Inside-to-outside temperature differential should be at least 10°C (18°F) to provide image discrimination adequate to identify air leaks and areas of missing insulation.

    - Interior surveys are preferred, except where cabinets, radiators and similar obstructions prevent the viewing of the interior wall surfaces.

- Exterior surveys cannot be done reliably when the sun is shining on the surface surveyed, and are best done at nighttime; exterior surveys may be needed to detect heat and air leaks at ceiling/wall and ceiling/floor joints, crawl spaces and under the eaves;

- For best results when checking for air leaks, the building should be under pressure or under a partial vacuum. For interior thermography, a partial vacuum will show air leaks most effectively; for exterior application, a positive pressure is required; (see Section 5.2.1 for an outline of pressurization and evacuation of houses by the "fan door").

- The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has published a proposed standard for the "Application of Infrared Sensing Devices to the Assessment of Building Heat Loss Characteristics" [56]. All surveys should be conducted in accordance with this standard.

5.2 AIR TIGHTNESS AND AIR CHANGE RATE

Air leakage accounts for approximately 20 to 40 percent of all heat losses in houses [57]. Control of air leakage through caulking of walls, sealing of attic bypasses, and weatherstripping of windows and doors (or replacement of leaky windows and doors) thus is a major and often inexpensive means of improving the energy efficiency of a house. To determine whether a particular house has excessive air leakage or not, air change rate or air tightness measurements are useful as part of an effective audit.

Air Leakage Rate is the volume of air movement per unit time across the boundary of the conditioned space, normally expressed as cubic metre per hour (m^3/h) (cubic feet per minute (cfm)). Air leakage rate is used to describe the air tightness of a building envelope.

Air Change Rate is the air leakage rate in volume per hour divided by the building space volume, normally expressed by air changes per hour (ACH or ACPH).

5.2.1 Air Tightness Test by Fan Pressurization

The tests of air tightness consist of pressurizing the interior of the house or creating a partial vacuum in the house, and measuring the air volume required to maintain the pressure or vacuum. This test is less realistic than the air change rate methods described below, as it imposes an artificial pressure differential across the entire building envelope. However, it is more readily reproducible and if the tests are performed both with pressure (positive) and partial vacuum (negative), the results should provide a meaningful measure of the building's air tightness. For research purposes, fan pressurization tests often use heavy, expensive, and complex equipment. Princeton University has developed a simplified type of equipment commonly called a "fan door" [58] specially designed for use in energy audits. Figure 19 shows a fan door which is used to induce the pressure and vacuum required for the air tightness test. The fan door is installed in lieu of the regular door and sealed into place. The fan is then run (usually by electric motor) to produce the air pressure differential desired. The air volume required to produce the pressure differential is determined based on the fan's air-handling capacity as measured by the fan's RPM and the pressure drop across the fan. All air tightness tests should be conducted in accordance with the provisions of ASTM Standard Practice E 779-81 [59].

5.2.2 Air Change Rate Test by Dilution Methods

Air change rate is customarily measured by the tracer gas dilution technique. In this technique, a known concentration of a gas (the "tracer") is released in the indoor air and the decay rate of its concentration is measured under ambient in-service conditions [60].

Although the exact measurement of the decay rate involves either time-consuming sampling over an extended period or the use of sophisticated equipment (see figure 20), a new and much simplified method was developed jointly by Princeton University and NBS in which a known amount of tracer gas is released at one point in time and the sample air is collected at a single interval (generally 1 hour) or in two separate samples, and the samples are sent to a laboratory for analysis [61]. Figure 21 shows the release of the gas and figure 22 shows the air sampling in a sealed bag. Figure 23 shows the automated equipment used in the laboratory to analyze the sample. This method provides an integrated measure of air change rate over time (1 to 2 hours), but the results are dependent on both indoor/outdoor temperature differences and on average wind speed during the testing period. Thus tracer gas dilution tests for measuring air change rates should not be performed at extreme temperatures and extreme wind conditions. Air change rate tests should be conducted in accordance with the provisions of ASTM Standard Practice E 741-80 [62].

Both the tracer gas and container method and the fan pressurization method are being used to monitor some 300 weatherized homes of the Community Services Administration (CSA) weatherization demonstration in 14 different climatic regions [63]. Comparative tests were also performed in the Princeton Twin Rivers project. To date, a definitive correlation between the two methods has not been established. However, in combination, the two methods appear to be well suited to establish the air infiltration characteristics of homes.

5.3 WINDOW AIR INFILTRATION RATE

Energy loss through windows account for some 5 percent of total energy use in this country [64]. It is for this reason that thermal replacement windows, among other window retrofit measures, are one of the energy conservation measures approved for the RCS Program. It is also for this reason that the DoE standard for thermal windows specifies a maximum allowable air infiltration rate. The measurement of air infiltration rates through windows thus is one element in the inspection of proper installation of windows. ASTM Standard Method for measurement of Air Leakage through installed exterior Windows and Doors, ASTM E 783-81 [65] should be used for field tests. ASTM E 283-73 [66] is for use in the laboratory and should not be used for field tests.

The air infiltration of windows installed in a building is usually greater than that measured in the laboratory. Nevertheless, the air tightness of good quality windows (either thermal windows or storm windows) measured in the field after installation can equal the tightness measured in the laboratory, if the installation is performed in accordance with good practice and the manufacturer's instructions. This is indicated by Weidt [67] reporting on a study performed for DoE in the Minneapolis/St. Paul area on field air leakage in newly installed residential windows: "Field air leakage performance of windows ranged from 0.06 $m^3/h\cdot m$ (0.01 cfm/lf) (an extremely tight window) to 13.68 $m^3/h\cdot m$ (2.28 cfm/lf) (an extremely leaky window), while manufacturer's performance specification ranged from 0.016 $m^3/h\cdot m$ (0.003 cfm/lf) to 0.08 $m^3/h\cdot m$ (0.50 cfm/lf)."

All field tests for air infiltration on windows use the same principle: an "air chamber" is built onto the window opening. Air is either blown into or evacuated from the chamber to create a predetermined pressure difference between the air in the "chamber" and the air on the other side of the window. The volume of air measured in cubic metre (cubic feet) required per hour (minutes) to maintain the pressure is then the air leakage rate of the window at the particular pressure difference. For comparison purposes, it is common to divide the total window air leakage rate by the length of "crack" (the length of joint between the movable sash and the stationary window frame). This then gives an air infiltration charcacteristic shown as $m^3/h\cdot m$ (cfm/lf). Alternatively, the total leakage is sometimes also divided by the area of the window (width times height) and given as $m^3/h\cdot m^2$ (cfm/sft).

The "chamber" used in a field test consists frequently of a simple 0.15 mm (0.006 inch) thick polyethylene film adhered to the window or opening with masking or duct tape. Sometimes a plywood panel, cut to the appropriate dimension and adequately supported, is used instead of the film. Other equipment necessary is a blower, an air flow meter, an air pressure gage and appropriate hoses. As a blower, a vacuum cleaner has been used; flow meters are usually either of the variable area type or simple gas meters, and for pressure measurements, inclined manometers are most frequently used. The accuracy and tolerances required in field tests should be approximately those specified in ASTM E283-73. When conducting tests with a polyethylene film, it is most important to prevent the film from acting as a sealer on the crack. The use of the film is therefore difficult in tests where the partial vacuum (negative pressure) is to be created between the film and the window.

Figure 24 gives a schematic drawing of the test installation used by Princeton University on the Twin Rivers Project. Notice that the flow of air could be reversed since, in service, windows experience both air flow from the outdoor to the indoors (infiltration) and from indoors to the outdoors (exfiltration). A single window can even experience both infiltration and exfiltration at the same time. For example, infiltration can occur on the bottom and exfiltration on the upper half of the window. Therefore, tests should be conducted twice--once each with air flowing in and with air flowing out.

Figure 25 shows a photograph of a portable instrument package which contains a blower and both the air flow meter and the pressure indicator.

A note to those interested in conducting field window air infiltration tests: Only personnel versed in measurement technology in building construction and in the various leakage and bypass paths through and around window openings should be conducting and interpreting test results. However, used judiciously by trained auditors, inspectors and installers field tests on existing windows can be very useful to determine whether a window needs replacement (audit test) or whether the replacement by a thermal window has achieved its stipulated reduced air leakage level of 0.08 m^3/mh (0.5 cfm/ft min) (inspection test).

6. PRODUCT CERTIFICATION AND LABORATORY ACCREDITATION

Under the RCS Rule, only program measures identified as conforming to DoE standards" may be installed, and only materials meeting the DoE material standards may be so identified. Thus, manufacturers who want to supply products for use under RCS need to engage in some type of certification process. Since the RCS Rule does not specify any details of the certification program required, State planning and administrative personnel, auditors, installers, lenders and inspectors should be familiar with the types of certifications available. Specifically, they may want to determine the reliability of a particular certification program, to distinguish between manufacturer's self-certification and third-party certification, and between accredited and nonaccredited laboratories.

6.1 PRODUCT CERTIFICATION

The quality of a product depends on two major elements:

- The design or formulation of the product; and

- The care and consistency of the manufacturing process.

The design or formulation of the product is, or can generally be, evaluated against specific criteria by physical testing or by design specification review. Tests done on prototype models, which are not necessarily identical to the production line output, indicate how the product, material, or formulation might perform rather than how it will perform. While successful prototype testing does not necessarily ensure that the production model performs as required, such tests are useful and for simple products sometimes sufficient.

The care and consistency of the manufacturing process depends on many variables such as, but not limited to, equipment used, equipment calibration and maintenance, training and experience of production and supervisory personnel, "workmanship", and sometimes environmental conditions (temperature and relative humidity) in the production room. The process that the manufacturer uses to assure himself of producing a product of consistent quality is called a quality control or quality assurance program.

When a supplier identifies his product as conforming to DoE standards, he certifies that the product as sold consistently meets or surpasses all the provisions of the appropriate DoE material standards. This is called self-certification. It does not mean that DoE has tested the product, or that DoE has checked the manufacturer's quality control program. The confidence that the buyer has in the self-certification label is dependent on his or her confidence in the integrity and capability of the manufacturer.

Third-Party Certification is the process where an outside organization other than the manufacturer supplier (such as an independent testing laboratory) assesses the manufacturer's quality control program. Thus the third-party certification is an extension, and not a replacement for the manufacturer's own in-house quality control program. With third-party certification, the buyer in general can have greater confidence that the products meet the standards consistently.

Third-party certification programs vary greatly. In some, one or several specimens of the product are tested once and no further follow-up testing or plant visits are conducted. Depending on the product involved, third-party programs of this type by themselves may be worth less than the self-certification by a reputable supplier. Other certification programs call for periodic product testing at appropriate intervals with or without prior notice to the manufacturer. In yet others, product testing is combined with regular checks on the manufacturer's own quality control program. Equipment used in the quality assurance program (for example, scales) may also be calibrated by the third party. The confidence of the buyer in the usefulness of the third-party certification of a particular product is thus dependent on the type and extent of that third-party's certification program.

The level of effort that is appropriate for the certification of a particular product depends on the complexity of the manufacturing process, the tolerances required and the consequences of a product's performance. Thus a product that is characterized by a simple manufacturing process, little need for close tolerances, and no significant safety hazards when installed will justify only a relatively low level of effort for certification. On the other hand, a complex product requiring many different processes for manufacture, very exacting tolerances, and posing severe safety consequences when malfunctioning in service will require a very comprehensive certification program. An example of the latter type of product may be electrically operated vent dampers and of the former, weatherstripping. In practice, most certification programs are somewhere between these extremes.

In third-party certification, an outside organization other than the manufacturer/marketer provides the manufacturer/marketer and the user with assurances that the product meets a particular standard. The third-party certifier can conduct all or only some of the certification procedures, and may contract with others (or have the manufacturer contract with others) to conduct the remaining procedures. A third-party certifier can be:

- A professional or technical society such as the American Society of Mechanical Engineers (ASME);
- A trade association, such as the Association of Home Appliance Manufacturers (AHAM) or the American Gas Association (AGA);
- An independent testing organization such as Underwriters Laboratories (UL), Factory Mutual Engineering and Research (FM), or ETL Testing Laboratories;
- A consumer organization, such as Consumers Union (CU);
- An organization of producers, testing laboratories, and sometimes consumers within a specific industry or combination of industries concerned with the well-being of that industrial group and/or its customers, such as the Solar Energy Industries Association (SEIA); or
- A government agency, such as the Department of Housing and Urban Development (HUD).

The types of procedures used in certification programs can be grouped as follows [68]:

- <u>Type-testing/Initial Inspection</u> - By itself this only provides assurance that the manufacturer's design specification <u>can</u> produce a product that conforms to a particular standard. It gives no guarantees, however, of the ability of the manufacturer to consistently produce products that meet the design specification.
- <u>Audit-Testing</u> - This procedure involves testing samples selected from the marketplace. A high level of this type of testing is usually required to provide adequate assurance that products are meeting the desired standard.
- <u>Surveillance of the Manufacturing Process</u> - This involves periodic assessment of a manufacturer's production and control processes. With minimum cost, it can provide assurance that the manufacturer's quality control procedures are adequate.
- <u>Field Investigations</u> - This involves investigating alleged failures of products in use to determine the cause of failure and to take the appropriate corrective action.
- <u>Batch-testing</u> - This involves selecting a sample from a batch of products and testing it for conformance to the standard. Provided the sampling procedure is adequate, batch-testing can provide confidence that all products in that batch will likely conform to the standard. It does not provide any assurance of the quality of products produced in earlier or subsequent batches. This is the procedure used by many certification programs relating to building products, such as energy conservation measures.

- 100 Percent Testing - This procedure involves testing each individual product to determine if it meets the desired standard. If the testing procedures are adequate, the procedure does provide the highest level of assurance that the product conforms to a particular standard. It can also be a very expensive procedure.

A certification program may use one or more of the above procedures to assure that a product conforms to a particular standard. The procedure(s) used can have a great bearing on the level of confidence that can be placed in the certification program. It will also affect the cost of the program [69].

ANSI has developed criteria to evaluate certification procedures [70] and to accredit third-party certification programs [71]. To date two product-certification programs have received ANSI accreditation, both relating to products that are used as energy conservation measures: Aluminum Windows and Sealed Insulating Glass.

6.2 LABORATORY ACCREDITATION

Related to the accreditation of product-certification programs is laboratory accreditation. The purpose of laboratory accreditation is to provide a mechanism which assures the manufacturer or user of a product that certain laboratories are technically qualified to conduct specific tests.

The most significant laboratory accreditation system which addresses energy conservation measures is the National Voluntary Laboratory Accreditation Program (NVLAP). The program is conducted by the Department of Commerce. NVLAP only concerns itself with products and tests which an industry group requests be included in the program. To date the program includes the accreditation of laboratories for specific tests related to: thermal insulation materials, freshly mixed field concrete, and carpets. The tests that laboratories currently can be accredited for are listed in the "Criteria" published in the Federal Register on January 23, 1980 [72]. The list includes some 50 tests related to thermal insulation and attached membranes, including many tests referenced in the DoE/RCS Material Standards.

Under NVLAP, both the manufacturer's own laboratories as well as commercial or independent laboratories can be accredited. Thus a NVLAP-accredited laboratory is not always an independent or third-party laboratory. The reason for this is that NVLAP only determines whether the laboratory is technically capable of performing the specified tests, whether it has available the required and properly calibrated equipment and appropriately trained personnel. It does not guarantee that a laboratory has no financial interest in the outcome of the product testing, nor does it guarantee that the laboratory will always perform the tests properly, or that the laboratory is capable of performing other tests for which it is not accredited. NVLAP only accredits testing capability. It is not concerned with other aspects of certification, such as the conduct of inspections or the evaluation of a manufacturer's quality assurance program.

The following describes some programs for tests and products other than those covered by NVLAP:

- HUD requires that third-party certifiers (validators) approve laboratories to test building materials;

- The Department of Defense, the General Services Administration, and other Federal agencies accredit laboratories to test products for conformance to procurement specifications;

- States and cities accredit laboratories to test for compliance with their regulatory requirements;

- Industry associations operate programs to accredit laboratories to test products for certification purposes;

- The American Association for Laboratory Accreditation, currently in its formative stages, proposes to accredit laboratories using ASTM criteria for evaluating testing laboratories.

Laboratory accreditation does not eliminate the need for or desirability of either self- or third-party certification, but accreditation does provide the consumer or user with assurance that tests are performed by qualified personnel using appropriate equipment. In the absence of a formal certification program, or if reliance is on self-certification such as under RCS, the knowledge that tests were performed by an accredited laboratory provides a measure of assurance that the product meets the quality standards prescribed.

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TABLE 1. NORMAL INDOOR RELATIVE HUMIDITY

CONDENSATION ZONE	INDOOR RELATIVE HUMIDITY, % (MONTH)				
	NOV	DEC	JAN	FEB	MAR
1	35	20	20	20	20
2	50	35	35	35	50
3	No Control Needed to Prevent Condensation				

TABLE 2. COMPILATION OF SOME CRITICAL TEMPERATURES (EXTRACTED FROM REFERENCE [50])

Barrier	Top Cover	FIXTURE A: Maximum Outside Barrier Surface Temperature	FIXTURE A: Supply Wire Without Additional Load	FIXTURE A: Supply Wire With 15A Additional Load	FIXTURE B: Maximum Outside Barrier Surface Temperature	FIXTURE B: Supply Wire With 15 A Additional Load	FIXTURE B: Supply Wire With 15 A Additional Load	FIXTURE C: Maximum Outside Barrier Surface Temperature	FIXTURE C: Supply Wire Without Additional Load	FIXTURE C: Supply Wire With 15 A Additional Load
X	Open	38 (100)	33 (91)	49 (120)	37 (99)	99* (210)	Not Measured	38 (100)	32 (92)	63 (145)
X	10 mm (3/8 Inch) Cardboard	74 (165)	71 (160)	87 (189)	59 (138)	113* (235)	Not Measured	65 (149)	45 (113)	75 (167)
X	R22 Fiberglass Batt	105 (221)	97 (207)	118 (244)	74 (165)	127* (261)	Not Measured	90 (194)	59 (138)	90 (194)
Y	Open	36 (97)	34 (93)	51 (124)	35 (95)	99* (210)	Not Measured	31 (88)	26 (79)	41 (106)
Y	10 mm (3/8 Inch) Cardboard	77 (171)	71 (160)	90 (194)	60 (140)	116* (241)	Not Measured	56 (133)	52 (126)	70 (158)
Y	R22 Fiberglass Batt	114 (237)	103 (217)	123 (253)	101 (214)	152* (306)	Not Measured	79 (174)	74 (165)	95 (203)
Z (Rectangular)	Bare Metal	85 (185)	95 (203)	111 (232)	57 (135)	137* (279)	Not Measured	56 (133)	62 (144)	79 (174)
Z (Rectangular)	100 mm (4 Inch) Loose Fill Fiberglass over Metal	146 (295)	124 (255)	Not Measured	96 (205)	150* (302)	Not Measured	92 (197)	78 (172)	99 (210)
Z (Square)	Bare Metal							70 (158)	55 (131)	86 (187)
Z (Square)	100 mm (4 Inch) Loose Fill Fiberglass over Metal							102 (216)	67 (153)	100 (212)

Temperatures in °C (°F)

Temperatures that are above the code limits below are underlined:

For maximum outside barrier surface temperature, Section 410-65(a) of 1978 NEC: 90°C (194°F), except for Fixture B, for Supply Wire, 1978 NEC Table 310-16: 60°C (140°F).

* Supply connections for Fixture B were made in a separate junction box located 18 inches from the Fixture. Wire rated for 150°C (302°F) was connected from this box through a flexible metal conduit to a connection with the lamp socket wire in Box B. Had 60°C (140°F) wire been used for this connection, the temperatures of this wire within Box B would have exceeded the NEC limits even with an open top barrier.

TABLE 3. SUMMARY TEMPERATURE DATA ON SURFACE MOUNTED LIGHTING FIXTURES
(EXTRACTED FROM REFERENCE [51])

		TEMPERATURES MEASURED IN °C (°F)			
Figure type (see Figures 8 through 11)	Measurement Location	60 watt Bulbs (Rated) No Insulation	R33 Batt Insulation	150 watt Bulbs (250% over-lamped) No Insulation	R33 Batt Insulation
A. (Two lamps)	Supply wire (No other load)	50 (122)	70 (158)	69 (156)	114 (237)
	Supply wire (full load)	66 (151)***	89 (192)	86 (187)	135 (275)
	Ceiling box	52 (126)	72 (162)	69 (156	116 (241)
B. (Three lamps)	Supply wire (No other load)	59 (138)	96 (205)	97 (207)	---**
	Supply wire (full load)	71 (160)	111 (232)	113 (236)	192 (378)
	Ceiling box (full load)	64 (147)	99 (210)	109 (237)	185 (365)
C. (Four lamps)	Supply wire (No other load)	46 (115)	73 (160)	66 (151)	117 (243)
	Supply wire (full load)	61 (142)	91 (196)	81 (178)	137 (279)
	Ceiling box (full load)	49 (120)	75 (167)	70 (158)	117 (243)
D. (One lamp)	Supply wire (no other load)	39 (102)	51 (124)	58 (137)	82 (180)
	Supply wire (full load)	54 (129)	69 (156)	76 (169)	100 (212)
	Ceiling box (full load)	45 (113)	56 (133)	66 (180)	89 (218)

* Temperatures corrected for ambient room temperatures of 20°C (68°F).
** No data collected.
*** Underlined temperatures indicate violations of NEC.

FIGURE 1 - CONDENSATION ZONE MAP (FROM REFERENCE 24).

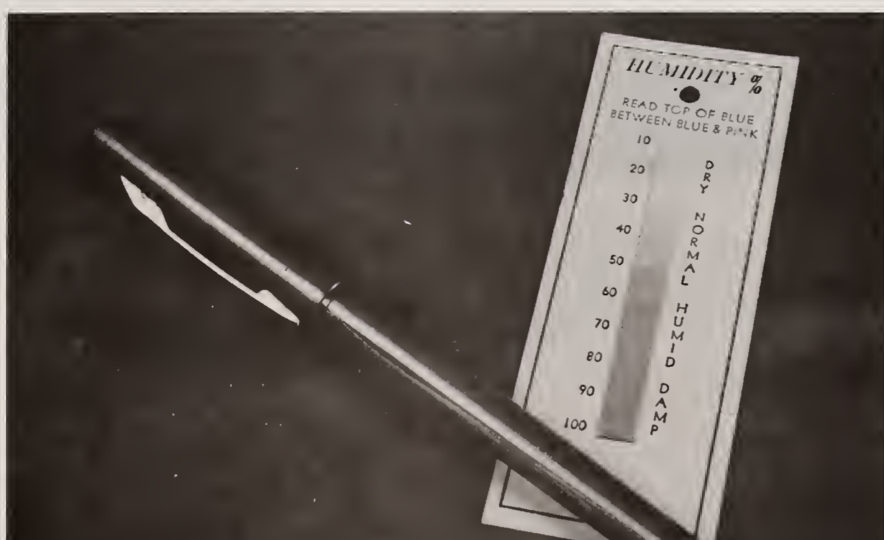


FIGURE 2 - PHOTOGRAPH OF COLOR CHANGE RELATIVE HUMIDITY INDICATOR.

FIGURE 3 - PHOTOGRAPH SHOWING FROST ON UNDERSIDE OF ROOF

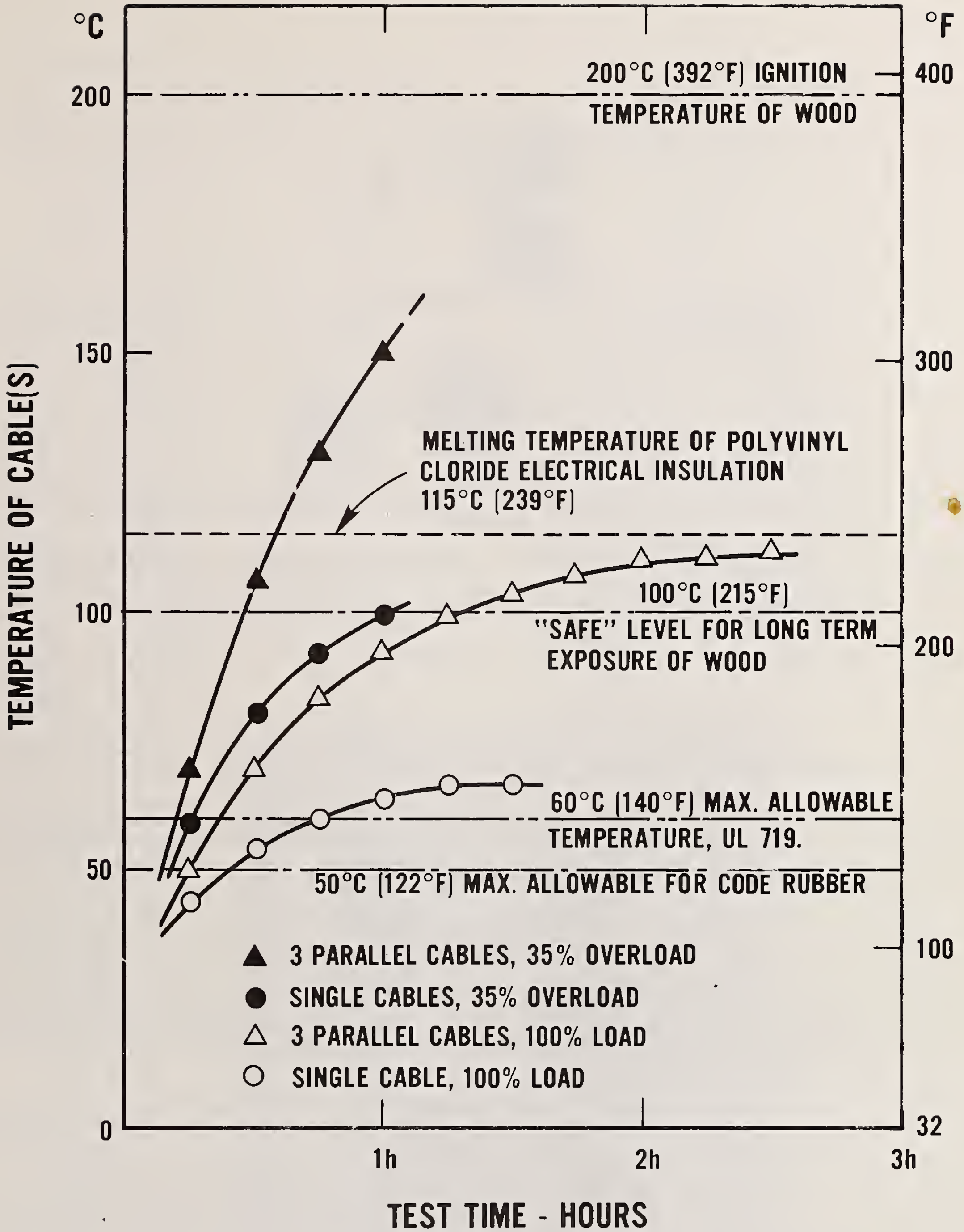


FIGURE 4 - TEMPERATURES OF ELECTRICAL CABLES ENCAPSULATED IN THERMAL INSPECTION

Non-Metallic-Sheathed Cable (Type NM-#12 AWG Solid Copper 2 Conductors With Ground), Between Two Layers of R-11 Glass Fiber Batts, Carrying 20 Amperes (100% Load) and 27 Amperes (135% Load).

FROM REFERENCE [37].

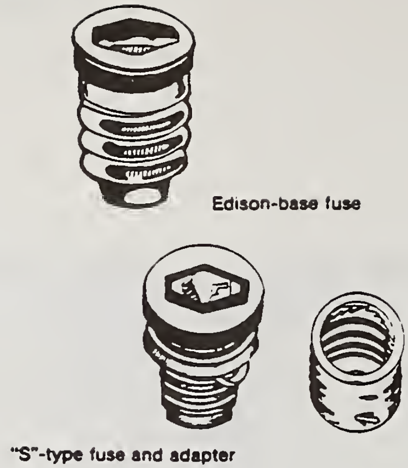
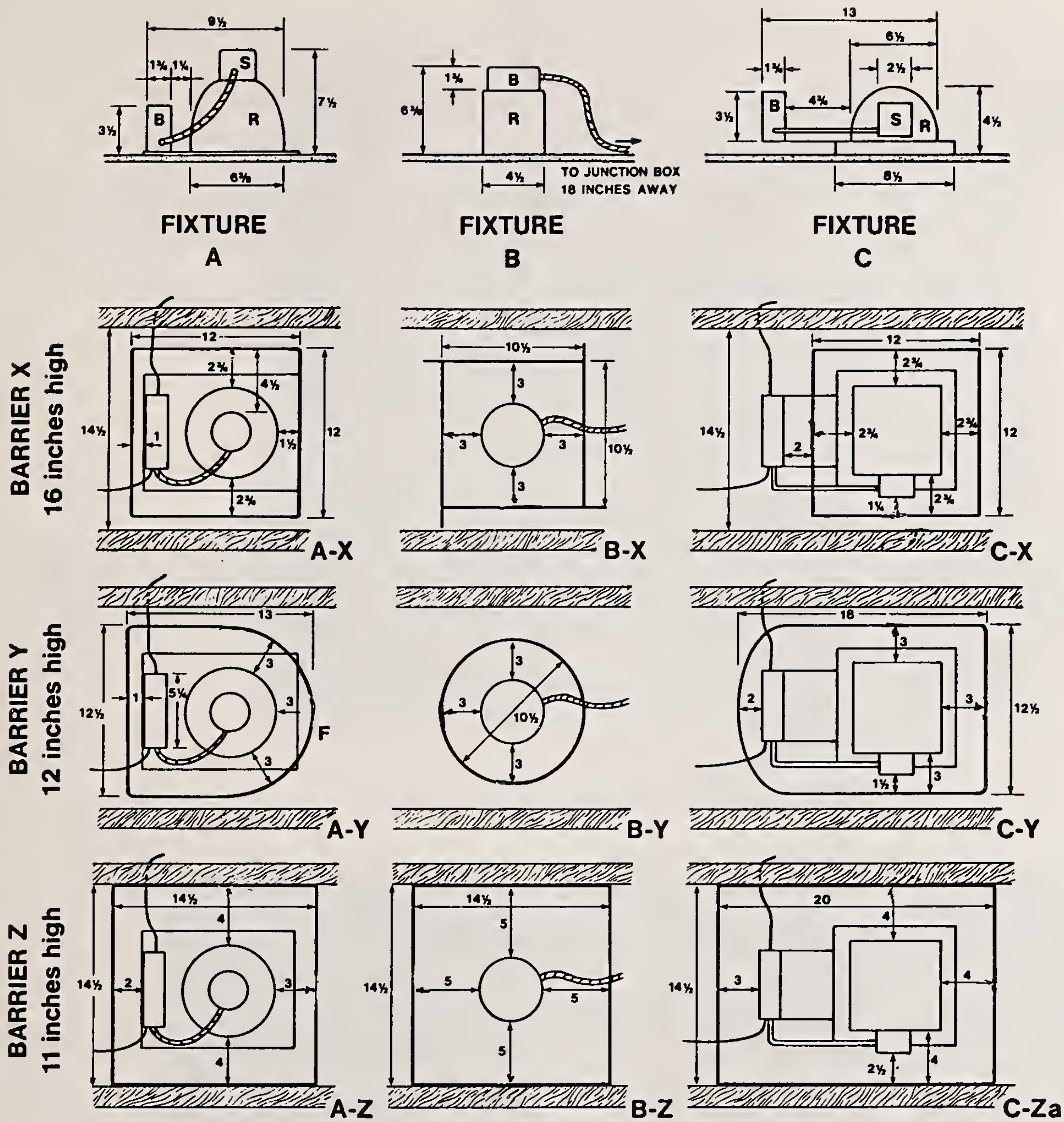
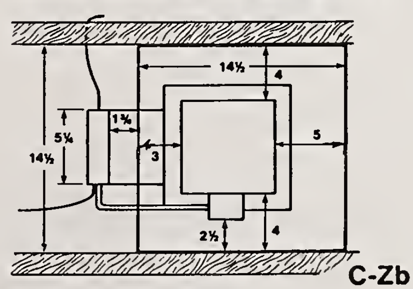


FIGURE 5 - EDISON AND S-TYPE FUSES FROM REFERENCE [46].

FIGURE 6 - PENETRATION OF CELLULOSE THERMAL INSULATION INTO WALL OUTLET BOX. FROM REFERENCE [37].



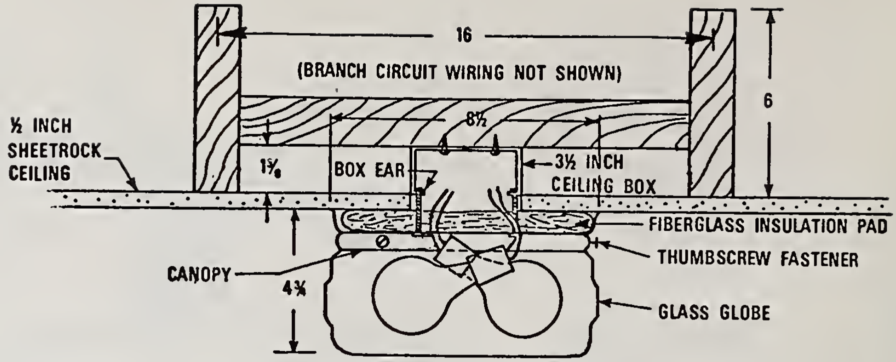


- Fixtures are mounted equidistant between 2x6 joists.
- Joists are spaced 16 inches on center.
- Branch circuit wiring is shown entering and leaving box for fixtures A and C.

B - Ballast
R - Reflector
S - Socket

FIGURE 7 - DIAGRAMS OF RECESSED LIGHTING FIXTURE/BARRIER CONFIGURATIONS. FROM REFERENCE [50].

FIGURE 8 - FIXTURE A
Flush Mount, Two Lamps
Rated for 60 Watts Max



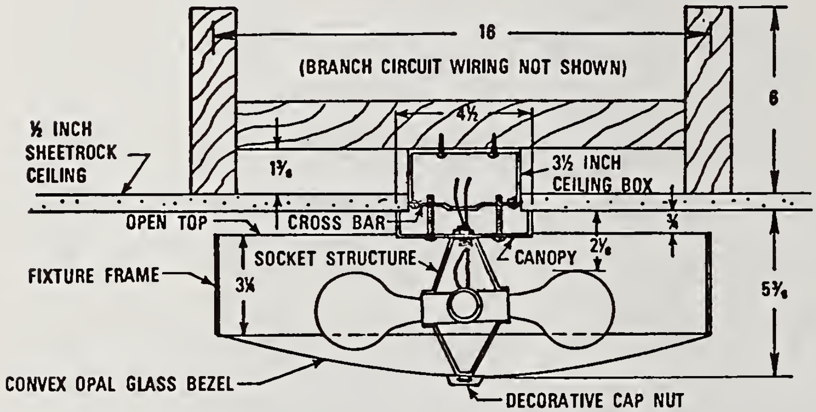
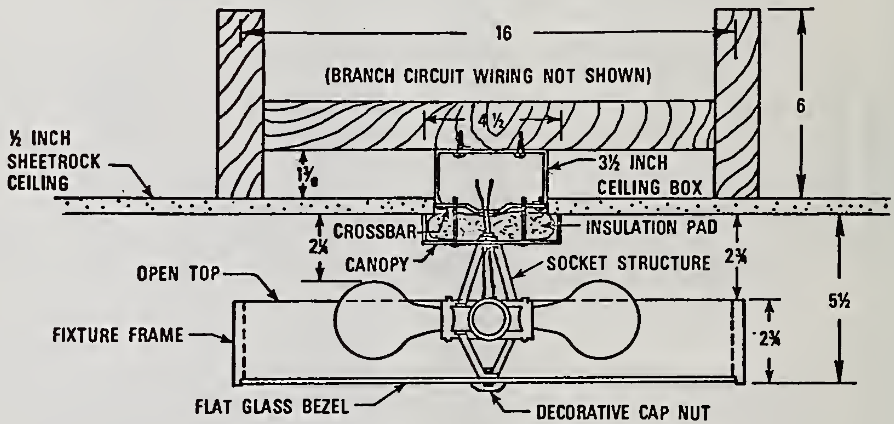


FIGURE 9 - FIXTURE B
Semi Flush Mount,
Three Lamps Rated
for 60 Watts Max

FIGURE 10 - FIXTURE C
Semi Flush Mount,
Four Lamps Rated
for 60 Watts Max



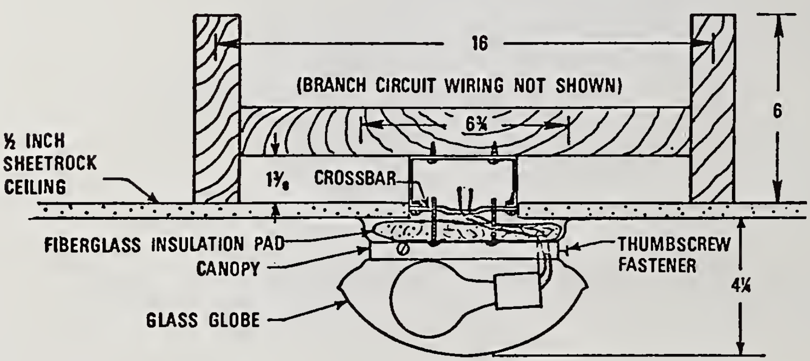


FIGURE 11 - FIXTURE D
Flush Mount, One Lamp
Rated for 60 Watts Max

FIGURES 8 THROUGH 11 FROM
REFERENCE [51].

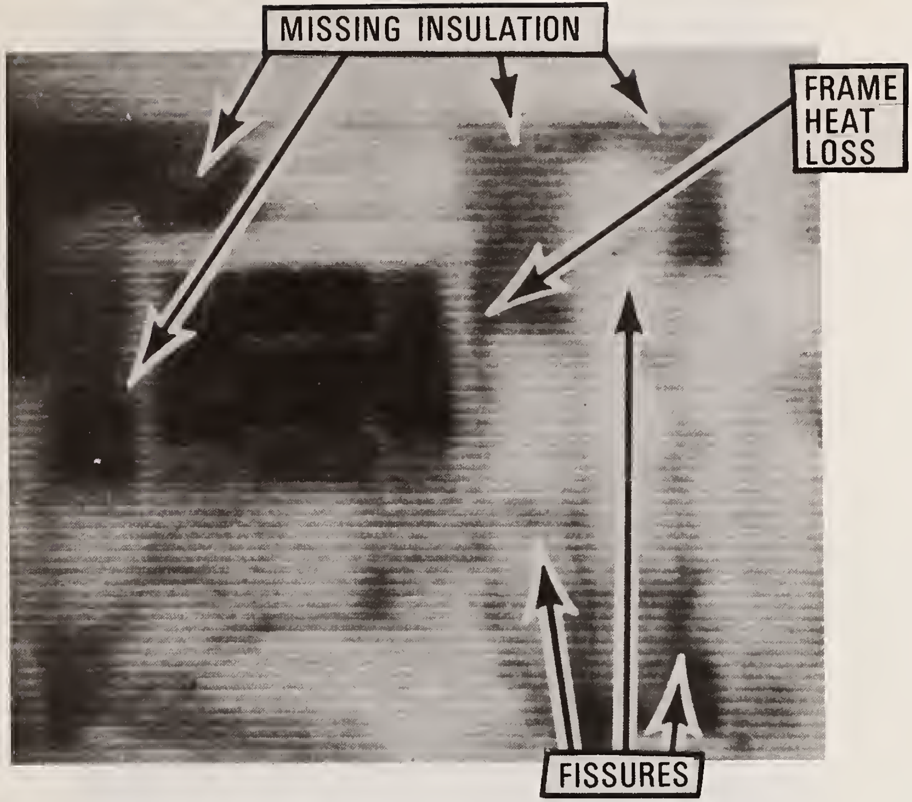


FIGURE 12 - THERMOGRAPH OF WALL (INTERIORS).

FIGURE 13 - PHOTOGRAPH OF SAME WALL.

FIGURE 14 - HIGH RESOLUTION THERMAL IMAGING EQUIPMENT.
FROM REFERENCE [53].

FIGURE 15 - HAND HELD THERMAL IMAGING APPARATUS.
FROM REFERENCE [53].

FIGURE 16 - LINE SCANNER DISPLAY.

FIGURE 17 - LINE SCANNER EQUIPMENT.
FROM REFERENCE [53].

FIGURE 18 - SPOT RADIOMETER. FROM REFERENCE [53].

FIGURE 19 - PHOTOGRAPH OF FAN DOOR (BY PERMISSION OF PRINCETON UNIVERSITY).

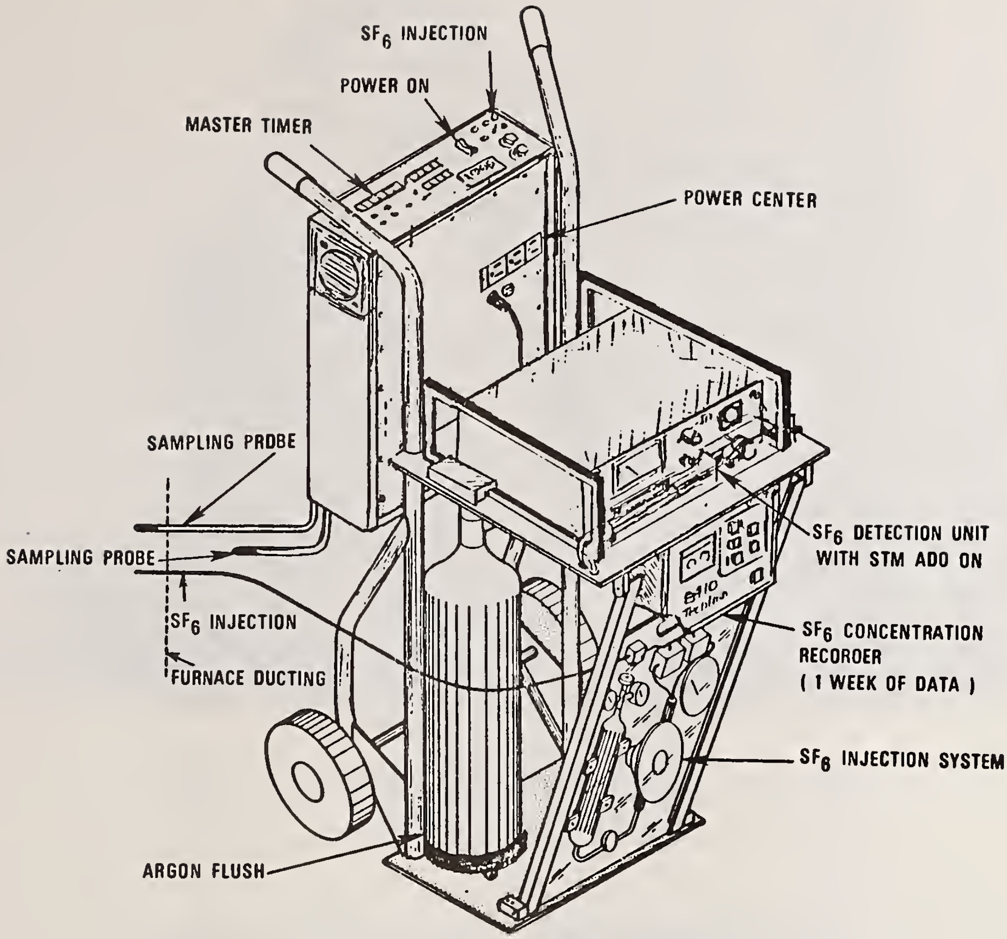


FIGURE 20 - EQUIPMENT FOR SF_6 TRACER GAS AIR EXCHANGE MEASUREMENT.

