Weatherization Procedures Manual

Maine State Housing Authority

March 2000

WEATHERIZATION PROCEDURES MANUAL

MAINE STATE HOUSING AUTHORITY

ENERGY AND HOUSING SERVICES DIVISION
Augusta, Maine

&
The Technical Committee
of the
Community Action Agency
Housing Council

March, 2000

This document is a cooperative effort among the technical staff of the Energy & Housing Services Division at Maine State Housing Authority and the Community Action Agency Housing Council Technical Committee. Thanks go to all others who contributed in any way. Special thanks go to Rick Karg for his invaluable contributions and to Betsy Mansir for her editing skills.

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PROCEDURES MANUAL

The Procedures Manual was developed to provide technical assistance and to facilitate implementation of Maine's low-income Weatherization Assistance Program by setting forth the State's interpretations of the U.S. Department of Energy (10 CFR 440) regulations.

The objective of this document is two-fold. It serves to define the appropriate application of Weatherization measures for each residence serviced. The manual delineates material specifications as well as the steps that should be followed to complete each measure. Alternative methods will continue to be allowed. Whatever method is used must meet or exceed the standards established by this document.

The second objective of the Procedures Manual is to set a guide as to the expectation of quality of the installed product. The Post Installation Procedures further provide a method to evaluate the installed quality of each conservation measure and, therefore, the overall quality of the completed unit.

It is anticipated that the Manual will help to improve the delivery of services to low-income clients under the Weatherization Assistance Program, and ensure that program funds are used in the most cost effective manner possible.

This document is intended to represent the best thinking at the time of writing. It is also intended to be a dynamic document, changing as necessary to stay with current best methods. The process for implementation of change will be either by recommendation by MSHA Technical staff to MSHA Director of the Energy & Housing Services Division, or by:

- Introduction to the Building Technology Committee (BTC) followed by recommendation to the Housing Council (HC).

- Acceptance of BTC recommendation by HC and recommendation to MSHA Director of EHS.

Followed by:

- Adoption by MSHA and circulation to WAP providers.

- Issuance of dated replacement pages reflecting changes as they are adopted.

All changes, however initiated, will be provided to the Housing Directors of all Subgrantees at least thirty days prior to implementation to allow the opportunity for their review and comment. The Housing Directors may then submit written comments regarding these changes to the EHS Program manager for review and consideration. The EHS Program Manager will respond to all comments received prior to implementation of these changes.

All testing procedures, inspections and safety check lists done by agency personnel will be done attempting to follow the tone of this manual. It is understood that the results constitute an opinion of observable conditions at the time of the audit/inspection. It is also understood that other deficiencies beyond those observed may exist. No testing is to be performed by persons not holding appropriate licenses for doing so.

MAINE STATE HOUSING AUTHORITY
WEATHERIZATION PROCEDURES MANUAL

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DEFINITIONS

INACCESSIBLE CAVITY	An area which is too confined to allow entry and/or sufficient space to maneuver by an average installer/ mechanic.
MEAFF	Maine Energy Audit Field Form
MEADOW 96	Maine's computer assisted Waiver Audit
MEANINGFUL BLOWER DOOR TEST	Achieving and recording a flow reading with a single point test of at least 15 PA house pressure.
MSHA	Maine State Housing Authority
SIR	Savings To Investment Ratio, as required in CFR 440.21, Section H, 1-7.
SIGNIFICANT HOLE	An unintentional opening between conditioned and unconditioned spaces which will allow sufficient air to pass to prevent meaningful blower door testing.
WAP	Weatherization Assistance Program

SECTION A

MAINE AUDIT SYSTEM

SECTION A

MAINE AUDIT SYSTEM

In order to comply with various DOE regulations, including Weatherization Program Notice 93-8, the Maine State Housing Authority (MSHA) has developed an Energy Savings Audit System. The purpose of this system is to prioritize in a descending order the most cost effective energy conservation activities that should be accomplished in any given client home.

In all instances it will be the responsibility of sub-grantee personnel to determine the individual measures which will provide the most cost effective energy savings activities in each client home. Considerations include:

A. What is the current and projected use of the structure?

B. Are the weatherization measures that you want to do technically feasible, i.e., sensible?

C. What is the most cost effective way to attain the standards of energy conservation as listed in
this manual.

D. What Health and Safety concerns will be a factor in the audit?

All weatherization measures must be performed in order of descending Savings to Investment Ratio (SIR), as established by this audit system. The MSHA recognizes that necessary exceptions do exist based on technical infeasibility. Such cases must be fully documented by the sub-grantee in the client's file. Other extenuating circumstances will be evaluated on a case by case basis by MSHA Technical staff in response to written requests from Sub-grantees.

SECTION A

Part I

ENERGY AUDIT PROCEDURES

Prior to initiating any weatherization activities sub-grantees shall do a complete audit of the client home using the State of Maine Weatherization Assistance Program Maine Energy Audit Field Form, (Section A, Part II, Page 8). The intent is two-fold, to establish the most cost effective weatherization measures for that particular home and to identify any potential health and safety issues which may be existing, affected and/or created by the contemplated weatherization activities. No weatherization activity shall commence until sub-grantee is satisfied, by performing appropriate testing, that in no foreseeable way will the activity adversely impact the livability and/or durability of the client home. Please see Section B - Health and Safety for further information.

Audits are to be conducted using the following format whenever practical, inserting information in the Maine Energy Audit Field Form. All weatherization personnel must keep in mind that the weatherization process can be a very personal experience for some clients. The weatherization process involves accessing all areas of the home and can make some people uneasy. Identification of the auditor and the agency by business card and/or photo identification badge can assist the auditor when making the initial visit to the home. All weatherization personnel and subcontractors must treat clients in a professional manner. Sub-grantees should report any suspected abusive situations to the proper authorities.

I. Client Interview:

A. Client Education

1. Explain program process
2. Distribute relevant educational pamphlets on Energy Conservation tips and Health and Safety issues.

B. Heating System Information

1. Fuel Consumption Data

   a. Vendor
   b. Client Records
   c. Client Estimate

2. CTE-may be necessary to assess condition. Use client's vendor when possible.

3. Note observable code violations

C. Special Problems

1. Dwelling structural problems
2. Problems with the heating system
3. Moisture problems
4. Client Health
5. Health and Safety Problems

D. Client Use of Dwelling

1. Heated Envelope
2. Thermostat settings

II. Visual assessment-record information

A. Note special problems

B. Note existing insulation levels and existing vapor barriers

C. Assess conditions of heating system - refer to a licensed technician if necessary.

D. Note building integrity

III. Pre and Post Testing Procedures: Detailed in Section A-part III *

A. Blower Door

B. Building Tightness Guidelines

C. Pressure Diagnostics

D. Computer Program for Pressure Diagnostics

E. Combustion Safety Tests

F. Warm Air Duct Diagnosis and Repair

G. Carbon Monoxide Tests

H. Carbon Dioxide Test

I. Combustion Efficiency Test

J. Infrared Scanning

* Obviously it is neither necessary nor possible to do all tests on all homes.

IV. Measures Determination: Note – Weatherization energy conservation measures selected must meet the payback requirements – savings to investment ratio – as determined by the MEADOW 96 computer assisted audit.

A. Input data into MEADOW 96.

B. Create work order.

SECTION A

Part II

MAINE ENERGY AUDIT FIELD FORM WITH INSTRUCTIONS

The intent of this form is to provide an organized system for the energy auditor to record dwelling information pre and post weatherization activities as required by DOE. All testing procedures are outlined in this manual.

- A completed Maine Energy Audit Field Form is required in every weatherization client file.
- Yearly fuel consumption data is presently intended as a tool for the auditor.
- Btu's/sf/dd is a formula to assist auditors in determining the energy savings potential of the unit.
- The moisture pollution assessment section is designed as a checklist. Place a check or "X" beside each applicable condition.
- Check items and/or fill in the blanks on the form with information pertaining to the dwelling.
- Information that does not pertain to the dwelling can be left blank, *except the shaded areas,*
- All shaded areas must be completed either with the appropriate test result or the reason why the test was not performed.
- Use the CFM50 figure from page 1 and the total of the CFM column under Mechanical Ventilation on page 2 to plot the home on the graph on page 2. The result is the probable depressurization caused by exhaust appliances in the home.
- Use the left side of page three to record the existing insulation amounts (by significant area) in the home. This information must be recorded for the major areas of all homes audited whether or not additional insulation is installed.
- Series leakage testing should not be done unnecessarily. It can be invaluable in determining air barrier locations, the adequacy of attic venting and/or building cavity interconnectedness.
- Pages four through six apply to homes with warm air heating systems. These pages should be eliminated from the client file if the dwelling being audited does not have a warm air system.
- Comments, drawings, and instructions for contractors may be incorporated on the back of these pages.
- Sub-grantees using the ACCESS database MEAFF must place a printout of the estimate in the client file.

(Maine Energy Audit Field Form on following pages)

MEAFF

Page 1

Agency Code	Last Name	First Name	Phone

Address	Town
SSN:	
Audited By:	Inspected by
Date of Audit	Date of Inspection
Building Type	Ceiling Height (Ft)
Comments	
Occupied Building, Ft2 =	Occupied, Conditioned Volume, Ft3 =
Building Age:	Building Condition

Primary Fuel		Yrly Fuel Consumption, Quantity Only, Primary	
Secondary Fuel		Secondary System, Quantity Only =	

Btu/Ft2/DD Primary	(Note: Exclude Domestic Hot Water)	BTU_Primary(MBTU)	
Btu/ft2/DD Secondary	(Note: Exclude Domestic Hot Water)	BTU_Secondry(MBTU)	Degree Days
Total Btu/Ft2/DD =	Comments:		

POLLUTION/MOISTURE ASSESSMENT/ Check All Applicable

CLIENT	MOISTURE		MOLD/MILDEW/COND.	OTHER HAZARDS
Smokers	Dirt Floor	Sill Rot	Crawlspace	Lead Paint
Fatigue	Standing Water	Kitchen Vent	Basement	Asbestos
Asthma	Sump Pump	Bathroom Vent	Bathroom	Radon
Dehumidifier	Water Staining	Roof Leaks	Kitchen	Unsafe Wiring
Bronchitis	Efflorescence	Gutters	Attic	Carbon Monoxide
Humidifier	Firewood	Plumbing Leaks	Windows	Unvented/Comb
Flu Symptoms	Clothes Drying	Humidifier Use	Closets	Other:
Other:	Dryer Not Vented	Aquarium	Ceiling	
	Unvented Space Heater		Walls	
	Other:		Other:	

Is there a need for mechanical ventilation	
Comments:	

BLOWER DOOR TEST DATA - BUILDING TIGHTNESS LIMITS

Blower Door Test Location					
Blower Door Config	Open	Ring A	Ring B	Ring C	
Test Conditions		Outside Temp			
Initial CFM50		Date		Tester	
Final CFM50		Date		Tester	
Total CFM50 Reduction					
Major Leakage Sites/Problems:					

	Pre-BTLa Test		Post-BTLa Test	
Weather Factor	Pre-BTLa Flow Exponent		Post-BTLa Flow Exponent	
Bldg Height	1.ELA		1.ELA	
	2.EqLA		2.EqLA	
	3.CFMnat=		3.CFMnat=	
Occupant Cnt	4.ACHnat=		4.ACHnat=	
	5.CFMnat/Occ		5.CFMnat/Occ=	
Floor Area	6.ELAmin=		6.ELAmin=	
	7.CFMmin=		7.CFMmin=	
House Volume	8.Vent. CFM=		8.Vent CFM=	
	9.BTLa		9.BTLa	

Agency Code	

MEAFF -- PAGE 2

COMBUSTION APPLIANCES

PRIMARY HEATING

Type:		
Fuel:		
	BEFORE	AFTER
Draft, O.F.		
Draft Breech		
Smoke		
O2 or CO2		
CO <50ppm		
Net Temp.		
S.S. Eff. %		
Chimney	☐ OK ☐ Bad	☐ OK ☐ Bad
Dedicatd Air		
Comments		

SECONDARY HEATING

Type:		
Fuel:		
	BEFORE	AFTER
Draft, O.F.		
Draft Breech		
Smoke		
O2 or CO2		
CO <50ppm		
Net Temp.		
S.S. Eff. %		
Chimney	☐ OK ☐ Bad	☐ OK ☐ Bad
Dedicatd Air		
Comments		

Air Exhaust Devices/Check All Applicable

DEVICE		CFM	VENTED
Kitchen (100)	☐		
Bath (35)	☐		
Cooktop (300)	☐		
Cntrl. Vac. (100)	☐		
Gas/Oil H2O(70)	☐		
2nd Bath (35)	☐		
Dryer (180)	☐		
Fireplace (400)	☐		
WoodstoveAT(10)	☐		
WdstveNAT(100)	☐		
Other	☐		
Air Total:			
Need for ventilation?			

WATER HEATER

Type:		
	BEFORE	AFTER
CO ppm		
Draft		
Temp. Set.		
Vented		
Dedicatd Air		
Comments		

GAS OVEN/RANGE

Condition		
	BEFORE	AFTER
CO Oven		
CO Burner 1		
CO Burner 2		
CO Burner 3		
CO Burner 4		
Vented		
Ambient CO		
Comments		

BACKDRAFT TESTING

	Pre-Wx	Post-Wx
Outdoor Tmp		
CAZ Door	☐ Open ☐ Closed	☐ Open ☐ Closed
Appliance 1		
Spillage(check ifapplies)	☐	☐
CAZ Depress		
Appliance 2:		
Spillage(check if applies)	☐	☐
CAZ Depress		
Appliance 3:		
Spillage(check if applies)	☐	☐
CAZ Depress		
Comments		

GAS CLOTHES DRYER

	BEFORE	AFTER
Vented		
CO ppm		
Dedicatd Air		
Comments		

FIREPLACE

	BEFORE	AFTER
Used?	☐	☐
Chimney	☐ OK ☐ Bad	☐ OK ☐ Bad
Damper	☐ OK ☐ Bad	☐ OK ☐ Bad
Dedicatd Air	☐	☐
Comments		

Agency Code	

MEAFF Form--Page 3

ATTIC/CEILING

INSULATION						SERIES LEAKAGE TESTS		
Location	Area	Type	PreR	Added Type	+ R		Before WX	After WX
						House/Zone)P1		
						Zone/Outside)P1		
						Hole Added	H/Z Z/O	H/Z Z/O
						Hole Size, in2 or Door Open CFM50		
						House/Zone)P2		
						Zone/Outside)P2		
						CFM50 House/Zone		
						CFM50 Zone/Outside		
						CFM50 Total Path		
Ventilation						Notes		