FIGURE 21 - TRACER GAS CONTAINER METHOD - RELEASE OF GAS.

FIGURE 22 - TRACER GAS CONTAINER METHOD - AIR SAMPLING.

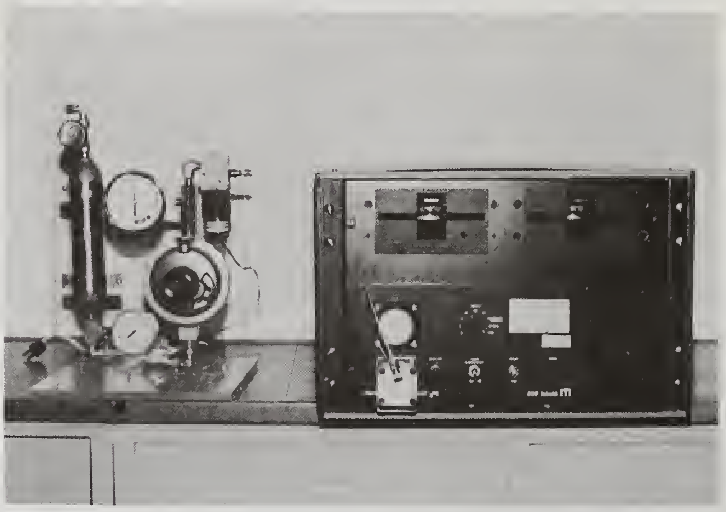


FIGURE 23 - TRACER GAS CONTAINER METHOD - EQUIPMENT FOR LABORATORY ANALYSIS.

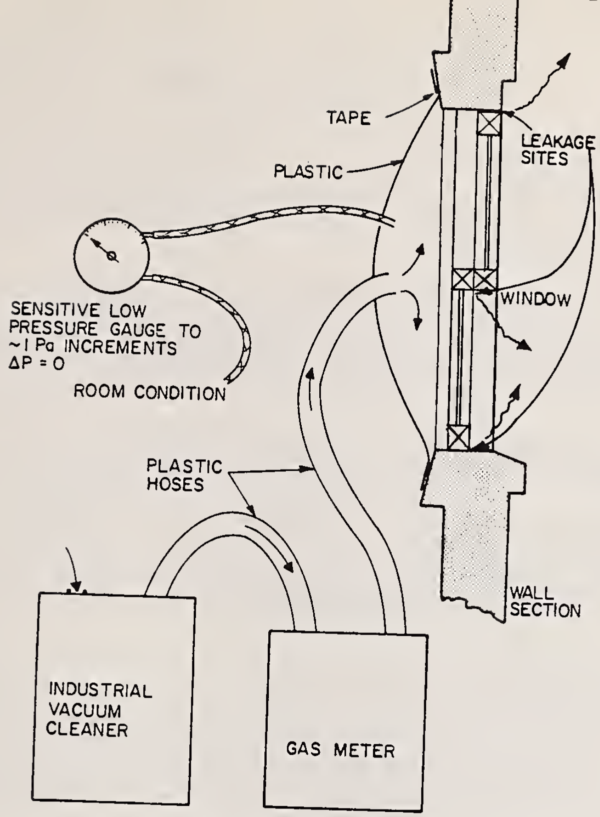


FIGURE 24 - WINDOW AIR LEAKAGE TEST - SCHEMATIC OF EQUIPMENT.

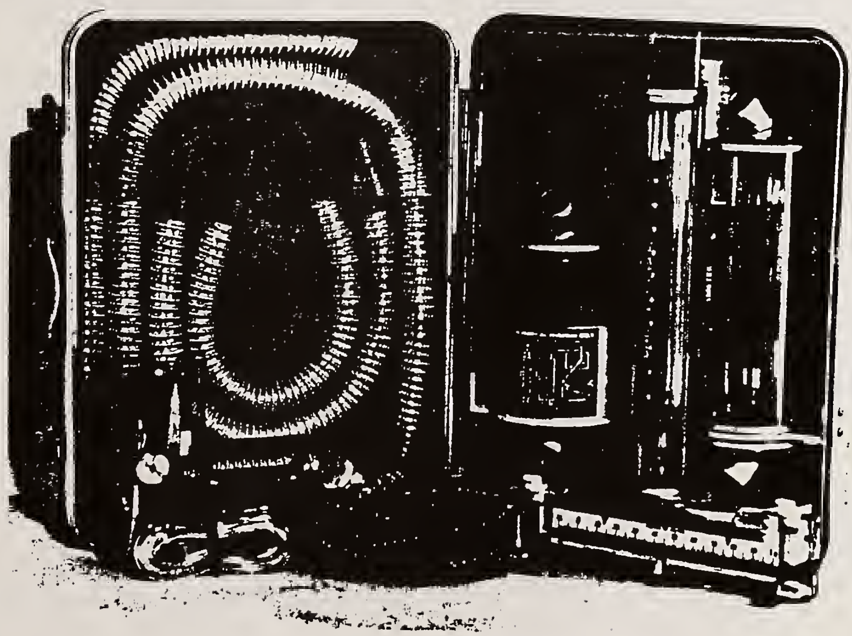


FIGURE 25 - COMMERCIALLY AVAILABLE PRE-PACKAGED UNIT.

PREFACE

In this part, the individual standard practices are provided essentially as published in the Federal Register. Where appropriate, additional recommendations for safer and more effective installations are also given, together with a commentary on the purpose or origin of major provisions. For clarity, the recommendations and commentary are indented, the actual rule provisions are not.

In general, the practices are included verbatim, except:

- For greater ease in use, a decimal numbering system for paragraphs replaces the identification method given in the rule;

- Sections provided in the rule as "Additional Requirements" but applying to all standards were included within the practices;

- Sections on "Applicable Documents," "Materials" and "Significance" were added for completeness and greater usefulness. The format thus obtained is that commonly used by ASTM and should facilitate the conversion of the standard into voluntary consensus documents;

- The SI conversion for all common units was placed in front, instead of behind the common units;

- Minor editorial revisions were incorporated, mostly to achieve greater consistency and compatibility of all standard practices. This applied particularly to the practices for urea-formaldehyde foam, vent dampers, and automatic intermitent ignition device;

- Many of the referenced documents have been updated since the publicaiton of the RCS Rule. While for regulatory purposes such references need to be updated according to the procedures of the Administrative Procedure Act, the most recent issue of all documents is referenced in this publication.

Each of the standards presented below is given in its entirety and complete in itself. This leads to some repetition of similar or identical provisions, recommendations and commentary. However, it is felt that clarity and ease of reference more than compensate for the repetitions. Also, individual users may well be interested only in the installation requirements for one particular product. For them, the format used will be more convenient.

Notes and references, tables, and figures are numbered starting with 1 in each practice.

The practices include all amendments published in the Federal Register, Vol. 46, No. 3, Tuesday, January 6, 1981, pages 1616 through 1625.

STANDARD PRACTICE FOR THE INSTALLATION OF LOOSE-FILL THERMAL INSULATION

1. SCOPE

1.1 This practice covers the installation of dry organic (cellulosic or wood) and mineral (rock, slag, or glass) fiber loose-fill thermal insulation on ceilings, attics, and in frame wall cavities, and mineral cellular (perlite or vermiculite) loose-fill thermal insulation in attics, and various masonry wall cavities of existing residential buildings.

Loose fill thermal insulation is sometimes also installed in floors over unheated space. However, such applications are rare and are therefore not covered by this practice.

1.2 A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

1.3 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

Under the DoE residential conservation service (RCS) program, manufacturer's installation instructions may be used in lieu of these practices only with the approval of the cognizant assistant secretary of DoE.

1.4 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.5 This practice further:

Applies only to the installation of dry loose-fill thermal insulation consisting of organic or mineral materials, by blowing or pouring. It does not apply to material installed in a wet condition or where liquid is added at any stage of the installation process.

Covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the production of the insulation materials, whether such production takes place in a factory or at the installation site.

Describes, in general terms, the procedures to follow so that a safe and effective installation is assured. It does not describe in detail the terminology and fundamentals of residential construction, or the codes or regulations that may be imposed by other Federal, State, or local agencies.

Covers aspects of installation relating to the effectiveness, durability, and safety of insulation in service. It does not address the safety of the person(s) installing the insulation.

Conditions in buildings vary greatly and in some cases substantial additional care and precaution may have to be taken to ensure effective and safe installation.

2. APPLICABLE DOCUMENTS

ASTM[1] C168-80a: Standard Definitions of Terms Relating to Thermal Insulating Materials.

ASTM C 755-73 (1979): Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulation.

ASTM E 136-79: Test for Non-Combustibility of Elementary Materials.

NFPA[2] -31: Standard for the Installation of Oil Burning Equipment.

NFPA-54: National Fuel Gas Code.

NFPA-70: National Electrical Code (Section 410-66).

NFPA-211: Standard for Chimneys, Fireplaces, and Vents.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, safety, and durability of insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation may reduce its thermal effectiveness, cause fire hazards and other unsafe conditions, and promote the deterioration of the structure in which it is installed.*

3.3 *Specific hazards that can result from improper installation include:*

Fire caused by heat buildup from recessed lighting fixtures covered by insulation;

Deterioration of wood structures, paint failures, and corrosion of metal fasteners and electrical components caused by prolonged moisture accumulation within building components; and

---

1 American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA. 19103.

2 National Fire Protection Association, 470 Atlantic Avenue, Boston, MA. 02210.

Deterioration or failure of electrical wiring components and heat buildup resulting from overcurrent protection devices (fuses and circuit breakers) incorrectly matched to wire.

4. DEFINITIONS

Certain technical terms relating to insulation but not defined below are used in this subpart in accordance with the definitions given in ASTM C 168-67.

Approved - acceptable to the authority which regulates the activity or material and its use. Such authority is usually a municipal, State, or Federal agency or a third party certification, inspection, or rating service.

Conditioned Space - any space in a residential building which is served by a heating or cooling system.

Mineral cellular loose-fill thermal insulating materials - (such as perlite or vermiculite) [3] mineral particular material in granular, modular, powdery, or similar form designed to be installed dry by pouring, blowing, or hand placement between retaining surfaces or as a covering layer.

Mineral fiber loose-fill thermal insulating materials - (such as fiberglass or rock wool)[3] insulation composed of mineral substances such as slag, rock, or glass suitable for pneumatic or poured application.

Organic loose-fill thermal insulating materials - (such as cellulose or wood fiber) thermal insulation composed of chemically treated cellulosic or wood fibers, or any combination thereof suitable for pneumatic or poured application.

Unconditioned space - any space, out-of-doors or in a residential building, which is not served by a heating or cooling system.

A space only intermittently or rarely heated or cooled could also be considered as a "unconditioned space," as long as its heating or cooling system is totally separate from the main system serving the residence.

Vapor Barrier - any material (as defined in ASTM C 755-73) that has a water vapor permeance (perm) rating of 5.7 $\mu kPa \cdot s \cdot m^2$ (1 perm) or less.

The following materials, upon proper application, constitute vapor barriers: asphalt-impregnated kraft paper, aluminum foil, plastic film, and paint and wallcoverings which are labeled by the manufacturer as having a perm rating of one (1) or less when applied in accordance with the manufacturer's instructions.

[3] The use of a trade name does not connotate recommendation, but simply indicates commonly recognized generic types of materials.

5. MATERIALS

5.1 Under the Residential Conservation Service program (RCS), install only loose-fill thermal insulating materials identified as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for a more detailed discussion.

5.2 *It is recommended that all insulation materials installed be tested by laboratories accredited by NVLAP for the particular tests, or have third-party.*

5.3 *Some important characteristics of loose-fill thermal insulation material are given in table 1.*

6. SAFETY PRECAUTIONS

6.1 During installation, do not smoke in the attic or in any truck or van used for installation.

Even if the insulation material used is non-combustible or treated with fire retardant, sparks from cigarettes, other smoking materials or discarded matches may initiate smoldering combustion or ignite flammable materials such as vapor barriers or stored old newspapers. Sparks that drop into the hopper of insulation-blowing equipment on trucks or vans may be conveyed into attics, causing fires.

6.2 *Loose-fill thermal insulation should not be installed so as to surround electrical cables in buildings with improperly matched overcurrent protection devices, because such cables could reach temperatures above those permitted by the National Electrical Code (NEC). Accordingly, prior to installing insulation, it should be ascertained that all electrical circuits have correctly matched overcurrent protection devices. See Part I, Section 4.2.1 for further discussion.*

If Edison type fuses are found to be installed, these should be replaced with S-type fuse adaptors; where incorrectly matched circuit breakers are installed, they should be replaced prior to installing thermal insulation.

6.3 *Because code rubber wires have a lower NEC-allowed temperature limit, no insulation should be placed so as to encapsulate such wire until the electrical system has been inspected by an approved electrician. Code rubber wiring is usually found in houses built prior to 1940. See Part I, Section 4.2.1 for further discussion.*

7. PRE-INSTALLATION PROCEDURES

7.1 GENERAL

7.1.1 Identify all recessed lighting fixtures (including wiring compartments and ballasts), furnaces, vents, chimneys, and other heat-producing devices in all areas where insulation is to be installed, so that adequate clearances from combustible materials and insulation can be provided.

All surface-mounted lighting fixtures should also be identified so that required clearances from combustible materials and insulation can be provided.

Pre-installation inspection is necessary to identify any potential safety hazards in the building and to assure that the installation can be performed effectively and without substantially decreasing the safety or durability of the structure. Certain precautions and preliminary steps must be taken so that the installation can be performed as prescribed in the Installation Procedures section.

7.1.2 Install blocking, such as wood, metal or unfaced mineral fiber batts, around all heat-producing devices to permanently maintain the clearances specified in paragraphs 7.1.3 and 7.1.4. Install all blocking at least as high as the height of the finished insulation and in a manner that ensures that all devices which may require maintenance or servicing remain accessible after the insulation is installed.

The clearances are required to provide free air circulation to prevent heat buildup.

7.1.3 Install blocking to provide a 75 mm (3 in) clearance around all recessed lighting fixtures (including associated wiring compartments and ballasts) and other heat producing devices not covered in paragraph 7.1.4. (See Figure 1.) Do not cover these devices so as to entrap heat or prevent the free circulation of air unless they are approved for the purpose.

This requirement is based on section 410-66 of the National Electrical Code (NFPA-70). Recessed lighting fixtures rely on the free movement of air around and above them to dissipate the heat generated by the bulbs, ballasts, and wiring compartments. Even if the insulation material itself is non-combustible, if it is installed above or around a recessed lighting fixture, temperatures within the fixture may become sufficiently high to ignite fixture components and surrounding framing members. It is recommended that blocking and clearances similar to those required for recessed lighting fixtures also be provided around the junction box over surface mounted lighting fixtures. See Part I, Sections 4.2.2 and 4.2.3 for additional information.

7.1.4 Install blocking around gas-fired appliances to provide the minimum clearances specified in NFPA-54. Install blocking around oil-fired appliances to provide the minimum clearances specified in NFPA-31. Install blocking around masonry chimneys (or masonry enclosing a flue) to provide a minimum 50 mm (2 in) clearance from the outside face of the masonry. Install blocking around vents, chimney and vent connectors, and chimneys other than masonry chimneys, to provide the minimum clearances specified in NFPA-211.

To provide a safe installation in accordance with recognized national codes and standards.

7.1.5 When installing mineral fiber or mineral cellular thermal insulation which, in addition to meeting all the requirements specified in DoE Material Standards, also has successfully passed ASTM Test E 136-79, the blocking and airspaces around vents and chimneys need not be provided.

The DoE material standards do not require that loose-fill thermal insulation meet the requirements of ASTM E 136-79. It should not be assumed that the material being installed has passed the test unless the label specifically states so.

7.1.6 Inspect the roof, walls, ceilings and attic floors to identify areas where a previous moisture problem has caused paint peeling, warpage, stain, visible fungus growth, rotting, or other structural damage. Do not install insulation in such areas until the resident has been informed and these conditions have been corrected and their source(s) eliminated. If the resident, after being informed of the moisture condition and the effect of installing insulation in such areas, elects to proceed with the insulation, the resident must so state in writing on the contract.

Installing insulation in an area which exposes it to moisture may contribute to further deterioration of the structure and loss of effectiveness of the insulation. Insulation in such areas may prolong exposure of components to moisture, creating a potential for fungus growth, rotting, and leaching of boric acid used as fire-retardant in some types of loose-fill insulation. Insulation should not be installed in the immediate area of the moisture damage. Immediate area is defined as the stud or joist space(s) in which prior moisture problems were observed. For information regarding the identification and evaluation of previous moisture problems, see Part I, Section 4.1.1.

7.1.7 Block all openings in ceilings, floors, and sidewalls through which the insulating material may escape. Seal all wall cavities which open into a basement or crawl space before wall insulation is installed.

It is especially important to ensure that all wall cavities are sealed properly in homes of balloon frame construction (see figure 2) since open-ended cavities are inherent in this type of design. Also, seal around plumbing and electrical openings, particularly beneath sinks, to prevent filling up a cabinet below the sink.

7.2 WALLS

7.2.1 For buildings located in Zone I of Figure 3, provide a vapor barrier on the interior surface of all walls to be insulated in bathrooms, and unvented kitchens and laundry areas. Caulk or seal all major cracks on the interior face of exterior walls of these rooms, including joints between the floor and wall (except where impractical because of carpeting), between wall and ceiling, at joints around window frames, and around wall penetrations for electrical services (outlets and switches) and plumbing stacks, and heating and air-conditioning ducts.

It is recommended that a vapor barrier and caulking, such as described in this paragraph, also be provided on all walls to be insulated in bathrooms and unvented kitchens and laundry areas in buildings in Zone II of Figure 3.

The above requirements for ventilation and moisture control are minimum requirements needed to prevent long-term moisture damage. Homes which are characterized by one or more of the following conditions are more likely to experience excessive moisture accumulation which can be corrected by application of a vapor barrier and caulking as described above and/or additional venting of the wall cavity from the exterior or additional ventilation of the occupied space.

(a) Homes with an area of less than 75 m^2 (800 ft^2);

(b) Homes with less than 23 m^2 (250 ft^2) per occupant;

(c) Homes with tight wall and ceiling construction and weatherstripped windows and doors;

(d) Electrically heated homes or homes with a heating system which uses outside combustion air;

(e) Homes that are humidified during the winter.

A relative humidity indicator may be installed to monitor the humidity level and determine when excessive moisture accumulation is likely to occur.

Although existing guidelines (such as ASHRAE) and standards (such as HUD Minimum Property Standards) emphasize the use of vapor barriers for the control of moisture damage, experts in the field now agree that moisture enters wall cavities more by mass transport through cracks and other openings than by diffusion through interior finish materials.

Compared to existing guidelines and standards, the above requirements are very lenient. The reasons are (a) the relative high cost of implementing current "good practice" in retrofit of existing buildings and (b) the lack of definitive analytical and experimental data to support more stringent requirements. See Part I, Section 4.1.2 for a more detailed discussion.

7.3 ATTICS AND CEILINGS

7.3.1 Identify and measure ventilation area in attics. Do not install insulation in attics unless ventilation openings in attic areas conform to one of the following requirements:

0.1 m^2 minimum of free ventilation area per 15 m^2 (1 ft^2 per 150 ft^2) of attic floor area, if no vapor barrier exists in the attic;

0.1 m^2 minimum of free ventilation area per 30 m^2 (1 ft^2 per 300 ft^2) of attic floor area if a vapor barrier does exist;

0.1 m^2 minimum of free ventilation area per 30 m^2 (1 ft^2 per 300 ft^2) of attic floor space if at least 50 percent of the required ventilating area is provided with fixed ventilation located in the upper portion of the space to be ventilated, with the remainder of the required ventilation provided by eave or soffit vents at least 900 mm (3 ft) below those located in the upper portion, if no vapor barrier exists.

If the free ventilation area of louvers is not known, assume that it is half of the gross area of the ventilation opening and increase the gross opening area accordingly.

Many louvers and vents have their free ventilation area stamped on their frames. Adequate attic ventilation is necessary to carry to the outdoors any moisture that enters the attic from the house.

More ventilation area needs to be provided in homes which do not have a vapor barrier on the attic floor or ceiling surface because moisture can be transmitted more readily through such ceilings. Where the location of attic vents is such that efficient air currents for ventilation will result, the ventilation requirements can be lower even where no vapor barrier exists. See discussion on attic ventilation in Part I, Section 4.1.3 for more details.

7.3.2 Ensure that all ventilation openings have suitable louvers or screens to prevent rain or snow from entering the attic.

Rain or snow entering the attic would wet the insulation, reduce its effectiveness and promote fungus growth (dry rot). Moisture above gypsum and gypsum board ceilings also accelerates their deterioration.

7.3.3 For buildings located in Zone 1 of Figure 3, if there is no existing insulation or if existing insulation is to be removed, provide a vapor barrier membrane on the upper surface of the ceiling material. Never install a vapor barrier on top of existing insulation.

A vapor barrier installed on top of insulation may trap moisture in the insulation and in construction components. This moisture may reduce the effectiveness of the insulation and may lead to the deterioration of the structure. Exposed vapor barriers can also increase flame spread in case of fire.

For buildings in Zones 1 and II of Figure 3, where there is existing ceiling insulation and no vapor barrier, it is recommended that a vapor barrier paint or wall covering be installed on the interior ceiling surface of bathrooms and unvented kitchens and laundry areas. It is also recommended that all cracks and penetrations on the interior ceiling surface of these rooms (such as around lighting fixtures and at wall and ceiling joints) be caulked.

The above requirements for ventilation and moisture control are minimum requirements needed to prevent long-term moisture damage. Homes which are characterized by one or more of a, b, c, or d of 7.2.1 are more likely to experience excessive moisture accumulation which can be corrected by application of a vapor barrier and caulking as described above or by additional ventilation of the occupied space.

A relative humidity indicator may be installed in the residence to monitor the humidity level and determine when excessive moisture accumulation is likely to occur.

See discussion in Part I, Section 4.1.2 for a more detailed discussion, including instructions for the use of humidity indicators.

7.3.4 Install permanent blocking around attic trap doors (see Figure 4) and vents which open into the attic, if the level to which the insulation will be installed exceeds their height. Ensure that the blocking is installed around vent openings in a manner that enables the free movement of air through the vent into the attic.

The venting of bathroom and kitchen air (and clothes dryers) into the attic is an undesirable building practice because it introduces excessive moisture into the attic which may condense when exposed to cooler *attic temperatures. The potential for condensation is further increased as insulation is added because the insulation reduces the rate of heat flow from the living area to the attic, causing attic temperatures to be lower. It is recommended that all such vents be extended and vented to the outside.*

7.3.5 Cover all bathroom and kitchen vent openings in the attic with temporary blockings prior to the installation of insulation to assure that no insulation material falls into the vents.

7.3.6 Install permanent blockings to restrain loose-fill insulation from clogging soffit vents at the eaves restricting attic ventilation. Install blocking so as to ensure free movement of air through soffit vents into the attic. See Figures 5 and 6.

Research work by Princeton University at Twin Rivers[4] *has shown that leaks of warm air around vertical chases account for substantial energy losses. All such chases should be sealed. Where the chase holds a chimney or prefabricated flue, the material used to block or seal the opening must pass the ASTM E 136-79 test. The conditions are shown in Figures 7 and 8.*

8. INSTALLATION PROCEDURES

8.1 GENERAL

8.1.1 Do not install insulation unless the pre-installation procedures have been carried out and any defects which were identified were corrected and their causes eliminated.

The purpose of the pre-installation procedures is to assure that the installation can be performed effectively and without adverse side effects detrimental to other building components and materials. For lasting results, it is important not only to correct effects, such as by replacing rotten wood, but to eliminate the source of the defect, such as water leaks which promoted the rot in the first place. In many instances, corrective measures can be taken with relative ease prior to the installation of insulation. After installation, correction may be more difficult and costly.

8.1.2 Structural damage can be caused by excessive pressures during the installation or can result from installing insulation in constructions too weak to support the imposed load. Install insulation with care to avoid any of the following conditions:

Separation of finish materials from joists or studs.

Cracking of finish materials or opening of joints between boards.

Deflection of finish material of more than 1/200 of the joist or stud spacing.

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[4] Socolow, Robert H., Saving Energy in the Home, Ballinger Publishing Company, Cambridge, Massachusetts, 1978, pages 105 through 110.

The strength of ceiling materials, such as gypsum board and lath and plaster, depends on many factors, including thickness, composition of materials, relative humidity, and temperature. For gypsum board, the strength also depends on whether the board is installed with its long side parallel or at right angle to the joists. Table 2 is provided as an aid in determining whether a particular gypsum board ceiling will adequately support the load of insulation. The table is based on tests and other data submitted by gypsum board manufacturers.

8.1.3 Handle all insulation material in accordance with manufacturer's instructions and keep it dry and free of extraneous materials.

Some materials can be crushed or otherwise rendered less effective by incorrect handling. Moisture in the material can both affect the effectiveness of insulations and support fungus growth. Extraneous materials, such as untreated organic matter, can reduce effectiveness, increase potential for fungus growth, and lead to insect and vermin infestation.

8.1.4 For pneumatic installation, use only equipment compatible with the insulation material, and operate the equipment in accordance with the manufacturer's instructions.

Effectiveness of installed loose-fill insulation is related to the installed density of the material. The installed density in turn is dependent on proper air flow rate in pneumatic equipment.

8.1.5 Install loose-fill insulation so that it will not be in contact with the ground or other sources of water.

Many loose-fill insulation materials are hygroscopic and may saturate themselves when in contact with ground or moist areas, losing effectiveness and promoting fungus growth, and corrosion of metal fasteners and electrical services components, and accelerating structural failure when condition persists.

8.1.6 For energy conservation, install insulation only between conditioned interior living areas and unconditioned spaces.

Insulation is only effective in conserving energy when placed between conditioned (served by a heating and/or cooling system) and unconditioned spaces (such as outdoors, an unheated garage, or the ground). Where adjacent conditioned spaces are maintained at different temperatures, the temperature differential is seldom such that the insulation would be cost-effective. One possible exception would be the case where one of two adjacent conditioned spaces is frequently, and for prolonged periods, neither heated or cooled at all, while the other is conditioned. In this case, the frequently unconditioned space should be treated as such. An example of this would be a home workshop attached to a house but only occupied and heated on week-ends.

Partitions between conditioned spaces are sometimes insulated to increase sound insulation. However, such applications do not conserve energy and are therefore outside the scope of RCS-arranged installations.

8.2 WALLS

8.2.1 Do not fill wall cavities which themselves are air ducts for heating, ventilation, and/or cooling systems.

8.2.2 Locate entry holes in walls (if required) to permit the complete filling of wall cavities.

A minimum of two openings per floor per stud space is recommended. The lower port should be no further than 1200 mm (4 feet) from the bottom of the wall and the upper port no more than 460 mm (1.5 ft) from the top of the wall. The number of holes required is based on the density of the material and its capability to flow within the wall during application. See Figure 9 for typical layout of fill ports. Follow the material manufacturer's recommendations for the number and location of entry holes. Points of entry in a typical wall are shown in Figures 10, 11, and 12. Some construction types may not require the drilling of entry holes to gain access to every cavity. It may be possible to gain access through eaves or overhang panels. In balloon construction, access may also be gained from the attic.

Entry holes should be opened in such a way as to permit easy closing and refinishing compatible with the appearance of the building.

8.2.3 After the entry holes have been opened, use them to check the wall cavity for fire stops and other obstructions which will necessitate additional entry holes to assure complete filling of the cavity.

Internal obstructions can be located by inserting a stiff piece of wire or plumb line into the wall cavity.

8.2.4 With the exception of spaces identified in the pre-installation inspection (7.1.2, 7.1.3, and 7.1.4), completely fill wall cavities in accordance with the insulation manufacturer's recommendations.

Follow the manufacturer's recommendations for air pressure and density. Keep a record of the number of bags used to ensure the installed insulation conforms to the manufacturer's recommended coverage shown on the material label.

8.2.5 Close all entry holes in a workmanlike manner using materials compatible with the original materials. Do not close entry holes in sheathing which is covered by an exterior brick veneer or siding.

It is not necessary to seal entry holes in sheathing if the exterior finish will protect the area from water leakage. It is, in fact, desirable to leave these open to enable additional ventilation of the cavity to ensure that no moisture condensation and accumulation occurs.

8.3 ATTICS AND CEILINGS

8.3.1 For pneumatic installation in ceiling areas, use the least air pressure meeting the manufacturer's instructions.

Follow the manufacturer's instructions for spread rate and install the insulation to a uniform depth at the recommended density for the R-value to be installed. The correct density and application rate is shown on the bag label. Keep a record of the number of bags used to ensure the installed insulation conforms to the manufacturer's recommended coverage shown on the material label.

8.3.2 Do not blow insulation into electrical devices or vents which open into the attic or other spaces identified in paragraphs 7.1.3 and 7.1.4.

Blowing insulation into these spaces would defeat the purpose of the blocking. If insulation accidentally is blown in, such insulation must be removed carefully to prevent damage to electrical wiring and fixture components.

8.3.3 Fit the attic side of trap doors or panels with insulation batt (or equivalent material) except where prevented by a retractable ladder.

Secure the insulation in place using staples or other appropriate fasteners. Insulation may be installed to the exterior of trap doors which have retractable ladders mounted on their interior. If the insulation is installed to the exterior (underside) of the trap door, a finish material (such as gypsum board) should be provided for appearance and to protect the insulation. Weatherstripping should be installed along the contact edge between the access panel and frame to reduce air infiltration.

9. POST-INSTALLATION PROCEDURES

9.1 Inspect the coverage and depth of the insulation. Fill all "pockets" and voids in the insulation. Level insulation in a manner which will not damage electrical wiring or any other items.

Ensure that the quantity of insulation specified on the bag label to provide the desired R-value for the area to be insulated has been installed. The depth or thickness of the insulation and density should conform to the information on the bag label.

9.2 Turn off electric power and clear all electric wall outlet boxes and switch boxes of any insulation material.

Electric power shut-down is essential to prevent electric shock hazard during the cleaning operation. It is necessary to clear electric boxes to prevent stray currents, to protect the building against possible ignition of combustible materials in the proximity of electrical contacts, and to prevent the corrosion of electrical components in contact with chemicals used as fire retardants in certain types of insulation. See section 4.2.1 of part I for details.

9.3 Remove all temporary blockings which were installed over vent openings in attics.

Temporary blockings are those that were provided during the pre-installation procedures (7.3.5) over bathroom, kitchen, and laundry vents which open into the attic. Do not remove any of the blockings that were installed to permanently prevent insulation inundation in vents, heat-producing devices, and other areas specified in this practice.

9.4 Comply with the "Certification Procedures for the Installation of Thermal Insulation Materials.

TABLE 1. CHARACTERISTICS OF LOOSE-FILL THERMAL INSULATING MATERIALS[5]

Material Type	Mineral Fiber Loose-Fill		Organic Loose-Fill	Mineral Cellular Loose-Fill	
Common Name	Fiberglass	Rock Wool	Cellulose	Perlite	Vermiculite
Thermal resistance per unit thickness @ 24°C (75°F)					
$\frac{m \cdot K}{W}$	0.39	0.51	0.56 - 0.65	0.44 - 0.56	0.42 -0.53
$\frac{R}{in} = \left(\frac{ft^2 \cdot h \cdot °F}{Btu \cdot in}\right)$	(2.2)	(2.9)	(3.2 - 3.7)	(2.5 - 3.7)	(2.4 - 3.0)
Location of application	Attics, Ceilings Attic Floors Frame Wall Cavities		Attics, Ceilings Attic Floors Frame Wall Cavities	Attic Floors Masonry Wall Cavities	
Method of application	Blown or Poured		Blown or Poured	Usually Poured	
Fire Safety: Physical characteristics	Some pass ASTM E 136-79 tests		Do not pass ASTM E 136 test; Treated with fire-retardant chemicals	Pass ASTM E 136-79 test	
Fire Safety: Application restrictions	Do not place near heat source unless material is labeled as ASTM E 136-79 test passing		Do not place near heat sources, even if treated	None	
Moisture absorption	< 1% by weight	2% by weight	5 - 20% by weight	Negligible	None
Density: kg/m^3	10 - 16	35 - 48	35 - 48	32 - 176	64 - 160
(lb/ft^3)	(0.6 - 1.0)	(1.5 - 2.5)	(2.2 - 3.0)	(2 - 11)	(4 - 10)

TABLE 2. SUGGESTED MAXIMUM LOADS SUPERIMPOSED ON GYPSUM BOARD CEILINGS[6]

Gypsum board ceiling thickness	Frame spacing	Suggested imposed uniform load*
13 mm (1/2 in.)	610 mm (24 in.) o.c.	6.3 kg/m^2 (1.3 psf)
13 mm (1/2 in.)	405 mm (16 in.) o.c.	10.7 kg/m^2 (2.2 psf)
16 mm (5/8 in.)	610 mm (24 in.) o.c.	10.7 kg/m^2 (2.2 psf)

* Includes the the weight of both the new and any existing insulation

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5 Extracted from "An Assessment of Thermal Insulation Materials and Systems for Building Applications", Brookhaven National Laboratory, BNL-50862, 1978.

6 Adapted from "Gypsum Construction Handbook", United States Gypsum Company, Chicago, Illinois, 1978, page 94.

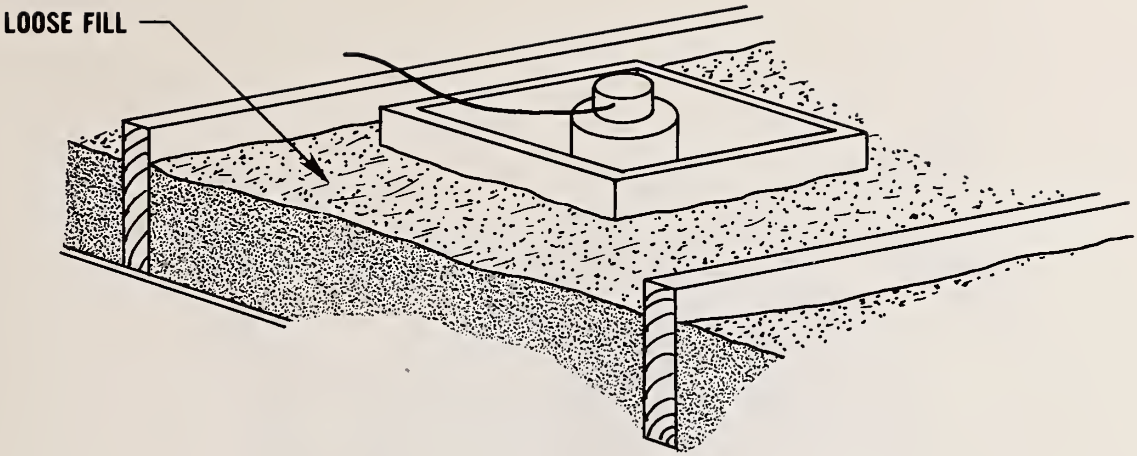

FIGURE 1 - BLOCKING AROUND RECESSED LIGHTING FIXTURES.

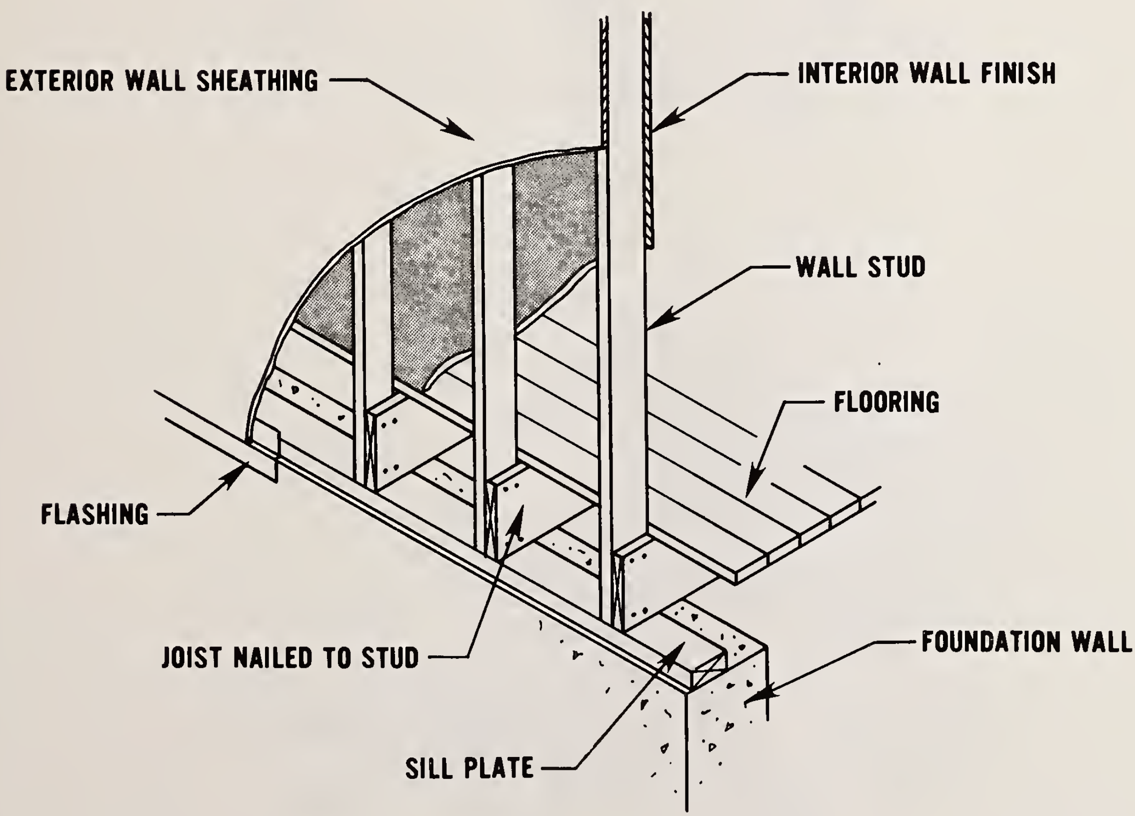

FIGURE 2 - BALLOON FRAMING.

FIGURE 3 - CONDENSATION ZONE MAP.

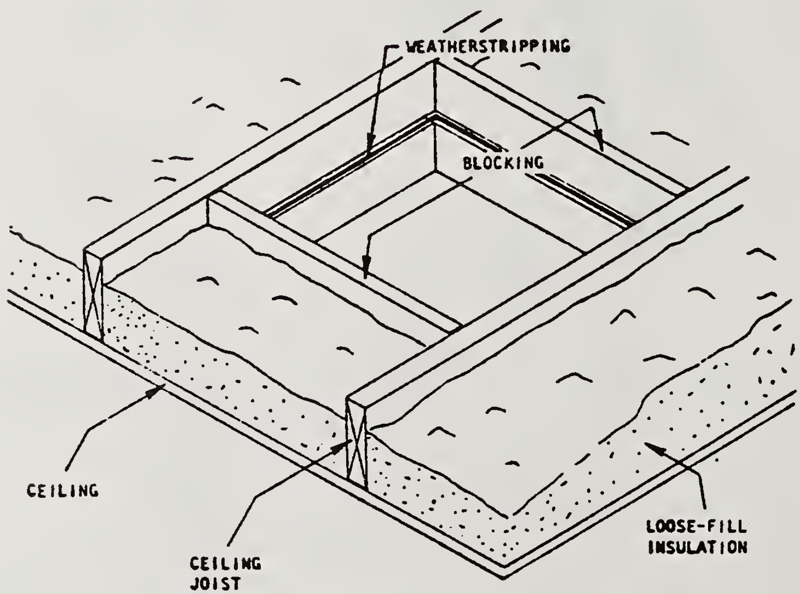

FIGURE 4 - BLOCKING AROUND ATTIC TRAP DOOR.

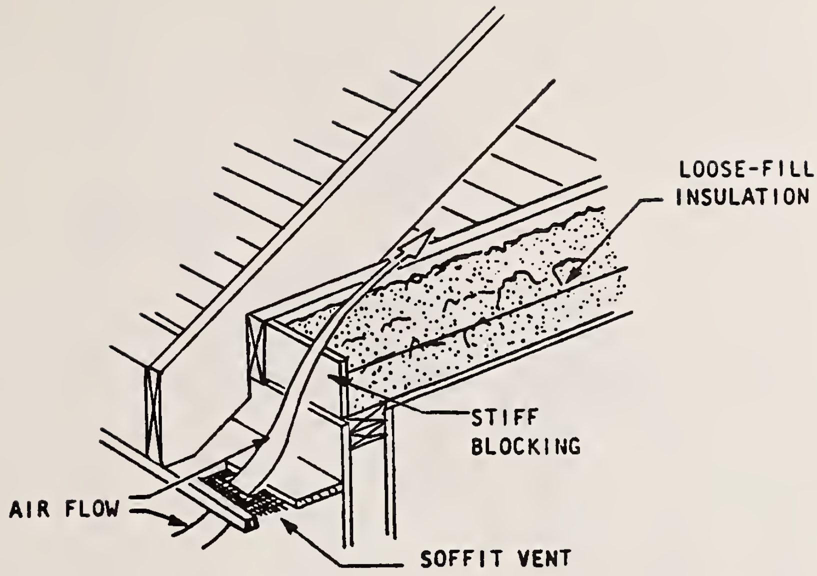

FIGURE 5 - BLOCKING AT SOFFIT VENT USING RIGID BAFFLE.

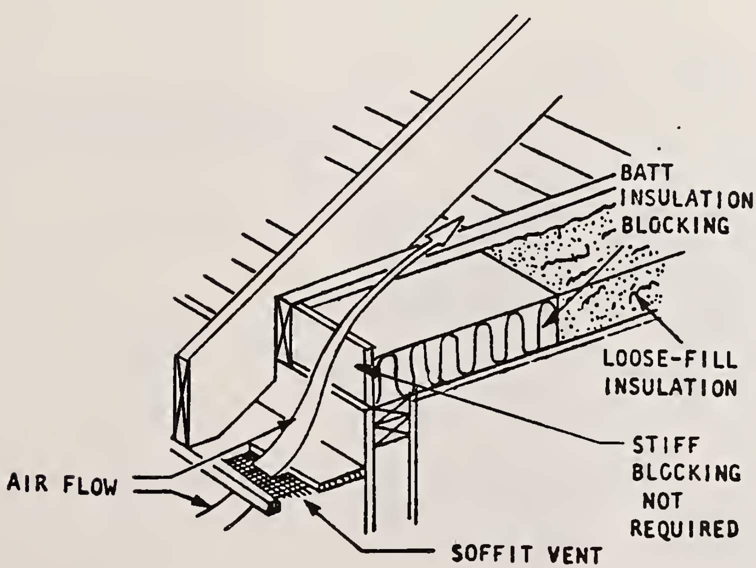

FIGURE 6 - BLOCKING AT SOFFIT VENT USING INSULATION BATT.

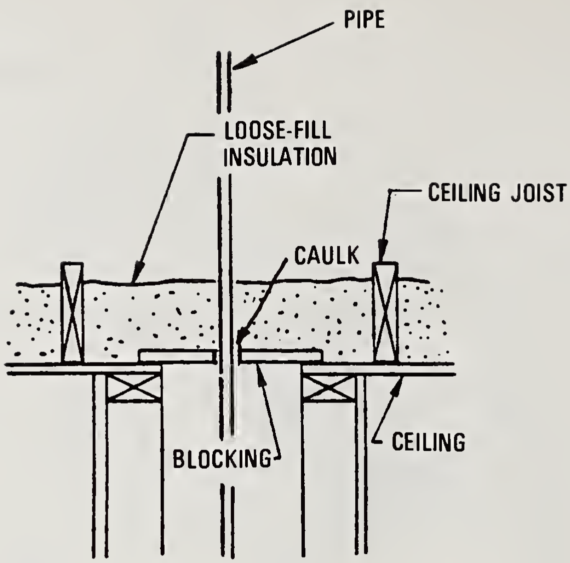

FIGURE 7 - BLOCKING OF PIPE CHASE.

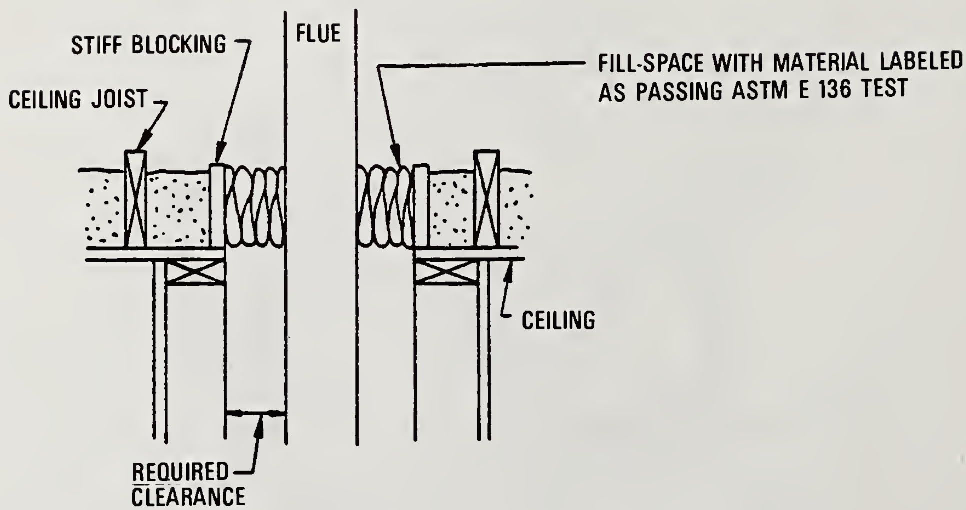

FIGURE 8 - BLOCKING AROUND FLUE.

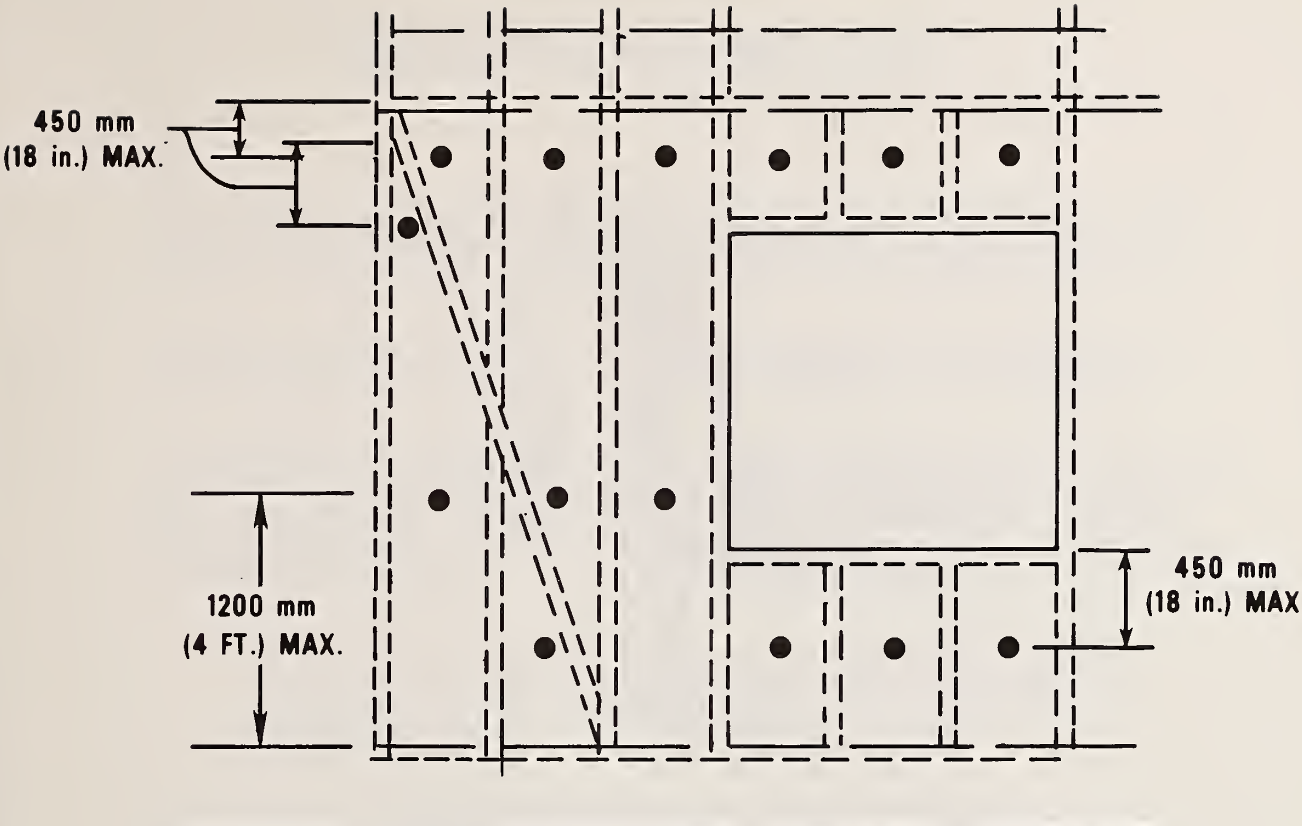

FIGURE 9 - TYPICAL WALL LAYOUT FOR FILL PORTS.

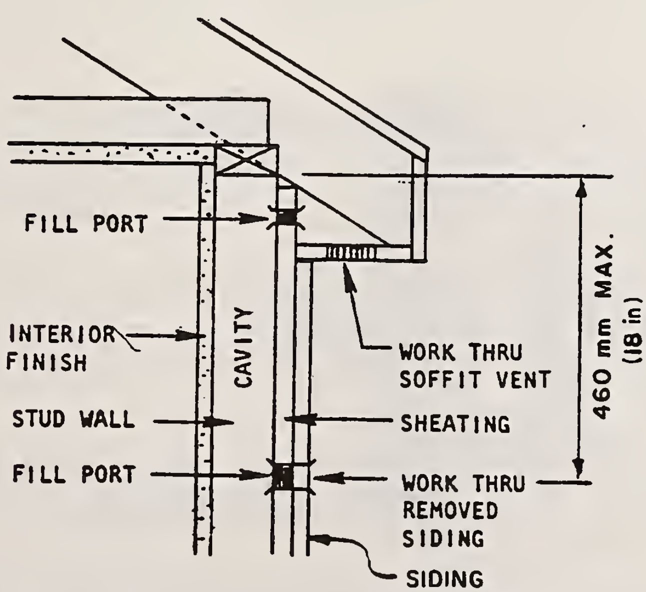

FIGURE 10 - WOOD FRAME CONSTRUCTION, TOP OF WALL ALTERNATE POINTS OF ENTRY.

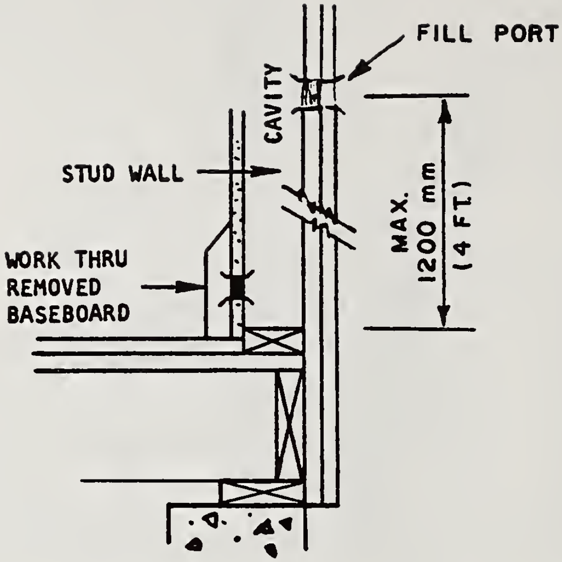

FIGURE 11 - WOOD FRAME CONSTRUCTION, BOTTOM OF WALL ALTERNATE POINTS OF ENTRY.

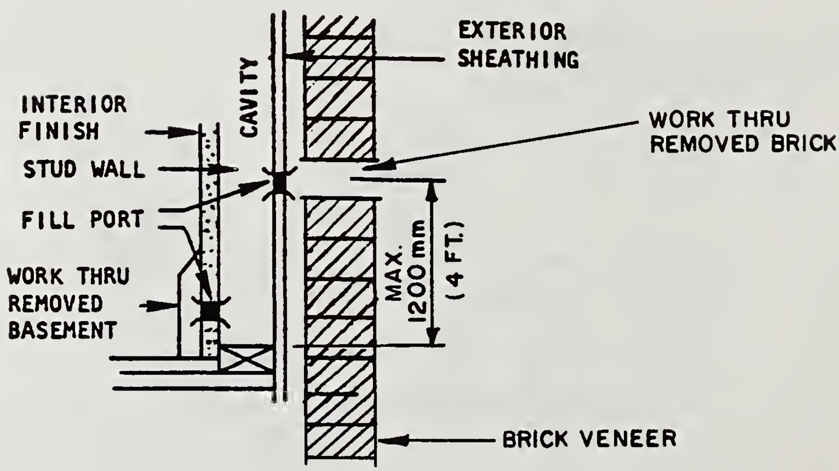

FIGURE 12 - WOOD FRAME WITH BRICK VENEER, ALTERNATE POINTS OF ENTRY.

STANDARD PRACTICE FOR THE INSTALLATION OF MINERAL FIBER BATTS AND BLANKETS THERMAL INSULATION

1. SCOPE

1.1 This practice covers the installation of mineral (rock, slag, or glass) fiber batt and blanket thermal insulation in ceilings, attics, floors, walls, and on basement and crawl space walls and ducts of existing residential buildings.

1.2 A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

1.3 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

Under the DoE residential conservation service (RCS) program, manufacturer's installation instructions may be used in lieu of these practices only with the approval of the cognizant assistant secretary of DoE.

1.4 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.5 This practice further:

Covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the production of the insulation materials, whether such production takes place in a factory or at the installation site.

Describes, in general terms, the procedures to follow so that a safe and effective installation is assured. It does not describe in detail the terminology and fundamentals of residential construction, or the codes or regulations that may be imposed by other Federal, State, or local agencies.

Covers aspects of installation relating to the effectiveness, durability, and safety of insulation in service. It does not address in detail the safety of the person(s) installing the insulation.

Provides minimum requirements that will help to ensure the installation of mineral fiber batts and blankets thermal insulation in a safe and effective manner. Actual conditions in buildings vary greatly and in some cases substantial additional care and precaution may have to be taken to ensure effective and safe installation.

2. APPLICABLE DOCUMENTS

ASTM[1] C 168-80a: Standard Definitions of Terms Relating to Thermal Insulating Materials.

ASTM C 755-73 (1979): Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulation. ASTM E 119-80: Standard Methods of Fire Tests of Building Construction and Materials.

ASTM E 119-80: Standard Methods of Fire Tests of Building Construction and Materials.

ASTM E 136-79: Test for Non-Combustibility of Elementary Materials.

NFPA[2] -31: Standard for the Installation of Oil Burning Equipment.

NFPA-54: National Fuel Gas Code.

NFPA-70: National Electrical Code, (Section 410-66).

NFPA-211: Standard for Chimneys, Fireplaces, and Vents.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, safety, and durability of insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation may reduce its thermal effectiveness, cause fire hazards and other unsafe conditions, and promote the deterioration of the structure in which it is installed.*

3.3 *Some specific hazards that can result from improper installation include:*

Fire caused by heat buildup from recessed lighting fixtures covered by insulation;

Deterioration of wood structures, paint failures, and corrosion of metal fasteners and electrical components caused by prolonged moisture accumulation within building components; flame spread on exposed flammable vapor barriers; and

Deterioration or failure of electrical wiring components surrounded by thermal insulation and heat buildup resulting from overcurrent protection devices (fuses and circuit breakers) incorrectly matched to wire.

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1 American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

2 National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

4. DEFINITIONS

Certain technical terms relating to insulation not defined below are used in this subpart in accordance with the definitions given in ASTM C 168-67.

Approved - acceptable to the authority which regulates the activity or material and its use. Such authority is usually a municipal, State, or Federal agency or a third-party certification, inspection, or rating service.

Conditioned space - any space in a residential building which is served by a heating or cooling system.

Mineral fiber batt and blanket thermal insulation materials - flexible units composed of felted inorganic fibers with or without binders in rolls or strips, with or without attached membrane covering.

Unconditioned space - any space, out-of-doors or in a residential building, which is not served by a heating or cooling system.

A space only intermittently or rarely heated or cooled could also be considered as a "unconditioned space," as long as its heating or cooling system is totally separate from the main system serving the residence.

Vapor Barrier - any material (as defined in ASTM C 755-73) that has a water vapor permeance (perm) rating of one (1) or less.

The following materials, upon proper application, constitute vapor barriers: asphalt impregnated kraft paper, aluminum foil, plastic film, and paint and wallcoverings which are labeled by the manufacturer as having a perm rating of one (1) or less when applied in accordance with the manufacturer's instructions.

5. MATERIALS

5.1 Under RCS, install only mineral-fiber batt and blanket thermal insulating materials identified as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for a more detailed discussion.

It is recommended that all insulation materials installed be tested by laboratories accredited by NVLAP for the particular tests or have third-party certification.

5.2 For duct insulation, use only mineral fiber batt and blanket insulation that meets the specific DoE Material Standards for this application.

6. SAFETY PRECAUTIONS

6.1 During installation, do not smoke in the attic.

Even if the insulation material used has passed ASTM Test E 136 or is fire retardant treated, sparks from cigarettes and other smoking materials, and discarded matches may initiate smoldering combustion or ignite flammable materials (such as vapor barriers or stored old newspapers).

6.2 *Batt and blanket insulation should not be installed so as to sandwich electrical cables between two layers of insulation in the house with improperly matched overcurrent protection devices, because such cables could reach temperatures above those permitted by the National Electrical Code (NEC). Accordingly, prior to installing insulation, it should be ascertained that all circuits have properly matched overcurrent protection devices. See Part I, Section 4.2.1 for further discussion.*

If Edision type fuses are found to be installed, these should be replaced with "S" type fuse adaptors; where incorrectly matched circuit breakers are installed, they should be replaced.

6.3 *Because code rubber wires have a lower NEC allowed temperature limit, no insulation should be placed so as to encapsulate such wires until the electrical system has been inspected by an approved electrician. Code rubber wiring is usually found in houses built prior to 1940. (See Part I, Section 4.2.1 for further discussion).*

6.4 *To prevent electrical shock hazard to installers and building occupants, metallic foil-backed batt or blanket insulation should not be installed in areas with deteriorated electrical wiring or ungrounded electrical equipment, or ungrounded metallic heating or air-conditioning ducts.*

7. PRE-INSTALLATION PROCEDURES

7.1 GENERAL

7.1.1 Identify all recessed lighting fixtures (including wiring compartments and ballasts), furnaces, vents, chimneys, and other heat-producing devices in all areas where insulation is to be installed.

All surface mounted lighting fixtures should also be identified.

Pre-installation inspection is necessary to identify any potential safety hazards in the building and to assure that the installation can be performed effectively and without substantially decreasing the safety or durability of the structure. Certain precautions and preliminary steps must be taken so that the installation can be performed as prescribed in the Installation Procedures section.

7.1.2 Inspect the roof, walls, and ceilings, and attic floors to identify areas where a previous moisture problem has caused paint peeling, warpage, stain, visible fungus growth, rotting, or other structural damage. Do not install insulation in such areas until the resident has been notified and these conditions have been corrected and their source(s) eliminated. If the resident, after being informed of the moisture condition and the effect of installing insulation in such areas, elects to proceed with the insulation, the resident must so state in writing on the contract.

The installing of insulation in a moist area contributes to the deterioration of the structure and reduces the effectiveness of the insulation. Insulation in such areas may prolong exposure of components to moisture, thus increasing the potential for fungus growth and rotting. DoE recommends against installing insulation in the immediate area of prior moisture damage unless the source of the damage has been eliminated. Immediate area is defined as the stud or joist space(s) in which prior moisture problems were observed. For information regarding the identification and evaluation of previous moisture problems, see Part I, Section 4.1.1 for further discussion.

7.2 ATTIC AND CEILINGS

7.2.1 Identify and measure ventilation area in attics. Do not install insulation in attics unless ventilation openings in attics conform to one of the following requirements:

0.1 m^2 minimum of free ventilation area per 15 m^2 (1 ft^2 per 150 ft^2) of attic floor area, if no vapor barrier exists in the attic;

0.1 m^2 minimum of free ventilation area per 30 m^2 (1 ft^2 per 300 ft^2) of attic floor area if a vapor barrier does exist;

0.1 m^2 minimum of free ventilation area per 30 m^2 (1 ft^2 per 300 ft^2) of attic floor space if at least 50 percent of the required ventilating area is provided with fixed ventilation located in the upper portion of the space to be ventilated, with the remainder of the required ventilation provided by eave or soffit vents at least 900 mm (3 ft) below those located in the upper portion, if no vapor barrier exists.

7.2.2 If the free ventilation area of louvers is not known, assume that it is half of the gross area of the ventilation opening and increase the gross opening area accordingly.

On many louvers and vents the free ventilation area is stamped on their frames. Adequate attic ventilation is necessary to carry to the outdoors any moisture that enters the attic from the house.

More ventilation area needs to be provided in homes which do not have a vapor barrier on the attic floor or ceiling surface because moisture can be transmitted more readily through such ceilings. Where the location of attic vents is such that more efficient air currents for ventilation will result, the ventilation requirements can be lower even where no vapor barrier exists. See discussion on attic ventilation in Part I, Section 4.1.3 for more details.

7.2.3 Ensure that all ventilation openings have suitable louvers or screens to prevent rain or snow from entering the attic.

Rain or snow entering the attic could wet the insulation and reduce its effectiveness, and promote fungus growth (dry rot). Moisture above gypsum and gypsum board ceilings accelerates their deterioration.

7.2.4 For buildings located in Zone 1 of Figure 1, if there is no existing insulation or if existing insulation is to be removed, provide a vapor barrier membrane on the upper surface of the ceiling material. <u>Never install a vapor barrier on top of existing installation</u>.

In cold climates, a vapor barrier is required to prevent moisture from penetrating into the cold attic where it could condense and cause moisture damage.

A vapor barrier installed on top of insulation may trap moisture in the insulation and in construction components. This moisture may reduce the effectiveness of the insulation and may lead to the deterioration of the structure. Exposed vapor barriers can also increase flame spread in case of fire.

If separate membrane-type vapor barriers are installed, all tears, penetrations and joints which are not overlapped by at least 75 mm (3 in) should be taped. Vapor barriers attached to batts and blankets should be stapled to joists with the barrier toward the conditioned space.

For buildings in Zones I and II of Figure 1, where there is existing ceiling insulation and no vapor barrier, it is recommended that a vapor barrier paint or wall covering be installed on the interior ceiling surface of bathrooms and unvented kitchens and laundry areas. It is also recommended that all cracks and penetrations on the interior ceiling surface of these rooms (such as around lighting fixtures and at wall and ceiling joints) be caulked.

The above requirements for ventilation and moisture control are minimum requirements needed to prevent long-term moisture damage. Homes which are characterized by one or more of a, b, c, or d below are more likely to experience excessive moisture accumulation which can be corrected by application of a vapor barrier and caulking as described above or by additional ventilation of the occupied space.

(a) Homes with an area of less than 75 m^2 (800 ft^2);

(b) Homes with less than 23 m^2 (250 ft^2) per occupant;

(c) Homes with tight wall and ceiling construction and weatherstripped windows and doors;

(d) Electrically heated homes or homes with a heating system which uses outside combustion air;

(e) Homes that are humidified during the winter.

A relative humdity indicator may be installed to monitor the humidity level and determine when excessive moisture accumulation is likely to occur. See Part I, Section 4.1.2 for discussion on use of relative humidity indicator.

Although existing guidelines (such as ASHRAE) and standards (such as HUD Minimum Property Standards) emphasize the use of vapor barriers for the control of moisture damage, experts in the field now agree that moisture enters wall cavities more by mass transport through cracks and other openings than by diffusion through interior finish materials.

Compared to existing guidelines and standards, the above requirements are very lenient. The reasons are (a) the relative high cost of implementing current "good practice" in retrofit of existing buildings and (b) the lack of definitive analytical and experiental data to support more stringent requirements. See Part I, Section 4.1.2 for a more detailed discussion.

7.3 FLOORS, BASEMENTS AND CRAWL-SPACE WALLS

7.3.1 Where insulation is to be installed beneath floors over crawl-space walls, install a ground cover which acts as a vapor barrier (such as 0.15 mm (6-mil) polyethylene sheeting lapped at the joints). Turn the ground cover up at least 150 mm (six inches) at the walls.

Moisture in the soil beneath the building may evaporate and condense in the insulation causing loss of thermal effectiveness and leading to possible fungus growth in the wood structure and corrosion in fasteners and electrical service components. This provision conforms to major building code requirements for new construction.

7.3.2 Where practical in crawl spaces provide a free ventilation area of 0.1 m^2 for every 150 m^2 (1 ft^2 for every 1500 ft^2) of the ground area of the crawl space. Provide cross ventilation where possible. (See paragraph 7.2.2, for guidance on estimating free ventilation area.)

This is to allow for the venting of the crawl space, preventing the build-up of moisture in the crawl space during the summer season. This provision conforms to major building code requirements for new construction.

7.3.3 Where insulation is to be installed on crawl-space walls, provide a means to seal off the ventilation area(s) during the heating season.

The purpose of the crawl-space wall insulation is to maintain a warmer crawl space in winter. The ventilation area, if not sealed, will permit the infiltration of cold air and thus defeat the purpose of the insulation.

7.3.4 *Install insulation only to within 50 mm (2 in) of any existing termite shields, unless they are extended to reach beyond the installed insulation.*

7.3.5 Provide a vapor barrier on the winter warm side of floor insulation in buildings located in Zones I and II of Figure 1.

That is to prevent vapor permeation from the warm and humid conditioned space through the floor. Such vapor, if condensed inside the floor construction may cause the insulation to become wet and less effective, and promote fungus growth on wood structures and corrosion on metal fasteners and electrical service components.

Insulation of floors over unheated spaces will cause these spaces to be colder. Accordingly, appropriate measures may need to be taken to keep water pipes from freezing during cold weather.

7.4 DUCTS

7.4.1 Inspect duct to assure that it is dry and clean and that all joints are securely connected. Seal all joints that do not appear airtight with duct tape or other appropriate materials.

Insulation of ducts located in unheated spaces will cause these spaces to be colder. Accordingly, appropriate measures may need to be taken to keep pipes in such spaces from freezing during cold weather.

8. INSTALLATION PROCEDURES

8.1 GENERAL

8.1.1 Do not install insulation unless the pre-installation procedures have been carried out and any defects which were identified were corrected, and their causes eliminated.

The purpose of the pre-installation procedures is to assure that the installation can be carried out effectively and without adverse side effects detrimental to other building components and materials. For lasting results, it is important not only to correct symptoms, such as replacing rotten wood, but to eliminate the source of the defect, such as water leaks, which promoted the rot in the first place. In many instances corrective measures can be taken with relative ease prior to the installation of insulation. After installation correction may be more difficult and costly.

8.1.2 Handle all insulation material in accordance with manufacturer's instructions and keep it dry and free of extraneous materials.

Some materials can be crushed or otherwise rendered less effective by incorrect handling. Moisture in the material can both affect the effectiveness of insulations and support fungus growth. Extraneous materials, such as untreated organic matter, can reduce effectiveness, increase potential for fungus growth and lead to insect and vermin infestation.

8.1.3 Install insulation so that it will not be in contact with the ground or other sources of water.

Many mineral-fiber batt and blanket insulations are hygroscopic and may saturate themselves when in contact with ground or moist areas, losing effectiveness and promoting fungus growth when the condition persists.

8.1.4 For energy conservation, install insulation only between conditioned and unconditioned spaces.

Insulation is only effective in conserving energy when placed between conditioned (served by a heating and/or cooling system) and unconditioned spaces (such as outdoors, an unheated garage or the ground). Where adjacent conditioned spaces are maintained at different temperatures, the temperature differential is seldom such that the insulation *would be cost-effective. One possible exception would be the case where one of two adjacent conditioned spaces is frequently, and for prolonged periods, neither heated or cooled at all, while the other is conditioned. In this case, the frequently unconditioned space should be treated as such. One example of this would be a home workshop attached to the house but only occupied and heated on weekends.*

Partitions between conditioned spaces are sometimes insulated to increase sound insulation. However, such applications do not conserve energy and are therefore outside the scope of RCS-arranged installations.

8.1.5 Install insulation so that it fits tightly between framing members on all sides. Cut insulation that is too long for a space to the correct size. If insulation is too short for a space, cut a piece to fill the void and tightly butt-joint batts. Do not double over or unnecessarily compress insulation.

8.1.6 Permanently maintain the clearances specified in paragraphs 8.1.7 and 8.1.8 below around all heat-producing devices.

The clearances are needed to prevent heat build-up, damage to electrical services equipment, and to appliances and their components, and to prevent initiation of smoldering or ignition of combustible materials in the proximity of heat-producing devices.

8.1.7 Provide a 75 mm (3 in) minimum clearance around all recessed lighting fixtures (including wiring compartments and ballasts) and other heat-producing devices not covered in paragraph 8.1.8. Do not cover these devices so as to entrap heat or prevent the free circulation of air unless they are approved for the purpose.

This requirement is based on section 410-66 of the National Electrical Code (NFPA-70). Recessed lighting fixtures rely on the free movement of air around and above them to dissipate the heat generated by the bulbs, ballasts, and wiring compartments. Even if the insulation material itself is non-combustible, if it is installed above or around a recessed lighting fixture, temperatures within the fixture may become sufficiently high to ignite fixture components and surrounding framing members. It is recommended that clearances similar to those required for recessed lighting fixtures also be provided around the junction box over surface mounted lighting fixtures. See Part I, Section 4.2.2 and 4.2.3 for additional information.

8.1.8 Provide the minimum clearances around gas-fired appliances specified in NFPA-54, the National Fuel Gas Code. Around oil-fired appliances, provide the minimum clearances specified in NFPA-31, Standard for the Installation of Oil Burning Equipment. Around masonry chimneys (or masonry enclosing a flue) provide a minimum 50 mm (2 in) clearance from the outside face of the masonry. Around vents, chimney and vent connectors and chimneys other than masonry chimneys, provide the minimum clearances specified in NFPA-211, Standard for Chimneys, Fireplaces, and Vents.

This is to provide a safe installation in accordance with recognized national codes and standards.

8.1.9 When installing mineral-fiber blanket insulation having no membrane (or having a non-flammable membrane) which, in addition to meeting all the requirements specified in the DoE Material Standards, also has successfully past ASTM Test E 136-79, the airspaces specified in this section need not be provided around vents and chimneys.

The DoE Material Standards do not require that thermal insulation and vapor barriers meet the requirements of ASTM E 136-79. It should not be assumed that the material being installed has passed the test unless the label specifically states so.

8.1.10 Assure that all devices which may require periodic servicing remain accessible after the insulation is installed.

8.2 WALLS

8.2.1 In Zones I and II of Figure 1, install a vapor barrier on the winter warm side of insulation installed in exterior walls. Secure the vapor barrier to the studs so as to avoid gaps and fishmouths. If the insulation does not have a vapor barrier attached to it provide a separate vapor barrier on the winter warm side over the installed insulation.

This is to conform with generally accepted practice, codes and standards in new building construction. This more stringent requirement (than that for loose-fill insulation) was adopted since when installing batt and blanket insulation, the cost for providing the vapor barrier is not different than that in new construction.

8.2.2 With duct tape (or equivalent), tape all tears and penetration in the vapor barrier and all joints which are not overlapped by at least three inches.

The vapor barrier must cover the insulated area completely and uniformly. Gaps through which moisture can migrate may result in excessive moisture accumulation, leading to a reduction in thermal effectiveness and other undesirable side effects. See Part I, Section 4.1.2 for a more detailed discussion.

8.2.3 If the insulation material is provided with a flammable vapor barrier, or if a separate vapor barrier which is flammable is installed, cover the insulation with a finish material having a finish rating of not less than 15 minutes when tested according to ASTM Designation E 119-80. For purposes of this standard 12.5 mm (0.5 in) or thicker plaster board, installed in accordance with the manufacturer's instructions is deemed to meet this requirement.

This is to assure that overall fire safety of the building is not diminished through the installation of the vapor barrier.

8.3 ATTICS, CEILINGS, AND FLOORS

8.3.1 Always place vapor barriers on the winter warm side of the insulation. Never install a combustible vapor barrier so that it remains exposed.

It is the purpose of the vapor barrier to prevent moisture from migrating from the warm interior space into or through the insulation.

An exposed combustible vapor barrier is a fire hazard. It can be ignited easily and in case of a fire can contribute to rapid flame spread.

8.3.2 When installing insulation around bridging or cross bracing of ceiling or floor joists, fit the insulation material tightly around these obstructions and assure that there are no gaps in the insulation.

8.3.3 When recessing insulation batts in floor joist cavities turn insulation up at the header or cut and attach pieces of insulation to the header to avoid heat loss through the header.

8.3.4 Fit insulation tightly in floor joist areas and secure in place with either wire fasteners, galvanized wire, or nylon mesh or galvanized screen held in place by stapling or nailing, or galvanized wire lacing held in place by stapling or nailing. See Figure 2.

Insulation must be held securely in place for long service life. Friction fit alone is not acceptable as a means of holding the insulation in place between the floor joists.

8.3.5 Do not cover soffit vents with insulation nor in any other way restrict attic ventilation.

This is to assure that the purpose of attic ventilation is not defeated by improper installation of insulation.

8.3.6 Install insulation around vents which open into the attic in a manner that will ensure free movement of air through the vent into the attic.

The venting of bathroom and kitchen air (and clothes dryer) into the attic is an undesirable building practice because it introduces excessive moisture into the attic which may condense when exposed to cooler attic temperatures. The potential for condensation is further increased as insulation is added because the insulation reduces the rate of heat flow from the living area to the attic, causing attic temperatures to be even lower. It is recommended that such vents be extended and vented to the outside.

8.3.7 Fit the attic side of trap doors or panels with insulation batt except where prevented by a retractable ladder.

Secure the insulation in place using staples or other appropriate fasteners. Insulation may be installed to the exterior of trap doors which have retractable ladders mounted on their interior. If the insulation is installed to the exterior (underside) of the trap door, a finish material (such as gypsum board) should be provided for appearance and to protect the insulation.

Weatherstripping should be installed along the contact edge between the access panel and frame to reduce air infiltration.

8.4 BASEMENT AND CRAWL SPACE WALLS

8.4.1 Where the joists run parallel to the wall, install the wall insulation by stapling the top of each batt to the band joist. Where the joists run at right angles to the wall, install short pieces of insulation against the header, ensuring that there are no gaps in the insulation. Then, install the wall insulation by stapling the top of each batt to the sill. See Figure 3.

8.4.2 Ensure that the batts fit snugly against each other and that they are sufficiently long to cover the wall and two feet of the crawl space floor.

The perimeter of the crawl space floor is a potential area for heat leaks. Insulation of the two feet of floor area adjacent to the crawl space wall will reduce this energy loss.

8.5 DUCTS

8.5.1 Install duct insulation only on ducts located in unconditioned spaces.

Insulating ducts in conditioned spaces will produce only insignificant energy savings, leading to an installation that is not cost-effective.

8.5.2 Install insulation batt or blanket with the vapor barrier on the outside.

8.5.3 Butt joints of batts tightly and in such a way that a vapor barrier tab overlaps the joints by at least two inches. Mechanically fasten the tab to the underlying vapor barrier and seal the joint with duct tape, or alternatively, overlay insulation and tape when vapor barriers are attached.

8.5.4 On rectangular ducts, install insulation so that at the corners it is not compressed more than 50 percent of its nominal thickness.

Excessive compression results in reduced thermal effectiveness of the insulation.

8.5.5 On horizontal ducts over 600 mm (24 in) wide, secure the bottom of the insulation with mechanical fasteners as required by the manufacturer. Seal fastener penetrations to provide an airtight system.

8.5.6 Install any protective covers required by local codes and regulations.

9. POST-INSTALLATION PROCEDURES

9.1 Ensure that insulation does not restrict attic soffit vents.

9.2 Ensure that all required clearances have been maintained.

9.3 Ensure that, where required, all insulation is covered with a suitable covering material as required in Section 8.2.3.

9.4 Comply with the "Certification Procedures for the Installation of Thermal Insulation Materials.

FIGURE 1 - CONDENSATION ZONE MAP.

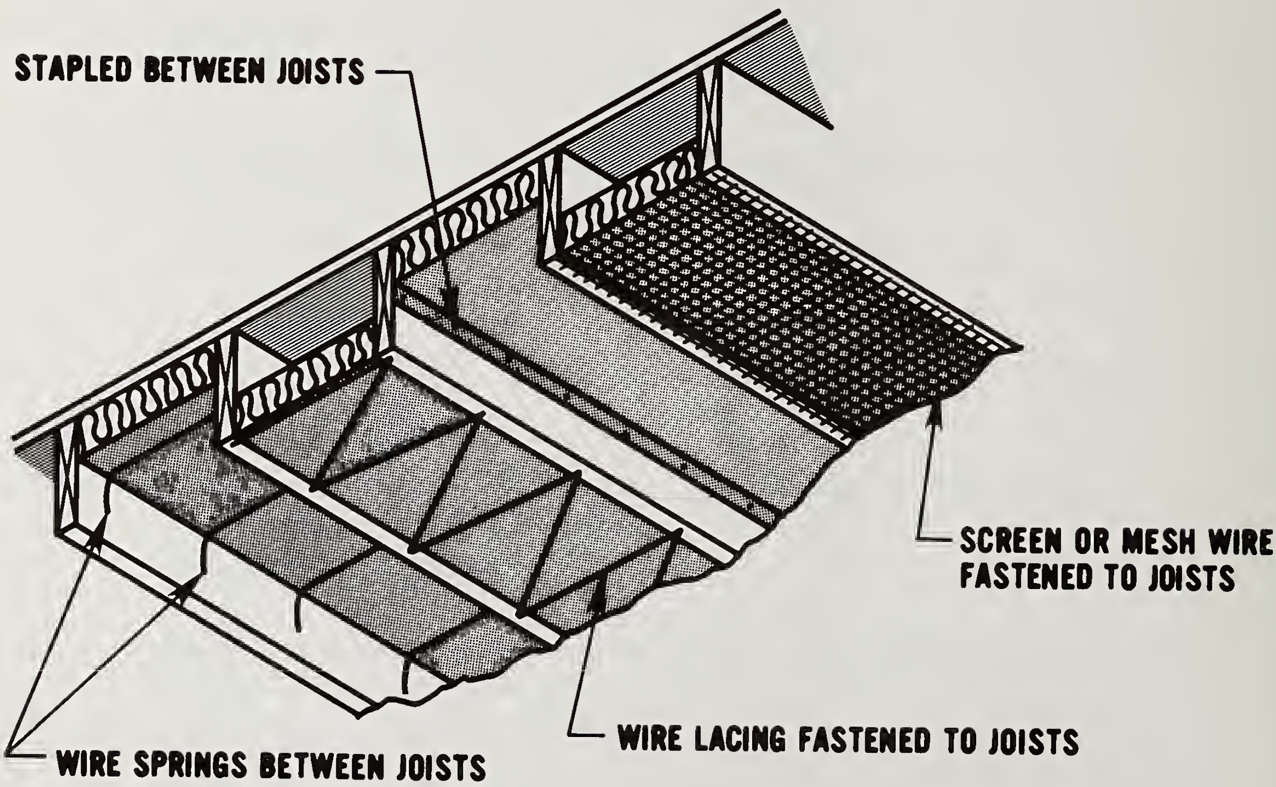

FIGURE 2 - METHODS FOR SECURING BATT BETWEEN FLOOR JOISTS.

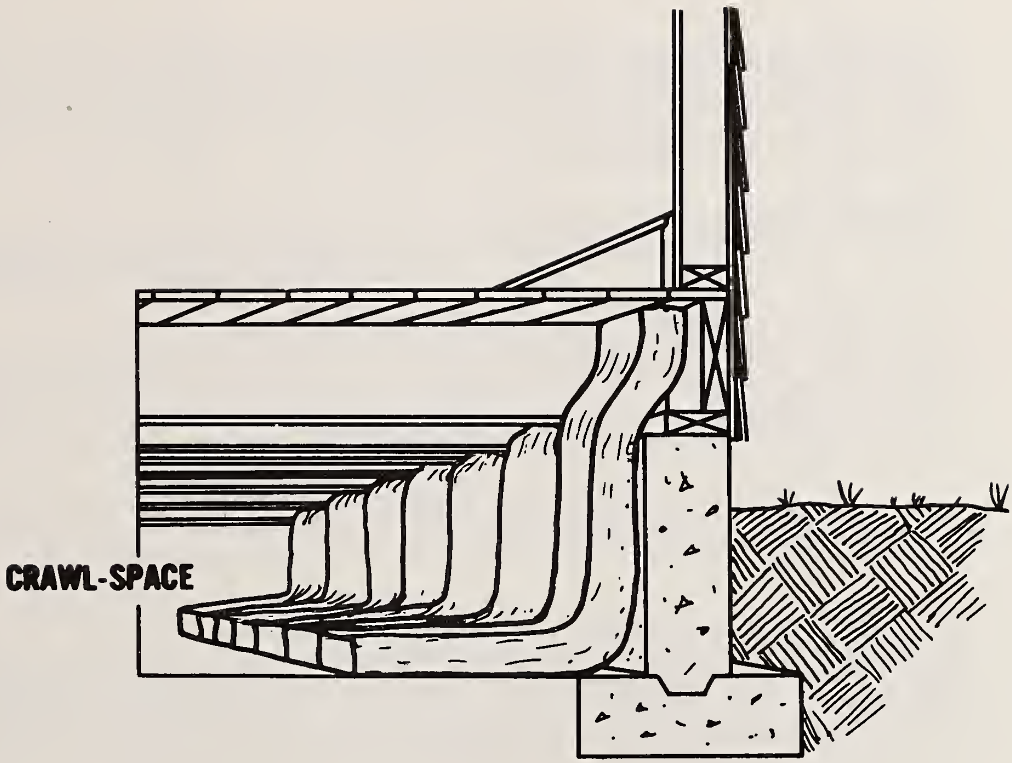

FIGURE 3 - CRAWL SPACE INSULATION.

STANDARD PRACTICE FOR THE INSTALLATION OF ORGANIC CELLULAR RIGID-BOARD THERMAL INSULATION

1. SCOPE

1.1 This practice covers the installation of organic cellular rigid-board thermal insulation on concrete floors, foundation perimeters, interior of masonry walls, interior of frame walls and ceilings, and as exterior sheathing on walls and roofs of existing residential buildings.

1.2 This practice covers the installation of the rigid-board but does not include in detail the installation of exterior siding and roofing required to protect rigid-board insulation from the effects of weather, or the installation of interior fire protective coverings.

1.3 A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

1.4 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

Under the DoE residential conservation service (RCS) program, manufacturer's installation instructions may be used in lieu of these practices only with the approval of the cognizant assistant secretary of DoE.

1.5 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained therein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.6 This practice further:

Covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the production of the insulation materials, whether such production takes place in a factory or at the installation site.

Describes, in general terms, the procedures to follow so that a safe and effective installation is assured. It does not describe in detail the terminology and fundamentals of residential construction, or the codes or regulations that may be imposed by other Federal, State, or local agencies. A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

Covers aspects of installation relating to the effectiveness, durability, and safety of insulation in service. It does not address the safety of the person(s) installing the insulation.

1.7 *Provides minimum requirements that will help to ensure the installation of organic cellular rigid board thermal insulation in a safe and effective manner. Actual conditions in buildings vary greatly and in some cases substantial additional care and precaution may have to be taken to ensure effective and safe installation.*

2. APPLICABLE DOCUMENTS

ASTM[1] C 168-80a: Standard Definitions of Terms Relating to Thermal Insulating Materials.

ASTM C 272-53 (1980): Test for Water Absorption of core materials for structural sandwich constructions.

ASTM C 355-64 (1973): Test for Water Vapor Transmission of Thick Materials.

ASTM C 755-73 (1979): Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulation.

ASTM E 119-80: Fire Tests of Building Constructions and Materials.

ASTM E 136-79: Test for Non-Combustibility of Elementary Materials.

NFPA[2] -31: Standard for the Installation of Oil Burning Equipment.

NFPA-54: National Fuel Gas Code.

NFPA-70: National Electrical Code (Section 410-66).

NFPA-211: Standard for Chimneys, Fireplaces, and Vents.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, safety, and durability of insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation may reduce its thermal effectiveness, cause fire hazards and other unsafe conditions, and promote the deterioration of the structure in which it is installed.*

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[1] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA. 19103.

[2] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA. 02210.