WALLS

INSULATION						SERIES LEAKAGE TESTS		
Location	Area	Type	PreR	Added Type	+ R		Before WX	After WX
						House/Zone)P1		
						Zone/Outside)P1		
						Hole Added	H/Z Z/O	H/Z Z/O
						Hole Size, in2 or Door Open CFM50		
						House/Zone)P2		
						Zone/Outside)P2		
						CFM50 House/Zone		
						CFM50 Zone/Outside		
						CFM50 Total Path		
Siding Type:						Notes		

BASEMENT/CRAWLSPACE

INSULATION						SERIES LEAKAGE TESTS		
Location	Area	Type	PreR	Added Type	+ R		Before WX	After WX
						House/Zone)P1		
						Zone/Outside)P1		
						Hole Added	H/Z Z/O	H/Z Z/O
						Hole Size, in2 or Door Open CFM50		
						House/Zone)P2		
						Zone/Outside)P2		
						CFM50 House/Zone		
						CFM50 Zone/Outside		
						CFM50 Total Path		
Basement Wall Type						Notes		

Agency Code	

Ductwork Assessment

	Before WX	After WX
DOMINANT DUCT LEAK; Main Body WRT Outside, Air Handler On		
MASTER BEDROOM DOOR CLOSED; Main Body WRT Outside, Air Handler On		
ALL INTERIOR DOORS CLOSED; Main Body WRT Outside, Air Handler On		
FIREPLACE/WOODSTOVE ZONE (FPWSZ), FPWSZ WRT Outside, Air Handler On		

PRESSURE IN EACH CLOSED ROOM, Room WRT Outside, Air Handler On

#	Room	Before	After	#	Room	Before	After
1				9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8				16			

If a room is more than 3 Pascals or less than -3 Pascals, consider pressure relief.

Does a fireplace or woodstove draw any portion of its combustion air from a zone that is depressurized more than -3 Pascals WRT outside? *If so, pressure relieve.*		
AS FOUND PRESSURE DIFFERENCE:		
Set Up House as You Found It, Main Body WRT Outside, Air Handler On		
STATIC PRESSURE: In Supply Plenum of System 1 of _____ Systems, Air Handler On:		
DUCT DECLARATION: Type of Duct System You Predict After Repair		
Inside by Pressure = 1 Outside by Pressure = 2 Inside/Outside by Pressure = 3		

PRESSURE PAN TESTS, Air Handler Off, Blower Door On at: _____ Pascals.

#	Room	Before	After	#	Room	Before	After
1				9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8				16			

Notes

Extended MEAFF Form--Lighting Piece

Agencycd	Fixture Location	# Bulbs	Hours/Day	Exis. Wattage	Repl. Wattage	Bulb Cost	Life Savings	Yrs. Payback

MEAFF -- Extended Form

Agency Code	2008CCI007340019	Estim. Age	Total Wattage	Estimated kWh/yr Usage	$/kWh
Removed Electric Heat		0	0	0	$0.00
New Space Heating System		Fuel Type	Distribution Type	Estimated Annual Savings	$/Unit Fuel
System Description/Notes				#Error	$0.00
		MN/yr	BTU/Unit Fuel	Installed Cost	Unit AFUE
			0	$0.00	0.00%

Electric Water Heater Replacement

Removed Electric Heater	Estim. Age	Tank Size	Estimated Annual kWh	Estimated Annual Cost
	0	0	$0.00	$0.00
New Water Heating System	Fuel Type	Energy Factor	Estimated Annual Savings	$/Unit Fuel
System Description/Notes		0	$0.00	$0.00
			Tank Size	Installed Cost
			0	$0.00

Refrigerator/Freezer Replacement

1. Existing Refrigerator	Yr Mfg 1984	Defrost type:	Style: ☑ Top freezer (TF) ☐ Side-by-side (SS) ☐ Bottom freezer (BF) ☐ Single door (SD)	Notes:
Brand Gibson	Estimated? ☑ No ☐ Yes	☐ Manual ☑ Automatic		puc change out/waivers
Model # RT19F3WMGJ				

	Temps.		Dimensions, inches Height	Width	Depth	Volume, cubic feet	
Avg. Annual Ambient Temp., AAAT	70						
Avg. Present AMbient Temp., PAT	70	Outside	66	31	26.5	Label vol.=	19
AAAT - PAT = Delta T	0	Fresh Food	39	28	18	Fresh food vol.=	11.375
Temp. Correction = Delta T * 2.5 % (may be positive or negative) (use this in line 1b. below)	0	Freezer	17	28	16	Freezer vol.=	4.40740740741
		Fresh + freezer vol.=	15.78240741	Adj.Inter.Vol=Fresh+(1.63*frzer)			18.5590740741
		Anti-sweat using electricity	☐ Yes	☑ No		☐ N/A	

Interior Fresh Food Temp	33.3	Fresh Food Control Set To	4	On A Scale Of:	5
Interior Freezer Temp	-0.6	Freezer Control Set To	8	On A Scale Of:	9

1a. kWh/yr =	1444	Derived from	☐ Watt meter	☑ AHAM book	☐ Auditor estimate
1b. Temp Corrected kWh/yr=	1444	New kWh/yr.=	354	New Refrig. Cost =	$469.00
1d. Electric cost per kWh=	$0.13	1e. With "AREFR" Zip Test Pro Equation Nugget, SIR=			3.43524307036247
2a. Metered Instantaneous Wattage=	0	(should be 250 Watts or less during steady-state, non-defrost mode)			
3a. Energy consumed since metering began-in kWh=	0	3b. Lapsed time since metering began, in hrs=			0
3c. Average consumption per hour, or (3a/3b)=	#Error	(should be 0.150 kWh per hour or less			
4a. Fractional Running Time, or (3c. * 1000)/2a/=	#Error	% (should be 70% or less)			

New Refrigerator	Style: ☑ TF	Hinge side:	EnergyGuide:		Outside Dimensions, inches			Replacement unit(s) cost, including disposal:
Brand	☐ SS ☐ BF	☐ Left	kWh/yr=	354	Height	Width	Depth	
Kenmore		☑ Right	Cubic Ft.=	15	60.1	28	31.5	469
Model No. 46-60532								

B. Existing Refrigerator/Freezer	Yr Mfg 1980	Defrost Type:	Refrigerator Style:	Freezer Style:
Brand Sears	Estimated?	☑ Manual	☐ TF ☐ SS	☐ Upright
Model Number 564.9215011	☐ No	☐ Automatic	☐ BF ☐ SD	☐ Chest
☐ Refrigerator ☑ Freezer	☑ Yes		Dimensions, inches	

	Temps.		Height	Width	Depth	Volume, cubic feet	
Avg. Annual Ambient Temp., AAAT	70	Outside	33	21	23.5	Label vol.=	0
Avg. Present AMbient Temp., PAT	70	Fresh Food	0	0	0	Fresh food vol.=	0
AAAT - PAT = Delta T	0	Freezer	27	18	17	Freezer vol.=	4.78125
Temp Correction = Delta T * 2.5 % (may be positive or negative) (use this in line 1b. below)	0	Fresh+freezer vol.=	4.78125	Adj inter vol=Fresh+(1.63 x freezer)=			7.7934375
		Anti-sweat using electricity	☐ Yes	☐ No		☐ N/A	