3.3 *Specific hazards that can result from improper installation include:*

Fire caused by heat buildup from recessed lighting fixtures covered by insulation;

Deterioration of wood structures, paint failures, and corrosion of metal fasteners and electrical components caused by prolonged moisture accumulation within building components; and

Ignition of and flame spread on insulation board not protected by an appropriate cover.

4. DEFINITIONS

Certain technical terms relating to insulation not defined below are used in this subpart in accordance with the definitions given in ASTM C 168-67.

Approved - acceptable to the authority which regulates the activity or material and its use. Such authority is usually a municipal State, or Federal agency or a third-party certification, inspection or rating service.

Conditioned Space - any space in a residential building which is served by a heating or cooling system.

Organic Cellular Rigid Board Thermal Insulation - An organic plastic foam composed principally of polymerized styrene resin or catalyzed reaction products expanded with a fluorocarbon blowing agent to form a homogeneous rigid mass of cells.

Unconditioned Space - any space, out-of-doors or in a residential building, which is not served by a heating or cooling system.

Vapor Barrier - any material (as defined in ASTM C755-73) that has a water vapor permeance (perm) rating of one (1) or less.

The following materials, upon proper application, constitute vapor barriers: asphalt-impregnated kraft paper, aluminum foil, plastic film, and paint and wallcoverings which are labeled by the manufacturer as having a perm rating of one or less when applied in accordance with the manufacturer's instructions.

5. MATERIALS

5.1 This practice applies to the installation of organic, cellular, rigid polystyrene, polyurethane and polyisocyanurate thermal insulation board.

5.2 Under RCS, install only organic cellular rigid-board thermal insulating materials identified as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for further discussion.

5.3 *It is recommended that all organic cellular rigid-board thermal insulation materials installed have third-party certification. If and when the National Voluntary Laboratory Accreditation Program (NVLAP) accredits laboratories to conduct tests on organic cellular rigid-board, it is recommended that the tests be performed by NVLAP accredited laboratories.*

5.4 *Install only insulation boards compatible with the particular application.*

6. SAFETY PRECAUTIONS

6.1 Do not smoke in any area in which insulation is being installed or cut.

Sawdust from foam board can easily be ignited and combustion products are toxic.

6.2 The vapors of many solvents used in the adhesives for the installation of organic cellular rigid board thermal insulation are flammable. Keep solvents in approved containers and follow the specific label instructions.

Provide adequate ventilation to prevent hazardous accumulation of solvent vapor during installation.

7. GENERAL REQUIREMENTS

7.1 For all rigid-board applications, carry out the pre-installation, installation, and post-installation procedures in the order prescribed in 7 through 18.

It is important that pre-installation procedures be carried out to assure that the installation can be performed effectively and without causing adverse side effects detrimental to other building components. For lasting results, do not only correct symptoms (such as replacing rotten wood) but eliminate the source of the problem (such as a water leak which promoted the rot in the first place). The procedures need to be taken in correct order. Some pre-installation checks and precautions can not be taken after the insulation is installed.

7.2 For interior applications of rigid-board insulation on walls and ceilings install, on all exposed faces and exposed edges of the insulation material, a cover having a finish rating of not less than 15 minutes, when tested according to ASTM E 119-76. For purposes of this standard, 12.5 mm (0.5 in) or thicker plaster board, installed in accordance with the manufacturer's instructions, is deemed to meet this requirement.

To prevent ignition of and retard flame spread on combustible insulating materials. This assures that the dwelling after installation of board insulation provides the same level of safety as before the installation. The requirement is also in conformance with most local and State building codes.

7.3 Install insulation only between conditioned and unconditioned spaces for energy conservation, except as provided in paragraphs 8, 9 and 11.

Insulation is only effective in conserving energy when placed between conditioned (served by a heating and/or cooling system) and unconditioned spaces (such as outdoors or an unheated garage). Where adjacent conditioned spaces are maintained at different temperatures, the temperature differential is seldom such that the insulation would be cost effective. One possible exception would be the case where one of two adjacent conditioned spaces is frequently, and for prolonged periods, neither heated nor cooled at all, while the other is conditioned. In this case, the frequently unconditioned space could be treated "unconditioned."

Partitions between conditioned spaces are sometimes insulated to decrease sound transmission. However, such applications do not conserve energy and are therefore outside the scope of RCS arranged installations.

7.4 Follow the requirements applicable to the control of moisture in buildings to be installed as detailed in Table 1.

Table 1 applies to frame exterior walls. For masonry walls, ceiling and roof application, use requirements for filled cavities.

See also Part I, Section 4.1.2 for information regarding moisture control.

7.5 Install all vapor barriers required by this practice on the interior of the innermost insulation.

Installed insulation board should be continuous and without gaps. If a vapor barrier is recommended and is provided as an integral part of the insulation board material, the joint of two insulation boards should be sealed to assure continuous moisture protection.

If a vapor barrier is installed separately from the insulation, the barrier should be overlapped and taped. Flammable vapor barriers should not be left exposed but should be covered by a material having a finish rating of 15 minutes. 12.5 mm (0.5 in) or thicker plaster board, installed in accordance with the manufacturer's instructions, is deemed to meet this requirement.

7.6 Follow all insulation manufacturer's recommendations relative to the venting of wall constructions.

7.7 Ensure that only mastics and solvents compatible with the board insulation material are used.

To effect a good bond. Incompatible mastic or solvent can also damage or even dissolve the insulation board.

7.8 *To ensure proper adhesion of rigid board, the surfaces to which the materials will be applied should be smooth and clean. Horizontal surfaces should be in broomswept condition prior to the installation of rigid board.*

7.9 *To prevent deterioration from exposure to ultraviolet radiation, insulation board materials should not be exposed to sunlight for extended periods.*

7.10 *To ensure that the insulation does not become wet and subject to degradation, it should not be in contact with the ground or other sources of water, except in the case of slab perimeter installations where insulation board specifically designed for this application is used.*

7.11 Provide a 75 mm (3 in) minimum clearance around all recessed lighting fixtures (including wiring compartments and ballasts) and other heat-producing devices not covered in the paragraph below. Do not install insulation so as to cover these devices and entrap heat or prevent the free circulation of air unless they are approved for the purpose.

This requirement is based on section 410-66 of the National Electrical Code (NFPA-70). Recessed lighting fixtures rely on the free movement of air around and above them to dissipate the heat generated by the bulbs, ballasts, and wiring compartments. If insulation board is installed above or around a recessed lighting fixture, temperatures within the fixture may become sufficient to ignite fixture components and surrounding framing members. See Part I, Section 4.2.2 for further discussion.

7.12 Provide the minimum clearances specified in NFPA-31 around oil-fired appliances. Install insulation around masonry chimneys or masonry enclosing a flue to provide a minimum 50 mm (two-inch) clearance from the outside face of the masonry. Install insulation around vents, chimney and vent connectors, and chimneys other than masonry chimneys so as to provide the minimum clearances specified in NFPA-211. Consult the foam manufacturer for additional requirements regarding the protection of foam from excessive heat.

To provide a safe installation in accordance with recognized national codes and standards.

8. FOUNDATION PERIMETER

8.1 APPLICABILITY

8.1.1 This section applies to the installation of organic cellular rigid board thermal insulation to the exterior of foundation walls and around the perimeter of concrete slab-on-grade floors. Only closed cell insulation boards which have a moisture absorption rate no greater than 0.3 percent when tested in accordance with ASTM C 272-53 and a water vapor transmission rate no greater than 2 perm per inch when tested in accordance with ASTM C 355-64 (1973) may be used for this application.

Because of its exposure to groundwater, only insulation board with low water absorption and permeance is suitable for this application.

8.2 PRE-INSTALLATION PROCEDURES

8.2.1 Identify any termite shields that would be covered by the insulation. Do not install board insulation unless the termite shield is effectively extended beyond the insulation and cover to be installed.

Installing materials that allow a by-pass of the termite shield will defeat the purpose of the shield and increase the risk of termite infestation in the structure of the house.

8.2.2 Prepare a trench of not less than 300 mm (12 inches) in depth on the exterior of the foundation.

The depth below grade to which the insulation is effective depends on local climate conditions. It is recommended that the insulation be installed to at least the depth of the frost line or to the bottom of the footing (if any), whichever is less.

8.2.3 Install any anchoring devices required for the application of the covering material.

Only anchoring methods recommended by the board manufacturer should be used.

8.2.4 Identify surface projections such as electrical outlets, utility meters, piping, and faucets, which will require special attention.

8.3 INSTALLATION PROCEDURE

8.3.1 Do not install insulation board with adhesives when the wall surface is wet or the temperature is below freezing.

Wet or below freezing conditions are detrimental to a permanent bond.

8.3.2 Cut board insulation to fit around any surface projections, around windows, and at corners so as to fit tightly against each other and against the anchoring devices.

8.3.3 Attach the insulation board against the wall or slab edge.

The insulation boards should be secured to the wall or slab firmly either mechanically or with adhesives in accordance with the insulation board manufacturer's recommendations.

8.3.4 To provide impact resistance to those parts of the boards which will remain exposed after backfilling, install a protective cover.

Various protective covers include, but are not limited to, metal and cementitious boards, wire and fiber reinforced cement plaster and heavy-bodied latex coatings. Consult the insulation board manufacturer for compatible coatings.

8.3.5 Back-fill and tamp ground around foundation or slab edge to slope away from the building.

To assure good drainage, to prevent water accumulation and prevent potential freeze damage.

8.4 POST-INSTALLATION PROCEDURES

Ensure that any termite shields are effectively extended beyond the insulation and its cover.

Give specific attention to corners and door sills to assure that no paths for termite passage exist.

Ensure that all joints in the cover are tight and that cement plaster covers are not cracked.

Ensure that all surface projections identified in preinstallation procedures are properly treated and that the installation does not interfere with the proper operation of the devices.

Ensure that all trenches that were dug are fully backfilled and tamped, and that they slope away from the wall or slab edge.

9. CONCRETE FLOORS

9.1 APPLICABILITY

9.1.1 This section applies to the installation of organic cellular rigid-board thermal insulation on concrete floors over unheated basements and crawl spaces or on concrete slabs on grade.

9.2 PRE-INSTALLATION PROCEDURES

9.2.1 Ensure that the concrete floor surface is clean, dry, and free of oil and loose paint.

Unless surface is clean, and dry, the waterproof barrier required under 9.2.5 will not adhere properly.

9.2.2 Fill any cracks in concrete floors with patching cement several days prior to installation.

To provide an even and continuous surface.

9.2.3 Seal joints between the floor and walls to reduce air infiltration.

Sealing of this joint is easy at this point and is an effective energy conservation method.

9.2.4 Identify all floor drains. Do not cover such drains unless permitted by local codes.

Most codes do not permit such cover. (Traps in drains may dry out, possibly resulting in sanitary or explosive hazards.)

9.2.5 Prior to installing insulation on a slab on grade, provide a waterproof barrier such as two separate brushed-on coatings of asphalt emulsion.

To prevent groundwater seeping through the concrete floor from contact with insulation.

9.3 INSTALLATION PROCEDURE

9.3.1 Cut the insulation board to appropriate size so as to provide tight but not force-fitted joints.

9.3.2 Adhere the insulation board to the concrete, assuring an intimate and continuous bond.

The insulation board should be installed as recommended by the manufacturer.

9.3.3 Mechanically fasten to the concrete floor slab a subfloor of sufficient strength to distribute any imposed, concentrated load so as not to crush the insulation.

Examples of suitable subflooring materials are 12.5 mm (1/2-inch) exterior grade plywood secured directly on top of the insulation board; or as an alternative, the subfloor can be fastened to sleepers which in turn are attached to the concrete slab. The joint between sleepers and insulation board should be tight but not force fitted. The subfloor joints should coincide with the center of the sleepers. If sleepers are used, a subfloor of 19 mm (3/4-inch) exterior grade plywood is suitable.

9.3.4 Protect the floor area around any permanently installed heat-producing equipment in accordance with the requirements of NFPA 31, or NFPA 54. Consult the manufacturer for additional requirements regarding the protection of the insulation from excessive heat.

9.4 POST-INSTALLATION PROCEDURES

9.4.1 Ensure that the subfloor is flat, all subfloor panel butt or tongue and groove joints are tight, and the subfloor is securely fastened.

An uneven subfloor causes early wear of the finish flooring material.

9.4.2 Ensure that, where required, protective coverings around heat-producing equipment have been provided.

10. MASONRY WALL INTERIOR

10.1 APPLICABILITY

10.1.1 This section applies to the installation of organic cellular rigid-board insulation to the interior of masonry walls, particularly basement walls, which separate conditioned and unconditioned spaces.

10.2 PRE-INSTALLATION PROCEDURES

10.2.1 Ensure that the walls are structurally sound; that they are dry and do not show signs of recent dampness (such as mold); and are clean, free of grease, loose paint, and loose material.

> *Structural rehabilitation, where required, needs to precede the installation of insulation board. Insulation board will not adhere properly to moist, molded or unclean areas.*

10.2.2 Remove any baseboards or moldings on walls to be insulated.

10.2.3 Install any anchoring devices required for the application of the covering material.

> *Only anchoring methods and devices recommended by the manufacturer should be used.*

10.2.4 Determine edge treatment to be provided at windows and doors after the insulation and covering are installed.

10.2.5 Identify all electrical outlets and switches. Have an approved electrician extend these to the level of the new surface, if required.

10.2.6 Identify and seal cracks at ceiling/wall and floor/wall joints and around window and door frames to reduce air infiltration.

10.3 INSTALLATION PROCEDURE

10.3.1 Cut the board insulation to fit around any surface projections such as windows, electrical outlets, conduits, and surface-mounted water and drain pipes.

10.3.2 Attach the insulation board to the wall.

> *Attachment can be directly to the wall or to furring strips. The latter method may be desirable if the masonry wall is not plumb or straight, or is uneven.*

10.3.3 Do not cover water or drain pipes with insulation board. If possible, wedge some insulating board pieces between the pipes and the outside of the wall.

> *During cold weather, heat from the house may be required to prevent the pipes from freezing.*

10.3.4 After all insulation board is applied, install a cover having a finish rating of not less than 15 minutes when tested according to ASTM E 119-76. For purposes of this standard, 12.5 mm (0.5 in) or thicker plaster board, installed in accordance with the manufacturer's instructions, is deemed to meet this requirement. Water and drain pipes may be covered with approved covering material.

10.3.5 Cover the edges of the insulation around electrical outlets and switches, leaving sufficient space to permit their convenient use.

10.3.6 Replace moldings at floors and install trim as needed around doors and windows.

10.4 POST-INSTALLATION PROCEDURES

10.4.1 Ensure that electrical outlets and switches operate freely.

10.4.2 Ensure that the required clearances around heat-producing equipment have been maintained.

10.4.3 *Ensure that all areas of insulation board, including edges, are covered by material having the required finish rating of 15 minutes.*

11. MASONRY CRAWL SPACE WALLS

11.1 APPLICABILITY

This section applies to the installation of organic cellular rigid-board insulation to the interior of crawl space walls as an alternative to insulating the floor over a crawl space.

11.2 PRE-INSTALLATION, INSTALLATION, AND POST-INSTALLATION

11.2.1 Ensure that all applicable provisions of the masonry wall section are carried out.

11.2.2 Do not cover ventilation openings but provide a means for closing the openings during the heating season.

To allow for the venting of the crawl space, preventing the build-up of moisture in the crawl space during the summer seasons. The free ventilation area should be 0.1 m^2 for every 150 m^2 (1 ft^2 for every 1500 ft^2). This provision conforms to major building code requirements for new construction. The ventilation area, if not sealed in winter, will result in cold air infiltrating the crawl space, defeating the purpose of the insulation. Crawl space ventilation openings should be provided with insect screens and louvers. If louvers are provided, the "free area" is usually stamped on the frame. If the free area is not known, assume it is one half of the total opening area (gross area).

11.2.3 Cover the ground surface with a ground cover which acts as a vapor barrier (such as 0.15-mm (6-mil) polyethylene sheeting lapped at the joints). Turn the ground cover up at least 150 mm (6 in) at the walls.

Moisture in the soil beneath the building may evaporate and condense on the underside of the floor above. This can promote fungus growth, corrosion of metal fasteners and electrical components. This provision conforms to major building code requirements for new constructions.

12. FRAME WALL INTERIOR

12.1 APPLICABILITY

This section applies to the installation of organic cellular rigid-board insulation to the interior of finished framed wall constructions which separate conditioned from unconditioned spaces.

12.2 PRE-INSTALLATION PROCEDURES

12.2.1 Ensure that all provisions of paragraph 10.2 are carried out.

12.2.2 Secure any anchoring devices required for the application of the covering material to the wall framing studs.

12.2.3 Identify water and drain pipes both on the surface of the wall and in the wall cavities. Provide nailers as needed for attaching the cover material.

12.3 INSTALLATION PROCEDURE

12.3.1 Install insulation boards in accordance with the requirements of paragraph 10.3 of this practice.

12.3.2 Do not install insulation over stud spaces that contain water supply or waste pipes. The fire protective covering material may be placed over stud spaces containing pipes.

> *During cold weather, heat from the house may be required to prevent the pipes from freezing.*

12.4 POST-INSTALLATION PROCEDURES

12.4.1 Conduct post-installation procedures in accordance with paragraph 10.4 of this practice.

13. GYPSUM PLASTER OR PLASTERBOARD CEILINGS

13.1 APPLICABILITY

13.1.1 This section applies to the installation of organic cellular rigid-board insulation to the underside (winter warm side) of existing plaster or gypsum board ceilings. See the following section on wood deck ceilings for requirements for the interior installation of insulation board to wood roof decks.

13.2 PRE-INSTALLATION PROCEDURES

13.2.1 Ensure that the ceilings are structurally sound; that they are dry and do not show signs of recent dampness, such as mold; and are clean, free of grease, loose paint, and loose material.

The insulation board and the finish material will impose an additional load to the ceiling and should not be installed if the ceiling is structurally unsound. Dampness, grease and loose materials can prevent an effective bond between ceiling and insulation board. If the ceiling is damp or shows signs of recent dampness, the roof above should be inspected and any leaks should be repaired prior to installing the insulation.

13.2.2 Remove any existing molding at the wall-to-ceiling joints or on the ceiling itself.

13.2.3 Identify electrical outlets and recessed lighting fixtures. Have an approved electrician lower these to the level of the new finished ceiling surface, if required.

13.2.4 Identify the location of ceiling joists.

13.2.5 Seal all cracks at wall-to-ceiling joints, and any other cracks such as at electrical outlets.

This reduces air infiltration and can be done readily at this time. It also reduces air leakage into the ceiling with the potential for excessive moisture condensation in the attic.

13.3 INSTALLATION PROCEDURE

13.3.1 Cut the insulation board to appropriate size and attach the board to the ceiling.

13.3.2 Install a cover having a finish rating of not less than 15 minutes when tested according to ASTM E 119-76. For purposes of this standard 12.5 mm (0.5 in) or thicker plaster board, installed according to the manufacturer's instructions, is deemed to meet this requirement.

13.3.3 If the cover consists of gypsum or similar board material, install the cover so that the joints fall on the center line of the ceiling joists and nail the cover to the joists with nails of sufficient length to penetrate the cover material, the insulation board, the existing ceiling, and into the ceiling joist.

13.3.4 Finish the ceiling joints with tape and finish with filler as required.

Some gypsum board finish ceiling materials may not require taping and finishing if rated at 15 minutes without such finishing.

13.4 POST-INSULATION PROCEDURES

13.4.1 Ensure that all surfaces and edges of insulation board are covered with a material having a finish rating of at least 15 minutes when tested according to ASTM E 119-76.

13.4.2 Ensure that the required clearances around heat-producing equipment have been maintained.

14. EXPOSED WOOD DECK CEILINGS

14.1 APPLICABILITY

14.1.1 This section applies to the installation of organic cellular rigid-board insulation to the underside (winter warm-side) of exposed wood roof decks.

14.2 PRE-INSTALLATION PROCEDURES

14.2.1 Apply all provisions of paragraph 13 of this practice.

14.3 INSTALLATION PROCEDURE

14.3.1 Cut the insulation board to fit snugly between any exposed joists or rafters.

14.3.2 Install the insulation board securely to the wood deck. If mechanical fasteners are used, do not puncture the roofing.

14.3.3 Install a cover having a finish rating of not less than 15 minutes when tested in accordance with ASTM E 119-76. For purposes of this standard 12.5 mm (0.5 in) or thicker plaster board, installed according to the manufacturer's instructions, is deemed to meet this requirement.

14.3.4 Secure the cover through the insulation board to the wood deck. Do not puncture the roofing.

14.3.5 Finish the ceiling with tape and spackle as required and install edge trim as needed.

Some gypsum board ceilings may not require finishing. See 13.3.4.

14.4 POST-INSTALLATION PROCEDURES

14.4.1 Ensure that all surfaces and edges of insulation board are covered with a material having a finish rating of at least 15 minutes when tested according to ASTM E 119-76. For purpose of this standard, 12.5 mm (0.5 in) or thicker plaster board, installed according to the manufacturer's instructions, is deemed to meet this requirement.

14.4.2 Ensure that the required clearances around heat-producing equipment have been maintained.

15. FRAME WALL EXTERIOR

15.1 APPLICABILITY

15.1.1 This section applies to the installation of organic cellular rigid-board thermal insulation to the exterior of frame walls.

15.2 PRE-INSTALLATION PROCEDURES

15.2.1 Assure that the walls are free of fungus growth (dry rot) and that they can support the load of the insulation and the weather resistant exterior finish. If the existing exterior wall cover is sound and free of rot, insulation can be installed over the existing siding. If the existing surface is attacked by fungus growth, remove the old siding. If the old siding is removed, assure that the structural integrity of the wall is maintained, either by the remaining cross bracing or the installation of new siding.

The siding, the interior face of exterior walls, and the roof should be inspected to identify areas where previous moisture problems have caused paint peeling, warpage, stain, fungus growth, rotting, or other structural damage. Insulation board should not be installed in these areas unless the causes of such moisture problems have been eliminated.

15.2.2 Remove any projecting trim around windows, doors, corners, and at the sills as required to install the insulation.

15.2.3 Identify any termite shields that would be covered by the insulation. Do not install board insulation unless termite shields are effectively extended beyond the insulation and cover to be installed.

15.2.4 Determine edge treatment to be given at corners, sills, windows, and doors.

15.2.5 Identify surface projections, such as electrical outlets, utility meters, and water faucets, which will require special attention.

15.3 INSTALLATION PROCEDURE

15.3.1 If the existing wood siding is sound and left in place, install the insulation board with mechanical fasteners to the wood siding in accordance with the manufacturer's instructions.

When used as exterior sheathing on buildings of more than one story, the insulation board should be fire-stopped at each floor level, at the ceiling of the uppermost story, and in between dwelling units.

15.3.2 If the existing siding was removed, or if the siding consists of light gauge metal over an "insulation board" sheathing, install the organic cellular rigid insulation board with mechanical fasteners to the wall studs or to an existing wood sheathing in accordance with the manufacturer's instructions.

15.3.3 Maintain the clearances around chimneys and vents specified in NFPA 211, Standard for Chimneys, Fireplaces, and Vents. Consult the foam manufacturer for additional requirements regarding the protection of foam from excessive heat.

15.3.4 Cover the insulation board with a suitable weather resistant exterior finish, such as wood, metal or plastic siding, wood or asbestos shingles, or metal lath and stucco.

15.3.5 Attach the cover through the insulation board and to the existing wood siding or sheathing or to the wood frame studs; or attach furring strips or a plywood nailer through the insulation board to the stud wall and attach the finish to the strips or nailer.

15.3.6 Install flashing and trim at windows, doors, corners, and sills so as to preclude the penetration of water into the wall cavity.

15.3.7 Install flashing and seal around any obstructions, such as at water faucets and electrical outlets.

15.3.8 Provide for weepage at the sill plate as required.

15.3.9 Where insulation board is installed on walls that have cavity insulation, provide for moisture control in accordance with the requirements of Table 1.

15.4 POST-INSTALLATION PROCEDURES

15.4.1 Ensure that the required clearances around chimneys and vents have been maintained.

15.4.2 Ensure that all surfaces of insulation board are covered with a suitable weather resistant finish material.

15.4.3 Ensure that joints in trim, flashing, and protective cover at windows, doors, corners, faucets, and electrical outlets are tight and sealed as required.

15.4.4 Ensure that weepage in the cover is provided as required and is free of clogging material.

16. MASONRY WALL EXTERIOR

16.1 APPLICABILITY

16.1.1 This section applies to the installation of organic cellular rigid-board insulation to the exterior of masonry or masonry veneer walls.

16.2 PRE-INSTALLATION PROCEDURES

16.2.1 Ensure that the walls are free of grease, loose paint and material, and major cracks or bulges.

16.2.2 Remove any protruding trim around windows, doors, corners, and at the sill as required to install the insulation.

16.2.3 Identify any termite shields that would be covered by the insulation. Do not install board insulation unless the termite shield is effectively extended beyond the insulation and cover to be installed.

16.2.4 Determine edge treatment to be given at corners, sills, windows, and doors.

16.2.5 Identify surface projections such as electrical outlets, utility meters, and faucets which will require special attention.

16.3 INSTALLATION PROCEDURE

16.3.1 Attach the insulation board to the wall as recommended by the manufacturer.

16.3.2 Maintain the clearances around chimneys and vents specified in NFPA 211, Standard for Chimneys, Fireplaces, and Vents. Consult the foam manufacturer for additional requirements regarding the protection of foam from excessive heat.

16.3.3 Cover the insulation board with a suitable weather resistant exterior finish, such as wood, metal or plastic siding, wood or cementitious shingles, or metal lath and stucco.

16.3.4 Fasten the cover through the insulation board onto the masonry wall; or secure furring strips or a plywood nailer base through the insulation board onto the masonry wall and attach the finish to the strips or nailer base.

16.3.5 Install flashing and trim at windows, doors, corners, and sills so as to drain penetrated water to the outside.

16.3.6 Flash and seal around any obstructions such as at water faucets and electrical outlets.

16.3.7 Provide weepage holes at the sill plate as required.

16.4 POST-INSTALLATION PROCEDURES

16.4.1 Ensure that the required clearances around chimneys and vents have been maintained.

16.4.2 Ensure that the insulation board has been properly covered.

16.4.3 Ensure that all required flashing and sealing has been provided.

16.4.4 Check that necessary weepage at the sill plate has been provided and is unobstructed.

17. ROOF EXTERIOR

17.1 APPLICABILITY

17.1.1 This section applies to the installation of organic cellular rigid-board insulation to the exterior of sloped roofs.

17.2 PRE-INSTALLATION PROCEDURE

17.2.1 Inspect the roof to assure that it is not sagging or showing evidence of rot in shingles, sheathing, or structural members. Do not install insulation on roofs that are not able to support the additional load of the insulation and new roofing system, or over roofs that show signs of rot.

Any corrections to deteriorated conditions of the existing roof, waterproof membranes or flashing should be performed by personnel qualified and approved for such work. Such corrections should be made prior to installing the insulation.

17.2.2 If there are two or more layers of roofing, remove all roofing. Insulation may be applied over a single layer of roofing.

Good roofing industry practice does not allow more than a total of two layers of shingles.

17.2.3 Install nailers the thickness of the insulation board along all edges and along the ridge.

This is to provide a firm basis for attaching plywood overlay at a critical location. Figure 2 illustrates location of nailers.

It is further recommended to install nailers to provide firm support at all plywood overlayment joints.

17.3 INSTALLATION PROCEDURE

17.3.1 Do not install insulation board on roofs over unheated attics.

Such insulation would not save appreciable amounts of energy and is thus not cost-effective.

17.3.2 Install insulation board as recommended by the manufacturer. Use an application method which fastens the insulation to the roof sheathing. Do not use adhesive to fasten the insulation to shingles or roofing felt only.

Maintain the clearances around chimneys and vents specified in NFPA 211, Standard for Chimneys, Fireplaces, and Vents. Consult the foam manufacturer for additional requirements regarding the protection of foam from excessive heat.

Install a plywood overlay, mechanically fastened to the original sheathing, on top of the insulation board and cover the plywood with roofing.

Use proper length roofing nails so as not to penetrate insulation.

Install flashing as required to prevent penetrating into the space between new and old roofing.

17.4 POST-INSTALLATION PROCEDURES

17.4.1 Ensure that the required clearances around chimneys and vents have been maintained.

17.4.2 Ensure that the new roofing entirely covers the insulation.

17.4.3 Ensure that all flashing is properly installed, particularly at edge nailers, dormers, chimneys, or where the roof adjoins vertical wall sections.

18. CERTIFICATION

18.1 Comply with the "Certification Procedures for the Installation of Thermal Insulation."

TABLE 1. MOISTURE CONTROL REQUIREMENTS APPLICABLE TO THE INSTALLATION OF RIGID BOARD THERMAL INSULATION ON FRAME WALLS

MATERIAL	WHERE INSTALLED	WALL CAVITY	REQUIREMENT
Board with vapor barrier facings (Also boards which are rated by the manufacturer to have a water vapor permeance of less than 57 μ/kPa•s•m^2 (1 perm) in the thickness in which they will be installed)	Interior	filled or empty	No additional winter-warm side vapor barrier
	Exterior	filled	In Zones 1 and 2 of Figure 1, vapor barrier on the winter warm-side and sealing of interior cracks
	Exterior	empty	No additional winter warm-side vapor barrier
Board without vapor barrier facings having boards or a permeance of 57 μ/kPa•s•m^2 (1 perm) or less.	Interior	filled or empty	In Zones 1 and 2 of Figure 1, vapor barrier on the winter warm-side and sealing of interior cracks
	Exterior	filled	In Zones 1 and 2 of Figure 1, vapor barrier and sealing of interior cracks only in bathrooms and other high moisture areas
	Exterior	empty	No additional winter warm-side vapor barrier required

FIGURE 1 - CONDENSATION ZONE MAP.

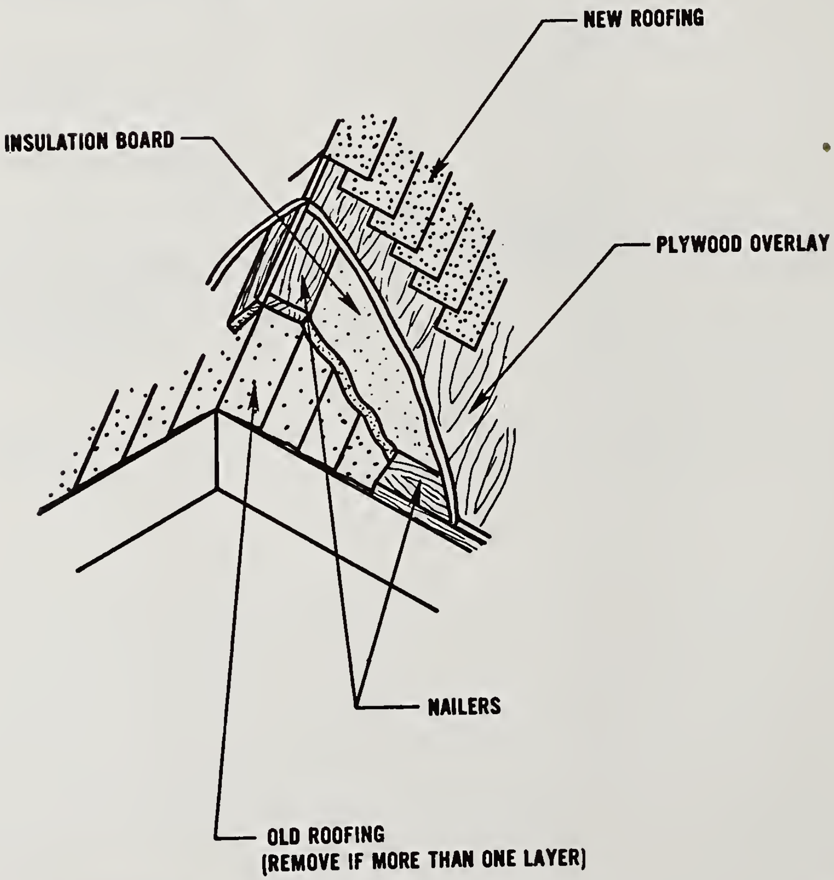

FIGURE 2 - INSTALLATION OF ORGANIC CELLULAR RIGID-BOARD THERMAL INSULATION ON ROOF.

INTERIM STANDARD PRACTICE FOR THE INSTALLATION OF UREA-FORMALDEHYDE FOAMED-IN-PLACE INSULATION

This practice is an interim standard pending the results of research on potential health effects of UF foam, sponsored by the Consumer Products Safety Commission.

To be compatible in form and style with the other practices, this practice was slightly revised editorially from that published in the Federal Register.

1. SCOPE

1.1 This practice covers the installation of urea-formaldehyde (UF) foamed-in-place insulation in masonry and frame wall cavities of existing residential buildings.

1.2 This practice covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the manufacture of the material components, but it does cover the process of combining components to form foam and it also covers field quality control procedures.

1.3 This practice provides minimum requirements that will help to ensure the installation of insulation in a safe and effective manner. It must be noted that actual conditions in existing buildings vary greatly and in some cases substantial additional care and precaution may have to be taken to assure effective and safe installation.

1.4 This practice covers aspects of installation relating to the safety of installers, building occupants and property, effectiveness and durability of insulation in service, and the prevention of related structural damage to the residence.

1.5 A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

1.6 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

1.7 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.8 *This practice describes in general terms the procedures to follow for a safe and effective installation. It does not describe in detail the terminology and fundamentals of residential construction, or the codes or regulations that may be imposed by other Federal, State, or local agencies.*

2. APPLICABLE DOCUMENTS

ASTM[1] C 168-80a: Standard Definition of Terms Relating to Thermal Insulating Materials.

ASTM C 755-73 (1979): Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulation.

NFPA[2]- 31: Standard for the Installation of Oil Burning Equipment.

NFPA-54: National Fuel Gas Code.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, durability, prevention of related structural damage, and safety of insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation may reduce its thermal effectiveness, cause damage to the structure and cause unsafe conditions.*

3.3 *Specific hazards that can result from improper installation include:*

Fire caused by heat buildup from recessed lighting fixtures covered by insulation;

Deterioration of wood structures, paint failures, and corrosion of metal fasteners and electrical components caused by prolonged moisture accumulation within building components;

Acceleration and aggravation of the deterioration or failure of electrical wiring components and heat buildup resulting from overcurrent protection devices (fuses and circuit breakers) incorrectly matched to wire; and

Unpleasant odor for prolonged time after installation.

3.4 *The potential for adverse health effects is currently the subject of extensive study by the Consumer Products Safety Commission (CPSC).*

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[1] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

[2] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210

4. DEFINITIONS

4.1 Certain technical terms relating to insulation not defined below are used in this subpart in accordance with the definitions given in ASTM C 168-67.

Approved - acceptable to whatever authority regulates the activity or material and its use. Such authority is usually a municipal, State, or Federal agency or underwriters' inspection or rating bureau.

Conditioned Space - any space in a residential building that is served by a heating or cooling system.

Foamed-in-place - sprayed or pumped in place to form rigid or semi-rigid insulation in its permanent location.

Independent test laboratory - a test facility which has no organizational tie or financial interest in a manufacturer, or in the promotion of the type of product being tested. It must have sufficient breadth of interest or activity so that the loss or award of a specific contract for test services would not be a substantive factor in financial well-being of the facility. It may offer test services under contract or on a fee basis and may be a profit or non-profit activity.

Insulation installer (installer) - the person who combines the component materials and foams the insulation in place.

Insulation manufacturer (manufacturer) - the organization or person that supplies the resin, foaming agent, and other ingredients to the foam insulation distributor and/or installer.

Unconditioned space - any space, out of doors or in a residential building, which is not served by a heating or cooling system.

Urea-formaldehyde foam insulation (UF foam) - A cellular plastic material generated in a continuous stream by mixing the components which are a urea-formaldehyde resin, air, and a foaming agent.

Vapor barrier - any material (as defined in ASTM Designation C 755-73) that has a water vapor permeance (perm) rating of one (1) or less.

The following materials, upon proper application, constitute vapor barriers: Asphalt impregnated kraft paper, aluminum foil, plastic film such as polyethelene and paint and wallcoverings which are labeled by the manufacturer as having a perm rating of one (1) or less when applied in accordance with the manufacturer's instructions.

5. MATERIALS

5.1 Under RCS, install only urea-formaldehyde component materials identified as complying with DoE standards.

This marking indicates that the component manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program.

5.2 Under RCS, the component materials manufacturer must have a continuing annual program of product testing by an independent laboratory. When accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP) is available, such independent laboratory tests must be performed by NAVLAP accredited laboratories.

DoE has requested that the Department of Commerce incorporate UF-foam test procedures into the National Voluntary Laboratory Accreditation Program (NVLAP).

6. SAFETY PRECAUTIONS

6.1 PRECAUTIONS RELATED TO THE INSTALLER

6.1.1 Wear safety equipment to protect hands and eyes against acid contained in the chemicals.

6.1.2 Avoid contact between the uncombined chemical components of UF-foam and building materials to prevent staining or corrosion.

6.1.3 Follow label instructions regarding hazards related to the materials.

6.1.4 Observe all safety rules provided by the installation equipment manufacturer. Properly set relief valves on pressurized liquid and air vessels and exercise care in the use of electrical power tools.

6.1.5 Keep all persons not involved in the installation a safe distance from work areas and installation equipment.

6.1.6 Maintain proper ventilation on the job to prevent excessive exposure to formaldehyde gas.

6.1.7 Follow the manufacturer's instructions for storage of UF-foam components and follow proper methods of disposal of old or unusable resin and foaming agent solutions.

6.2 Precautions related to occupant and building safety.

6.2.1 *UF foam should not be installed in cavities which contain electrical cables of circuits with improperly matched overcurrent protection devices because such cables could reach temperatures above those permitted by the National Electrical Code (NEC). Accordingly, prior to installing insulation, it should be ascertained that all electrical circuits have correctly matched overcurrent protection devices. See Part I, Section 4.2.1 for further discussion.*

6.2.2 *Edison-type fuses should be replaced with S-type fuse adaptors; where incorrectly matched circuit breakers are installed, they should be replaced with correct ones.*

6.2.3 *Because code rubber wires have a lower NEC-allowed temperature limit, no insulation should be placed in cavities containing such wire until the electrical system has been inspected by an approved electrician. Code rubber wiring is usually found in houses built prior to 1940. See Part I, Section 4.2.1 for further discussion.*

7. INSTALLER REQUIREMENT

7.1 Under RCS, the installation of UF-foam may be performed only by insulation installers trained and certified by the material components manufacturer.

The DoE interim material standard for UF-foam provides a complete list of subjects to be covered by the component material manufacturer's training activity. The relevant section of the material standard 456.810(d)(12) is appended to this practice as Appendix C.

7.2 Persons installing UF foam must have a working knowledge of the applicable codes and regulations, tools, equipment, and methods necessary for the installation of thermal insulation materials. These persons are also required to have an understanding of the fundamentals of residential construction that affect the installation of insulation.

The rigorous training and qualification requirements for persons installing UF foam is deemed appropriate as one element that can help to assure that this insulation material is installed in a safe and effective manner. The requirements are responsive to the fact that the installation of UF-foam is more complex, requires greater care, and is subject to more errors than the installation of other insulation materials.

8. EQUIPMENT

8.1 Use only equipment which has been recommended by the manufacturer for use with the manufacturer's product.

The use of equipment not properly matched to the specific component materials can lead to incorrect mixing and an unsatisfactory installation.

8.2 Ensure that hose lengths conform to the insulation manufacturer's requirements.

8.3 Check the equipment for proper functioning and cleanliness before starting a job. Clean and maintain the equipment according to the equipment manufacturer's instructions but at a minimum, at the following intervals:

Before installing each new batch of UF foam.

After every down time of more than 15 minutes.

At the conclusion of the installation process.

Proper functioning of equipment is essential for safety and effectiveness of UF foam-in-place insulation. Cleanliness is a major element in assuring proper functioning.

9. FOAM GENERATION AND FIELD QUALITY CONTROL PROCEDURES

9.1 Follow the manufacturer's instructions for generating the foam.

In addition to general application guidelines, different products require specific foam generation techniques because of differences in component material formulation from manufacturer to manufacturer. Quality control procedures specific to individual products are not covered in this practice.

9.2 Do not use containers of resin or foaming agent after the shelf-life expiration specified on the container labels by the manufacturer.

Chemical reactions take place continuously in the container. When these reactions have taken place to a certain (product specific) degree, proper mixing and curing of the foam components is no longer possible.

9.3 Use only materials supplied by the same insulation manufacturer and, where that manufacturer supplies more than one product, ensure that the individual components to be combined are compatible.

The manufacturer formulates individual component materials which are compatible to produce a foam with specific properties and characteristics. If incompatible components are combined, the foam may not meet applicable standards.

9.4 Handle all insulation materials in accordance with the manufacturer's instructions. Keep powdered products dry and free of extraneous materials.

9.5 Perform all field quality control checks prescribed by the manufacturer. At a minimum, perform the following checks at the specified frequencies:

9.5.1 Setting time (gel time). Test in accordance with Standard for Urea-Formaldehyde Foamed-in-Place Insulation [see Appendix A]. Test before installation each day on each job for each material batch. Check setting time after any change in chemical concentration. Setting time must conform with the manufacturer's recommendations for the type of structure and procedure being used but shall not exceed 60 seconds nor be less than 10 seconds.

See 11.12 for additional requirement regarding setting time to cavity size.

9.5.2 Wet density. Test in accordance with Standard for Urea-Formaldehyde Foamed-in-Place Insulation [see Appendix B], and ensure that wet density is within manufacturer's specifications. Check the wet density prior to each new job and new batch of materials, and after each down time of at least 45 minutes. Whenever changing from an empty to full container, the density must be retested.

The density must also be repetitively tested throughout the foam-making period at a frequency depending on the setting time: for a set time of 20 seconds, check the density at intervals of no more than twenty (20) minutes; for a 60 second set time, check the density at intervals of no more than sixty (60) minutes.

For each manufacturer's system, there is a correlation between wet and dry density. Thus the wet density provides a measure on whether the foam will meet the manufacturer's intended dry density.

9.5.3 Ratio of resin to foaming agent. Determine the ratio of resin to foaming agent for each batch of materials on each day on each job by measuring the number of gallons of each liquid used.

Assure that ratio is in agreement with that specified by the manufacturer of the component materials. If the ratio is found not to be in agreement with the specification determine why the ratio is out of specification. Adjust equipment to correct the problem. Recheck setting time and wet density, and redetermine ratio of resin to foaming agent on a small test batch.

9.5.4 Temperature of liquids. The temperature of the liquids shall be within the acceptable range specified by the manufacturer.

Proper chemical reaction and handling requires for materials to be within specified temperature ranges.

9.5.5 Specific gravity of dilute resin. Check the specific gravity of each batch of dilute resin with a hydrometer to ensure that the specific gravity is within the upper and lower limits specified by the manufacturer. Do not use materials whose specific gravity is out of range.

During the measurement of specific gravity, assure that material is thoroughly mixed and is not stratified.

9.5.6 Water temperature and hardness. When reconstituting powdered UF foam components, ensure that the water temperature and hardness are within the acceptable ranges specified by the manufacturer. Maintain a reconstitution record for each batch of material prepared.

The solubility of the dry resin in water is affected by temperature and hardness of water. If the resulting resin solution does not have the correct concentration, poor foam will result.

9.5.7 Ensure that the foam is characterized by uniform cell distribution.

Conduct a visual inspection of slices of the setting time sample taken in 9.5.1.

9.6 Maintain a record of the results of all field quality control checks and of other pertinent information required by the manufacturer, including, but not limited to:

Date of application;
Outdoor ambient air temperature;
Material lot number(s);
Expiration date(s) (shelf-life);
Equipment identification number.

10. PRE-INSTALLATION PROCEDURES

10.1 Inspect and identify areas where a previous moisture problem has caused paint peeling, warpage, stain, visible fungus growth, rotting, or other structural damage. Do not install insulation in such areas until the resident has been notified and these conditions have been corrected and their source(s) eliminated. If the resident, after being informed of the moisture condition and the effects of installing insulation in such areas, elects to proceed with the installation, the resident must so state in writing on the contract.

Installing insulation in an area which exposes it to moisture may contribute to further deterioration of the structure and loss of effectiveness of the insulation. Insulation in such areas may prolong exposure of components to moisture, creating a potential for fungus growth and rotting. DoE recommends against installing insulation in the immediate area of the moisture damage. Immediate area is defined as the stud or joist space(s) in which prior moisture problems were observed. For further information regarding the identification and evaluation of previous moisture problems, see Part I, Section 4.1.1.

10.2 Block all openings in sidewalls through which the insulation material may escape. Seal all wall cavities which open into an attic, basement, or crawl space prior to installing insulation.

It is especially important to ensure that all wall cavities are sealed properly in homes of balloon frame construction (see figure 1) since open-ended cavities are inherent in this type of design. Also, seal around plumbing and electrical openings, particularly beneath sinks, to prevent filling up a cabinet below the sink.

10.3 For buildings located in Zone I of Figure 2, provide a vapor barrier on the interior surface of all walls to be insulated in bathrooms and unvented kitchens and laundry areas. Caulk or seal all major cracks on the interior face of exterior walls of these rooms including joints between the floor and wall (except where impractical because of carpeting), between wall and ceiling, at joints around window frames, and around wall penetrations for electrical services (outlets and switches), plumbing stacks, and heating and air-conditioning ducts.

It is recommended that a vapor barrier and caulking, such as described in this section, also be provided on all walls to be insulated in bathrooms and unvented kitchens and laundry areas in buildings in Zone II of Figure 2.

The above requirements for moisture control are minimum requirements needed to prevent long-term moisture damage. Homes which are characterized by one or more of the following conditions are more likely to experience excessive moisture accumulation which can be corrected by application of a vapor barrier and caulking as described above and/or additional venting of the wall cavity from the exterior or by additional ventilation of the occupied space:

(a) Homes with an area of less than 75 m^2 (800 ft^2)

(b) Homes with less than 23 m^2 (250 ft^2) per occupant.

(c) Homes with tight wall and ceiling construction and weatherstripped windows and doors.

(d) *Electrically heated homes or homes with a heating system which uses outside combustion air.*

(e) *Homes humidified during the winter.*

A relative humidity indicator may be installed to monitor the humidity level and determine when excessive moisture accumulation is likely to occur. See Part I, Section 4.1.2 for discussion on use of relative humidity indicator.

10.4 Examine the material on the indoor side of wall cavity. Ensure that it has a finish rating of at least 15 minutes when tested in accordance with ASTM E 119-76. Gypsum board 12.5 mm (0.5 in) thick installed according to the manufacturer is deemed to have the required rating.

UF-foam insulation should not be installed if the indoor side of the wall cavity does not have the required finish rating. Some UF foam manufacturers do not recommend applying foam directly against certain types of wall coverings, such as wood and particle board. Check with the manufacturer prior to installation.

10.5 Determine if the structure has dissimilar metals with large surface areas exposed in the same cavity. (Since the foam is wet with mild acidity, rapid electrochemical corrosion can take place.) Contact the manufacturer to obtain assistance with such application, and follow the manufacturer's recommendations.

An example condition that might lead to electrolytic corrosion following UF-foam insulation installation is an exterior wall cavity enclosing both copper plumbing lines and aluminum electric wiring.

10.6 Inspect window frames. Identify any windows which contain internal mechanisms such as springs, counterbalance weights, friction strips, etc. in their frames. Follow the manufacturer's specific installation procedures for foaming these areas.

Incorrect foaming around windows with internal mechanisms can immobilize the mechanism and prevent future opening or closing of the window.

10.7 Provide the customer with a statement identifying the effective thermal resistivity of the material to be installed, as determined by the test method in the DoE material standard for Urea-Formaldehyde Foamed-in-place Insulation, and a statement containing the safety information contained in Appendix D.

11. INSTALLATION PROCEDURES

11.1 Do not install insulation unless the pre-installation procedures have been carried out and any defects which were identified were corrected and their causes eliminated.

The purpose of the pre-installation procedures is to assure that the installation can be carried out effectively and without adverse side effects detrimental to other building components and materials. For lasting results, it is important not only to correct symptoms, such as replacing rotten wood, but to eliminate the source of the defect, such as water leaks which promoted the rot in the first place. In many instances corrective measures can be taken with relative ease prior to *the installation of insulation. After installation, correction may be more difficult and costly.*

11.2 Do not install insulation unless all field quality control and equipment checks required to be performed prior to installation have been completed. Conduct tests as required during the installation.

11.3 Install UF-foam in exterior sidewalls only. Do not install the material in attics, above ceilings, in knee walls, under floors or below grade, between a dwelling and other spaces, such as garages or storage areas, and in mobile homes.

High temperatures and humidity in attics and above ceilings may cause hydrolytic deterioration of the foam resulting in offgassing of formaldehyde vapors. Because the vapors are denser than air, they may sink into the living spaces below.

Attic kneed walls face similar conditions as atttics.

Under floors or below grade, installations are likely to have high relative humidities. Also, vapors and moisture can not be vented to the exterior of the residence.

The installation of UF-foam in walls with both sides facing enclosed spaces does not permit the rapid venting of vapors and moisture to the exterior of the residence.

Most mobile homes have an impermeable exterior metal skin which restricts venting to the outdoors.

11.4 Operate all installation equipment in accordance with the equipment manufacturer's instructions.

11.5 Structural damage can be caused by excessive pressure during installation or can result from installing UF-foam insulation in constructions too weak to withstand normal pressures. Assure that installation does not cause the failure of the wall construction or its components. Specifically, the following conditions must not result from the installation:

Separation of finish materials from studs

Cracking of materials or openings of joints betweeen boards

Deflection of more than 1/200 of the stud spacing.

11.6 Open all entry holes with a technique that permits refinishing with little or no change in appearance.

11.7 Do not install insulation in wall cavities which themselves are air ducts for heating, ventilation, and/or cooling systems.

11.8 Do not install insulation when the atmospheric relative humidity, or outdoor ambient temperature, or cavity temperature is not within the acceptable range specified by the manufacturer.

Ambient conditions affect the curing of the foam. The limits of acceptable ambient conditions differ with the products formulated by different manufacturers.

11.9 Install insulation only in cavities which will preclude contact by the insulation with the ground or other sources of water.

11.10 UF-foam is a combustible material. Install UF-foam so as to meet the applicable requirements listed below:

If a wall cavity contains recessed lighting fixtures or other heat-producing devices, either provide a three-inch minimum clearance around the recessed lighting fixtures (including wiring compartments and ballasts) and other heat-producing devices not covered in paragraph (B) or do not install UF-foam in the cavity containing such heat producing device(s). Do not cover these devices so as to entrap heat or prevent the free circulation of air, unless they are approved for such purpose.

Provide the minimum clearances around gas-fired appliances specified in NFPA-54, the National Fuel Gas Code. Around oil-fired appliances, provide the minimum clearances specified in NFPA-31, Standard for the Installation of Oil Burning Equipment. Around masonry chimneys or masonry enclosing a flue, provide a minimum two-inch clearance from the outside face of the masonry. Around vents, chimney and vent connectors and chimneys other than masonry chimneys, provide the minimum clearances specified in NFPA-211, Standard for Chimneys, Fireplaces, and Vents.

11.11 Remove any foam which is inadvertently sprayed on glass or exterior siding before drying occurs.

The foam can permanently stain the siding and may be hard to remove after drying.

11.12 Setting time must be sufficient in duration to permit complete filling of the cavity before setting begins.

Depending upon the application technique, larger cavities may need longer setting time than that required for small cavities. See also section 13.4 for additional applicable criteria for setting time when applying foam in continuous masonry wall cavities.

12. INSTALLATION PROCEDURE - FRAME WALLS

Insulation frame construction walls (including masonry veneer construction) by either Method A or B.

12.1 METHOD A

12.1.1 Do not foam cavities in excess of 3 m (10 ft) in height by this method.

12.1.2 Make an entry hole (fill port) between half and three quarters of the way up the wall. Make the fill port at least 12.5 mm (1/2 in) larger in diameter than the outside diameter of the hose to allow air relief and maneuvering of the hose.

12.1.3 Probe the cavity for blockages and make additional fill ports as necessary to ensure complete filling of the cavity. For a typical layout of fill ports, see Figure 3.

12.1.4 Insert the applicating hose into the cavity within approximately 50 to 100 mm (2 to 4 in) from the bottom (see Figure 4, Position "A").

12.1.5 Retrieve the hose at a rate approximately equal to the rate of foam dispensation unless the manufacturer specifically recommends that the hose remain at the extremity of the cavity for the total filling time.

12.1.6 When the foam reaches the level of the fill port repeat the procedure for the upper part of the cavity (see Figure 4, Position "B").

12.2 METHOD B

12.2.1 This method may be used to foam cavities in excess of 3 m (10 ft) in height as well as shorter cavities.

12.2.2 For each unobstructed cavity, make at least three entry holes which correspond to the size of the applicating hose (or adaptor, if used). Place the fill ports at approximately 1200 mm (4 ft) from the bottom and 450 mm (1-1/2 ft) from the top of the cavity (see Figure 5). An air relief hole may also be provided at the very top of the cavity.

12.2.3 Place the applicating hose up to or just inside the bottom fill port and dispense the foam until the next fill port level is reached.

12.2.4 Repeat this procedure by foaming through the top level fill port until foam reaches the center fill port.

13. INSTALLATION PROCEDURES -- MASONRY CAVITY WALLS

13.1 This method applies to the installation of UF foam in masonry cavity walls consisting of concrete block, brick, or brick and block. Do not apply this method to brick veneer on wood frame construction. Attempts to fill brick veneer construction by this method may cause buckling, breaking, or other damage to the walls. Brick veneer construction should be foamed in accordance with the instructions for frame construction in paragraphs 12.1 and 12.2.

13.2 The internal void area (cavity) in masonry wall constructions usually runs the entire distance of the wall. Provide holes at 900 mm (3 ft) -- intervals along the horizontal distance of the wall at 600 mm (2 ft) -- intervals along the vertical distance of the wall. Begin the bottom-most row of holes at a distance of between 300 and 600 mm (1 and 2 ft) from the bottom of the wall cavity.

Application of this method requires that the wall cavity is continued over a length greater than typical stud spacing. It may not be applicable to masonry walls with window or door openings at frequent intervals.

13.3 Begin foaming at one of the bottom corners of the wall and continue foaming until foam is detected at the horizontally adjacent hole.

13.4 Ensure that the setting time is longer than the time it took the foam to travel between the horizontal holes.

13.5 Move to the adjacent horizontal hole and repeat the procedure specified above.

13.6 After the bottom row has been foamed, proceed to the next row and repeat the procedure until the entire wall has been filled.

14. INSTALLATION PROCEDURE -- WALLS WITH EXTERIOR METAL SURFACES

Buildings with a metal exterior surface require special installation techniques. UF foam should not be installed in these buildings unless adequate means are provided to allow for moisture and other vapor to escape to the outside. Follow the manufacturer's specific instructions for application of foam to these types of structures.

15. INSTALLATION PROCEDURE -- WINDOW AND DOOR FRAMES

15.1 Do not apply UF-foam to window and door frames until after the walls have been insulated.

15.2 Drill entry holes which correspond to the size of the applicating hose (or adaptor, if used) into the void areas around the frames. Drill holes into the fascia of the frame wherever possible.

15.3 Foam each entry hole until foam appears at the adjacent hole or until foam emerges from cracks in and around the moldings.

15.4 If the window has any moving parts within the space to be insulated, work the mechanism of the closure. For a fast setting time (10 seconds) work the mechanism within 15 minutes of filling. For a slow setting time (60 seconds) work the mechanism within 30 minutes of filling.

This procedure will ensure that the interior mechanisms of the unit remain operative after the installation of UF-foam insulation.

16. POST-INSTALLATION PROCEDURES

16.1 Seal all entry holes on the exterior of the wall system in a manner compatible with the original materials and appearance. Seal all entry holes on the interior of the wall system immediately following the completion of foaming.

16.2 Determine if many coats of exterior paint or caulking form an impermeable vapor barrier on the exterior wall. Take corrective measures, such as loosening up the siding, removing caulking between wood laps, or installing vents/diffusers, to reduce the effect of moisture barrier and allowing drying to take place. Ensure that the venting provided does not result in rain water leakage into the wall system.

Substantial amounts of water are introduced in the wall cavity during foaming. This water, in the form of water vapor, should be allowed to escape from the cavity to the outdoors. A tight moisture barrier at the outside face of the wall will either result in a potential for increased venting to the indoors (with potential odor and health problems) or may be retained in the wall cavity, possibly leading to fungus growth and rot problems.

16.3 Inspect the interior of electrical wall outlet boxes and other electrical devices and, where necessary, remove any insulation which entered during the foaming process. Ensure that electrical power has been turned off prior to conducting this procedure.

16.4 Ensure that windows and doors operate properly.

16.5 Ensure that any insulation which has come in contact with glass, aluminum, or vinyl building components or has otherwise permeated the interior of the residence has been cleaned off.

16.6 Offer the customer a sample of the foam installed at the customer's premises, at no cost to the customer. The sample must be approximately the size required for the dry density test, packaged in a manner to prevent deterioration for at least three years.

16.7 Comply with the "Certification Procedures for the Installation of Thermal Insulating Materials.

APPENDIX A

EXCERPT FROM INTERIM STANDARD FOR UREA-FORMALDEHYDE FOAMED-IN-PLACE INSULATION 456.810 (f)
(*Federal Register*, September 25, 1980)

(9) Test Method for Setting Time

A conical specimen with a bottom diameter of approximately 30 cm (12 in) and a height of approximately 30 cm (12 in) shall be made by foaming from a hose. Start a stopwatch immediately after the cone has been formed and immediately commence slicing the cone with a spatula. Record the time when the foam no longer slices as if it were whipped cream but shears off leaving a smooth surface. This time is the setting time.

APPENDIX B

EXCERPT FROM INTERIM STANDARD FOR UREA-FORMALDEHYDE FOAMED-IN-PLACE INSULATION 456.810(f)
(*Federal Register*, September 25, 1980)

(5) Test Method for Wet Density

Weight to the nearest gram a measured quantity of freshly foamed material in a tared container within five minutes after formation. Calculate wet density using the formula:

$$\text{Density in kg/m}^3(\text{lbs/ft}^2) = 1000 \times \frac{\text{Weight of Foam and Container in g (lbs)} - \text{Tare Weight of Container in g (lbs)}}{\text{Volume in cm}^3\ (\text{ft}^3)}$$

APPENDIX C

EXCERPT FROM INTERIM STANDARD FOR UREA-FORMALDEHYDE FOAMED-IN-PLACE INSULATION 456.810(d)
(*Federal Register*, September 25, 1980)

(12) Training Requirements

(i) The manufacturer of the UF-foam components shall train and certify the installers of UF foamed-in-place thermal insulation. An approved training course and comprehensive examination shall require and demonstrate proficiency in the following:

(A) Overview of heat transfer and thermal insulation

- (1) condensation control/vapor barriers
- (2) effects of moisture on thermal insulations
- (3) air infiltration

(B) Overview of UF-foam insulation

- (1) physical properties
- (2) mechanical properties
- (3) thermal properties
- (4) chemical properties

(C) UF-foam technology

- (1) manufacture and composition of UF-foam components, i.e., resin and catalyst solutions
- (2) chemical reactions during production of UF-foam and of final foamed product
- (3) field manufacture of UF foam *in situ*

(D) Post-installation curing of UF foam

(1) shrinkage
  (i) normal
  (ii) excessive
(2) formaldehyde release
  (i) inherent post-installation release
  (ii) possible delayed release
  (iii) solids content of components and foam
  (iv) factors affecting rate of drying

(E) Installation procedures

(1) general guidelines
  (i) vapor barriers
  (ii) wall venting
  (iii) drilling and plugging requirements
  (iv) problem installations
(2) specific guidelines (covers opening and closing techniques and equipment and tools to use)
  (i) brick-on-brick
  (ii) concrete block
  (iii) brick veneer on frame construction
  (iv) drill and plug
  (v) wood shingle and wood shake siding
  (vi) slate shingles
  (vii) aluminum, vinyl, and steel siding
  (viii) clapboard wood siding
  (ix) metal-clad buildings
  (x) stucco and pebbledash
  (xi) imitation brick asphalt roll or sheet
  (xii) balloon construction
  (xiii) pipe chases
  (xiv) windows and door frames

(F) Problem applications

(1) knee walls
(2) mobile homes
(3) ceilings
(4) below grade

(G) Proper cavity fill techniques

(1) stud cavity
  (i) check for obstructions
  (ii) how to determine number of holes per cavity necessary for complete fill
  (iii) methods of preventing overpressurized or ruptured walls
  (iv) demonstration of proper fill technique
(2) continuous cavity, i.e., brick-on-brick
  (i) methods of preventing overpressurized or ruptured walls
  (ii) demonstration of proper fill technique
(3) other cavities
  (i) methods of preventing overpressurized or ruptured walls
  (ii) demonstration of proper fill techniques

(H) Resin and foaming agent/catalyst handling

(1) storage conditions
(2) solution temperatures during application
(3) shelf life

(4) safety precautions
(5) shipping requirements

(I) Practical demonstration

(1) proper foaming technique
(i) pre-foaming quality control checks
(ii) pre-installation quality control checks
(iii) quality control checks during installation
(2) trouble shooting off-specification foam
(i) off-ratio foam
(ii) incorrect density foam
(iii) overaged resin
(iv) incorrect solution temperatures
(v) faulty, malfunctioning, or inadequate equipment
(vi) overacidified or underacidified foaming agent
(vii) effects of using equipment not properly maintained

(J) Equipment

(1) manufacturer's recommended equipment
(2) proper care and maintenance
(3) troubleshooting

(K) Recordkeeping

(1) required disclosures to consumer
(2) manufacturer's required recordkeeping

APPENDIX D

Interim Standard for Urea-Formaldehyde Foamed-in-Place Insulation, §456.810 (d) (11) (ii).

This product may release formaldehyde gas into your home over a long period of time.

Formaldehyde gas may cause eye, nose, and throat irritation, coughing, shortness of breath, skin irritation, nausea, headaches, and dizziness. People with respiratory problems or allergies may suffer more serious reactions, especially persons allergic to formaldehyde.

The symptoms may appear immediately, or not until months after installation.

The U.S. Department of Energy recommends application of U-F foam in exterior sidewalls only, because other installations may increase the likelihood of formaldehyde release into the home. In some instances the formaldehyde gas cannot be controlled by ventilation or other means.

If you have health concerns, call your doctor. Also, contact (installer-phone) or (material supplier-phone).

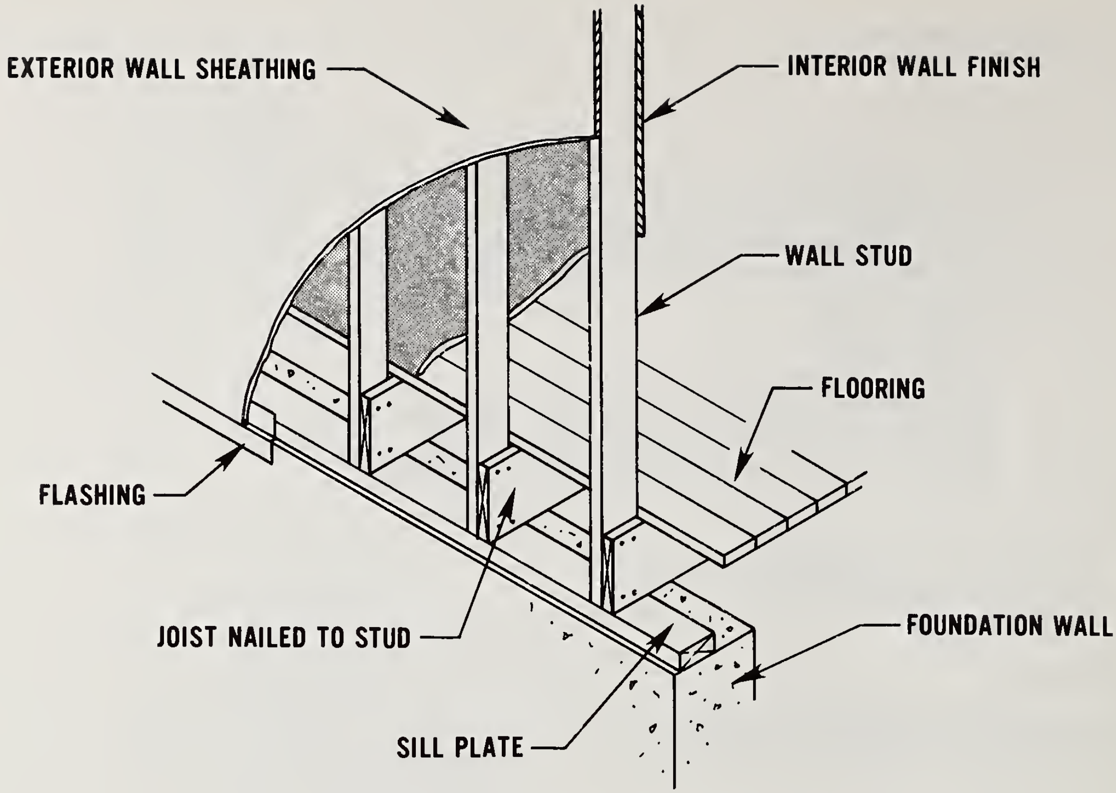

FIGURE 1 - BALLOON FRAME CONSTRUCTION.

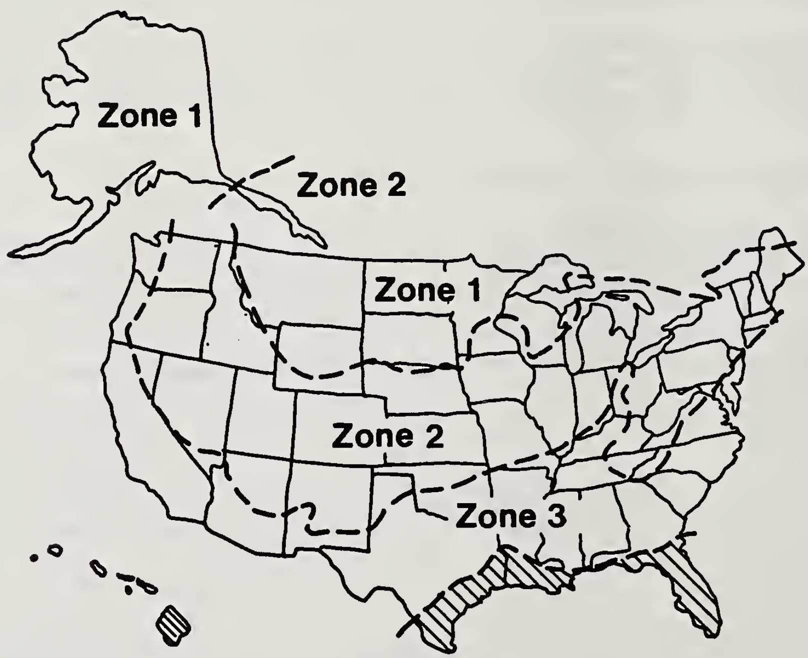

FIGURE 2 - CONDENSATION ZONE MAP.

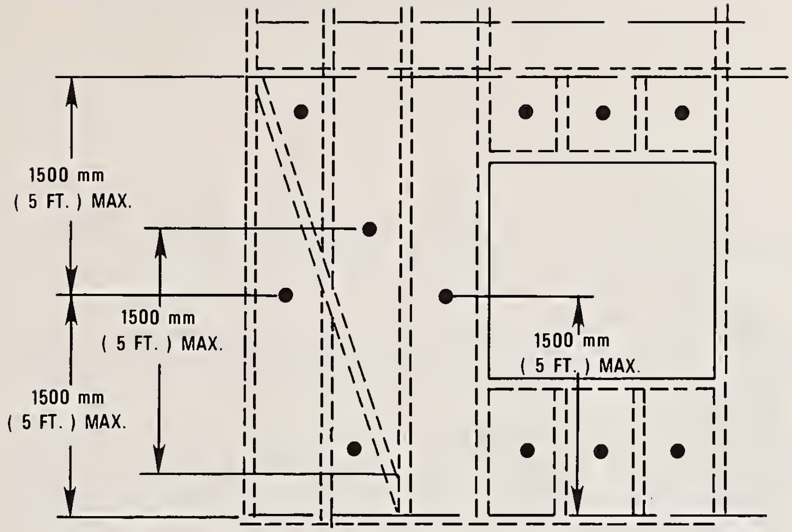

FIGURE 3 - FILL PORT LAYOUT IN FRAME CONSTRUCTION, METHOD A.

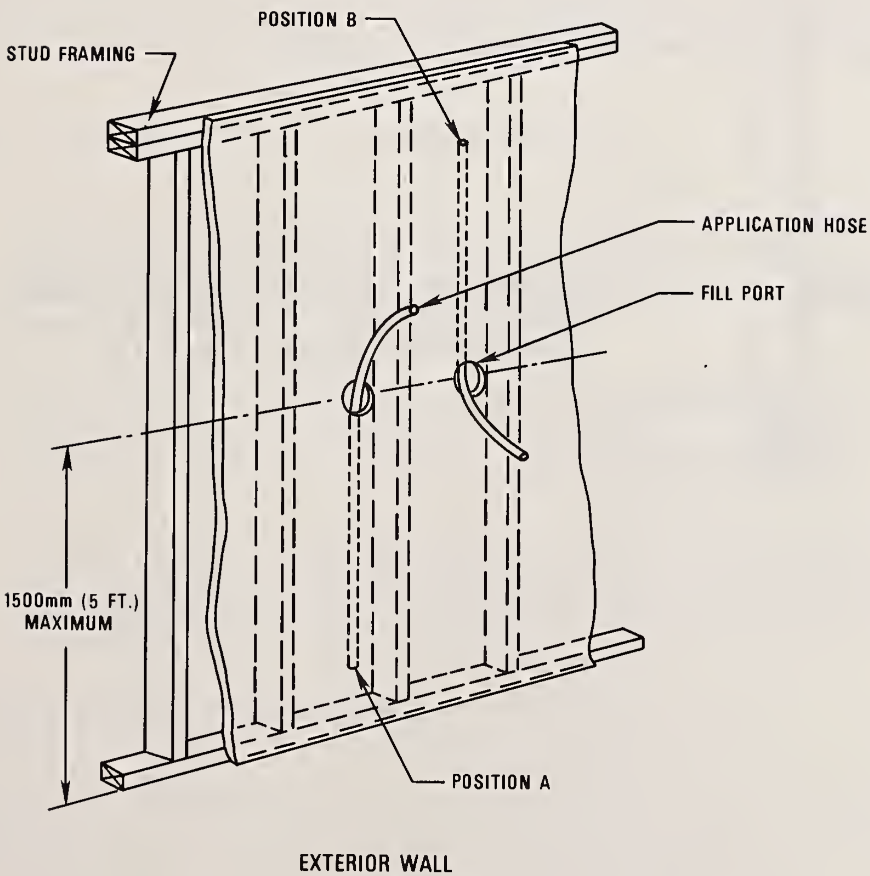

FIGURE 4 - POSITIONS OF APPLICATION HOSE, METHOD A.

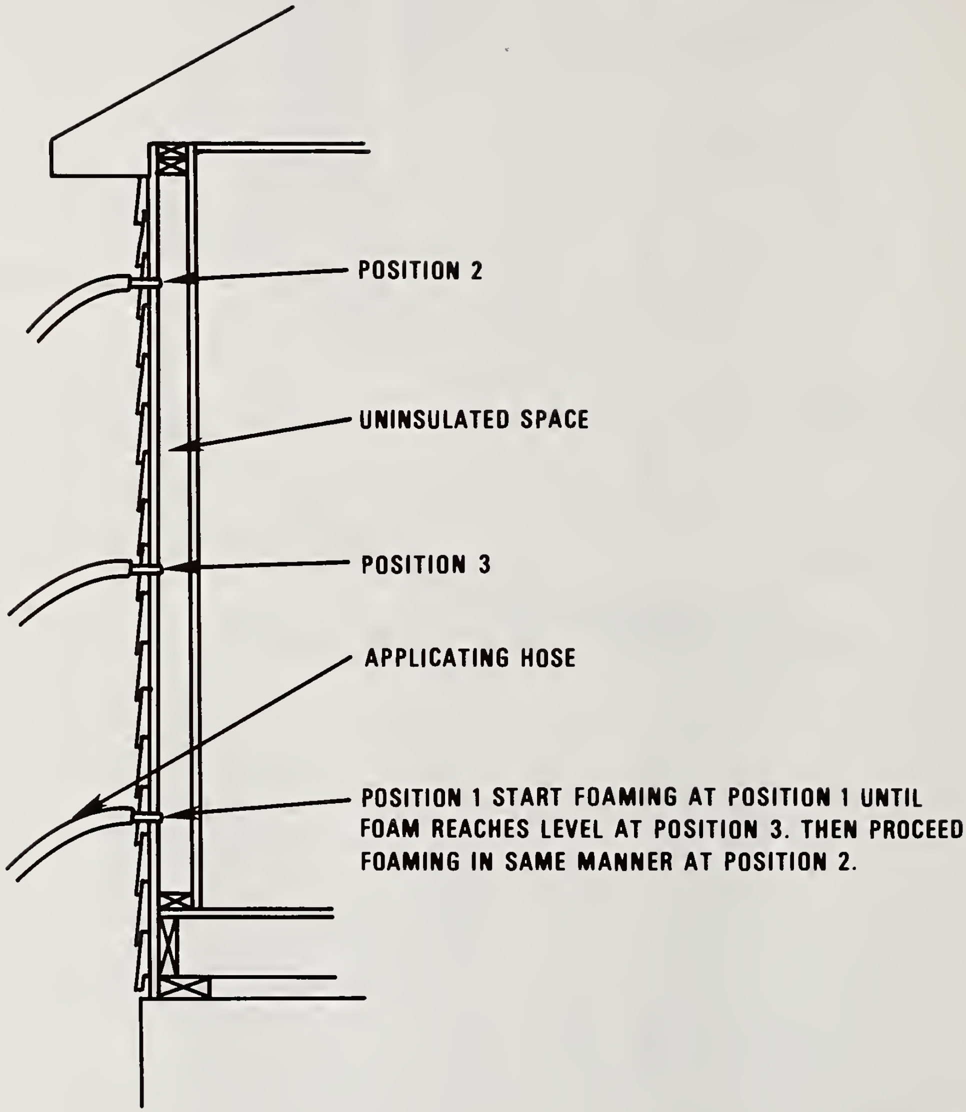

FIGURE 5 - FILL PORTS IN FRAME WALL, METHOD B.

STANDARD PRACTICE FOR THE INSTALLATION OF REFLECTIVE INSULATION

1. SCOPE

1.1 This practice covers the installation of reflective (aluminum foil) insulation in ceilings, attics, floors and wall cavities of existing residential buildings.

1.2 A working knowledge of the terminology and fundamentals of construction and applicable codes is necessary for the proper application of this standard.

1.3 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

1.4 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.5 This practice further:

Describes, in general terms, the procedures to follow so that a safe and effective installation is assured. It does not describe in detail the terminology and fundamentals of residential construction, or the codes or regulations that may be imposed by other Federal, State, or local agencies.

Covers aspects of installation relating to the effectiveness, durability, and safety of insulation in service. It does not primarily address the safety of the person(s) installing the insulation.

Provides minimum requirements that will help to ensure the installation of insulation in a safe and effective manner. Actual conditions in buildings vary greatly and in some cases substantial additional care and precaution may have to be taken to ensure effective and safe installation.

2. APPLICABLE DOCUMENTS

ASTM[1] C 168-80a: Standard Definitions of Terms Relating to Thermal Insulating Materials.

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[1] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM C 755-73 (1979): Recommended Practice for Selection of Vapor Barriers for Thermal Insulations.

NFPA[2] -70: National Electrical Code (Section 410-66).

3. SIGNIFICANCE

3.1 *Effectiveness, safety, and durability of insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation can reduce its thermal effectiveness, cause fire and electrical hazards and other unsafe conditions, and promote deterioration of the structure in which it is installed.*

3.3 *Due to its electrical conductance, reflective foil poses hazards from electrical shocks during and after installation if installed so as to be in contact with ungrounded electrical service components.*

3.4 *Specific hazards that can result from improper installation include electrical fires due to wiring with frayed, cracked, deteriorated, or missing electrical insulation in contact with the insulation, electrical shock hazards from improper grounding, deterioration in wood structures due to moisture accumulation, and corrosion of metal fasteners and wiring components.*

4. DEFINITIONS

Certain technical terms relating to insulation but not defined below are used in this subpart in accordance with the definitions given in ASTM C 168-80a.

Approved - acceptable to the authority which regulates the activity or material and its use. Such authority is usually a municipal, State, or Federal agency or a third-party certification, inspection or rating service.

Conditioned space - any space in a residential building which is served by a heating or cooling system.

Reflective thermal insulation - thermal insulation depending for its efficiency in large part on reduction of radiant heat transfer across spaces by use of one or more surfaces of high reflectance and low emittance.

Unconditioned Space - any space, out-of-doors or in a residential building, which is not served by a heating or cooling system.

Vapor Barrier - any material (as defined in ASTM C 755-73 (1979)) that has a water vapor permeance rating of 57.4 $\mu g/kPa \cdot s \cdot m^2$ (1 perm) or less.

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[2] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

The following materials, upon proper application, constitute vapor barriers: asphalt-impregnated kraft paper, aluminum foil, plastic film, and paint and wallcovering which are labeled by the manufacturer as having the above permeance rating or less when applied in accordance with the manufacturer's instructions.

5. MATERIALS

5.1 Under RCS, install only reflective insulating materials labeled as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for further discussion.

5.2 *It is recommended that reflective insulation materials installed have third-party certification.*

6. SAFETY PRECAUTIONS AND PRE-INSTALLATION PROCEDURES

6.1 GENERAL

6.1.1 Identify and examine all visible wiring, junction boxes, and other metallic or electrical equipment in the areas where insulation is to be installed. Do not install reflective insulation if the wiring is found to have frayed, cracked, deteriorated, or missing electrical insulation.

Contact of metallic reflective insulation with deteriorated electrical wiring can lead to shock hazard and potential fire risk.

6.1.2 Ensure that all electrical equipment in the building is grounded. Do not install reflective (aluminum foil) insulation in buildings in which electrical equipment is not grounded.

Contact of metallic reflective insulation with ungrounded electrical equipment can lead to shock hazards and potential fire risk.

6.1.3 Identify air supply and return ducts, pipes, electrical wires, and other obstructions located in spaces between joists and studs. Ground all metallic heating and air conditioning ducts which may come in contact with the installed insulation. Do not install reflective insulation where metallic heating and air conditioning ducts are not grounded.

Repairs or replacement of electrical wiring to eliminate defects, as well as all other electric-related activities, are to be carried out only by personnel approved for such work.

Insulation of floors over unheated spaces will cause these spaces to be colder. Accordingly, appropriate measures may need to be taken to keep water pipes from freezing during colder weather.

6.2 ATTICS AND CEILINGS

6.2.1 Identify and measure ventilation area in attics. Do not install insulation in attics unless 0.1 m^2 minimum of free ventilation area per 30 m^2 (1 ft^2 per 300 ft^2) of attic floor area is provided.

Adequate attic ventilation carries to the outdoors moisture that enters the attic from the house. For additional information see Part I, Section 4.1.3.

6.2.2 If the free ventilation area of louvers is not known, assume that it is half of the area of the gross ventilation opening and increase the gross opening accordingly. Many louvers have their free ventilation area stamped on their frames.

6.2.3 Ensure that all ventilation openings have suitable louvers or screens to prevent rain or snow from entering the attic.

6.2.4 Identify all recessed lighting fixtures (including wiring compartments and ballasts) and other heat-producing devices in areas to be insulated.

Identification is necessary prior to installation so that proper precautions can be taken during installation.

6.3 FLOORS

6.3.1 Where insulation is to be installed beneath floors over crawl spaces, cover the ground surface with a ground cover which acts as a vapor barrier (such as 0.15 mm (6-mil) polyethylene sheeting lapped at the joints). Turn the cover up at least 150 mm (6 inches) at the walls.

6.3.2 Where practical in crawl spaces, provide a free ventilation area of 0.1 m^2 for every 150 m^2 (1 ft^2 for every 1,500 ft^2) of the ground area of the crawl space. Provide cross-ventilation where possible. (See 7.2.2 for guidance on estimating free ventilation area.)

To allow for venting of the crawl space to prevent moisture build-up. This provision conforms to major building code requirements. Provision should be made to close off the ventilation opening during cold weather.

7. INSTALLATION PROCEDURES

7.1 GENERAL

7.1.1 Do not install insulation unless the pre-installation procedures have been carried out and any defects which were identified have been corrected and their causes eliminated.

The purpose of the pre-installation procedures is to assure that the installation can be carried out effectively and without adverse side effects detrimental to other building components and materials. For lasting results, it is important not only to correct symptoms, such as replacing rotten wood, but to eliminate the source of the defect, such *as water leaks which promoted the rot in the first place. In many instances corrective measures can be taken with relative ease prior to the installation of insulation. After installation correction may be more difficult and costly.*

7.1.2 Install insulation only between conditioned and unconditioned spaces.

Insulation is effective in conserving energy only when placed between conditioned (served by a heating and/or cooling system) and unconditioned spaces (such as outdoors or an unheated garage). Where adjacent conditioned spaces are maintained at different temperatures, the temperature differential is seldom such that the insulation would be cost-effective. One possible exception would be the case where one of two adjacent conditioned spaces is frequently, and for prolonged periods, neither heated or cooled at all, while the other is conditioned. In this case, the frequently unconditioned space could be treated as such. One example of this would be a home workshop attached to the house but only occupied and heated on weekends.

7.1.3 Do not cover recessed lighting fixtures (including wiring compartments and ballasts) and other heat-producing devices so as to entrap heat or prevent free circulation of air unless they are approved for the purpose. See Part I, Section 4.2.2 for additional information.

This requirement is based on Section 410-66 of the National Electrical Code (NFPA-70). Recessed lighting fixtures rely on the free movement of air around and above them to dissipate the heat generated by the bulbs, ballasts, and wiring compartments.

7.1.4 Handle the insulation materials in accordance with the manufacturer's instructions.

7.1.5 Ensure that the reflective surfaces are free of dirt, oil film, and other surface coatings which can reduce the effective reflectance of the surfaces.

Coating of the reflective surfaces may reduce the thermal effectiveness of the material.

7.1.6 Install reflective insulation flush or recessed with the framing members, as shown in Figures 1 and 2.

The reflective insulation must be properly mounted in place to achieve the proper air space.

7.1.7 Secure the insulation in place with aluminum, coated copper-clad steel, plastic, or coated galvanized steel fasteners.

Uncoated metal fasteners can cause galvanic corrosion.

7.1.8 Ensure that the insulation is cut to the correct size, fits tightly between joists and studs on all sides, and that there are no wrinkles or fishmouths. Where wrinkles and fishmouths cannot be avoided, tape the joint between the insulation and framing members, or between adjacent sections of insulation (in flush installations).

Air circulation around foil decreases its effectiveness.

7.1.9 Ensure that where the material is installed to form multiple reflective air spaces, the spaces measure, at a minimum, 20 mm (3/4 in). Maintain the distance between reflective surfaces as uniformly as possible. Reflective surfaces must not touch each other or the thermal performance of the insulation will be reduced.

Air spaces less than 20 mm (3/4 in) have reduced thermal effectiveness.

7.1.10 Tape and seal all splices and tears in the insulation. Seal all punctures in the insulation by taping reflective material to the damaged area.

Air leakage between insulating spaces reduces the insulation's effectiveness.

7.1.11 Avoid joints within joist or stud spaces. Seal any required joints with tape.

7.1.12 Tightly seal the ends of reflective insulation against the surfaces which they contact.

7.1.13 Fit insulation closely around plumbing and other obstructions and tape securely to eliminate gaps through which air may pass into the reflective air spaces.

7.2 WALLS

7.2.1 Do not install insulation in contact with the ground or other sources of water.

This prevents the paper backing of the insulation from becoming wet and prevents its deterioration.

7.3 ATTIC, CEILINGS, FLOORS

7.3.1 When installing insulation around bridging or cross bracing of ceilings or floor joists, ensure that the insulation material is fitted tightly around these obstructions and that there are no gaps in the insulation.

7.3.2 Do not cover soffit vents with insulation or in any other way restrict attic ventilation.

7.3.3 Install insulation around vents which open into the attic in a manner that will ensure the free movement of air through the vent into the attic.

The venting of bathroom and kitchen (and clothes dryer) air into the attic is an undesirable building practice because it introduces into the attic excessive moisture which may condense when exposed to cooler attic temperatures. The potential for condensation is further increased as insulation is added, because the insulation reduces the rate of heat flow from the living area to the attic, causing attic temperatures to be even lower. It is recommended that all such vents be extended and vented to the outside.

7.3.4 Fit the attic side of access doors or panels with insulation batt (or equivalent material) except where prevented by a retractable ladder.

Secure the insulation in place using staples or other appropriate fasteners. Insulation may be installed to the exterior of trap doors which have retractable ladders mounted on their interior. If the insulation is installed to the underside of the trap door, a finish reasons and to protect the insulation. Weatherstripping should be installed along the contact edge between the access panel and frame to reduce infiltration losses in this area.

8. POST-INSTALLATION PROCEDURES

8.1 Ensure that the reflective insulation provides a continuous and unbroken surface between framing members, that no gaps, tears, and other openings exist, and that all joints are tightly taped.