		Fresh Food Control Set To		On A Scale Of	
Interior Fresh Food Temp	0	Freezer Control Set To		On A Scale Of	
Interior Freezer Temp	0	Derived from:	☐ Watt meter	☐ AHAM book	☑ Auditor estimate
1a. kWh/yr =	0	New kWh/yr. =	357	New Refrig. Cost =	$429.00
1b. Temp Corrected kWh/yr =	0	1e. With "AREFR" Zip Test Pro Equation Nugget, SIR=			-1.13540979020979
1d. Electric cost per kWh=	$0.12				
2a. Metered Instantaneous Wattage=	0	(should be 250 Watts or less during steady-state, non-defrost mode)			
3a. Electricity Consumption in kWh / hour=	0	3b. Lapsed time since metering began, in hrs			0
3c. Average consumption per hour, or (3a/3b)=	#Error	(should be 0.150 kWh per hour or less)	New Refrigerator Funds Source:		
4a. Fractional Running Time, or (3c. * 1000)/2a. =	#Error	(should be 70% or less)			

Agency Code	[redacted]	Number of Family Members:	1

MEAFF--Extended--Appliances

#	Appliance	App. Wat.	Avg.Hrs/M./#	Actual Hrs/M./#	Avg. kWh/M.	Notes
0	Air conditioner, window, 8000 Btu	860	30	0	0	
0	Auto block heater	300 - 1500	100	0	0	
0	Clothes dryer, electric, 7 loads per week	4800	7.5	0	0	
1	Clothes washer, excluding hot water	500	1.75	0.5	0.25	
0	Coffee maker	1100	5	0	0	
0	Computer	250	50	0	0	
0	Crock pot	1400	8	0	0	
0	Dehumidifier, 30 pint, 12 hours per day	650	90	0	0	
0	Dishwasher, excluding hot water	720	0.75	0	0	
0	Electric lawn mower	1250	8	0	0	
0	Electric blanket	175	60	0	0	
0	Fan, ceiling, without light	75	37.5	0	0	
1	Fan, furnace distribution	295	270	270	79.65	
0	Fan, whole-house or attic	360	15	0	0	
0	Fan, window	200	37.5	0	0	
0	Fish 1 tank, heated 15 gallons	120	300	0	0	
0	Fish 2 tank, heated 30 gallons	170	300	0	0	
0	Fish 3 tank, heated 55 gallons	290	300	0	0	
0	Fish 4 tank, reef type 180 gallons, heater, etc.	1600	300	0	0	
1	Freezer, manual defrost	300	200	200	60	
0	Freezer, automatic defrost	450	320	0	0	
0	Heat tape - 24 feet, 7 Watts/foot	168	720	0	0	
0	Humidifier	177	45	0	0	
1	Lighting and small appliances			0	30	
1	Microwave oven	1500	2.5	2.5	3.75	
1	Oil burner	266	225	225	59.85	
0	Oxygen machine	450	720	0	0	
0	Pump, boiler water distribution	120	250	0	0	
0	Pump, septic system	746	2	0	0	
0	Pump, sump	690	60	0	0	
0	Pump, well	746	7.5	0	0	
2	Range burner, 6 inches, on high	1300	7.5	7.5	19.5	
2	Range burner, 8 inches, on high	2400	7.5	7.5	36	
1	Range oven, baking	3200	3.75	3.75	12	
1	Range oven, broiling	3600	0.5	0.5	1.8	
0	Range oven, self-cleaning feature	4000	0.625	0	0	
1	Refrigerator 1 - calculated from data on Extended Page				120.333333333333	
0	Refrigerator 2			0	0	
0	Security light, outdoor, mercury vapor	300	360	0	0	
0	Spece 1 heater, electric, low setting	500	90	0	0	
0	Space 2 heater, electric, medium setting	1000	90	0	0	
0	Space 3 heater, electric, high setting	1500	90	0	0	
0	Stereo equipment	300	22.5	0	0	
0	Television, color, 19"	100	45	0	0	
1	Television, color, 27"	200	45	45	9	
0	Television, black and white	300	25	0	0	
1	Toaster Oven	1500	1	1	1.5	
1	VCR	30	15	15	0.45	
0	Water heater, bath, 20 gal. hot water	4500	7.5	0	0	
0	Water heater-clothes washer-warm w/cold rinse	4500	1.75	0	0	
0	Water heater, dishwasher, 13 gal. hot water	4500	0.75	0	0	
0	Water heater, dish washing by hand, 4 gal. hot	4500	0.25	0	0	
0	Water heater, shower, 5 min., low-flow head	4500	0.25	0	0	
0	Water heater, shower, 5 min., no low-flow head	4500	0.25	0	0	
0	Water heater, average use per adult each month	Number of Adults in home->		0	0	
0	Waterbed 1 heater, king-size, covered, 90/70	350	326	0	0	
0	Waterbed 2 heater, king-size, unmade, 90/70	350	428	0	0	
0	Waterbed 4 heater, queen-size, unmade, 90/70	350	330	0	0	
0	Waterbed 5 heater, soft-side, 90/70	190	350	0	0	
0	Wheel chair (electric) battery charger	445	360	0	0	
Total kWh/month estimate					434.083333333333	
Average monthly base load usage from electric bills, kWh/month					221.53	

Notes:

SECTION A

Part III

TEST GUIDELINES & PROCEDURES

Blower Door

Building Tightness Guidelines

Pressure Diagnostics

Duct Assessment

Electrical Circuit Test Protocol

Combusion Appliance Carbon Monoxide Production Test Protocol from the *Maine Auditor/Health & Safety Field Guide*

Heating System Safety Tests

Combustion Efficiency and/or Draft Testing

Zip Test Pro Building Diagnostics is incorporated by reference

BLOWER DOOR

The following is excerpted from the Minneapolis Blower Door Model III operators manual. Please see the manual for further detail.

The Blower Door is a diagnostic and measurement tool designed to measure and quantify the airtightness of houses. This airtightness measurement is used for a variety of purposes including:

- Documenting the construction airtightness of new houses.
- Estimating natural infiltration rates in houses.
- Measuring and documenting the effectiveness of retrofit weatherization activities.
- Measuring duct leakage in forced air distribution systems.

In addition, blower doors assist in locating air leaks in houses by inducing air infiltration or exfiltration. The blower door exaggerates existing air leakage paths making them easy to locate with a smoke generator, infrared camera or simply using your fingers. Blower door diagnostic techniques are also extremely useful in locating and pinpointing major leakage sites in forced air distribution systems.

Where To Install The Door Frame – Set up the blower door in a centrally located exterior door. Choose a doorway with the least number of obstructions within 3 feet of the blower door fan. If the doorway leads to a porch or garage, make sure this space is open to the outside by opening doors and/or windows. The door frame is almost always installed from the inside of the house and may be installed in place of the prime door, the storm door, or anywhere in between.

Remove the gauge board from the accessory case and tighten the C-clamp to the edge of a nearby door (typically the door in which the blower door is installed). Mounted on the gauge board are 3 pressure gauges and the fan speed controller.

House Pressure Gauge – The top gauge measures pressures from 0 to 60 pascals and will be used to measure the change in house pressure caused by the fan. One of the 10 foot clear plastic hoses should be connected to the upper pressure tap of this gauge. Unwind the plastic hose from the gauge board. To warm-up the gauge and prepare it for zeroing, gently blow on the hose until the gauge reads 60 Pa and then release the pressure. Feed a couple of inches of the end of the tube through the leather patch of the nylon panel. If there are any obstructions on the outlet side of the fan that could deflect airflow back at the end of the hose, extend the hose well away from the building where it will not be in the exhaust flow from the fan (a hose coupler and extra hose are included for this purpose). The lower pressure tap of the hose pressure gauge should remain open with no hoses connected to it. If the fan exhausts into an unheated space such as a porch or garage, run the hose to the outside.