8.2 Ensure that insulation installed in attics does not restrict soffit or other vents which open into the attic.

8.3 Ensure that the required clearances around heat-producing devices have been provided.

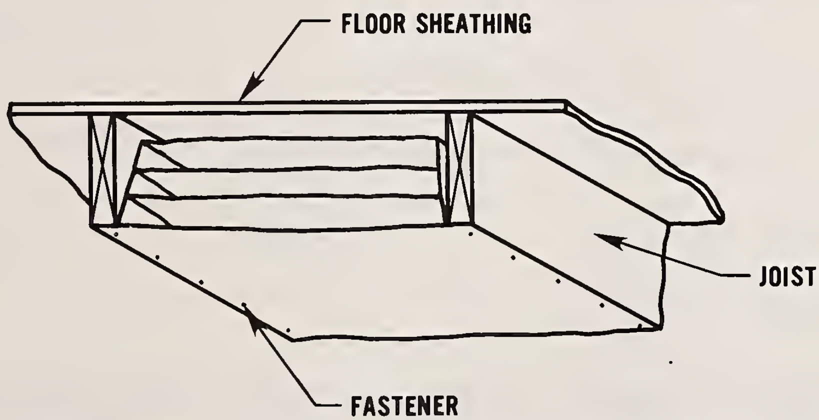

FIGURE 1 - ATTACHMENT OF REFLECTIVE INSULATION ON FACE OF JOISTS OF STUDS.

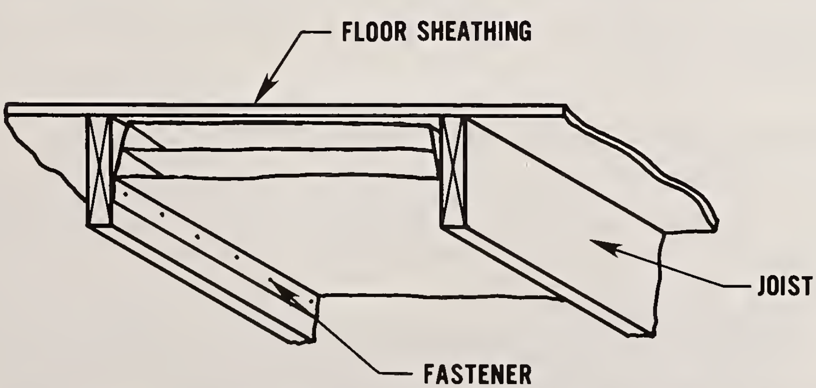

FIGURE 2 - ATTACHMENT OF REFLECTIVE INSULATION OF SIDE OF JOISTS OR STUDS.

CERTIFICATION PROCEDURES FOR THE INSTALLATION OF THERMAL INSULATION MATERIALS

1. SCOPE AND PURPOSE

1.1 Upon completion of each installation of thermal insulation materials performed under the RCS Program, the person responsible for carrying out such installation shall complete, in triplicate, a "Certification of Insulation" form such as exhibited in Figure 1.

> *Because insulation is installed in areas not easily visible to the homeowner, a "certificate" is required to provide a permanent record of what was installed. Such a record is needed particularly if at a later date (when fuel prices are higher) the installation of additional insulation is contemplated. To serve its intended purpose, it is necessary that this information be available not only to the present but also to future owners.*

2. CONTENT

The certificate of installation shall contain the following information:

Address of the building;

Date of completion of installation;

Name and address of the contractor;

Insulation type;

Insulation manufacturer;

Location and dimension in square meter (feet) of each space which was insulated;

The amount of insulation which was installed in each of the locations identified given in the units in which the material is most commonly available, such as the number of batts, bags, etc., of a specified size or the number of square meters (feet), etc.;

The R value installed in each of the locations;

A statement, signed by an authorized individual, certifying that the installation was carried out in conformance to the applicable standard practices, codes, and regulations.

> *This refers to the DoE Material Standards, DoE Installation Practices, building codes applicable in the particular locality, and any other regulations imposed by local, State, and Federal standards.*

3. DISTRIBUTION AND POSTING

The "Certification of Installation," shall be distributed and posted as follows:

One copy shall be permanently affixed to the structure in an accessible but inconspicuous location;

One copy shall be submitted to the homeowner or building occupant; and

One copy shall be retained for a period of five years by the agency responsible for the installation.

PART I - GENERAL

ADDRESS OF RESIDENCE:

____
____
____

NAME AND ADDRESS OF CONTRACTOR:

____
____
____

PART II - AREAS INSULATED

WALLS (______ sq. ft.)	CEILINGS (______ sq. ft.)	FLOORS (______ sq. ft.)
TYPE OF INSULATION:	TYPE OF INSULATION:	TYPE OF INSULATION:
____________	____________	____________
MANUFACTURER:	MANUFACTURER:	MANUFACTURER:
____________	____________	____________
____________	____________	____________

R VALUE INSTALLED	AMOUNT INSTALLED	R VALUE INSTALLED	AMOUNT INSTALLED	R VALUE INSTALLED	AMOUNT INSTALLED

PART III - CERTIFICATION

I, ________________________ certify that the residence identified in PART I was
(PRINT NAME)
insulated as specified in PART II and that the installation was conducted in conformance to applicable codes, standards, and regulations.

________________________ Date

________________________ Authorized Signature

FIGURE 1 - CERTIFICATION OF INSULATION

STANDARD PRACTICE FOR THE INSTALLATION OF CAULKS AND SEALANTS

1. SCOPE

1.1 These practices apply to the on-site installation of caulks and sealants used to control rain water leakage and major air infiltration through building walls.

1.2 These practices do not apply to the sealing of minor cracks at the building's exterior.

2. APPLICABLE DOCUMENTS

ASTM[1] C 790-74 (1979), Standard Recommended Practices for Use of Latex Sealing Compounds.

ASTM C 797-75, Standard Recommended Practices and Terminology for Use of Oil and Resin Based Putty and Glazing Compounds.

ASTM C 804-75, Standard Recommended Practices for Use of Solvent-Release Type Sealants.

Federal Specification[2] TT-S-00230C "Sealing Compounds, Elastomeric Type, Single Component (for Caulking, Sealing and Glazing in Buildings and Other Structures)."

Federal Specification TT-S-00227E "Sealing Compound, Elastomeric Type, Multi-Component (for Caulking, Sealing and Glazing in Buildings and Other Structures)."

Federal Specification TT-S-001657 "Sealing Compound, Single Component Butyl Rubber Base, Solvent Release Type (for Buildings and Other Types of Structures)."

Federal Specification TT-S-001543A "Sealing Compound, Silicone Rubber Base (for Caulking, Sealing, and Glazing in Buildings and Other Structures)."

Federal Specification TT-C-00598C "Caulking Compound, Oil and Resin Base Type (for Building Construction)."

Federal Specification TT-P-00791B "Putty Lindseed-Oil Type, (for Wood-Sash-Glazing)."

ASTM Committee C 16 is currently developing and revising standard practices for the installation of caulks and sealants. Users of this publication are urged to contact ASTM for status of the various practices under C 16's jurisdiction.

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1 American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

2 Federal Specifications, Customer Service, Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

3. SIGNIFICANCE

3.1 *Water leakage, air leakage, excessive energy use, accelerated deterioration, and reduced comfort can result from lacking, inadequate or improperly installed caulks and sealants.*

3.2 *This practice recognizes that effectiveness and durability of caulked and sealed joints depends not only on the quality of materials used but also on their proper and workmanlike installation.*

3.3 *Improper installation of caulks and sealants may also contribute to moisture condensation and accumulation within building elements which can lead to various forms of deterioration such as fungus growth on wood structure, corrosion of metal fasteners, pipes and electrical service components. Moisture also can reduce the effectiveness of insulations. With some insulation materials, excessive moisture can also cause the leaching of fire retardants and thus contribute to increased fire hazards.*

4. MATERIALS

4.1 Under RCS, install only caulks and sealants identified as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for further discussion.

5. MATERIAL SELECTION, JOINT PREPARATION AND INSTALLATION PROCEDURES

5.1 The type of caulk or sealant chosen for a given application depends on the composition of the adjacent materials, temperature fluctuation, exposure to direct sunlight, width and depth of the crack or joint to be sealed, and movement in the joint. Select caulks and sealants, prepare the joint and substrate, and install the material in conformance with the following standards and provisions:

Putty and Oil and Resin Base Types: ASTM C-797-75.

Acrylic (Solvent Type) and Butyl Rubber: ASTM C-804-75.

Latex Sealing Compounds: ASTM C-790-74.

Chlorosulphonated Polyethylene, Polysulfide-Single Component, Polysulfide-Multicomponent, Polyurethane-Single Component, Polyurethane-Single Component, Polyurethane-Multi-Component and Silicone: Follow the provisions relating to application and use included in the applicable Federal Specifications (see Section 2 above).

6. PROVISIONS TO PREVENT MOISTURE DAMAGE RESULTING FROM CAULKING AND SEALING JOINTS IN WALLS

6.1 *On the exterior of building walls, joints should be sealed at head, jambs, and sills of windows, louvered openings, exterior access panels, and at penetrations of plumbing and electrical supply lines to prevent rain water from entering the building construction and wall cavities from the outside.*

6.2 *Weep holes such as at windows, doors, and access panels should not be sealed.*

6.3 *Major and obvious locations of excessive air leakage at the exterior of building walls should be sealed. Minor cracks at the building exterior should not be sealed except where necessary to prevent rain water leakage. Some air exchange between wall cavities and outside is desirable.*

6.4 *To reduce air infiltration and reduce the potential for hidden condensation, it is recommended to seal and caulk on the interior face of exterior walls all cracks such as at window and door frames, ceiling/wall and ceiling/floor joints, plumbing penetrations, electrical fixtures and electrical outlet and switch boxes, air supply and return registers.*

6.5 *For electrical outlet and switch boxes, foam rubber gaskets can be used to seal against air leakage instead of the sealants indicated (see Section 4).*

STANDARD PRACTICE FOR INSTALLATION OF STORM WINDOWS, REPLACEMENT WINDOWS, MULTI-GLAZING, STORM DOORS, AND REPLACEMENT DOORS[1]

1. SCOPE

1.1 This practice covers the installation of storm windows, replacement windows, multi-glazing, storm doors, and replacement doors in residential buildings.

1.2 This practice applies to wood, metal, and plastic-framed storm windows or replacement windows, sealed multi-glazing units, non-sealed multi-glazing systems, storm doors, and replacement doors. This practice also applies to multi-glazing systems which include heat-absorbing or heat-reflective glazing.

This practice does not cover the installation of temporary plastic films where such films are attached to the window or its framed opening directly.

1.3 This practice covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the fabrication or assembly of units, whether such fabrication takes place in a factory or at the installation site.

Specifically, this practice does not cover the assembly of knock-down units, or the installation of glazing into storm or replacement windows, with the exception of the installation of multi-glazing in existing windows or doors.

1.4 This practice covers aspects of installation relating to effectiveness, durability, and safety in service. It does not cover aspects relating to the safety of the person installing the units.

1.5 This practice provides minimum requirements that will help to ensure the installation of storm windows, replacement windows, multi-glazing, storm doors, and replacement doors in a safe and effective manner. Actual conditions in existing buildings vary greatly, and in some cases substantial additional care and precaution may have to be taken.

2. APPLICABLE DOCUMENT

2.1 ASTM[2] Standard C 755-73 (1979): "Recommended Practice for Selection of Vapor Barriers for Thermal Insulation."

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[1] This practice was developed jointly by the American Society for Testing and Materials, the Department of Energy, and the National Bureau of Standards. It was published originally as part of the RCS Rule in the Federal Register of November 7, 1979, and was issued by ASTM under the designation E 730-80 in March, 1980. The DoE standard was withdrawn and replaced by a reference to the ASTM Standard by notice in the Federal Register, Vol. 46, No. 3, Tuesday, January 6, 1981.

[2] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

3. <u>SIGNIFICANCE</u>

3.1 This practice recognizes that effectiveness, safety, and durability of installed units depend not only on the choice and quality of materials, design, adequacy of assembly, and support system, but also on their proper and workmanlike installation.

3.2 Improper installation of units may reduce their thermal effectiveness, lead to excessive air and water leakage and condensation, and may promote the deterioration of wall constructions, windows and doors, and their respective finishes. Additionally, improper installation of metal units may result in accelerated corrosion of metal frames, trim, anchors, fasteners, and finishes. Also, unsafe conditions are created when frames require excessive force for operation because of poor installation.

3.3 The application of this practice requires a knowledge of applicable Federal, State, and local codes and regulations, specifically, but not limited to required means of egress and requirements for safety glazing.

3.4 The application of this practice also requires a working knowledge of the tools, equipment, and methods necessary for the installation of storm windows, thermal windows, and multi-glazing and storm doors. It further assumes familiarity with caulking and sealing and with glass handling procedures, painting where applicable, and an understanding of the fundamentals of residential construction that affect the installation of these units.

This practice applies to the installation of units by professional installers. It does not address untrained homeowners. Where homeowners or other untrained persons plan to install units, it is recommended that they consult available "how-to" or "do it yourself" books, carefully read the manufacturers' instruction, or seek assistance from qualified persons prior to starting with the installation.

4. <u>DEFINITIONS</u>

Galvanic corrosion - a form of deterioration resulting from the electrochemical reaction that occurs when certain dissimilar metals are in contact in the presence of moisture.

In the installation of metal windows and doors, dissimilar metals that should not be in direct contact are aluminum and steel or iron, aluminum and bronze, and aluminum and brass. Aluminum should only be used in contact with other aluminum or stainless steel, and not with other dissimilar metals.

Multi-glazing - an arrangement of two or more separated layers of glazing providing one or more insulating air spaces. Multi-glazing can be achieved by installing a pre-assembled, sealed insulating glass unit or by affixing one or more additional sheets of glazing onto an existing window, sash, or glass.

Prime window (door) - the original window (door) to which a storm window (door) or multi-glazing is added to provide greater thermal resistance.

Heat-absorbing glass - glass having the property of absorbing a substantial percentage of radiant energy in the visible and near-infrared region of the solar spectrum.

Reflective glass - glass having the property of reflecting a substantial percentage of radiant energy in the visible and near-infrared region of the solar spectrum.

Replacement door - a door that is intended to replace an existing prime door. It is often a door with improved thermal performance through insulating construction and effective weatherstripping.

> *Under RCS, only thermal doors meeting DoE standards for thermal doors and so identified may be installed as replacement doors. The identification indicates that the manufacturer certifies his product to meet the applicable DoE standards. It does not imply that DoE has conducted tests on the product or that the manufacturer uses an approved quality assurance program. See Part I, Section 6.1 for further discussion.*

Replacement window - a window that is intended to replace an existing prime window. It is often a window system with improved thermal performance through the use of multiple glazing and more airtight construction. Some replacement windows also provide an insulating frame and sash to provide greater thermal efficiency.

> *Under RCS, only replacement windows meeting DoE standards for thermal windows and so identified may be installed as replacement windows.*

Residential building - any building used or intended for residential occupancy.

Storm door - a door installed outside or inside a prime door, creating an insulating air space.

> *Under RCS, only storm doors meeting DoE standards and so identified may be installed.*

Storm windows - a unit consisting of glazing installed in a window opening either outside or inside a prime window, creating an insulating air space. The storm window may be removable or permanently attached, operable or fixed.

> *If the storm window is placed outside of the prime window, it should be less airtight; if placed inside, it should be tighter than the prime window. This is to prevent excessive condensation from occurring at the interior face of the outer window.*
>
> *Under RCS, only storm windows meeting DoE standards and so identified may be installed.*

Unit - a storm window, replacement window, multi-glazing, storm door, or replacement door as defined herein. It is a manufactured item assembled in a factory, or a knockdown unit assembled at the site before installation.

Vapor barrier - any material (as defined in Recommended Practice ASTM C 755-73 (1979)) that has a water vapor permeance rating of 57.4 $\mu g/kPa \cdot s \cdot m^2$ (1 perm) or less.

The following materials, upon proper application, constitute vapor barriers: asphalt-impregnated kraft paper, aluminum foil, plastic film, and paint and wallcoverings that are labeled by the manufacturer as having the permeance rating given above when applied in accordance with the manufacturer's instructions.

Descriptions of terms used in this practice are in accordance with those contained in Figures 1 through 3.

5. SAFETY PRECAUTIONS

5.1 Do not install window or door devices that would restrict means of egress required by applicable codes and regulations.

Both windows and doors may be required means of egress for use during an emergency such as a fire. Some door devices are difficult to open by children or handicapped persons and their installation is not permitted. Consult local or State codes for details.

5.2 In doors, sidelights, and panels, install only safety glazing in accordance with Consumer Product Safety Commission requirements.[3]

6. STORM WINDOWS

6.1 PRE-INSTALLATION PROCEDURES

6.1.1 Examine the framing of the prime window to ensure that it is sound, free of decay, corrosion, or other deterioration and will provide secure anchorage for the storm frames.

Proper performance of storm windows depends on their secure fastening. Fasteners do not hold reliably in decayed structures.

6.1.2 Examine and repair weatherstripping and sealant of the prime window.

Where the prime window is not weatherstripped, it is recommended that weatherstripping be installed.

6.1.3 Ensure that the frame contact areas are free of protrusions that would interfere with proper installation of the storm window.

Protrusions prevent proper seating of storm windows and can lead to twisted installed units which are difficult to open and close, and which may not provide the required water and air tightness.

6.1.4 Measure and plumb the prime window or its opening in accordance with the manufacturer's instructions, noting if it is out of square or not in plane.

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[3] Federal Register, vol. 43, No. 4, January 6, 1977, p. 1428-1450.

6.1.5 Ensure that the storm window is the correct size and type for the opening, including tolerances and provisions for adjustment to out of squareness.

If opening and window units are not properly matched, a good installation can not be achieved and should not be attempted. Instead, either the opening should be adjusted or a new window unit ordered and installed.

Aesthetically, it is desirable that the meeting rails or stiles of storm windows align with the meeting rails or stiles of the prime window.

6.1.6 Ensure that the storm window has not been damaged during shipping or assembly.

6.1.7 Ensure that adequate weepage is provided for exterior storm windows.

It is usually difficult to provide weepage after installation of the storm window.

6.2 INSTALLATION PROCEDURES

6.2.1 Do not install storm windows unless the pre-installation preparation has been performed, any identified defects correct, and their causes eliminated.

6.2.2 Give a liberal brush treatment of commercially available water repellent preservative to all cut or planed edges of wood storm windows.

Application of the preservative is particularly important on edges that will be covered or enclosed after installation. Lack of drainage can lead to prolonged exposure to moisture promoting fungus growth (dry rot) in such areas.

6.2.3 Position storm windows to provide a minimum gap of 12 mm (1/2 in) between the prime and storm glass.

It is the air space between the storm and prime windows which provides the primary insulating and energy conservation benefits of storm windows. An air space of less than 12 mm (1/2 in) is not as effective.

6.2.4 Where both the storm and prime windows are metal, either position the storm window frame so that it does not contact the prime window frame or secure a nonmetallic spacer between the prime and storm window frames.

The purpose of the space or spacer is to provide a thermal break between the outside and inside of the prime/storm window frame combination. Without the thermal break, frost could build up on the interior frame surfaces during cold weather. The following materials are examples of acceptable spacers: 3 mm (1/8 in) thick spacers of water-repellent preservative-treated wood; vinyl; rubber; or high-density polyurethane.

6.2.5 Secure aluminum storm windows only with aluminum or compatible stainless steel fasteners to avoid galvanic corrosion.

In some very dry climates, such as in some parts of the Southwest, plated steel fasteners may perform adequately. On the other hand, in maritime climates, particularly in the San Francisco Bay area, stainless steel type 316 may be required to prevent pitting and staining.

6.2.6 In exterior installed storm windows, seal the joints at jambs and head to resist rain penetration.

The prime purpose of sealing the storm window is to exclude water. Deletion of sealant at the sill will aid in draining any infiltrated water.

6.2.7 Seal indoor storm window systems to provide greater airtightness than that of the prime window.

The purpose of the requirement is to prevent warm moist indoor air from penetrating into the insulating air space between the prime and storm windows, causing condensation on the colder prime window. In extreme cases, such condensed water could flow down onto the sill, accumulate and cause the deterioration of the sill and of both windows.

6.3 POST-INSTALLATION PROCEDURES

6.3.1 Ensure that all weep holes are clear and provide complete drainage of the sill area.

6.3.2 Check removable storm windows for ease of removal and reinstallation. Ensure that storm windows fit snugly with minimal apparent opportunity for air leakage through perimeter cracks.

6.3.3 Ensure that operable storm sash moves freely within the storm frame and that all hardware operates properly.

7. REPLACEMENT WINDOWS

Most commentary provided under storm windows is also applicable to Replacement Windows and is not repeated here.

7.1 PRE-INSTALLATION PROCEDURES

7.1.1 Examine the existing window opening for signs of decay, corrosion, or other deterioration.

7.1.2 Measure and plumb the window opening in accordance with the manufacturer's instructions, noting if it is out of square or not in plane, to ensure that the unit can be installed plumb, square, and level.

7.1.3 Check for damage to interior finishes. If water damage is found to be caused by leakage from the outside, as opposed to condensate, locate the source of the leakage and establish whether replacing the window will correct the problem.

If replacing the window will not correct the problem, take necessary corrective measures before installing the thermal window.

Water leakage may have been the prime reason for the deterioration of the original window in the first place. Unless the cause of such leakage is eliminated, the replacement window may also deteriorate. Moisture within the wall also reduces the effectiveness of insulation and causes the deterioration of the wall construction.

7.1.4 Ensure that the replacement windows are the correct size and type for the openings, including tolerances and provisions for adjustments to out of squareness.

7.1.5 Ensure that no replacement windows are damaged and, where sealed glass units are used, that their inside surfaces are free of condensation, fogging, or staining.

7.1.6 Ensure that the frames are free of any burrs or splinters, that the sash operates freely within the frame and latches securely, and that the weatherstripping is properly installed in all locations specified.

7.2 INSTALLATION PROCEDURES

7.2.1 Do not install replacement windows unless the pre-installation preparation has been performed, any identified defects corrected, and their causes eliminated.

7.2.2 Remove the existing window in a manner that will minimize damage to the remaining construction. Remove all fasteners, and clear the frame opening of obstructions or protrusions that would interfere with the installation of the replacement window.

7.2.3 Examine the exposed wall frame and remaining window construction, and replace unsound material.

New sound wood in contact or proximity of rotten wood will soon also deteriorate. Also, fasteners will not hold in unsound materials.

7.2.4 Where the existing window openings are reframed to a smaller size, insulate the voids between framing members and the window. Install a vapor barrier on the room side of the insulation and provide interior and exterior coverings compatible with the existing construction.

7.2.5 Install flashing at the head, jambs, and sill of the window as required to preclude the penetration of water into the wall cavity.

7.2.6 Give a liberal brush treatment of commercially available water-repellent preservative to all cut or planed edges of wood replacement windows.

7.2.7 Anchor the unit in accordance with the manufacturer's instructions. Ensure that clearances specified in the manufacturer's instructions are maintained.

7.2.8 For aluminum units use only aluminum or compatible stainless steel anchors and fasteners.

7.2.9 Shim the replacement window as necessary to ensure it is plumb, square, and level.

7.2.10 Separate metal windows from incompatible materials (such as siding or frames of dissimilar metals) in the structure or frame with a nonmetallic spacer to prevent galvanic corrosion.

7.2.11 Fill all gaps of 6 mm (1/4 in) or more with backup or filler materials such as nonabsorbing foam or sponge before installing the sealant.

Many sealants do not perform reliably when applied in thicknesses greater than 6 mm (1/4 in). See also requirements of the "Standard Practice for the Installation of Caulks and Sealants."

7.2.12 Seal the joints between the supporting structure and window frame, using one of the following sealants: acrylic, butyl, chlorosulfonated polyethylene, polysulfide, polyurethane, or silicone. Apply sealants in accordance with sealant manufacturer's instructions. Use only sealant material that the manufacturer recommends for the intended application.

The installation of replacement windows is a costly undertaking. As sealants are critical to the long-term performance of the installation and their cost is a minor part of the total installation cost, only high quality sealants should be used. Under RCS, use only sealants labeled as meeting DoE Standards.

7.2.13 The seal between the supporting structure and the window frame should not be adhered to the coverings, such as siding or shingles, but adhered to the sheathing below.

Sealing between the covering (such as shingles, metal or plastic siding) can leave open air and water bypasses from the outside into the wall cavity.

7.3 POST-INSTALLATION PROCEDURES

7.3.1 Ensure that the sashes move freely within the frames, and that all hardware operates correctly.

7.3.2 Ensure that window frame and sashes are square, plumb, and level.

7.3.3 Ensure that all weatherstripping makes full contact with mating surfaces.

8. MULTI-GLAZING -- SEALED INSULATING GLASS

8.1 PRE-INSTALLATION PROCEDURES

8.1.1 Measure and plumb the opening for the sealed insulating glass unit. Note if it is out of square and not in plane.

8.1.2 Inspect the opening to ensure that there are no burrs, dirt, or deformation of glazing channels which may cause stress concentrations in the glass.

8.1.3 To prevent the prolonged exposure of sealed insulating edges, ensure that an adequate weeping system is incorporated in the glazing system as recommended by the sealed insulating glass manufacturer.

Three weep holes 9 mm (3/8 in) or more in diameter, one each near the jambs and one in the middle, have been recommended by one manufacturer.

8.1.4 Ensure that clearances and nominal "bite" (containment of the glass) are as specified by the manufacturer.

Incorrect clearances can lead to glass falling out of the frames under wind pressure or to glass breakage resulting from thermal stresses.

8.1.5 During handling, place cushioning material between the glass and hard materials, and do not set the glass on hard surfaces or turn it on its corners. This can damage the glass or seal, or both.

8.1.6 Ensure that neither the glass nor the edge seal are damaged, and that the units exhibit no signs of fogging and condensation. Do not install defective units.

8.2 INSTALLATION PROCEDURES

8.2.1 Face Glazed Systems

8.2.1.1 Do not install sealed insulating glass units unless the pre-installation preparation has been performed, any identified defects corrected, and their causes eliminated.

8.2.1.2 Set the glass on two identical setting blocks of Shore A durometer 90 neoprene or equivalent material. The blocks shall be located equidistant from the center of the edge, preferably at the quarter points. They may, however, be moved towards the vertical edges but not closer than 150 mm (6 in) or 1/8 the glass width, whichever is greater.

Resilient setting blocks assure that the weight-bearing surface of the glass is in total contact with the glass. The spacer blocks, while being small in contact area, do provide uniform bearing over their entire area. Only two blocks should be used to avoid glass stresses.

8.2.1.3 Do not locate setting blocks so as to obstruct the weeping arrangement provided in the glazing system according to 8.1.3.

8.2.1.4 Use setting blocks that are narrower than the full channel width but that are at least 1.5 mm (1/16 in) wider than the insulating glass and high enough to ensure minimal edge clearance but provide required bite for the glass.

The spacers should be narrower than the channel so that they do not bind when inserted.

8.2.1.5 Install sealed insulating glass units containing heat-absorbing or reflective glass so that the heat-absorbing or reflective sheet is the outermost sheet. This allows the heat-absorbing glass to reradiate the greater part of absorbed heat to the outdoors, and the reflective glass to reflect the greater part of the impinging solar radiation to the outdoors[4]. Follow all additional precautions for installation prescribed by the manufacturer of the heat-absorbing or reflective glass.

If a so-called "heat mirror" is used, it should be installed in such a way as to reflect the heat back into the room.

8.2.1.6 Where necessary, set jamb blocks in place before installing glass to ensure proper lateral positioning of the glass. Maintain recommended clearances and bite.

8.2.1.7 Use only continuous resilient spacers to maintain face clearances. Do not use intermittent shims.

Continuous resilient spacers provide continuous support for the glass under positive and negative wind pressures. Continuous spacers also reduce water leakage into the glazing channel.

8.2.1.8 Install only glazing sealants that are resilient, nonhardening compounds, tapes, or gaskets. Install only sealants recommended by the manufacturers of the unit and sealants recommended by their manufacturer for the intended use.

Non-hardening glazing sealants do allow thermal movement of the glass, and impose no stress points under wind load. These situations could cause glass breakage or damage to the edge seal. Sealants should comply with manufacturers' specifications. Sealants which contain solvents that are incompatible with the sealant used in organically sealed insulating glass units can cause the early deterioration of the insulating seal.

8.2.1.9 Install glazing compounds with a slope to ensure rainwater runoff.

8.2.2 Channel (Marine) Glazed Systems

8.2.2.1 Apply the wrap-around vinyl or neoprene gasket in one piece around the entire perimeter of the sealed insulating glass, ensuring that the glass is engaged by full channel depth of the wrap-around vinyl. Ensure that the seam in the wrap-around vinyl occurs at the head of the unit.

8.2.2.2 Prevent corner bulges of wrap-around vinyl or neoprene, and provide for water drainage by a 90° cutout.

8.2.2.3 Install only gaskets with a slope to ensure rainwater runoff.

8.2.2.4 See 8.2.1.5 for requirements regarding heat-absorbing or reflective glass.

8.3 POST-INSTALLATION PROCEDURES

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[4] S. Robert Hastings, Richard W. Crenshaw, "Window Design Strategies to Conserve Energy," NBS Building Science Series 104, 1977, pp. 4-10.

8.3.1 Ensure that weep holes are not blocked.

8.3.2 Ensure that gaskets and sealants are properly installed.

9. MULTI-GLAZING -- UNSEALED INSULATING GLASS

9.1 Various innovative products are now being marketed that permit the installation of multi-glazing other than through the use of factory-sealed insulating glass. Since the products, systems, and methods in such innovative applications differ widely, no generally applicable installation instructions can be given. However, the principles given under Sections 5, 6, and 7 must be considered and the manufacturer's installation instructions followed.

10. STORM DOORS

Many commentaries provided under storm windows also apply to storm doors. These are not repeated here.

10.1 PRE-INSTALLATION PROCEDURES

10.1.1 Examine the framing of the prime door to ensure that it is sound, free of decay and corrosion, and provides secure anchorage for the storm door.

10.1.2 Ensure that the frame contact areas are free of protrusions that would interfere with proper installation of the storm door.

10.1.3 Measure and plumb the door opening in accordance with the manufacturer's instructions, noting if it is out of square or not in plane.

10.1.4 Ensure that the storm door is the correct size and type for the opening, including tolerances and provisions for adjustment to out-of-squareness.

10.1.5 Ensure that the storm door has not been damaged.

10.1.6 Ensure that the storm door meets applicable standards for safety glazing.

10.1.7 Ensure that adequate weepage is provided on exterior storm doors.

10.2 INSTALLATION PROCEDURES

10.2.1 Do not install storm door unless the pre-installation preparation has been performed, any identified defects corrected, and their causes eliminated.

10.2.2 If required for proper fit, adjust the storm door or its frame to the size and out-of-squareness of prime door frame.

10.2.3 Give a liberal brush treatment of commercially available water-repellent preservative to all cut or planed edges of wood storm door.

10.2.4 Anchor the storm door to the framed opening in accordance with the manufacturer's instructions. Secure aluminum storm door only with aluminum or compatible stainless steel fasteners to avoid galvanic corrosion.

10.2.5 Install the door catches, closers, and chains in accordance with the manufacturer's instructions.

10.2.6 Install weatherstripping in accordance with the manufacturer's instructions.

10.2.7 Maintain a gap of at least 1.5 mm (1/16 in) between the storm door and frame opening, unless otherwise specified by the manufacturer.

10.2.8 For an expander-type aluminum storm door, ensure that the expander edges are flush with the frame opening. Secure the expander edges using hardware and fasteners compatible with aluminum.

10.2.9 Do not use excessive force when installing the storm door frame of a pre-hung door into the door opening.

10.2.10 Seal the joint between the storm door frame of the pre-hung door and the framed opening to prevent rain penetration.

10.3 POST-INSTALLATION PROCEDURES

10.3.1 Ensure that adequate drainage is provided to prevent water accumulation at the sill.

10.3.2 Ensure that the storm door operates freely and does not bind when closed.

10.3.3 Ensure that the weatherstripping is installed properly and forms a weathertight seal.

10.3.4 Ensure that the closer and chain assemblies operate properly, that the door handles and latch assemblies properly secure and lock the storm door, and that the hardware of the storm door does not interfere with the operation of the prime door.

10.3.5 If the storm door includes operable sashes, ensure that the sashes operate properly.

11. REPLACEMENT DOORS

Many commentaries provided for storm windows, replacement windows and storm doors apply also to replacement doors. These are not repeated here.

11.1 REPLACEMENT OF DOOR LEAF ONLY

11.1.1 Pre-Installation Procedures

11.1.1.1 Examine the existing door frame to ensure that it is sound, free of decay or corrosion, and provides secure anchorage for the replacement door.

11.1.1.2 Ensure that the frame contact areas are free of protrusions that would interfere with the proper installation or operation of the replacement door.

11.1.1.3 Measure and plumb the door opening in accordance with the manufacturer's instructions, noting if it is out of square or not in plane.

11.1.1.4 Ensure that the replacement door is the correct size and type for the opening, including tolerances and provisions for adjustment to out squareness.

11.1.1.5 Ensure that the replacement door has not been damaged.

11.1.2 Installation Procedures

11.1.2.1 Do not install replacement doors unless the pre-installation inspection and preparation has been performed, any identified defects corrected, and their causes eliminated.

11.1.2.2 Give a liberal brush treatment of commercially available water-repellent preservative to all cut or planed edges of wood replacement doors.

11.1.2.3 Anchor the replacement door to the existing frame in accordance with the manufacturer's instructions. Secure steel doors with plated steel fasteners, and aluminum doors with aluminum or compatible stainless steel fasteners, to avoid corrosion. Install lock hardware in accordance with the lock manufacturer's installation instructions.

11.1.2.4 Maintain a clearance of at least 1.5 mm (1/16 in) between the replacement door and the door opening unless otherwise specified by the manufacturer.

11.1.2.5 If the threshold does not seal tightly against the bottom cap of the thermal door, replace the threshold.

11.1.3 Post-Installation Procedures

11.1.3.1 Ensure that adequate drainage is provided to prevent water accumulation at the threshold.

11.1.3.2 Ensure that the door operates freely and does not bind when closed.

11.1.3.3 Ensure that weatherstripping is installed properly and forms a weathertight seal.

11.1.3.4 Ensure that the threshold is adjusted to provide a tight seal against the bottom edge of the door.

11.1.3.5 Ensure that the door catches, handles, and latch assemblies properly secure and lock the replacement door.

11.1.3.6 Ensure that the entire wood door including top and bottom edges is sealed in accordance with 11.1.2.2.

11.2 REPLACEMENT OF DOOR FRAME

11.2.1 Pre-Installation Procedures

11.2.1.1 Remove the existing door frame in a manner that will minimize damage to the remaining construction. Remove all fasteners and clear the frame opening of obstructions or protrusions that would interfere with the installation of the replacement door frame.

11.2.1.2 Examine the existing rough framing for signs of decay, corrosion, or other deterioration, to provide secure anchorage for the replacement frame.

11.2.1.3 Measure and plumb the door opening, and note if it is out of square or not in plane.

11.2.1.4 Ensure that the replacement frame or its parts, or both, have not been damaged.

11.2.2 Installation Procedures

11.2.2.1 Do not install replacement door frames unless the pre-installation preparation has been performed, any identified defects corrected, and their causes eliminated.

11.2.2.2 Give a liberal brush treatment of commercially available water-repellent preservative to all cut or planed edges of replacement door frame.

11.2.2.3 Install flashing at head, jambs, and sill as required to preclude the penetration of water into the wall cavity.

11.2.2.4 Anchor the replacement door frame to the rough opening. Secure steel frames with plated steel fasteners, and aluminum frames with aluminum or compatible stainless steel fasteners, to avoid galvanic corrosion.

11.2.2.5 Shim frame to provide an opening that is plumb and square, giving particular attention to jamb at lockstrike and hinges.

11.2.2.6 Seal the joints between the supporting structure and replacement door frame in accordance with the provisions in 7.2.10, 7.2.11, and 7.2.12.

11.2.2.7 Install the door leaf in accordance with 11.1. Do not prepare the door frame for lock hardware until the installation of the door leaf.

11.2.3 Post-Installation Procedures

11.2.3.1 Ensure that adequate drainage is provided to prevent water accumulation at the sill.

11.2.3.2 Ensure that the replacement frame provides an opening that is plumb and square.

11.2.3.3 Ensure that weatherstripping is installed properly and forms a weathertight seal.

11.2.3.4 Ensure that all parts of a wood frame are sealed in accordance with 6.2.2.

11.3 PRE-HUNG DOORS

11.3.1 Pre-Installation Procedures

Conduct pre-installation preparation according to the provisions of 11.2.1.

11.3.2 Installation Procedures

11.3.2.1 Conduct installation according to the provision of 11.2.2.

11.3.2.2 Do not use excessive force when installing the pre-hung door into the opening.

11.3.2.3 Anchor the pre-hung door to the opening in accordance with the manufacturer's instructions.

11.3.3 Post-Installation Procedures

Conduct post-installation procedures according to the provisions of 11.1.3 and 11.2.3.

The standard as published by ASTM also has the following patent and policy notes appended:

"The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and *should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race Street, Philadelphia, PA, 19103, which will schedule a further hearing regarding your comments. Failing satisfaction there, you may appeal in the ASTM Board of Directors."*

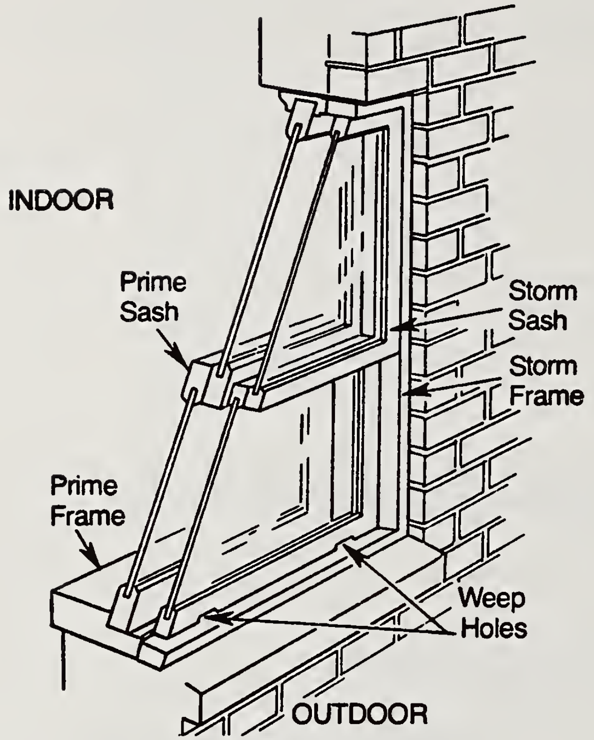

FIGURE 1 - EXTERIOR STORM WINDOW.

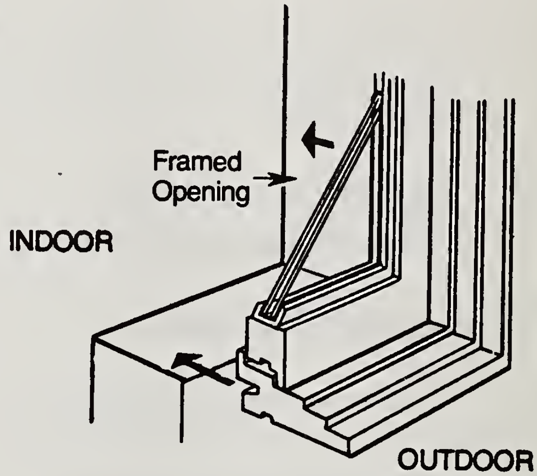

FIGURE 2 - THERMAL WINDOW

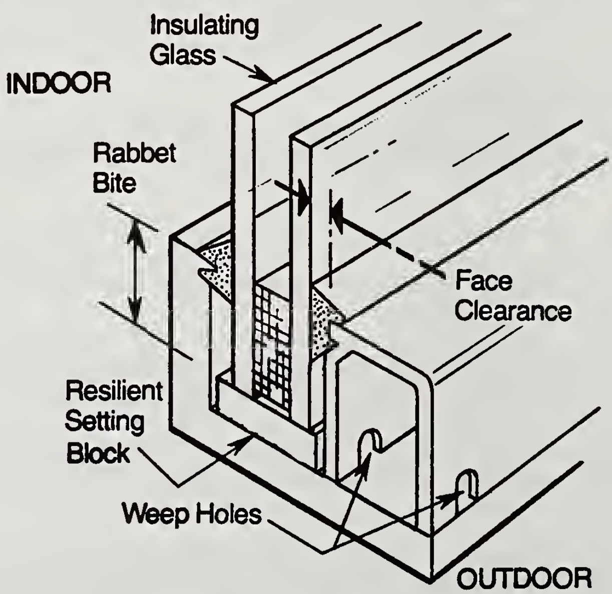

FIGURE 3 - MULTI-GLAZING.

STANDARD PRACTICE FOR THE INSTALLATION OF THERMAL INSULATION ON DOMESTIC HOT WATER HEATERS

1. SCOPE

1.1 This practice covers the installation of insulation around gas-fired, oil-fired, and electric resistance water heaters.

1.2 A working knowledge of the terminology and fundamentals of domestic hot water heaters and applicable codes is necessary for the proper application of this standard.

1.3 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

1.4 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply; when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

This practice further:

1.5 *Covers the installation process from pre-installation procedures through post-installation procedures. It does not cover the production of the insulation materials, whether such production takes place in a factory or at the installation site.*

1.6 *Describes, in general terms, the procedures to follow so that a safe and effective installation is assured. It does not describe in detail the terminology and fundamentals of domestic hot water heating or of residential construction, or the codes and regulations that may be imposed by other Federal, State, or local agencies.*

1.7 *Covers aspects of installation relating to the effectiveness, durability, and safety of insulation in service. It does not address the safety of the person(s) installing the insulation.*

2. APPLICABLE DOCUMENTS

2.1 NFPA[1] 211: "Standard for Chimneys, Fireplaces and Vents."

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[1] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, safety, and durability of water heater insulation depend not only on the quality of the insulating materials, but also on their proper and workmanlike installation.*

3.2 *Improper installation of insulation may reduce its thermal effectiveness, cause fire hazards and other unsafe conditions, and promote the deterioration of the water heater to which it is installed.*

4. DEFINITIONS

Approved - acceptable to the authority which regulates the activity or material and its use. Such authority is usually a municipal, State, or Federal agency or a third-party certification, inspection or rating service.

Barometric draft regulator - a component of oil-fired water heaters which mixes secondary air with the combustion gases leaving the unit, thus enabling a smooth, continuous relief of gases up the vent pipe.

Draft hood - a component of gas-fired water heaters which mixes secondary air with the combustion gases leaving the unit, thus enabling a smooth, continuous relief of gases up the vent pipe.

Hi-limit switch - a temperature control that senses temperature changes in electric, gas, and oil-fired water heaters and cuts off the energy supply or fuel flow to the unit when the internal water temperature rises above a certain point.

Pressure relief valve - a safety valve which opens to vent pressure when the pressure in the water tank exceeds a preset level due to excessive water temperature.

Vent pipe - an exhaust pipe carrying products of combustion from oil-fired and gas-fired water heaters to the outside environment.

Vent damper - a device which automatically closes the vent on oil- and gas-fired appliances to prevent the escape of heat through the vent pipe when the main burner is not being fired.

5. MATERIALS

5.1 Under RCS, install only materials identified as conforming to DoE standards for water heater insulation.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The identification does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program.

5.2 The material may be packaged specifically for the purpose of insulating water heaters or it may not be so packaged. In either case under RCS, it must be labeled as required in 5.1. In addition, the material must also be marked with the R-value and the flame spread rating of the facing.

6. PRE-INSTALLATION PROCEDURES

6.1 GENERAL

6.1.1 Determine the fuel type (gas, electrical, oil) of the water heater.

The installation criteria differ with fuel type used.

6.2 ELECTRIC RESISTANCE WATER HEATER

6.2.1 Determine the location of the pressure relief valve, thermostat control, and hi-limit switch (see Figure 1).

The pressure relief valve needs to be left exposed to assure its proper functioning. The thermostat control and hi-limit switch need access for adjustments. The drain valve must remain exposed so that the heater can be drained periodically.

6.3 GAS-FIRED WATER HEATER

6.3.1 Determine whether the gas-fired water heater is equipped with a vent damper. Do not insulate gas-fired water heaters so equipped.

Insulation of water heaters equipped with vent dampers may lead to overheating equipment because the heat from the pilot light does not as readily escape through a closed vent. To a similar extent, this problem may be caused by excessively large burners in older model water heaters (i.e., older than 8 to 10 years old). For water heaters equipped with automatic ignition devices, insulation could be installed even if the heaters were equipped with a vent damper.

6.3.2 Determine the location of the pressure relief valve and draft hood on the water heater (See Figure 2).

The pressure relief valve needs to be left exposed to assure its proper functioning. Care must be exercised not to cover the draft hood, since this would interfere with proper combustion and lead to safety hazards.

6.3.3 Determine the location of the burner air inlet, pilot light access plate, and drain valve (See Figure 2).

Care must be exercised not to cover the burner air inlet since this would interfere with proper combustion and lead to safety hazards. Covering of the pilot light access plate would require removal of insulation whenever the pilot needs to be relighted. The drain valve must remain exposed so that the heater can be drained periodically.

6.4 OIL-FIRED WATER HEATER

6.4.1 Determine the location of the pressure relief valve, vent pipe, and barometric draft gauge (see Figure 3).

The pressure relief valve needs to be left exposed to assure its proper functioning; the vent pipe needs to be identified to determine whether the top of the heater can be insulated; the barometric draft gauge needs to be left exposed for proper functioning and adjustment.

6.4.2 Determine the location of the thermostat control, peep sight, and drain valve (see Figure 3).

The thermostat control needs to be left exposed for proper functioning and adjustment. The peep sight must be open for inspection and the drain valve must remain exposed so that the heater can be drained periodically.

7. INSTALLATION PROCEDURES

7.1 GENERAL

7.1.1 Do not install insulation unless the pre-installation procedures have been carried out.

7.1.2 Handle insulation in accordance with manufacturer's instructions and keep dry and free of extraneous materials.

Protect the material from accidental wetting and contamination.

Prepare the section(s) of insulation in accordance with the insulation manufacturer's instructions. If no instructions are available, the following procedure is recommended:

Cut the insulation such that the finished height is 100 mm (4 in) less than the distance from the floor to the top of the water heater and the length is 180 mm (7 in) greater than the circumference (distance around) of the water heater.

Cut an additional piece of insulation to fit the top of electric water heaters only. Slit the piece to enable mounting around pipes on top of the unit.

7.1.3 Apply the insulation to the water heater with the facing to the outside.

The facing is designed to protect the insulation from damage.

7.1.4 Secure the sections of insulation to the water heater using a tape of the size and type recommended by the insulation manufacturer.

Vinyl duct tape 76 mm (3 in) or wider is recommended unless the insulation manufacturer specifically recommends another product.

It is recommended that the insulation be secured as shown in Figure 4 to minimize the likelihood of the insulation slipping down.

7.1.5 Do not install insulation over the water heater operating instructions and other components identified below.

Easy access to operating instructions is necessary for continued safe and effective operation, particularly for future homeowners and repair personnel. Covering of the instruction plate could result in less than adequate maintenance and operation of the water heater.

7.2 ELECTRIC RESISTANCE WATER HEATER

7.2.1 *Ensure that the exterior facing of the insulation material is marked as having a flame spread rating of no more than 150. This rating is required in the RCS Material Standard for material used to insulate electric resistance water heaters.*

7.2.2 Install insulation on the sides and top plate of the water heater.

7.2.3 Cut the insulation to leave holes for the pressure relief valve, thermostat control, hi-limit switch, plumbing pipes, and other necessary access plates.

This will provide the needed access for servicing the water heater after insulation installation, and for proper operation of the water heater.

7.3 GAS-FIRED WATER HEATER

7.3.1 *Ensure that the exterior facing of the insulation material is marked as having a flame spread of no more than 25. The rating is required in the RCS Material Standard for material used to insulate gas-fired water heaters.*

7.3.2 Do <u>not</u> install insulation on the top plate of gas-fired water heaters.

The pilot light of a gas-fired water heater continuously generates heat. The uninsulated top of the water heater provides for the necessary heat loss to prevent or reduce substantially the potential for overheating. Furthermore, the draft hood is sometimes blocked if insulation is installed on the top of gas water heaters. A partially blocked draft hood and insufficient flue draft could prevent carbon monoxide from properly venting to the outdoors and could cause hazardous indoor air pollution.

7.3.3 Cut the insulation to leave holes for the burner air inlet, thermostat control, pilot light access plate, drain valve, plumbing pipes, and other necessary access plates.

7.4 OIL-FIRED WATER HEATER

7.4.1 *Ensure that the exterior facing of the insulation material is marked as having a flame spread rating of no more than 25. This rating is required in the RCS material standard for material used to insulate oil-fired water heaters.*

7.4.2 If the vent pipe is top mounted, do <u>not</u> install insulation on the top plate of the water heater.

Flue pipe temperature may range from 370°C (800°F) to 430°C (800°F). The placement of insulation closer than four inches from such pipes may expose the material to temperatures which may cause ignition of its coverings. For top mounted pipes, the 100 mm (4 in) clearance requirement makes the insulation of the remaining top impractical and not cost-effective.

7.4.3 If the vent pipe is side mounted, maintain the minimum vent connector clearances specified in the latest edition of NFPA 211.

This recommended clearance could be as much as 18 inches for single-wall metal pipe chimney connectors. See Table 5-5(a) in NFPA 211 for specific installation criteria.

7.4.4 Cut the insulation to leave holes for the pressure relief valve, thermostat control, flame peep sight, burner access plate, drain valve, plumbing pipes, and other necessary access plates.

Covering of the items indicated in the pre-installation procedure would prevent access for needed servicing and operation of the water heater after the installation of insulation.

8. <u>POST-INSTALLATION PROCEDURES</u>

8.1 Ensure that the insulation is securely attached to the water heater.

Insecure attachment may allow the insulation to slide down or to the floor, or off the appliance entirely. This will reduce the effectiveness of the insulation. If the insulation slips down over the burner air inlets on gas- and oil-fired appliances, it will interfere with proper combustion and reduce efficiency, and may cause the release of toxic combustion products.

8.2 Ensure that the required clearances have been maintained around vent pipes and that insulation has not been installed on the top of oil-fired water heaters which have a top-mounted vent pipe, or on gas-fired water heaters.

8.3 Ensure that air inlets, access plates, drain valves, temperature controls, and pressure relief valves are not covered by insulation.

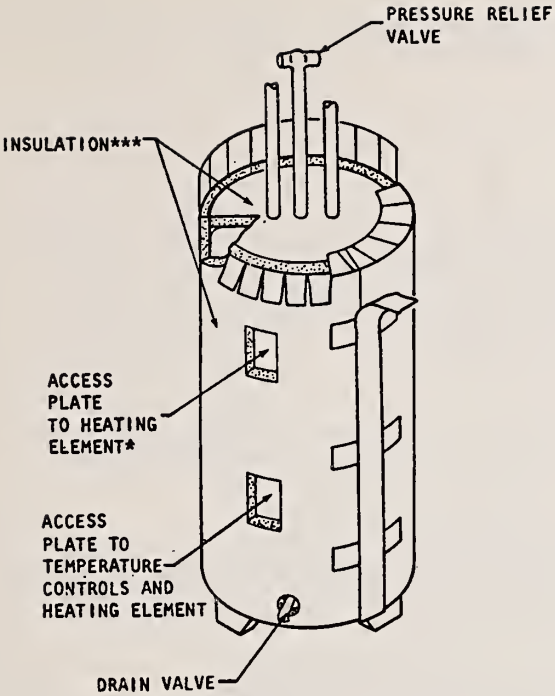

FIGURE 1 - ELECTRIC WATER HEATER.

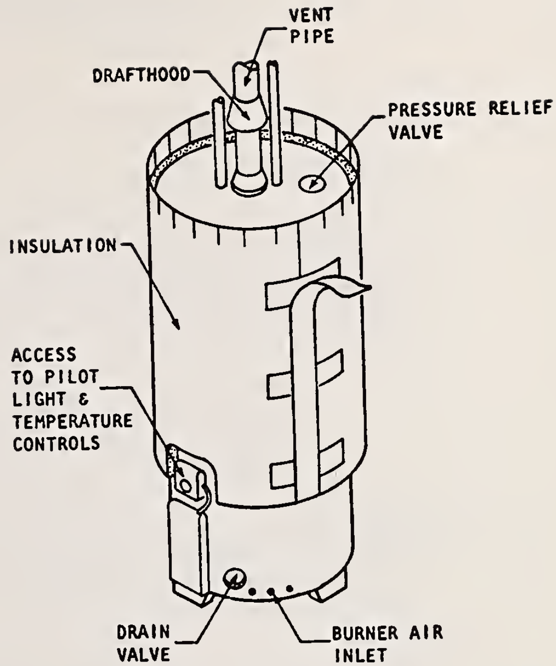

FIGURE 2 - GAS FIRED WATER HEATER

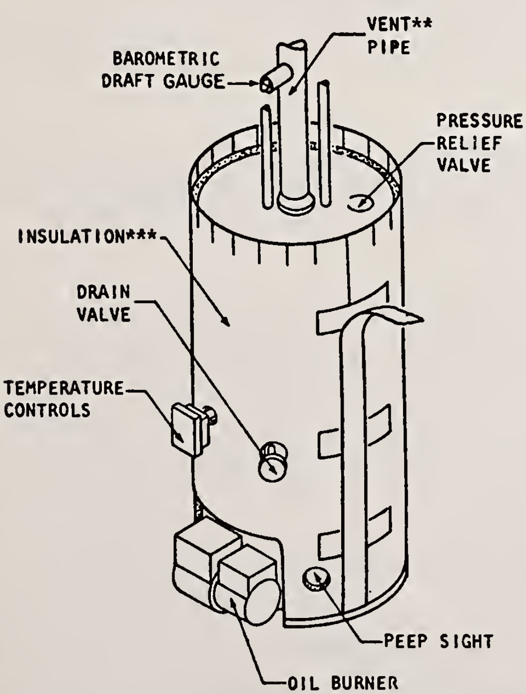

FIGURE 3 - OIL FIRED WATER HEATER.

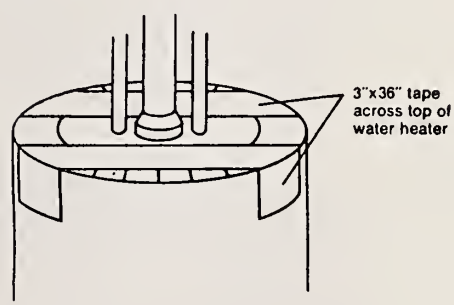

FIGURE 4 - RECOMMENDED METHOD FOR SECURING INSULATION.

* only found on water heaters with two heating elements

** the pipe may be side-mounted

*** top insulated on all electic water heaters and oil fired water heaters with side-mounted five pipes.

STANDARD PRACTICE FOR THE INSTALLATION OF REPLACEMENT OIL BURNERS IN RESIDENTIAL HEATING SYSTEMS

1. SCOPE

1.1 This practice provides minimum requirements for the installation of replacement oil burners for the purpose of significantly reducing the amount of fuel oil consumed by increasing combustion efficiency and reducing firing rate. It is intended for use on warm air, hot water, and steam systems, but does not cover firing rate reductions for steam heating systems.

Steam boilers are considerably less flexible in accepting firing rate modifications than furnaces or hot water boilers because of the steam boilers' need to provide the rate of generation required to obtain suitable steam distribution throughout the system.

1.2 This practice covers the installation process from pre-installation inspection for inefficient operation through post-installation tune-up for best efficiency. Special considerations for maximizing system efficiency are emphasized.

1.3 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

1.4 This practice is not intended to supersede the authority of State and local codes but is intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply, when State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.5 This practice is intended for use by approved installers. It outlines the general procedure to be followed, but leaves the detailed step-by-step methodology to the approved installers. It is therefore not intended for use by the general public or by untrained persons, since such use may be unsafe or result in damaged equipment.

1.6 *This practice covers aspects of installation relating to the effectiveness, durability, and safety of replacement oil burners in service. It does not address the safety of the installer.*

2. APPLICABLE DOCUMENTS

ANSI[1]/ASTM[2] 2156-65 (1975): ANSI Standard Method of Test for Smoke Density in the Flue Gases from Distillate Fuels."

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[1] American National Standards Institute, 1430 Broadway, New York, NY 10018.

[2] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ANSI Z91.2-1976: Performance Requirements for Automatic Pressure Oil Burners of the Mechnical Draft Type.

ANSI Z95.1 - 1974 (NFPA[3] 31-1974): Standard for the Installation of Oil Burning Equipment.

ANSI Z96.2-1974 UL[4] 296: Oil Burners.

EPA[5] 600/2-75-069 a (October 1975): Guidelines for Residential Oil Burner Adjustments.

3. SIGNIFICANCE

3.1 *This practice recognizes that effectiveness, safety, and durability of replacement oil burners depends not only on the quality of the materials but also on their proper and workmanlike installation.*

3.2 *Substantial amounts of fuel oil can be conserved by replacing burners that are inefficient through design, wear, or extreme oversizing with respect to the building's heating requirements, with new, properly sized, high-efficiency burners.*

3.3 *Even where a burner was properly sized at the time of its installation in an uninsulated and unweatherstripped house, the installation of energy conservation measures may have improved the thermal performance of the building's envelope to the degree that the burner is now substantially oversized and inefficient.*

4. DEFINITIONS

4.1 Approved - acceptable to whatever authority regulates the installation of replacement burners Such authority is usually a municipal, State, or Federal agency.

4.2 Draft regulator - A component of oil-fired furnaces which mixes secondary air with the combustion gases leaving the unit, thus enabling a smooth, continuous release of gases up the vent pipe.

4.3 Oil burner - A device which, for oil-fired heating equipment in a residential building, atomizes, vaporizes, or otherwise disperses the fuel-air mixture, and is an integral part of an oil-fired furnace or boiler, including the combustion chamber.

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[3] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

[4] Underwriters Laboratory, 207 E Ohio Street, Chicago, IL 60611.

[5] Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460.

4.4 Replacement oil burner - An oil burner which, because of its design, achieves a reduction in the oil used from that used by the device which it replaces.

5. MATERIALS

5.1 Under the Residential Conservation Service program (RCS), install only oil burners labeled as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE has conducted tests on the material or that the manufacturer uses an approved quality assurance program.

Applicable State and local codes require that all replacement oil burners have third-party certification.

5.3 Under RCS, replacement oil burners must conform to the requirements of the most recent revisions of American National Standard Safety Standard for Oil Burners, Z96.2 (UL 296) and American National Standard Performance Requirements for Automatic Pressure Atomizing Oil Burners of the Mechanical Draft Type, Z91.2.

6. TUNE-UP AND EVALUATION OF EXISTING BURNER

6.1 Clean, adjust, and measure the efficiency of the existing burner. Carry out the following procedures:

6.1.1 Clean soot from heat transfer surfaces.

6.1.2 Seal air leaks around burner tube, and clean-out doors, and seal secondary air dampers and firing doors on converted coal burners.

6.1.3 Clean or replace air filter.

6.1.4 Clean or replace oil filters.

6.1.5 Check flame ignition. Ignition should be nearly instantaneous. Adjust electrodes or make other repairs necessary to achieve nearly instantaneous ignition.

6.1.6 Observe flame color. Repair or adjust burner to achieve an acceptable flame color for the type of furnace being evaluated.

6.1.7 Observe flame shape. If the flame is lopsided or distorted, replace the nozzle, adjust the electrodes, or repair the air cone.

6.1.8 Check for flame impingement on walls of furnace or combustion chamber. Correct impingement resulting in soot or petroleum coke deposits on the target wall.

6.1.9 Check for flame cut off. The flame should disappear within three seconds of cut off. If the flame lingers check that the burner is level. It may be necessary to install an oil supply line solenoid to ensure rapid cut off.

6.1.10 If possible check the nozzle size, type, and spray angle against the burner specifications recommended by the manufacturer. Manufacturers' nozzle specifications should always be followed.

6.1.11 Start the burner. Determine and correct the cause of any abnormal starting or running noise.

6.1.12 Measure either flue or over-fire draft as specified by the manufacturer. Adjust draft regulator to provide the manufacturer-specified draft. Ensure that the draft regulator is operating smoothly.

6.1.13 Check oil supply pressure. Adjust pressure regulator to manufacturer's specification.

6.1.14 Check oil pressure entering pump. Reading should be 6.76 to 10.14 kPa (two to six inches of mercury) vacuum when the tank is below the burner and zero or above when the tank is above the burner. If there is a low reading, correct a possible restriction in the fuel supply.

6.1.15 Allow the burner to run at least 15 minutes to reach a steady-state operating condition. Check for odor at observation port and draft regulator and, if appropriate, correct improper draft, improper venting, or a defective nozzle.

6.1.16 Adjust the air gate to give a smoke reading of #1 or greater when measured in accordance with the procedure outlined in American National Standard ANSI/ASTM D2156-65 (1975) [after 6.1.17 below has been completed, restore burner to a smoke reading of #1 or less].

6.1.17 Measure the flue gas temperature and the percentage of CO_2 in the flue gas through a 6 mm (1/4 in) diameter hole in the flue located between the barometric draft regulator and the furnace flue outlet.

6.1.18 Using Figure 1, determine the steady-state efficiency of the furnace from the flue gas temperature and percent CO_2 concentration. As an alternative, steady state efficiency may be calculated using the procedures given in Appendix A.

> *Cleaning, adjustment and efficiency measurements are needed to determine whether the replacement of the oil burner is cost effective. Tuning, cleaning, and optimizing the nozzle size may increase the efficiency of the existing oil burner considerably so that a replacement burner may no longer be justified.*
>
> *As a further alternate method for determining steady state efficiency, DoE has approved the use of oxygen concentration.*

7. <u>REPLACEMENT CRITERIA</u>

7.1 Replace the burner only if the estimated savings resulting from installation of a more efficient burner will pay for the cost of the replacement burner. If the savings calculated in Table 1 below, multiplied by the homeowner's desired payback period in years exceed the total cost of burner replacement (labor plus parts), the burner should be replaced.

7.2 Table 1 shows the annual dollar savings per $100 of annual fuel costs that can be achieved by increasing furnace efficiency.

7.3 The efficiency of the furnace with a new burner conforming to the requirements of ANSI Z91.2 may be estimated by assuming a stack CO_2 concentration of 10 percent and a stack temperature equal to that measured in 6.1.8. If the burner manufacturer specifies a CO_2 concentration greater than 10 percent for his burner when tested in accordance with ANSI Z91.2, this should be used instead of the minimum value of 10 percent which that standard requires.

As an example, if the original stack conditions were 6 percent CO_2 and 260°C (500°F) (72 percent efficiency) and the manufacturer of the replacement burner stated that 12 percent CO_2 was obtainable with his burner, the assumed new conditions with the replacement burner installed would be 12 percent CO_2 and 260°C (500°F) (81 percent efficiency).[6] Using these values, an estimated annual saving of $11.10 per $100 of annual fuel cost can be read. If the annual fuel costs were $1000, the annual savings would be $11.10 x 10 = $111. If the desired payback period were seven years, the total savings justifying burner replacement would be $111 x 7 = $777. In this example the burner should be replaced if the total replacement cost (labor plus parts) is less than $777 and should not be replaced if the total replacement cost is more than $777.

Use an additional average savings of $5.80 per $100 of annual fuel cost in the payback period calculation if the firing rate of the new burner is optimized as described in paragraph 8.1 and the resulting value is smaller than the original firing rate by 20 percent or more.

8. SELECTION OF REPLACEMENT BURNER

8.1 Determine design nozzle size. Using the local outdoor design temperature for the area and the measured average winter K-factor for the residence (degree days per gallon) determine the minimum nozzle size by the formula:

$$\text{minimum nozzle size (in gallons per hour)} = \frac{(65 - T_D)}{(\text{K factor})(24)} \times \frac{\text{efficiency of furnace measured in 6.1.17.}}{\text{expected efficiency of furnace with new burner as calculated in 7.3.}}$$

where T_D is the local outdoor design temperature in °F and the K-factor is in degree days per gallon of oil. If the outdoor design temperature is not known, refer to Chapter 33 of the ASHRAE Handbook and Product Directory - 1977 Fundamentals. Use the 97.5 percent values for the nearest weather station listed.[7]

8.2 The winter K-factor is an average value derived over one or more complete heating seasons. The K-factor for a residence is defined as the number of degree days occurring in a time period divided by the total number of gallons of oil used during the same period to maintain a house at its normal thermostat setting. Determine from the occupant whether storm windows or a substantial amount of new

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[6] Instructions for calculating furnace efficiency are given in the appendix.

[7] Because of incompatibility of weather data records, calculations involving degree days can not at this time be expressed in SI units.

insulation has been installed since the last heating season. If so, the calculation of the K-factor with the above formula may be too low and must be adjusted accordingly.

8.3 *If the heat requirement of the house has been significantly reduced by insulation of storm windows and/or insulation, it may also be possible to reduce the cutoff set point of the aquastat on hot water boilers by 10° to 20°F to reduce standby heat losses. This setback may not be desirable, however, if the boiler is used to heat domestic hot water.*

8.4 Thermostat setback is to be encouraged as an additional energy conservation practice. If the owner plans to practice nighttime setback, in order to ensure adequate temperature recovery, increase the size of the burner replacement nozzle by adding a value in (liters) gallons per hour equal to the heated house floor area in m^2 $(ft)^2$, times the pickup capacity factor (PCF), divided by 39,000 (140,000), where PCF is given in Table 2.

8.5 Select a nozzle that gives the spray pattern and angle recommended by the manufacturer of the replacement burner that is not larger than the original nozzle.

8.6 Choose the replacement burner recommended by its manufacturer for use with the design nozzle size calculated in 8.1 above.

8.7 Do not select a flame retention replacement burner for use on a hot water or steam boiler equipped with a stainless steel combustion chamber.

Higher temperature levels produced by high performance flame retention burners may cause the combustion chamber to burn out. See also 9.3 below.

9. INSTALLATION OF REPLACEMENT BURNER

9.1 Install fixed firing rate replacement burner with a nozzle of the size calculated in paragraph 8. above.

9.2 Replace the burner in accordance with the manufacturer's instructions following normal good installation practices.

9.3 It is anticipated that most burner replacements will involve replacing a conventional burner with a high speed, flame retention head burner. If this is done, the combustion chamber must be brought into conformance with the burner manufacturer's specifications for size and design. In addition, the combustion chamber material must have a minimum rating of 1260°C (2300°F) (most existing chambers for conventional burners have a rating of 980°C (1800°F)).

Flame retention burners operate at 980°C higher temperatures of 1260°C vs. 980°C (2300°F vs. 1800°F) than conventional burners and could cause damage to a firebox refractory designed for use with conventional burners.

10. POST-INSTALLATION PROCEDURES

10.1 Check that the completed installation is in conformance with all local and state building and fire safety codes. Where local codes do not exist, verify conformance with American National Standard Installation of Oil Burning Equipment, Z95.1 1974 (NFPA 31 - 1974).

10.2 Test-operate the installed burner and measure its efficiency following the guidelines of U.S. Environmental Protection Agency Report No. EPA 600/2-75-069a (October 1975), "Guidelines for Residential Oil Burner Adjustments." If the replacement burner results in an appreciable reduction in stack temperature, the stack switch heat controls (if the unit is so equipped) for ignition cutoff may need to be readjusted.

10.3 The temperature of the combustion gases entering the draft regulator must be at least 188°C (370°F) for chimneys enclosed within the insulated structure to prevent condensate and subsequent corrosion. The temperature of the combustion gases entering the draft regulator must be at least 232°C (450°F) if 2 or 3 sides of the chimney are exposed to an outdoor ambient design temperature of -18°C (0°F) or less, to prevent condensation and freezing within the chimney. If the temperature of the combustion gases entering the draft regulator is below the specified minimum value, fit a larger nozzle to increase that temperature.

10.4 Record the following information in duplicate and leave one copy with the owner and one as a tag attached to the equipment:

Date of replacement

Name of installing mechanic and company

The original burner make, model, model number, and nozzle size

The replacement burner make, model number, and nozzle size

The number and size of any additional nozzles tried in the replacement burner

Other modifications to the unit.

The initial and final CO_2 concentration, net stack temperature, efficiency, and smoke readings.

This information will be helpful for future servicing of the unit and in troubleshooting any problems which arise immediately after burner replacement and/or firing rate reduction.

APPENDIX

DETERMINATION OF STEADY-STATE EFFICIENCY

The steady-state efficiency of the furnace may be determined directly from Figure 2 for furnaces using No. 2 fuel oil.

Alternatively, the following equations may be used to calculate the furnace efficiency:

$$N_{SS} = 100 - L_{L,A} - L_{S,SS,A}$$

$$R_{T,F} = A + \frac{B}{X_{CO_2,S}}$$

$$L_{S,SS,A} = \frac{100}{HHV_A} \sum_{i=1}^{5} [(1 + A/F)\ (CF(i)] + (A/F)(R_{T,F} - 1)(CA(i))]$$

$$\times\ [(TF,SS + 460)^1 - (TRA + 460)^1]$$

where

N_{SS} = steady-state, full-load efficiency %

$L_{L,A}$ = average latent loss, % = $\begin{cases} 6.55 \text{ for No. 1 oil} \\ 6.50 \text{ for No. 2 oil} \end{cases}$

$L_{S,SS,A}$ = average sensible heat loss, %

$R_{T,F}$ = ratio of combustion air to stoichiometric air

$X_{CO2,F}$ = concentration by volume of CO_2 present in dry flue gas, %

$T_{F,SS}$ = flue gas temperature at steady-state, °F

T_{RA} = ambient temperature in furnace room, °F

Additional required constants are as follows:

	For No. 1 oil	For No. 2 oil
HHVA	19,800	19,500
A/F	14.56	14.49
A	0.0679	0.06668
B	14.22	14.34
CF (1)	2.4416834×10^{-1}	2.4361163×10^{-1}
CF (2)	3.3711449×10^{-6}	3.6702686×10^{-6}
CF (3)	8.8906305×10^{-9}	8.7098897×10^{-9}
CF (4)	$-1.3619019 \times 10^{-12}$	$-1.3094378 \times 10^{-12}$
CF (5)	$-1.4367410 \times 10^{-16}$	$-1.5029209 \times 10^{-16}$

For Air

CA (1)	2.5462121×10^{-1}
CA (2)	$-3.0260126 \times 10^{-5}$
CA (3)	2.7608571×10^{-8}
CA (4)	$-7.4253321 \times 10^{-12}$
CA (5)	$6.4307377 \times 10^{-16}$

This calculation procedure is explained more fully in NBSIR 78-1543, "Recommended Testing and Calculation Procedures for Determining the Seasonal Performance of Residential Central Furnaces and Boilers," and Department of Energy "Final Energy Conservation Test Procedures," Federal Register, Part II, May 10, 1978, 43 FR 20128 through 20147.

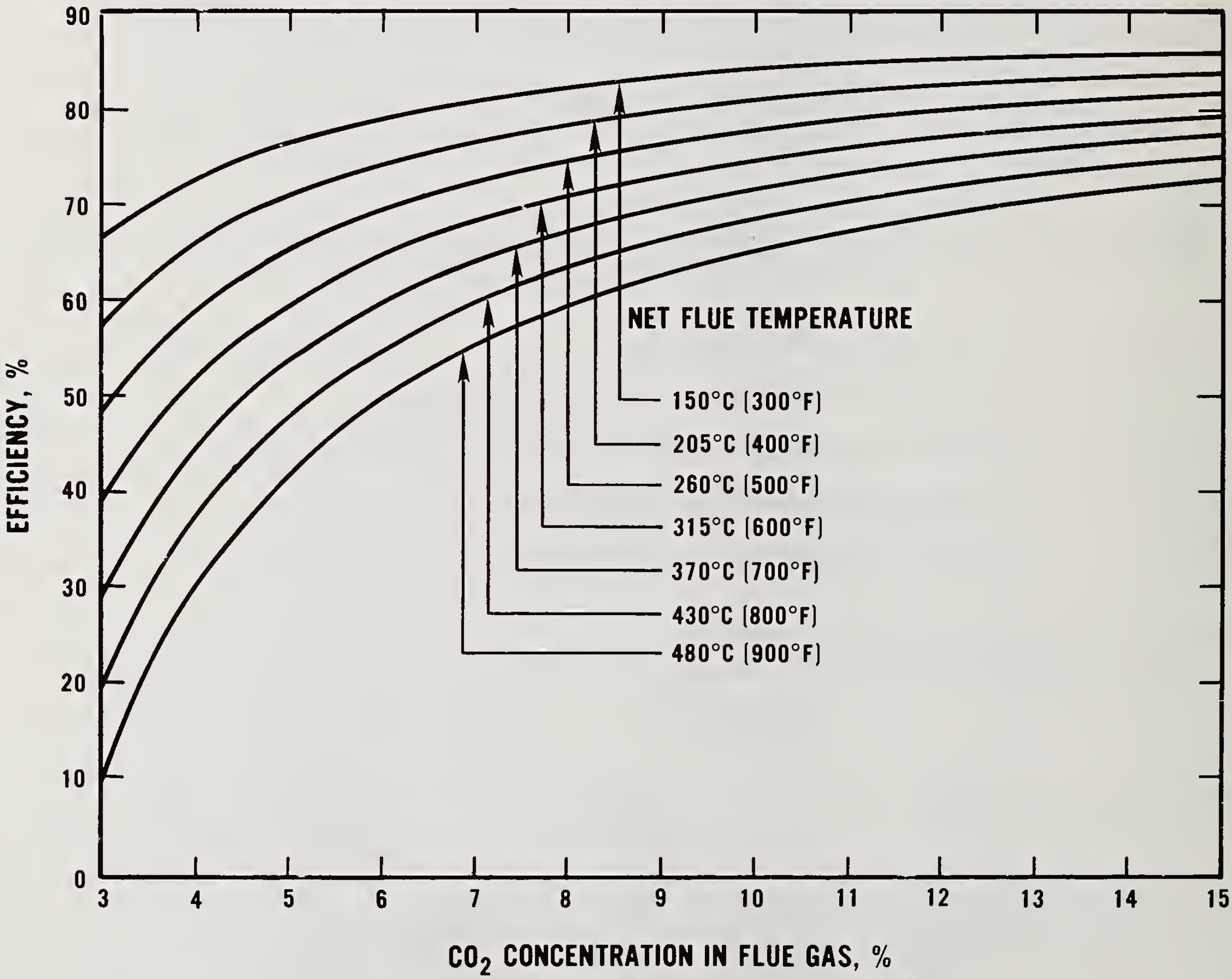

FIGURE 1 - EFFECT OF NET FLUE GAS TEMPERATURE AND PERCENT CO_2 CONCENTRATION ON EFFICIENCY FOR FURNACES OPERATING ON NO. 1 AND NO. 2 HEATING OIL.

Note: The RCS practice published in the Federal Register on November 7, 1979, contained separate figures for No. 1 and No. 2 fuel oil. However, the difference was insignificant for the intended use and a single figure is shown.

TABLE 1. ANNUAL DOLLAR SAVINGS FOR $100 OF ANNUAL FUEL COST AS A RESULT OF INCREASED FURNACE EFFICIENCY

From original efficiency* of (Percent)	To an increased efficiency of (percent)						
	74	76	78	80	82	84	86
50	$32.40	$34.20	$35.90	$37.50	$39.00	$40.50	$41.90
52	29.70	31.60	33.30	35.00	36.60	38.10	39.50
54	27.00	28.90	30.80	32.50	34.10	35.70	37.20
56	24.30	26.30	28.20	30.00	31.70	33.30	34.90
58	21.60	23.70	25.60	27.50	29.30	31.00	32.60
60	18.90	21.10	23.10	25.00	26.80	28.60	30.20
62	16.20	18.40	20.50	22.50	24.40	26.20	27.90
64	13.50	15.80	17.90	20.00	22.00	23.80	25.60
66	10.80	13.20	15.40	17.50	19.50	21.40	23.30
68	8.10	10.50	12.80	15.00	17.10	19.00	20.90
70	5.40	7.90	10.30	12.50	14.60	16.70	18.60
72	2.70	5.30	7.70	10.00	12.20	14.30	16.30
74		2.60	5.10	7.50	9.80	11.90	14.00
76			2.60	5.00	7.30	9.50	11.60

* The original furnace efficiency is the value calculated in 6.1.18.

TABLE 2. PICKUP CAPACITY FACTOR AS A FUNCTION OF OUTDOOR DESIGN TEMPERATURE

Outdoor Design Temperature °C	°F	Pickup Capacity Factor* W/m^2	$Btu/h/ft^2$
5		28.7	
	40		9.5
0		39.4	
	30		13.0
- 5		45.7	
	20		14.9
-10		48.8	
	10		15.8
-15		52.0	
	0		17.0
-20		54.0	
	-10		17.7
-25		56.9	
	-20		18.8
-30		60.5	

* This table is based on a 6°C (10°F) thermostat setback and a two-hour pickup time.

STANDARD PRACTICE FOR THE INSTALLATION OF AUTOMATIC VENT DAMPERS ON EXISTING GAS-FIRED CENTRAL FURNACES AND LOW PRESSURE DOMESTIC HOT WATER BOILERS[1]

1. SCOPE

1.1 This practice applies to the field installation of electrically-operated, mechanically-actuated, and thermally-actuated automatic vent dampers on existing gas-fired central furnaces and low pressure hot water boilers in existing residential buildings.

1.2 This practice applies only to the installation on individual, automatically operated, gas-fired, hot air (forced or gravity) central furnaces and gas-fired low pressure hot water boilers equipped with draft hoods.

1.3 This practice is intended for use by qualified approved installers only.

This practice outlines in general terms the procedures to be followed, but leaves the installed step-by-step methodology to the approved installer. It is therefore not intended for use by the general public or by untrained persons, since such use may be unsafe or result in damaged equipment.

This practice covers aspects of installation relating to the effectiveness, durability, and safety of installed vent dampers in service. It does not primarily address the safety of the installer.

1.4 Proper application of this practice requires specialized training in the installation of vent dampers and a working knowledge of the applicable codes and regulations, tools, equipment and methods necessary for the safe installation of vent dampers, and an understanding of the fundamentals of gas-fired heating and domestic hot water systems.

Because of the potential hazards involved, vent dampers should never be installed by untrained people. This requirement is also consistent with existing codes and rules in many localities and States.

1.5 This practice outlines the general procedure to be followed. No procedure can anticipate all situations. Accordingly, in some cases deviation from this procedure may be necessary for a safe installation.

When departing from the substance of this practice, details and rationale for such departures should be noted on the verification card required under 9.19 and in the DoE Material Standards for Vent Dampers.

1.6 This practice is intended to establish a minimum level of performance for safety and effectiveness. When a manufacturer's installation instructions regarding specific requirements that affect safety and effectiveness result in a higher level of performance for these characteristics, such manufacturer's installation instructions may be used.

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[1] This practice is based on guidelines developed by the Calspan Advanced Technology Center, a division of Calspan Corporation and on the applicable documents identified. The guidelines have been revised editorially to be compatible with the format of the other practices in this publication.

1.7 This practice is not intended to supersede the authority of State and local codes but is instead intended to establish minimum criteria for safety and effectiveness. When State or local codes specifically address the substance of provisions contained herein, they may apply. When State and local codes do not address the substance of specific provisions contained herein, this practice shall prevail.

1.8 *This practice covers the installation process from pre-installation through post-installation procedures. It does not cover the production of the vent dampers or their assembly, whether such production or assembly takes place in a factory or at the installation site. The RCS Material Standards require that only factory assembled vent damper be installed.*

2. APPLICABLE DOCUMENTS

ANSI[2] Z21.66-1977: American National Standard for Electrically-Operated Automatic Vent Damper Devices for Use with Gas-Fired Appliances.

ANSI Z21.67-1978: American National Standard for Mechanically-Actuated Automatic Vent Damper Devices for Use with Gas-Fired Appliances.

ANSI Z21.68-1978: American National Standard for Thermally-Actuated Vent Damper Devices for Use with Gas-Fired Appliances.

ANSI Z21.13-1977: American National Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers.

ANSI Z21.47-1978: American National Standard for Gas-Fired Central Furnaces (except direct vent and separated combustion central furnaces).

ANSI Z223.1-1974 (NFPA [3] 54-1974): "American National Standard National Fuel Gas Code, Part 1, Installation of Gas Piping and Gas Equipment on Nonindustrial Premises.

NFPA[3] 70-1975: National Electrical Code.

3. SIGNIFICANCE

3.1 Improper installation can result in injury or death from venting exhaust gases, including carbon monoxide, into the residence.

Automatic vent dampers are potentially very dangerous if they are not installed properly. Vent dampers are intended to shut off the flow up the vent during periods when the burner is not firing, thereby saving the loss of conditioned air. However, during periods when the burner

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[2] American National Standards Institute, 1430 Broadway, New York, NY 10018.

[3] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

is firing, the damper <u>must</u> be open to allow hazardous combustion products to be vented outside of the residence. <u>If improperly installed, the vent damper could shut off the vent during burner firing, and cause hazardous combustion products to be vented into the residence with possibly fatal results</u>.

3.2 Improper installation can also result in electrical shock hazard to the installer or others.

4. DEFINITIONS

4.1 *Additional Gas Valve (also sometimes called a "Redundant" Gas Valve) - A second operating gas valve in series with another operating gas valve, both of which operate with each call for heat. The additional (redundant) gas valve may be either an additional valve (without pilot features) located in the gas line between the existing valve and the main burner or a replacement valve that includes two operating valves within a single unit.*

4.2 *Heating Appliance - An individual, automatically-operated, gas-fired hot air (forced or gravity) furnace or gas-fired low pressure hot-water boiler equipped with a draft hood.*

4.3 Approved - acceptable to the authority which regulates the activity or material and its use. Such authority may be a municipal, State, or Federal agency or underwriters' inspection or rating bureau.

4.4 *Boilers - a self-contained, gas burning appliance intended to supply hot water at gage pressures not exceeding 1.1 mPa (160 psi) having residential space heating as primary purpose.*

4.5 *Comfort Thermostat - An automatic control device for a residential space heating system actuated by room air temperature and designed to respond to the room air temperature.*

4.6 *Furnace - a self-contained, gas-burning appliance for heating air by the transfer of heat from combustion through metal to the air for the purpose of residential space heating.*

4.7 Vent Damper - a device which automatically closes vents on gas-fired appliances to prevent the escape of heat through the vent pipe when the main burner is not being fired. The device may be electrically-operated, mechanically-actuated, or thermally actuated.

5. MATERIALS

5.1 Under the Residential Conservation Service program (RCS), install only vent dampers identified as complying with DoE standards.

This marking indicates that the manufacturer certifies that the product meets the applicable DoE standards. The label does not imply that DoE *has conducted tests on the material or that the manufacturer uses an approved quality assurance program.*

5.2 In addition, all vent dampers installed under RCS also must carry a label stating: "This device must be installed only by a qualified installer."

5.3 A safe installation requires that safe vent damper and heating appliance designs be used.

5.3.1 The vent damper must, as a minimum, be listed by a nationally recognized testing laboratory and must meet ANSI Standards Z21.66-1977, Z21.67-1978 or Z21.68-1978.

5.3.2 Heating appliances to which vent dampers are installed must meet currently applicable State and local codes and the appropriate nationally recognized standards in force at the time of their manufacture. The most recent of these standards are listed under "2. APPLICABLE DOCUMENTS."

Often the authority having jurisdiction over the installation of gas equipment in a locality will have requirements that must be met before equipment is considered safe and is approved for use in that locality. Often equipment must be listed before it is approved. Listed equipment is that included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of the production of equipment that it lists. Each listing states that the equipment either meets nationally recognized standards or has been tested and found suitable for use in a specified manner. Listed vent dampers and heating appliances are intended to include only safe designs. However, using a listed vent damper on a listed heating appliance does not necessarily imply a safe retrofitted system, since not all listed vent dampers are compatible with all listed heating appliances. In addition, the safety of a retrofitted system depends not only on the safe designs of the existing heating appliance and vent damper but also on the manner in which the vent damper is installed.

6. SAFETY PRECAUTIONS

6.1 If at any point during the pre-installation (7), installation (8), or post-installation (9) procedures it is determined that there is a condition which could result in unsafe operation of the heating system, the appliance must be shut off, the owner informed of the required repairs, and the repairs made before continuing with the installation.

7. PRE-INSTALLATION PROCEDURES

7.1 Perform pre-installation procedures before making an attempt to install a vent damper. Do not install the vent damper on the appliance if the determinations required below can not be made.

The purpose of the pre-installation procedure is to determine that the gas heating appliance is properly installed and is in a safe condition for continuing use.

7.2 Determine that the heating appliance is not in a space that is essentially at outdoor temperature, such as an unheated attic, crawl space (unless the crawl space serves as a heating plenum), or basements with openings directly to the outdoors.

Vent dampers save energy by reducing the flow of heated air up the vent during periods when the main burner of the heating appliance is off. If the appliance is located in an unheated area, the air flow prevented during periods when the main burner is off is not heated air.