Fan Pressure Gauges – The two bottom gauges will be used to measure the air flow through the fan. These gauges measure in both cubic feet per minute (CFM) and pressure (Pascals). The fan pressure readings can be easily converted into flows (CFM) by using the conversion table or flow can be read directly from the gauges.

A second 10 foot plastic hose should be connected to the lower pressure tap on the bottom gauge. The pressure taps for the two bottom gauges are connected together so that both gauges read simultaneously. Warm-up these two gauges by sucking on the hose until the bottom gauge reads about 500 Pa and then releasing the pressure. The top pressure taps on these 2 gauges should remain open. Leave the end of the second 10 foot hose unconnected at this point. Make sure that the hoses are not pinched or obstructed.

Fan Speed Controller – Insert the female plug into the receptacle located on the fan housing. The remaining cord should be plugged into any standard household 110 Volt outlet (be sure the fan controller knob is turned all the way counter clockwise to the "off" position before plugging into the house outlet). If desired, the controller can be unclipped from the gauge board by sliding it to the right.

Before conducting the blower door test, we need to put the house in its normal heating or cooling configuration. This includes closing adjustable openings and preparing combustion appliances.

Adjustable Openings

- Close all storm and prime windows.
- Close all exterior doors and attic or crawlspace hatches connected to heated spaces. Also close exterior crawl space hatches.
- Open all interior doors to rooms that are heated. The object here is to treat the entire house as one heated space. Because few basements can be completely sealed from the house and usually some heat to the basement is desirable, they are typically included as heated space.
- Tape plastic over window air conditioners if they appear to be a source of air leakage into the house and they are removed during the winter. (Close AC fresh air vents.)

Combustion Appliance/Exhaust Devices

- Adjust any combustion appliances so they do not turn on during the test. This is usually done by turning off power to the heating system and turning the water heater to the "Pilot" setting. *NOTE: If vented combustion appliances turn on during a depressurization test, it is possible for flames to be sucked out of the combustion air inlet (flame rollout). This is a fire hazard.*
- Be sure that fires in fireplaces and wood stoves are completely out. Take precautions to prevent ashes from being blown into the house during the test. In most cases, closing the dampers and doors is sufficient, but when they are leaky or absent it will be necessary to either tape doors shut, clean out the ashes, or cover the ashes with newspaper.

- Turn off any exhaust fans, vented dryers, air conditioners and HVAC fans.

- Do not seal combustion flues, dryer vents or ventilation system exhaust or intake vents.

Before turning on the fan, check to see that fan direction switch is in the proper location. The fan direction switch (located on the fan housing) determines which direction the fan rotates. To conduct a depressurization test, air must flow through the fan inlet and out of the house. Whether or not you begin the test with the low-flow rings installed will depend on the condition of the housing stock being tested. For purposes of this manual, we will assume that the test begins with the low-flow plates removed (open fan).

Slowly turn the fan controller clockwise until the fan motor engages and the blade begins to turn. Once the fan is turning you should see a reading on the top 60 pascal (or house pressure) gauge. As you increase the fan speed, the house pressure should also increase. If the house pressure gauge doesn't register, or is registering less than zero, check to see that the clear plastic tube is firmly connected to the top pressure tap and that the fan is blowing air out of the house and not into the house. As the fan speed increases, the readings from the bottom 2 fan pressure gauges should also increase. These 2 fan gauges are used to determine the flow of air through the fan.

As you increase the fan speed, you will be increasing the house pressure and as a result, increasing the pressure exerted on the wood or aluminum door frame installed in the door opening. If you did not properly securely install the door frame, the frame may pop out of the doorway at high house pressures (over 30 pascals). If this happens, simply reinstall the frame more securely. When installed properly, the frame will easily stay in place up to a house pressure of 80 pascals or more (although there is no reason to achieve pressures over 60 Pa). Before making measurements, you may want to quickly walk around the house with the fan producing 30 Pa of house pressure to check for any problems such as windows or doors blown open or blowing ashes from a fire or wood stove.

Note: When taking blower door measurements, do not stand directly in front of the fan assembly. This may affect the flow readings and result in erroneous measurements. For best accuracy, stand at least 12 inches from the side of the fan inlet when conducting a blower door test.

CFM50 – "One Point Test"

The most common blower door measurement used by weatherization crews is the fan flow needed to maintain a constant house pressure of 50 Pascals (or CFM50). One-point CFM50 measurements provide a simple way to estimate house airtightness without the need to have a computer to analyze the blower door test data.

Increase the fan speed until the house pressure gauge reads a constant 50 pascals. The fan flow needed to generate a 50 Pa house pressure can be determined from one of the 2 fan flow gauges.

> Determining Fan Flow: If you are operating the fan without low-flow rings, fan flow in CFM can be read directly from the scale labeled "Open Fan" on either of the bottom 2 gauges. When Low-Flow Rings A or B are installed, flow can be read directly from the scales labeled "Ring A" or "Ring B" respectively (Figure 18). Fan flow can also be found by reading fan pressure from the top scale (in Pascals) and converting that pressure reading to CFM by using Table 1. Fan flows should be read off the middle fan gauge (125 PA Gauge) unless the gauge is "pegged" at full scale – then read flow from the bottom gauge.

If the house is very leaky and you are not able to generate 50 pascals of house pressure with the open fan operating at full speed, you can use "Can't Reach 50 (CRF) Factor" to estimate CFM50 flow. First determine the flow required to maintain the highest achievable house pressure. Multiply this flow by the corresponding "Can't Reach Fifty (CRF) Factor" from the chart provided with the blower door.

Note #1: If the measured fan flow is less than 2400 CFM or the fan pressure is less than 25 pascals, you should install Low-Flow Ring A to improve the measurement accuracy.

Note #2: Allow the gauge needles to stabilize before reading the gauge. During strong or gusty winds, pressure readings can vary significantly. Under these conditions, you will need to spend more time watching the gauges to determine the "best" reading. To help with windy conditions, we have equipped the gauges with an internal wind dampening device, which causes them to react slowly to changes in pressure.

Be sure you have returned the house in its original condition before leaving. This includes turning the thermostat and water heater temperature controls to their original setting. Always check to see that furnace and water heater pilot lights have not been blown out during the blower door test – re-light them if necessary. Remove any temporary seals from fireplaces, wood stoves or other openings sealed during the test. In addition, combustion safety tests should usually be performed before leaving the house.

When disassembling and transporting the blower door, carefully handle the house and fan pressure gauges. The gauge board should always be stored in the accessory case when transporting the unit to avoid damage to the gauges.

Important Points To Remember

- If the fan is operated for long periods of time at fan pressures of less than 15 pascals, it is possible for the fan motor to overheat. The motor is protected by a thermal switch which will cut the power to the motor until it cools down enough to operate again. At this time, the motor will automatically start up again. For this reason, it is important to turn the fan speed control knob to "off" when overheating occurs and try turning the fan on every couple of minutes until it has cooled enough to operate. To avoid overheating, operate the fan at higher speeds. Install one of the low-flow rings if you want the same airflow but at a higher fan speed.

- Do not reverse the fan direction (by flipping the fan direction switch) when the fan is turning. This could damage the fan motor.

- The fan is a very powerful and potentially dangerous piece of equipment. Carefully examine the fan before each use. If the fan housing, fan guards, blade, controller or cords become damaged, do not operate the blower door until repairs have been made. Keep people and pets away from the fan when it is operating. If you notice any unusual noises or vibrations, stop the fan for examination and contact The Energy Conservatory if you are unable to locate the source of the problem.

- It is always a good idea to periodically check for leaks in the flow sensor. To check for flow sensor leaks, first tape over the 4 small holes located on the side surface of the sensor. Now connect the hose to the fan pressure tap and suck on the hose. If the flow sensor is not leaking, you should create a vacuum in the hose. You can tell if there is a vacuum by sucking on the hose and then quickly putting your tongue over the end of the hose – the house should stick to your tongue.

- You should also periodically check the hoses on your blower door to be sure they are not leaking. An easy way to check the hoses is to gently blow into each hose while it is connected to the top pressure tap of a gauge. Blow gently until you reach 75 percent of full gauge scale. Be careful not to blow too hard or you could damage the gauge. Crimp off the open end of the hose (making an airtight seal) and see if the gauge needle maintains a constant reading. A slowly dropping gauge reading indicates a leaky hose, leaky hose connection, or possibly a leaky gauge seal.

Building Tightness Guidelines: When Is a House Too Tight?

by George Tsongas

When it comes to weatherization, what's good in Arkansas may be bad in Maine. New guidelines will help blower door users tailor air tightness levels to the house and its setting—preserving air quality and energy savings.

After more than a decade of training and field experience, low-income weatherization crews are substantially increasing the air tightness of homes. That's positive from an energy-use point of view, but in many cases it's causing over-tightening, which can lead to indoor air quality problems. Blower doors are increasingly used to measure air tightness. They depressurize a house and measure air flow through it when the pressure between the inside and the outdoor air is set at a difference of 50 Pascals (a metric unit of pressure). The flow through the fan typically is measured in cfm (cubic feet per minute) and is usually referred to as "cfm_{50}." Yet serious questions plague blower door users, such as "How tight is too tight?" and "What factors affect the answer?" "Is there a difference if two elderly people live in a house or if eight people live there?" "What difference does house size have?" "What if smokers live there?" Crews want answers and specific guidelines!

New Basis for Tightness Guidelines

Building tightness limits (BTLs) have been developed in some states. BTLs are guidelines based on estimates of the minimum air exchange rate of a building necessary to provide enough fresh air to maintain satisfactory health of the occupants and durability of the structure. They are increasingly important to the Department of Energy's Weatherization Assistance Program.[1] Utilities also are struggling to develop such guidelines.

BTLs usually specify a building's minimum air leakage rate—cfm_{50}min—for comparison with the measured value of cfm_{50}. A few years ago, based on the recommendations of 15 cfm of outdoor air per person in a building set out in ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) Standard 62-1989, Minnesota and Wisconsin adopted cfm_{50}min values of 1,200 and 1,500, respectively. These single values were never intended for use by other states, yet they have been adopted because using a single number is simple. They were adopted for conditions in Minnesota and Wisconsin—conditions which are not likely to be the same elsewhere.

Blower doors measure a building's tightness (essentially its leakage area), and the natural infiltration rate of a house is estimated from that value based on a number of parameters. A single BTL does not incorporate factors like climate, a building's wind exposure, building size, or the number of occupants. Air exchange rates can vary widely depending on such factors.

In response to the need for BTLs that factor in such variables, tables have been developed by this author for each of the four climate zones in the United States based on the work of Max Sherman of the Lawrence Berkeley Laboratory (see "Infiltration: Just ACH_{50} Divided by 20?" *HE*, July/Aug. '86). The tables (see p. 21) account for the number of occupants, the number of stories of the building, and its wind shielding characteristics. The factor in the Sherman method which accounts for the type of leaks (large or small) is not included because even highly trained professionals have difficulty identifying them.

These tables assume that the only concern is with providing adequate fresh air for occupants, that there is little or no mechanical ventilation, and that there are no unusual air pollutant generation rates. They also assume that the issues of combustion safety and makeup air for exhaust fans and combustion appliances will be dealt with separately. The tables include a U.S. map, divided into four climate zones. Weatherization personnel can use the map to find their particular zone and then select the appropriate table with the correct cfm_{50}min values. The BTL tables ease the tension between saving energy and preserving indoor air quality. Using them is straightforward.

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Brent Schauer

Blower doors, such as the one that the author is installing, are an important tool in estimating building air infiltration rates before and after energy conservation measures. But how far can the air infiltration rates fall before indoor air quality problems arise?

The Number of Occupants

If the number of occupants is not known, a rule of thumb for determining it is to double the number of bedrooms. However, a minimum of five people in a residence is assumed to account for potential changes in occupancy after weatherization. This assures that if additional people move into a house after weatherization, there's ample fresh air. If more than eight occupants live in a residence, add to the eight occupant cfm_{50} min value for each additional resident an amount determined by multiplying 15 cfm by the LBL correlation factor N in the tables.

The Stack Effect

Warm air exfiltrates out of the top of the building as a result of the stack effect much like a hot air balloon rises. The tables account for the stack effect as expressed through the number of stories of the building. The taller the building, the greater the stack effect. Confusion in selecting the appropriate number comes when deciding how to deal with basements. It helps to remember that the number of stories refers to the average height of the volume of heated air in the house that has stack effect-induced air leakage. Since there is little infiltration except through the top portion of basements, generally they should *not* be included in the number of stories.

There are exceptions. A partial daylight basement exposed on one side but not on the opposite side might be counted as a half story. A split-level house with half of the lower level being bedroom space and the other half unheated garage space might have the lower level counted as a half story. A heated attic room of, say, 600 ft^2 might be counted as a half a story if the main living space below was 1,200 ft^2.

Precautions

There are situations where no tightening should be performed or where it should at least be put off until certain tests or measures are undertaken, particularly if the house has an indoor air quality problem that can not be remedied or the house has an unvented space heater that can not be replaced—for example an oven that is used as the main space heater in the house. Products of combustion, including carbon monoxide and oxides of nitrogen as well as water vapor, are emitted directly into a living space by such space heaters. They already can be extremely hazardous. Air tightening can make them even more dangerous.

One of the most important considerations should be combustion safety. Two aspects impact air sealing. The first is the possible existence of elevated levels of carbon monoxide (CO) in the indoor air from combustion appliances such as furnaces, water heaters, stoves or ovens, and even gas clothes dryers. The CO can get into the ambient air by direct venting of the combustion products, including CO, or by indirect leakage through a defective furnace heat exchanger, or by backdrafting or spillage. Testing for CO in the ambient air and in the undiluted flues or vents of all combustion appliances is essential.[2]

- If any combustion appliances exist, no air tightening should be undertaken until the undiluted flue gases are monitored for CO and found to be less than 50 parts per million (PPM). If levels above 50 PPM are found, no air tightening should proceed until the combustion appliance is fixed and the CO level is below 50 PPM.
- If flame change is noted in the furnace when the furnace fan comes on, the heat exchanger may be cracked and introduce undesirable combustion products into the living space. No air tightening should be undertaken until the problem is fixed.

Any device that exhausts air from a tight house (exhaust fans, clothes dryers, furnace fans, furnace and water heater vents, fireplaces) can compete with the normal venting of combustion products from combustion appliances. This can lead to backdrafting and spillage (see "Backdrafting Causes and Cures" *HE*, May/June '91, p. 30). In tight houses, exhaust devices can cause so much depressurization inside the house that the normal chimney or flue flow of combustion products from furnaces and water heaters reverses. This can cause minor moisture damage or even death. Tightening a house can create this situation or increase it where it already exists.