7.3 Because vent capacities are reduced when the difference between indoor and outdoor temperatures are the least, and, generally, when wind velocities are low, all checks of venting capacity or draft hood spillage must be conducted when the outside temperature is above 18°C (65°F) and the wind velocity is less than 16 km/h (10 mph). Exception: When it is necessary to conduct tests of venting capacity or draft hood spillage when outdoor temperatures are below 18°C (65°F) and/or wind velocities higher than 16 km/h (10 mph), the installer must employ another method to ensure that the entire venting system will have adequate capacity and will not produce draft hood spillage. One acceptable alternate method is a thorough inspection of the venting system wherein the interior of the flue of the heating appliance, the vent connector, and the chimney flue are visually inspected for obstructions, blockage, or restrictions such as might be caused by fallen mortar or bricks, a dead bird, bird nest, etc. This inspection is in addition to the inspections called for in 7.7 below. Venting may be particularly dependent on wind conditions in certain special situations. Extra caution must be exercised in certain special situations that include exposed locations in high wind areas; locations in very hilly terrain; difficult constructional features for venting purposes, such as high pitched roofs; and neighborhoods with sharply varying building heights. In these situations, wind currents directed at the top of the chimney may cause downdrafts at times. If any of these situations are suspected of causing draft problems, it will be necessary to conduct the vent capacity or draft hood spillage checks on several days under various wind conditions.

7.4 Determine with suitable instruments that there is no detectable concentration of combustible gas in the vicinity of the heating appliance. The absence of combustible gas is indicated by a reading of less than 20 percent of the lower explosive limit on the appropriate instrument or by a smell test indicating complete freedom from odor. (The lower limit for detecting fuel gas by smell is approximately 20 percent of the lower explosive limit[4]). The absence of CO is indicated by a reading of less than 50 ppm, which is the lowest marking on several CO test instruments in common use.

Limits of combustible gas and carbon monoxide concentrations are set as a preliminary indication of a safety hazard. The given levels are both quite detectable and provide satisfactory safety.

7.5 Determine that the heating system installation meets the requirements of all applicable codes and regulations. The heating system installation should at least meet the requirements of the National Fuel Gas Code, ANSI Z 223.1-1974 (NFPA No. 54-1974).

The purpose of this practice is to provide a minimum requirement. It does not have the authority to supersede State and local codes.

7.6 Conduct a gas leakage test of the appliance piping and control system downstream of the shut-off valve in the supply line to the appliance. Do not use a flame or other source of ignition to check for gas leaks.

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[4] Gas Engineers Handbook, Section 861, Industrial Press Inc., New York, NY 10016, 1974, p. 9/108-9/111.

This is to serve as an initial check for the safety of the installer and for continued safe operation.

7.7 Inspect the venting system to determine that the cross-sectional area of the vent connector is not less than the area of the draft hood outlet (the chimney side of the draft hood) and that the area of the vent is not less than the area of the largest connected draft hood outlet plus 50 percent of the areas of additional connected draft hood outlets. If these criteria are not met, the vent system must meet the provisions of the National Fuel Gas Code (ANSI Z 223.1-1974) paragraphs 1.5.6.3 and 1.5.8.3. Determine that there are no manually adjustable dampers in the vent system. Also visually inspect for positive horizontal pitch [not less than 20 mm/m (1/4 in/ft)] and determine that there is no blockage, restriction, leakage, corrosion, etc., which could cause an unsafe condition.

Existing safety standards have specified vent sizes as providing adequate vent capacity. Positive pitch is required to reduce the collection of condensate.

7.8 Determine that the outside termination of the vent is satisfactory (see ANSI Z 223.1-1974, 1.5.5.2 and 1.5.6.3). Determine that the chimney is unobstructed, does not have excessive soot buildup, is in good condition, and is either a lined masonry chimney or an approved Type B or Type L vent, or factory built chimney. Do not install a vent damper in a heating system using any other chimney type, including unlined masonry chimneys and uninsulated, single-wall metal pipes. Determine that the vent connector does not project into the chimney.

A satisfactory chimney is necessary for proper draft and to prevent leakage of hazardous combustion products into the living area.

7.9 Determine that the comfort thermostat(s) is (are) in satisfactory operating condition. Check for excessive dust, corrosion, pitted contacts, and cracked or broken base or housing. Note the comfort thermostat setting so it can be reset after the installation is completed, then adjust the thermostat for continuous operation. Determine that the burner input is in accordance with the heating appliance manufacturer's instructions.

A stuck thermostat could cause hazardous overheating and an open thermostat could cause dangerously low temperatures. The burner input must be in accordance with the heating appliance manufacturer's instructions to be operating within its design parameters. Operating at other than rated input could cause flame impingement, excess carbon monoxide production, poor ignition, and a variety of other hazardous conditions.

7.10 Visually determine that the main burner gas is burning properly and that there is no floating, lifting, or flashback. Adjust the primary air shutter(s) as required. If the appliance is equipped with flame modulation, check for proper main burner operation at low and high flame. Observe burner for evidence of plugged burners, improper flame alignment, combustion product leakage, and improperly adjusted pilot lights.

These determinations are required to indicate necessary adjustments that could affect later tests and are necessary for proper operation of appliances. Improper burning could cause excessive carbon monoxide, overheating of furnace components, fire hazard from exposed flame, or leakage of hazardous combustion products.

7.11 Shut off all gas to the appliance using the shut-off valve in the supply line to the appliance. Shut off the main burners of all other appliances located within the same room or connected to the same vent. Note the settings of any thermostats that are to be changed so they can be reset after the installation is completed.

The heating appliance is shut off so that some inspections can be made while the appliance is off and to allow time for the appliance to cool before conducting the draft hood spillage test. Other appliances located in the same room or connected to the same vent are turned off to minimize vent system priming. They will be turned on later to provide full vent loading and to maximize combustion air requirements.

7.12 Determine that there is sufficient combustion air. In unconfined spaces in buildings of conventional frame or masonry construction, infiltration normally is adequate to provide air for combustion, ventilation, and dilution of flue gases. If the unconfined space is within a building of unusually tight construction, air must be obtained from outdoors or from spaces freely connected with outdoors. Permanent openings having a total free area of not less than 100 mm^2 in 230 W (1 in^2 in 5000 Btu/h) of total input rating of all appliances must be provided. For appliances located within confined areas, follow the recommendations of the National Fuel Gas Code ANSI Z223.1-1974, paragraphs 1.3.4.3 through 1.3.4.6. Check any ducts for obstructions and other unsafe conditions.

This requires that sufficient combustion air be available, gives a specification for the area of openings required, and indicates a source of additional information for unusual situations. Insufficient combustion air could cause large increases in carbon monoxide and poor combustion, with attendant hazards.

If the combustion and dilution air is obtained from the outside, the provisions of 7.2 apply and no vent damper should be installed.

7.13 Shut off electricity to the heating appliance. Determine that no electrical wiring at the appliance has loose connections, charred insulation, cracked or worn insulation, or potential shorting to ground. Determine that fuses and circuit breakers are of correct size and that wires are of correct size for the appliance. Turn on electricity.

Incorrect or deteriorated electrical systems components could result in shock hazards or improper furnace operation.

7.14 Determine that no appliance burners and gas manifolds are blocked or corroded. Determine that the burner is properly aligned and shows no evidence of burner misalignment that could cause hot spots on the heat exchanger.

Requires burner and manifold inspections that are not included in the existing standards. The listed defects could cause improper burner operation.

7.15 Applicable only to furnaces: Determine that the heat exchanger does not have cracks, openings, leakage deposits, excessive corrosion, and/or evidence of excessive hot spots. Determine that the recirculating air section of the appliance does not incorporate flammable materials or materials that could emit toxic fumes on being heated.

Leakage paths could result in the leakage of hazardous combustion products.

7.16 Applicable only to boilers: Determine that there is no evidence of water or combustion product leaks.

Leaks could cause improper boiler operation.

7.17 Insofar as is practical, close all building outside doors and windows. Turn on all exhaust fans (range hood, bathroom exhausts, etc.) so they will operate at maximum capacity. Turn on any clothes dryers vented to the outside. Do not operate summer exhaust fans. Make certain that no fireplace(s) is (are) operating. Close all fireplace dampers.

This is to decrease the pressure in the heating appliance area for the required tests below, exhaust fans must be turned on. A requirement for turning on any clothes dryers vented outside is specifically included since this exhaust fan might otherwise be neglected. The required position of inside doors is given in 7.18.

7.18 For the following vent system checks, the worst venting conditions that may reasonably exist should be duplicated. The worst venting conditions exist when the space occupied by the heating appliance is at the lowest pressure. If there are exhaust fans in the same room as the heating appliance, or if there are no exhaust fans in the residence, the lowest pressure will probably occur when the doors to other spaces of the building are closed. If there are exhaust fans in other rooms, the pressure will probably be lowest when doors connecting these rooms with the heating appliance space are open. Based on these considerations, open or close doors to other spaces of the building as required to produce the lowest pressure in the space occupied by the heating appliance. If it is not known which condition results in the lowest pressure, apply the requirements of 7.18 through 7.22 twice--once with doors to other spaces of the building open and once with the doors closed. After the appliances have been off for at least 30 minutes, turn on the gas to the appliance being inspected and place it in operation. Follow the manufacturer's lighting instructions. Adjust the comfort thermostat for continuous, full-burner appliance operation.

The worst venting conditions must be duplicated to ensure that the following test is adequate to determines that spillage and attendant hazards do not occur under any foreseeable combination of ventilator operations and door openings and closings.

7.19 Conduct test for spillage at the draft hood relief opening at 2 minutes after start of main burner operation. This short time is necessary if the test is to simulate a reasonably severe condition. Use a device that will produce unpressurized flame or smoke, such as a match flame or cigarette smoke. Considerable care must be used to determine if flow is in or out of the draft hood. Adequate lighting must be provided for observation and the flow through all areas of the draft hood opening(s) must be carefully observed. After testing for spillage at the heating appliance draft hood, test also for spillage at other draft hoods connected to the same vent.

The tendency for spillage is greatest at the beginning of the burner firing cycle because the vent system is cool and vent flows have not been established. Therefore, it is important that spillage tests be conducted at a specified time that is short compared to the burner firing time. The National Bureau of Standards has determined that 3.87 minutes is an average burner firing time for furnaces, and 9.68 *minutes is an average burner firing time for boilers.[5] Many operating cycles would have a shorter burner firing time. On the other hand, the amount of spillage may be only a very small percentage of the total gases being vented and this spillage may have been tolerated in the past. However, recent measurements indicate that inside pollution levels may be adversely affected by even small amounts of spillage. Based on the above considerations, a time of 2 minutes of testing for spillage of was determined to be necessary. Also, because of the critical nature of this test, some additional instructions are given for conducting it. Because spillage at other draft hoods connected to the same vent is also a hazardous situation, a spillage check at these other draft hoods is also required.*

7.20 Shut off the main burner and let the appliance cool for at least 15 minutes.

The main burner is shut off and the heating appliance is allowed to cool to minimize priming of the vent system. Although full cooling may require a longer period, the 15 minutes of cooling is used to shorten the installation time.

7.21 Turn on all other fuel-burning appliances that are within the same room or that are connected to the same vent so they will operate at their full inputs. Turn on the appliance being inspected so that it will operate at its full rated input.

All other fuel-burning appliances within the same room and connected to the same vent are turned on to create the greatest load on the vent system and to maximize combustion air requirements.

7.22 Repeat requirements and provisions given in 7.19.

Paragraph 7.19 included a test for spillage with only the heating appliance operating. Other appliances connected to the same vent may induce additional flow from the heating appliance draft hood outlet or, conversely, they may cause an increase in the vent system load and reduce flow from the heating appliance draft hood outlet. Therefore, both conditions must be duplicated. Also, the increase in combustion air requirements reduces the pressure in the room in which the heating appliance is located and thereby promotes spillage.

7.23 After 5 minutes of main burner operation, measure the flue gas temperature and carbon monoxide (CO) concentration at a point 25 mm (1 in) before the inlet to the draft hood at the center of the flue passage(s). This temperature should be at least 93°C (200°F). This temperature is necessary to limit condensation within the vent. This temperature should also be less than 288°C (550°F), the vent damper's maximum design temperature. The maximum carbon monoxide concentration should be 0.04 percent (400 ppm), as permitted for new heating appliances. If the heating appliance is equipped with flame modulation, rerun the minimum 93°C (200°F) flue gas temperature test and the CO test at the lowest flame conditions.

There are three levels of temperature that are important to the installation of vent dampers. A minimum temperature is required to limit condensation within the vent system that could lead to corrosion

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[5] Joseph Chi, George E. Kelly, "A Method for Estimating the Seasonal Performance of Residential Gas and Oil-Fired Heating Systems," ASHRAE Transactions, 1978, Vol. 84, Part 1, p. 411.

damage. This minimum temperature is dependent on the characteristics of the particular vent system. Therefore, no one value is satisfactory for all vent systems, but values of about 93°C (200°F) have generally been accepted as adequate. This single value of 93°C (200°F) has been given to provide a usable installation guideline that will provide more protection than existing standards, which do not require any minimum temperature.

Listed vent dampers are tested at a maximum temperature of 300 ± 15°C (575 ± 25°F) and, therefore, the vent temperature should be limited to 290°C (550°F). The temperature is to be measured in the flue because it represents the maximum temperature to which the vent damper could be exposed in operation. This exposure would occur under the condition of no diluting air flow. At the time of measurement, there may be diluting air entering the draft hood, reducing the temperature at the location where the vent damper will be installed, but this may not be the condition at some later time.

Listed heating appliances must meet the requirement of a maximum of (0.04 percent) of carbon monoxide (air free). All appliances to be retrofitted should also meet at least the specified carbon monoxide concentration.

7.24 For thermally-actuated vent dampers only: Measure the temperature at the center of the vent connector 150 mm (6 in) six inches downstream the outlet of the draft hood. The vent gas temperature must be at least 188°C (370°F) but less than 288°C (550°F). The damper design has been tested for flow restriction at 188°C (370°F). Lower vent gas temperatures at full input could result in flow restriction and spillage.

7.25 For electrically-operated and mechanically-actuated vent dampers only: If the vent damper is not installed with a redundant gas valve, it must be equipped with a damper-closing temperature control, and the temperature at the center of the vent connector, 150 mm (6 in) downstreams of the outlet of draft hood must be measured. This damper closing temperature control is intended to keep the damper open whenever the main burner is operating. The vent gas temperature must be more than 190°C (375°F) under normal conditions to ensure that the damper-closing temperature control will function properly (i.e., hold the damper open) under an abnormal condition of restricted fuel gas input. If the vent gas temperature at full output is not above 190°C (375°F), do not install a vent damper with a damper-closing temperature control.

Listed dampers that have a damper-closing temperature control must not automatically close when the vent gas temperature is above 107°C (225°F) when tested under specified conditions. The purpose of damper-closing temperature control is to keep the damper open if there is a malfunction of the automatic gas valve such that gas flows without a call for heat. This can occur if the automatic gas valve sticks open or if contamination holds it open. With these types of automatic gas valve malfunctions, the amount of gas flowing may be any value between zero and full flow. Listed vent dampers with damper-closing temperature controls must have 10 percent open area in the nominally closed position. Therefore, the damper-closing temperature control must protect against automatic gas valve leakage rates from full flow down to 10 percent of full flow.

It has been calculated that a vent gas temperature of 190°C (375°F) measured at full gas flow will provide a vent gas temperature of at least 107°C (225°F) for the majority of hazardous leaking valve *conditions. If the above conditions are not met the damper could be closed during an automatic gas valve malfunction with resulting continuous spillage--a hazardous condition.*

7.26 Return doors, windows, exhaust fans, fireplace dampers, and other appliances to their previous conditions of use.

7.27 Determine that the pilot light(s) is (are) burning properly and that main burner ignition is satisfactory by turning the main power supply switch for the heating appliance off and on. Test the pilot safety device to determine if it is operating properly by extinguishing the pilot burner(s) when the main burner is off and determine that the main gas valve does not open upon a call for heat beyond the safety shut-off time specified by the automatic gas ignition device manufacturer. If this time is not known, a safety shut-off time of one minute must be met. Relight the pilot(s) after this time check.

This specifies checks of the pilot light and safety device. Listed automatic ignition devices are required to shut off main gas flow in the absence of a flame within the times specified by their manufacturer. This step requires that a check be made of the shut-off time. In many instances, the manufacturer's specified shut-off time will not be known because this fact is not required to be marked on the ignition device. In these cases, a shut-off time of one-minute has been specified because this is representative of the shorter shut-off times of ignition devices that may be found in the field.

7.28 Applicable only to furnaces: Check both the limit control and the fan control to determine that they operate within the heating appliance manufacturer's specfications.

Improper operation could result in overheating or excessive fan operation.

7.29 Applicable only to hot water boilers: Test low-water cutoffs, automatic-feed controls, high-pressure limit controls, high-temperature-limit controls, relief valves, water pumps, and the circulating system to determine that they are operating within the manufacturer's specifications.

To test operation of the safety features.

8. INSTALLATION PROCEDURES

8.1 Do not install vent dampers unless the pre-installation procedures have been carried out, the heating appliance has been found to be properly installed and in a safe condition, and that any required repairs have been made.

8.2 If at any point during the pre-installation procedures or anytime during installation it is it was determined that there is a condition that could result in unsafe operation of the heating system, the appliance must be shut off, the owner informed of the necessary repairs, and the repairs made before the installation is continued.

8.3 This general installation procedure is to be used in conjunction with installation instructions supplied by the automatic vent damper manufacturer to ensure the safe installation of the vent damper on an existing appliance.

8.4 Install mechanically-actuated vent dampers only on appliances with which they are compatible. Determine compatibility by comparing the appliance with diagrams furnished by the damper manufacturer showing interconnections among the heating appliance, the damper, the motive force and the control circuits. Install electrically-operated vent dampers and thermal vent dampers with electrical connections only on appliances where the wiring diagrams supplied by the vent damper manufacturer show the device to be compatible with the appliance. Do not install the vent damper if a wiring or interconnection diagram applicable to the heating system is not supplied by the vent damper manufacturer.

8.5 Determine that the heating system and vent damper are both listed and approved models. Ensure that the damper and other materials are in good condition and free of damage resulting from shipping or other causes and ensure that all parts are included. Determine whether the vent damper includes a damper-closing temperature control. On any damper with electrical connections, ensure that the required voltage of the damper is compatible with the voltage of the control circuit of the heating appliance. If the damper installation requires interconnection with the heating appliance's automatic gas valve, determine whether this gas valve has a manual override feature which would permit operation of the heating appliance while the damper is in the closed position or while any damper safety system is not operational. If a valve with such an override feature is found, the manual override feature must be removed or replaced before proceeding with installation of the interconnected damper.

8.6 <u>For mechanically-actuated vent dampers only</u>: Determine that the range of available motive force (gas pressure, water pressure, etc.) is within the vent damper manufacturer's specified operating range. Determine that the heating appliance automatic gas valve does not have a manual override feature that would permit manual operation of the heating appliance while the damper remains closed.

8.7 Shut off all gas and electricity to the heating appliance. To shut off the gas, use the shut-off valve in the supply line to the appliance. To shut off the electricity, use the main power switch for the heating appliance.

The heating appliance is shut off to prevent accidental operation of the appliance during the vent damper installation. The electricity is shut off to eliminate electrical shock hazards.

8.8 Install the automatic vent damper in accordance with the manufacturer's installation instructions. Make certain that the damper is located in the portion of the venting system that serves only the appliance on the which the damper is being installed and that it is between the appliance draft hood and the first branch (if any) in the vent system. The vent damper must be installed <u>after</u> the draft hood, that is, between the draft hood and the chimney. If the damper is equipped with a damper-closing temperature control, the damper must be located within three diameters of the draft hood. The inlet size of the vent damper must not be less than the outlet size of the draft hood. <u>Do not add any components (such as relays) not specified by the manufacturer</u>.

Listed vent dampers are required to have most of these instructions included. They are reiterated here because of their importance to the safe installation of vent dampers. The installer is cautioned not to add any components that are not specified by the manufacturer. Adding such components could create a hazardous failure mode that might not be evident immediately.

8.9 Determine that the vent system is adequately supported to hold the additional weight of the vent damper without sagging. This may require band iron straps attached overhead and/or self-tapping screws at each joint. Visually inspect the modified venting system for proper horizontal pitch [not less than 20 mm per 1 m (1/4 in/ft)].

> *Some precautions are given relative to the support of the vent system so that it does not fail structurally during operation, resulting in leakage of hazardous combustion products. A significant number of improper support conditions have been found in a field evaluation by Walden[6].*

8.10 For installation of electrically-operated or mechanically-actuated vent dampers only: If the vent damper is not equipped with a damper-closing temperature control, an additional ("redundant") approved automatic gas valve must be installed in accordance with the vent damper manufacturer's installation instructions. This gas valve is intended to shut off gas flow if the other gas valve should fail to close completely. It may be either an additional valve (without pilot features) located in the gas line between the existing valve and the main burner or a replacement valve that includes all main gas valves within the single unit. Follow vent damper manufacturer's instructions. After installing a new gas valve, purge air from the affected gas lines and conduct a gas leakage test of the appliance piping and control system downstream of the shut-off valve in the supply line to the appliance.

> *The additional ("redundant") automatic gas valve is critical to the safety of dampers not equipped with a damper-closing temperature control. The importance of this valve needs to be stressed. The system would operate properly until there was a malfunction of the existing automatic gas valve. If only one automatic gas valve were installed, and it malfunctioned, gas could be flowing but the damper would be closed resulting in continuous spillage--a hazardous condition.*

8.11 Assure that electrical connections are tight and wires are clear of high-temperature locations and are properly supported. Route wires to minimize the possibility of their being damaged. All wiring must meet the requirements of all applicable codes and regulations. As a minimum, wiring must meet the requirements of the National Electrical Code.

9. POST-INSTALLATION PROCEDURE

9.1 This post-installation procedure determines that the automatic vent damper is properly installed and that the retrofitted system is in a safe condition for use. If at any point it is determined that there is a condition that could result in unsafe operation of the heating system, the appliance must be shut off, the owner informed, and the necessary repairs made before permitting the operation of the appliance to which the vent damper was installed.

9.2 Turn on electrical power to the heating appliance.

9.3 For the installation of electrically-operated and mechanically-actuated vent dampers only: By operating the furnace burner through the control circuit, deter-

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[6] L. Katzman and J. Monat, "Study to Evaluate the Energy Efficiency Improvement of Residential Heating Equipment Modifications," Walden Division of Abcor, Inc., Wilmington, Massachusetts, May 1978, pp. 4-7.

mine that the damper operates properly and is correctly sequenced with the heating appliance's operating controls (comfort thermostat). The damper must be nearly open before the gas valve(s) opens and it must remain open when there is a call for main burner operation. The gas valve(s) must close when the damper begins to close. The gas valve and damper should remain closed when there is no call for heat. The damper must open and close freely without evidence of interference or binding. Also determine that the gas valve(s) and damper close fully. If boiler gas valve(s) is sequenced by an aquastat, determine that the damper has opened fully or is nearly open prior to the opening of gas valve(s).

Improper sequencing could indicate the absence of proper interlock between the damper and the automatic gas valve. This could result in a hazardous condition at a future time if the damper did not open for some reason.

9.4 If the damper has electrical current requirements, determine the amperage draw of all circuits served by the heating appliance transformer (including such items as thermostats, humidifers, controls for electrical filters, etc.) and the vent damper. Check the heating appliance transformer for adequate capacity. Replace the transformer if it does not have adequate capacity.

It must be determined that the appliance transformer has adequate capacity since the vent damper may put additional load on the transformer.

9.5 Check the setting of any heat anticipator in the comfort thermostat and readjust as necessary. Replace the heat anticipator if it does not have sufficient amperage capacity.

The vent damper may change the current flow through the thermostat. This may require a readjustment of a heat anticipator for the same level of comfort. If the heat anticipator does not have sufficient amperage capacity, it could eventually burn out.

9.6 Insofar as is practical, close all building outside doors and windows. Turn on any exhaust fans (range hood, bathroom exhausts, etc.) so they will operate at maximum speed. Turn on any clothes dryers vented to the outside. Do not operate summer exhaust fans. Make certain that no fireplace(s) is (are) operating. Close all fireplace dampers.

9.7 For installation of thermally-actuated vent dampers only: For the following vent system checks, the worst venting conditions that may reasonably exist should be duplicated. The worst venting conditions exist when the space occupied by the heating appliance is at the lowest pressure. If there are exhaust fans in the same room as the heating appliance, or if there are no exhaust fans in the residence, the lowest pressure will probably occur when the doors to other spaces of the building are closed. If there are exhaust fans in other rooms, the pressure will probably be lowest when doors connecting these rooms with the heating appliance space are open. Based on these considerations, open or close doors to other spaces of the building as required to produce the lowest pressure in the space occupied by the heating appliance. If it is not known which condition results in the lowest pressure, perform the work specified in 9.7 through 9.9 twice--once with doors to other spaces of the building open and once with doors closed.

After the appliances have been off for at least 30 minutes, turn on the gas to the appliance on which the damper has been installed and place the appliance in operation. Follow the manufacturer's lighting instructions. Adjust the comfort thermostat for continuous full burner appliance operation.

9.8 For installation of electrically-operated and mechanically-actuated vent dampers only: Turn on the gas to the heating appliance and place it in operation. Follow the manufacturer's lighting instructions. Adjust the comfort thermostat for continuous full-burner operation.

9.9 Test for spillage at the draft hood relief opening for 2 minutes of main burner operation. This short time is necessary to simulate a reasonably severe test. Use a device that will produce unpressurized flame or smoke, such as a match flame or cigarette smoke. Considerable care must be used to determine if flow is in or out of the draft hood. Adequate lighting must be provided for observation and the flow through all areas of all openings must be carefully observed.

9.10 For thermally-actuated vent dampers only: If the appliance is equipped with flame modulation, repeat 9.6 and 9.7 at the lowest flame conditions.

This is to confirm proper burner operation after the installation of the vent damper.

9.11 Visually determine that main burner gas is burning properly and that there is no floating, lifting, or flashback. If the appliance is equipped with flame modulation, determine that proper main burner operation at low and high flame is maintained.

9.12 Determine that the pilot light(s) is (are) burning properly and that main burner ignition is satisfactory by turning the main power supply switch for the heating appliance off and on. Test the pilot light safety device to determine that it is operating properly by extinguishing the pilot burner(s) when the main burner is off and determining that the main gas valve does not remain open upon a call for heat beyond the safety shut-off time specified by the automatic gas ignition device manufacturer. If this time is not known, a safety shut-off time of no longer than 1 minute must be met. Relight the pilot(s) after this check.

This is to confirm proper operation after installation of the vent damper.

9.13 For thermally-actuated vent dampers only. Cycle the heating appliance through at least three normal operating cycles. The damper must open and close properly without evidence of interference or binding. Determine that the damper closes fully. The damper may not close immediately with the thermostat but after a period of time, it should close.

9.14 For electrically-operated and mechanically-actuated vent dampers only: Cycle the heating appliance through at least three normal operating cycles. Determine that the damper is nearly fully open before the main burner gas flow begins and that the main burner gas flow stops as the damper begins to close. The damper must open and close freely without evidence of interference or binding. The damper must close fully. If the vent damper includes a damper-closing temperature control, the damper may not close immediately with the thermostat. Test this by operating the heating appliance for 10 minutes. Then lower the setting on the comfort thermostat to shut off the main burner gas flow. The damper should remain open for a period of time and then close.

If the heating appliance is equipped with flame modulation and the vent damper includes a damper-closing temperature control, operate the heating appliance for 10 minutes at the lowest flame conditions. Then reduce the comfort thermostat to shut off the main burner gas flow. The damper should remain open for a period of time and then close.

This is to confirm proper damper operation and sequencing with the heating appliance in operation. Paragraph 9.3 required a preliminary check of damper operation without the heating appliance in operation. A check of the damper-closing temperature control, if included, is also required for added safety.

9.15 Applicable only to furnaces: If the furnace electrical circuit has been modified during vent damper installation, check both the limit control and the fan control to determine that they operate within the heating appliance manufacturer's specifications.

This is to confirm proper furnace limit control and fan control operation after installation of the vent damper, in case the installation caused a change. If there is a change, improper installation is indicated.

9.16 Applicable only to boilers: If the boiler electrical circuit has been modified during vent damper installation, test low-water cutoffs, automatic-feed controls, high-temperature-limit controls, water pumps, and the circulating system to determine that they are operating within manufacturer's specifications.

This is to confirm proper operation of boiler controls after installation of the vent damper.

9.17 For thermally-actuated vent dampers only: Return doors, windows, exhaust fans, fireplace dampers, other appliances, and comfort thermostat(s) to their previous conditions of use.

9.18 Fill in a label with the name and address of the installing company and the full name of the individual installer and the date of the installation, and apply to the vent damper.

9.19 Complete the verification-of-installation card supplied by the vent damper manufacturer pursuant to the DoE Material Standard and return this promptly to the manufacturer.

The verification card completed by the installer and returned to the manufacturer facilitates notification of homeowners if there is a product recall. Any departure from the installation practice should be marked on the verification-of-installation card or in a separate letter to the manufacturer.

9.20 Leave the vent damper manufacturer's homeowner's operation and maintenance instructions in a conspicuous location near the heating appliance and urge the resident to read these instructions, especially for observations to be performed by the resident.

The homeowners' manual needs to be available to the homeowner (and future homeowners) to assure proper operation and maintenance of the vent damper.

9.21 As required by codes and regulations, notify the appropriate authority that the installation has been completed and turn off the heating appliance until the required inspection is completed.

Under RCS, every installation of vent dampers must be inspected. These practices, the vent damper manufacturer's installation instructions and a DoE prepared check list will form the basis for the inspection.

The requirement for inspection of vent damper installations is consistent with many existing State and local codes and regulations.

STANDARD PRACTICE FOR THE INSTALLATION OF AUTOMATIC INTERMITTENT PILOT IGNITION SYSTEMS

The Federal Register Notice of September 24, 1980[1] requires that automatic intermittent pilot ignition systems be installed in accordance with the provisions if the first draft (dated October, 1979) of the applicable proposed American National Standard (ANSI)[2].

A revised second draft of the ANSI standard was circulated for comment and review in September, 1980, and was revised during a working committee on October 1, 1980. The September draft, including the December 1980 revisions are referred to in this document as the "1980 draft." The relevant provisions for the installation are Exhibit A, Recommended Procedures for Safety Inspection of an Existing Appliance Installation as a Preliminary Step to Applying an Automatic Intermittent Pilot System, and Exhibit B, Procedures for Installing Automatic Intermittent Pilot Systems. The 1979 and 1980 draft of the inspection and installation procedures (Exhibit A and B) do not differ substantially and DOE has decided not to issue a revision to the rule prior to the final adoption of the ANSI standard.

Below is reprinted, verbatim, the first (October 1979) draft of Exhibits A and B with notes, pointing out the differences of this first draft with the 1980 draft. The notes are shown indented, the 1979 draft provisions are not indented. The ANSI draft standard's scope and selected definitions are also included. Installers of automatic intermittent pilot ignition systems are urged to consult with ANSI regarding the status of the standards provisions at the time of installation.

The draft standard is reprinted with the permission of the Chairman of ANSI Committee Z21. The cooperation of ANSI and its relevant committee is gratefully acknowledged.

Excerpts from ANSI Standard Relating to Installation

Part I

1.1 SCOPE

1.1.1 This standard applies to the construction[3] and installation procedures for newly produced automatic intermittent pilot ignition systems (see Part II, Definitions), hereinafter referred to as "systems", constructed entirely of new, unused parts and materials and designed to be adapted to existing continuous pilot burners on listed forced air heating appliances and boilers equipped with atmospheric burners.

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[1] Federal Register, Vol. 45, No. 187, Wednesday, September 24, 1980, page 63453, § 456.915, Residential Conservation Service Program, Final Rule.

[2] American National Standards Institute, 1430 Broadway, New York, NY 10018.

[3] Construction features are included in the draft ANSI standard; they are not within the scope of the DoE Installation Practice.

1.1.2 This standard does not apply to a system for use on appliances equipped with power burners or to direct vent appliances.

1.1.3 Systems covered by this standard shall be comprised of:

The 1980 draft adds at the end of the sentence "at least."

a. Pilot igniter(s) and cable(s),
b. Pilot flame sensor(s),
c. Associated system control,
d. Two automatic valves in series, controlling main burner gas,
e. Associated system wiring, and
f. Class II pressure regulator(s).

In the 1980 draft the "Class II" is deleted.

1.6 INSTRUCTIONS

1.6.1 Each system shall be accompanied by printed instructions and diagrams adequate for its proper field assembly, installation, checkout procedure, safe operation and servicing. These instruction shall include the following:

In the 1980 draft, the words "adequate for" are replaced by "clearly describing."

b. A statement that the qualified installer must fill in and attach the label specified in 1.6.1-m.

The relevant statement 6. of the 1980 draft reads:

b. A statement that the qualified installing agency must fill in and attach the label specified in 1.6.1-o.

m. The location and instructions for applying a label stating the appliance has been modified to use an automatic intermittent pilot system. This label should warn the homeowner not to try to lighting the appliance manually.

In the 1980 draft, a similar statement is given as 1.6.1-n: Application of a label in a prominent location on the appliance stating that the appliance has been modified to use an automatic intermittent pilot system and warning the homeowner not to try to light the appliance manually as burn injury on electrical shock may result.

This label shall be provided, shall be made of material not adversely affected by water and shall be attachable by means of non-water-soluble adhesive.

n. Provisions for showing date of installation, name of installer and where installer can be reached, either by address or telephone number. This information may be provided on the label specified in "m" above or on a separate label.

In the 1980 draft, this statement is 1.6.1-o and the reference to the label is n.

1.7 HOMEOWNER'S INFORMATION

1.7.1 Each automatic intermittent pilot system shall be accompanied by separate printed instructions for use by the homeowner.

1.7.2 These instructions shall contain clearly defined, legible and complete instructions for at least the following:

The 1980 draft reads: These instructions shall be clear, concise and shall provide a least the following:

a. A statement that the appliance has been modified from a continuously burning pilot to an intermittent pilot operation;

b. Operation instructions;

The September 1980 draft reads:

b. Complete operating instructions for the system; and

c. A statement that if system will not operate, the installer must be called for service; and

The September 1980 draft reads:

c. A statement that if the system fails to operate or becomes inoperative, it is recommended that the installer or a qualified servicing agency be contacted for service.

d. A recommendation that the appliance be inspected annually be a qualified service person.

In the September 1980 draft, this statement d. is deleted.

PART II

Definitions

In addition to those given below, many applicable definitions are given in the Standard for Automatic Gas Ignition Systems and Components, ANSI Z21.20. These also apply to this practice.

Automatic Intermittent Pilot Ignition System - For the purpose of this standard, a system comprised of a pilot ignition device, pilot flame sensing means, control system and associated automatic valving for application to an existing pilot burner and design to:

1. Ignite the pilot burner gas on a call for heat,

2. Prove the presence of the pilot and allow man burner gas to flow, and

3. Automatically act to shut off the gas supply to the main burner and pilot burner when the pilot is not proved.

The September 1980 draft reads:

3. Automatically act to shut off the gas supply to:

a. the main burner(s); and

b. the pilot burner when used with gases having a specific gravity greater than 1.0.

Listed - Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

Main Burner - A device or group of devices essentially forming an integral unit for the final conveyance of gas, or a mixture of gas and air, to the combustion zone, and on which combustion takes place to accomplish the function for which an appliance is designed.

Pilot - A gas flame(s) utilized to ignite gas at the main burner(s).

EXHIBIT A

RECOMMENDED PROCEDURE FOR SAFETY INSPECTION OF AN EXISTING APPLIANCE INSTALLATION AS A PRELIMINARY STEP TO APPLYING AN AUTOMATIC INTERMITTENT PILOT SYSTEM

The following procedure is intended as a guide to aid in determining that an appliance is properly installed and is in a safe condition for continuing use.

This procedure is predicated on central furnace and boiler installations equipped with an atmospheric gas burner(s) and not of the direct vent type. It should be recognized that generalized test procedures cannot anticipate all situations. Accordingly, in some cases, deviation from this procedure may be necessary to detrmine safe operation of the equipment.

a. This procedure should be performed prior to any attempt at modification of the appliance or the installation.

b. If it is determined there is a condition which could result in unsafe operation, the appliance should be shut off and the owner advised of the unsafe condition.

The following steps should be followed in making the safety inspection:

1. Conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.

2. Visually inspect the venting system for proper size and horizontal pitch and determine there is no blockage or restrictions, leakage or corrosion or other deficiencies would could cause an unsafe condition.

3. Shut off all gas to the appliance and shut off any other fuel-burning appliance within the same room. Use the shutoff valve in the supply line to each appliance.

4. Inspect burners and crossovers for blockage and corrosion.

5. Applicable only to warm air heating appliances. Inspect heat exchangers for cracks, openings or excessive corrosion.

6. Applicable only to boilers. Inspect for evidence of water or combustion product leaks.

7. Insofar as is practical, close all building doors and windows and all doors between the space in which the appliance is located and other spaces of the building. Turn on the clothes dryers. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers. If after completing Steps 7 through 12, it is believed sufficient combustion air is not available, refer to 1.3.4 of the National Fuel Gas Code (Z223.1)[4] for guidance.

8. Place in operation the appliance being inspected. Follow the lighting instructions. Adjust thermostat so appliance will operate continuously.

9. Determine that the pilot is burning properly and that main burner ignition is satisfactory by interrupting and reestablishing the electrical supply to the appliance in any convenient manner.

The September 1980 draft reads:

9. a. Determine that the pilot is burning properly and that main burner ignition is satisfactory by interrupting and reestablishing the electrical supply to the appliance in any convenient manner.

b. Determine manifold pressure in order to match input after the new control is installed.

10. a. Visually determine that main burner gas is burning properly: i.e., no floating, lifting or flashback. Adjust the primary air shutter(s) at low flame.

11. Test for spillage at the draft hood relief opening after 5 minutes of main burner operation. Use a draft gage, the flame of a match or candle, or smoke from a cigarette, cigar or pipe.

12. Return doors, windows, exhaust fans, firplace dampers and all other fuel-burning appliances to their previous conditions of use.

13. Applicable only to warm air heating appliances. Check both limit control and fan control for proper operation. Limit control operation can be checked by temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.

14. Applicable only to boilers:

a. Determine that the water pumps are in operating condition.

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[4] "National Fire Code", National Fuel Gas Code, National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

In the 1980 draft, the word "circulating" is inserted in front of "water pumps."

b. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls and relief valves in accordance with the manufacturer's recommendations and instructions to determine they are in operating condition.

> *In the 1980 draft, the word "water" is inserted between "feed" and "controls".*

EXHIBIT B

PROCEDURE FOR INSTALLING AUTOMATIC INTERMITTENT PILOT SYSTEMS

Prior to beginning this procedure, a preliminary examination of the appliance and the automatic intermittent pilot system should be made to determine that the automatic intermittent pilot system can be properly applied to the appliance.

This procedure is intended as a guide to aid in safety installing a listed automatic intermittent pilot system on an existing listed appliance equipped with an atmospheric gas burner(s) and not of the direct vent type.

This procedure is based on the assumption that the history of the specific installation has been one of safe and satisfactory operation.

This procedure is predicated on central furnace and boiler installations, and it should be recognized that generalized procedures cannot anticipate all situations. Accordingly, in some cases deviation from this procedure may be necessary to determine safe operation of the equipment.

The following steps should be followed in making the modifications:

1. Perform a safety inspection of the existing appliance installation. See Exhibit A for a recommended procedure for such a safety inspection.

2. Shut off all gas and electricity to the appliance. <u>To shut off gas use the shutoff valve in the supply line to the appliance</u>. Do not use the shutoff valve which is provided as part of a combination control.

3. Install the automatic intermittent pilot system in strict accordance with the manufacturer's installation instructions.

4. Turn on all gas and electricity to the appliance.

5. Determine that the appliance transformer has adequate capacity by following the steps outlined below:

a. Compute the total current draw by adding the current draw of the automatic intermittent pilot system to (1) the current draw of the associated valving, and (2) the current draw of any relays or other devices operated by the transformer.

> *The September 1980 draft reads:*
>
> *a. Compute the approximate current draw by adding the current draw of the automatic intermittent pilot system to (1) the current draw of the associated valving, and (2) the current draw of any relays or other devices operated by the transformer.*

b. Multiply the total current draw as computed above by 24V to determine the total VA (volt-ampere) required.

c. The total VA (volt-ampere) required should be equal to or less than the VA rating of the transformer.

d. If the total VA (volt-ampere) required is greater than the VA rating of the transformer, the transformer must be replaced with a Class 2 transformer of adequate rating.

6. Check the heat anticipator in the comfort thermostat to determine if it is properly adjusted to the current draw of the control system. Follow the thermostat manufacturer's instructions.

7. Make certain wiring connections are tight and wires are positioned and secured so they will not be able to contact high temperature locations.

8. Conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.

9. Adjust the thermostat to its highest temperature setting. Visually determine that main burner gas is burning properly: i.e., no floating, lifting or flashback. Adjust the primary air shutter(s) as required.

The September 1980 draft reads:

9. a. Adjust the thermostat to its highest temperature setting and test manifold pressure and adjust the pressure regulator to match original input as required. (Refer to Exhibit A, Step 9b).

b. Visually determine that main burner is burning properly: i.e., no floating, lifting or flashback. Adjust the primary air shutter(s) as required.

10. If the appliance is equipped with high and low flame controlling or flame modulation, check for proper main burner operation at both high and low flame.

11. Determine that the pilot is igniting and burning properly and that main burner ignition is satisfactory by interrupting and reestablishing the electrical supply to the appliance in any convenient manner. Make this determination with the appliance burner both cold and hot. Perform this step as many times as is necessary to satisfy yourself that the automatic intermittent pilot system is operating properly.

12. Test the pilot safety device: (1) to determine if it is operating properly, and (2) for turndown characteristics according to the manufacturer's installation instructions.

The September 1980 draft adds:

No adjustments should be made other than those recommended by the system manufacturer.

13. Sequence the appliance through at least three operating cycles.

14. Applicable only to furnaces. Check both the limit control and the fan control for proper operation. Limit control operation can be check by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.

15. Applicable only to boilers.

a. Determine that the water pumps are in operating condition.

b. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls and relief valves in accordance with the manufacturer's recommendation to determine they are in operating condition.

16. Add the labels (see 1.6.1-m and -n) on the appliance.

In the September 1980 draft, the reference is to 1.6.1-n and -o.

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

Standard installation practices were developed to assist in assuring the effectiveness and safety of energy conservation measures installed under the Residential Conservation Service (RCS). They serve as mandatory standards under RCS but are recommended guides for all installations of the covered materials and products. The criteria are being used by DoE to develop training manuals for installers, inspectors, and energy auditors.

Part I provides information on the intended use of the practices, outlines the RCS program, and discusses specific major technical and related issues that were considered in the development of the standards: moisture and building retrofit, attic ventilation, electrical wiring, recessed and surface-mounted fixtures, the use of diagnostic tools (infrared thermography, air change rate, and window air leakage measurements), and product certification.

Part II provides the actual practices together with commentary and additional recommendations. The products covered are loose-fill, batts and blankets, rigid foam boards, UF foam and reflective insulations, window devices, caulks and sealants, water heater insulation, oil burner replacements, and vent dampers.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

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