- If any combustion appliances exist, backdraft/spillage and draft testing should be performed before and after

Building Tightness Limits ($cfm_{50}min$)

Using the BTL Tables: An Example

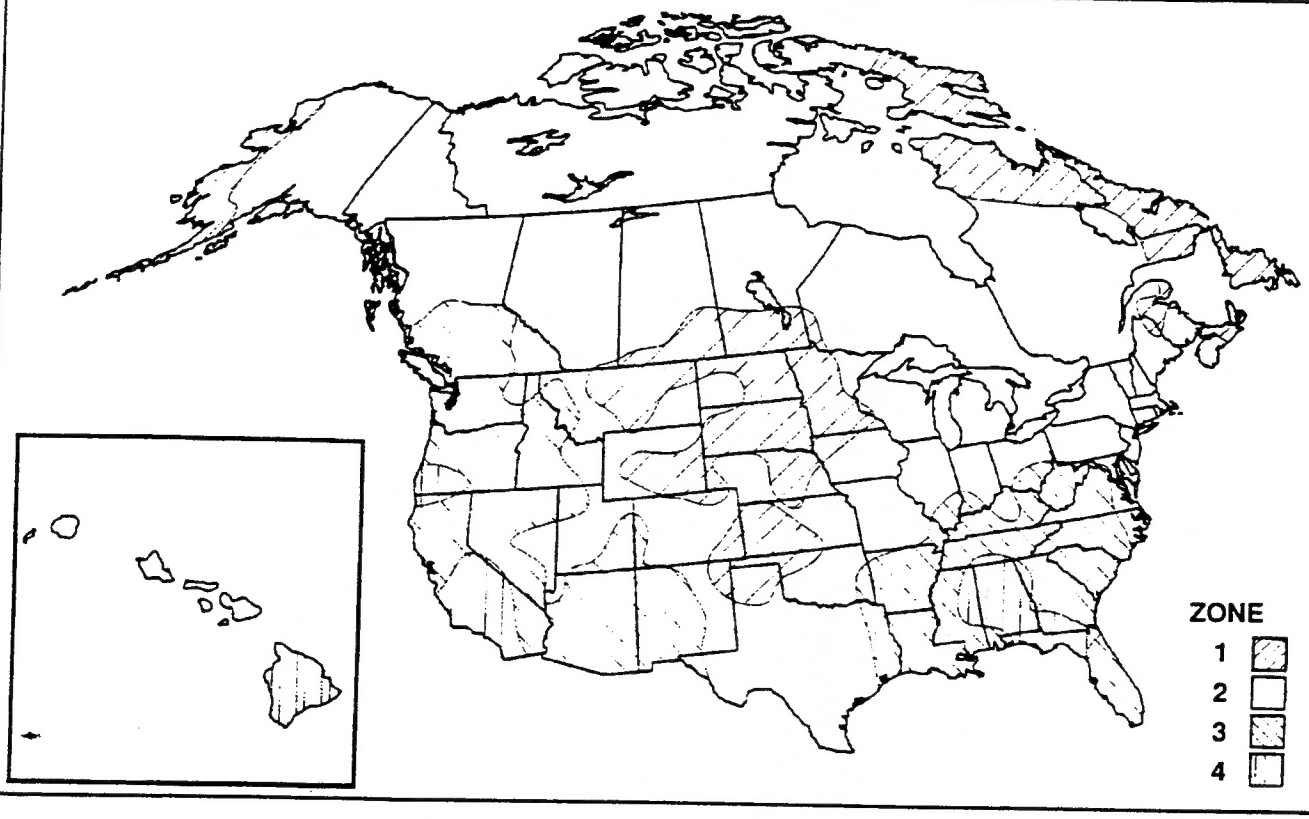
Consider a single story house with an unheated basement and four occupants in Rochester, N.Y. With the map, it is determined that the house is in Zone 2; From the table for that zone, the number of stories is "1," wind exposure is "normal," and the number of occupants is in the "five or less" category. The resultant Building Tightness Limit value is 1,390.

Values for cfm_{50} can be converted to ACH_{50} values (air changes per hour at a 50 Pascals (Pa) pressure difference across the house envelope) by multiplying cfm_{50} by 60 and dividing by the heated house volume. In our sample home, if the measured cfm_{50} value was 2,000 and the house volume was 10,000 ft^3, then the ACH_{50} value would be:

$$2.000 \times 60/10,000 = 12.$$

The tabulated values of the Lawrence Berkeley Laboratory (LBL) correlation factor N can then be used to estimate the natural infiltration rate ACHnat by dividing the ACH_{50} by N. In the example, the tabulated value of N is found to be 18.5, and the resultant ACHnat value is:

$$12/18.5 = 0.65.$$



NOTES:

Max ft²

Persons	Total cfm (15 cfm × Persons)	Max. ft²
5	75	1,610
6	90	1,930
7	105	2,250
8	120	2,570

- If house area exceeds Max ft², do *not* use tabulated values. Calculate:

$$cfm_{50}min = 0.35 \times (\text{Volume}) \times \frac{N}{60}.$$

$$ACHnat = \frac{cfm_{50} \times 60}{\text{Volume} \times N}$$

- For each occupant greater than 8, add 15N.
- Consider adding another occupant or two for each person who smokes.
- Regardless of the above limits, air sealing shall not be undertaken if the house has an indoor air quality problem that has not been fixed or can not be remedied.

Wind Shielding Factors

Well Shielded	Urban areas with high buildings or sheltered areas. Buildings surrounded by trees, bermed earth, or higher terrain.
Normal	Buildings in a residential neighborhood or subdivision setting, with yard space between buildings. 80–90% of houses fall in this category.
Exposed	Buildings in an open setting with few buildings or trees around. Buildings on top of a high hill or ocean front, exposed to winds.

Building Tightness Limits (cfm_{50}min)

ZONE 1	Number of stories		1	1.5	2	3
	Five occupants	Well shielded	1,395	1,255	1,115	975
		Normal	1,165	1,045	930	815
		Exposed	1,045	940	835	730
	Six occupants	Well shielded	1,675	1,505	1,340	1,170
		Normal	1,395	1,255	1,115	975
		Exposed	1,255	1,130	1,005	880
	Seven occupants	Well shielded	1,955	1,760	1,560	1,365
		Normal	1,630	1,465	1,300	1,140
		Exposed	1,465	1,320	1,170	1,025
	Eight occupants	Well shielded	2,230	2,010	1,785	1,560
		Normal	1,860	1,675	1,490	1,300
		Exposed	1,675	1,505	1,340	1,170
	LBL correlation factor (N)	Well shielded	18.6	16.7	14.9	13.0
		Normal	15.5	14.0	12.4	10.9
		Exposed	14.0	12.6	11.2	9.8
ZONE 2	Five occupants	Well shielded	1,665	1,500	1,330	1,165
		Normal	1,390	1,250	1,110	970
		Exposed	1,250	1,125	1,000	875
	Six occupants	Well shielded	2,000	1,800	1,600	1,400
		Normal	1,665	1,500	1,330	1,165
		Exposed	1,500	1,350	1,200	1,050
	Seven occupants	Well shielded	2,230	2,100	1,865	1,630
		Normal	1,945	1,750	1,555	1,360
		Exposed	1,750	1,575	1,400	1,225
	Eight occupants	Well shielded	2,665	2,400	2,130	1,865
		Normal	2,220	2,000	1,775	1,555
		Exposed	2,000	1,800	1,600	1,400
	LBL correlation factor (N)	Well shielded	22.2	20.0	17.8	15.5
		Normal	18.5	16.7	14.8	13.0
		Exposed	16.7	15.0	13.3	11.7
ZONE 3	Five occupants	Well shielded	1,935	1,740	1,550	1,355
		Normal	1,615	1,450	1,290	1,130
		Exposed	1,450	1,305	1,160	1,015
	Six occupants	Well shielded	2,320	2,090	1,860	1,625
		Normal	1,935	1,740	1,550	1,355
		Exposed	1,740	1,565	1,395	1,220
	Seven occupants	Well shielded	2,710	2,440	2,165	1,895
		Normal	2,260	2,030	1,805	1,580
		Exposed	2,030	1,830	1,625	1,420
	Eight occupants	Well shielded	3,095	2,785	2,475	2,165
		Normal	2,580	2,320	2,065	1,805
		Exposed	2,320	2,090	1,860	1,625
	LBL correlation factor (N)	Well shielded	25.8	23.2	20.6	18.1
		Normal	21.5	19.4	17.2	15.1
		Exposed	19.4	17.4	15.5	13.5
ZONE 4	Five occupants	Well shielded	2,205	1,985	1,765	1,545
		Normal	1,840	1,655	1,470	1,285
		Exposed	1,655	1,490	1,325	1,160
	Six occupants	Well shielded	2,645	2,380	2,115	1,850
		Normal	2,205	1,985	1,765	1,545
		Exposed	1,985	1,785	1,590	1,390
	Seven occupants	Well shielded	3,085	2,780	2,470	2,160
		Normal	2,575	2,315	2,060	1,800
		Exposed	2,315	2,085	1,850	1,620
	Eight occupants	Well shielded	3,530	3,175	2,820	2,470
		Normal	2,940	2,645	2,350	2,060
		Exposed	2,645	2,380	2,115	1,850
	LBL correlation factor (N)	Well shielded	29.4	26.5	23.5	20.6
		Normal	24.5	22.1	19.6	17.2
		Exposed	22.1	19.8	17.6	15.4

any air sealing is undertaken. If spillage, backdrafting, or insufficient draft exists, no air sealing should be undertaken until the problem is remedied.[2]

Observations Concerning Tabulated Values

The wide variation (730–3,530) indicates that a single value is not appropriate. Barring extenuating circumstances, no house in the United States should be tightened below 730 cfm_{50}. For homes with BTL values below 1,200, tightening to the limit reduces air leakage, yielding greater energy savings. On the other hand, there are numerous conditions where cfm_{50}min values exceed 1,200, especially in Zone 4. Thus many agencies using a single value may likely be over tightening and exacerbating indoor air quality problems.

There are clear trends in the tables. There's an increase in cfm_{50}min values with increasing climate zone number, which correlates with less severe weather. In milder climates there is less natural infiltration, and thus larger cfm_{50}min values are necessary to maintain satisfactory indoor air quality. Houses with more stories have greater natural infiltration, and hence lower cfm_{50}min values are allowed. Finally, increasing the building's wind exposure decreases the cfm_{50}min values. An exposed house has a greater natural infiltration rate than a shielded house. Therefore it can be tighter.

Adjusting the Values—or Not

In some cases, it may be necessary to adjust the BTL values to account for factors such as large buildings, smokers, and heating and ventilation system types.

Building Size

If the heated area of a house exceeds the maximum noted in the tables, the table values of cfm_{50}min should not be used. That is because the tabulated values, based on 15 cfm per person, are lower than the values based on a minimum natural air change rate for a building of 0.35 ACH. ASHRAE Standard 62-1989 specifies that the larger of the two values should be used.

For such "large" buildings the appropriate cfm_{50}min values need to be calculated using the equation:

$$cfm_{50}min = 0.35 \times (\text{House Volume}) \times N/60.$$

The factor N is the LBL correlation factor shown in the tables. For example, suppose a one story house in New York (Zone 2) with normal exposure (average N = 18.5) and four occupants has a total living space of 2,500 ft^2 and 8 ft ceilings. The calculated value of cfm_{50}min = 0.35 × (2,500 × 8) × 18.5/60 = 2,160. That's higher than the tabulated value of 1,390 cfm_{50}min and *should be used.*

Smokers

When there are smokers, additional air exchange may be needed. The 15 cfm per person of fresh outdoor air recommended by ASHRAE Standard 62-1989 accounts for smoking. A safe approach is to add the equivalent of one or two persons for each smoker.

Combustion Air

Some suggest that cfm_{50}min values should be adjusted upward to reflect the air needs of natural gas or propane appliances. Another common approach is to simply install combustion air inlets in all houses being weatherized, with no adjustments to BTL values. Unfortunately, neither of these approaches adequately addresses the complicated interactions between house, airtightness, and combustion safety.

What Affects Air Tightness The Most?

- A broken window and a leaky or no fireplace damper are obvious leaks.
- Blowing insulation into walls usually increases tightness substantially.
- Duct leaks—especially in mobile homes—are often significant.
- Attic bypasses typically constitute a major fraction of the house's leakage area.
- Houses are often tight enough after blowing insulation into walls and sealing ducts and bypasses, without any caulking or weather-stripping.

Dedicated combustion air is often thought to prevent the appliance from being air starved and/or to provide pressure relief in the combustion appliance room to prevent backdrafting or spillage. In fact, the air requirements of a combustion appliance are fairly small and typically are met easily with basement or house air. An exception would be if the appliance is located in a small, airtight room.

With respect to pressure relief, combustion room depressurization is frequently found, even after code-approved combustion air inlets are installed. This is because passive combustion air inlets do not provide sufficient air flow to relieve negative pressure caused by large or numerous exhaust appliances or forced air distribution system imbalances. Furthermore, under certain wind conditions, a combustion air inlet may actually increase combustion room depressurization.

So what do we do to address pressure-induced combustion safety problems? Most importantly, comprehensive combustion safety testing, including worst case depressurization tests, must be performed on all houses with natural draft combustion appliances. This should be done after air tightening and pressure balancing of forced air distribution systems. If testing reveals a potential pressure-induced spillage or backdrafting problem, installation of combustion air is warranted. If the addition of combustion air does not relieve the problem, additional measures will be necessary.

Stoves and Fireplaces

There is no need to adjust the BTL value for a home with an airtight wood stove or fireplace insert. They typically require only about 10–15 cfm. Air leakage in even the tightest home will provide considerably more than that. How-

ever fireplaces require more combustion air, often 200–400 cfm. Such large exhaust flows can cause considerable depressurization, especially in tight houses, and subsequent backdrafting of furnaces, boilers, or water heaters.

At a minimum, depressurization in the combustion appliance area(s) should be measured with a fire in the fireplace. A depressurization of 3 Pascals or more can lead to backdrafting. This kind of testing is difficult and seldom done. Yet serious backdrafting can lead to sickness and even death. One option is not to tighten homes with fireplaces. Another is to replace a natural draft furnace, boiler, or water heater with a new induced draft or power-vented model, the ultimate solution for all backdrafting problems. Or a power venter kit, or a high-flow, fan-assisted combustion air inlet system can be installed. If one of those approaches is taken, there is no need to alter the BTL value because the value is based on providing fresh air for occupants rather than for combustion appliances. Cracking a window when the fireplace is in use may or may not help, depending on wind speed and direction.

Forced Air Heating Systems

The tables do not differentiate between types of space heating systems, such as ducted versus non-ducted. A house with a forced air system will tend to have higher pressure differentials between the inside and outside air and therefore higher leakage. Tests on new homes in the Pacific Northwest indicate that the average natural infiltration rate for ducted homes is significantly higher than for non ducted homes. Thus, in principle, BTLs should be lower for houses with forced air systems. Deciding how much lower is difficult, especially for older, low-income housing.

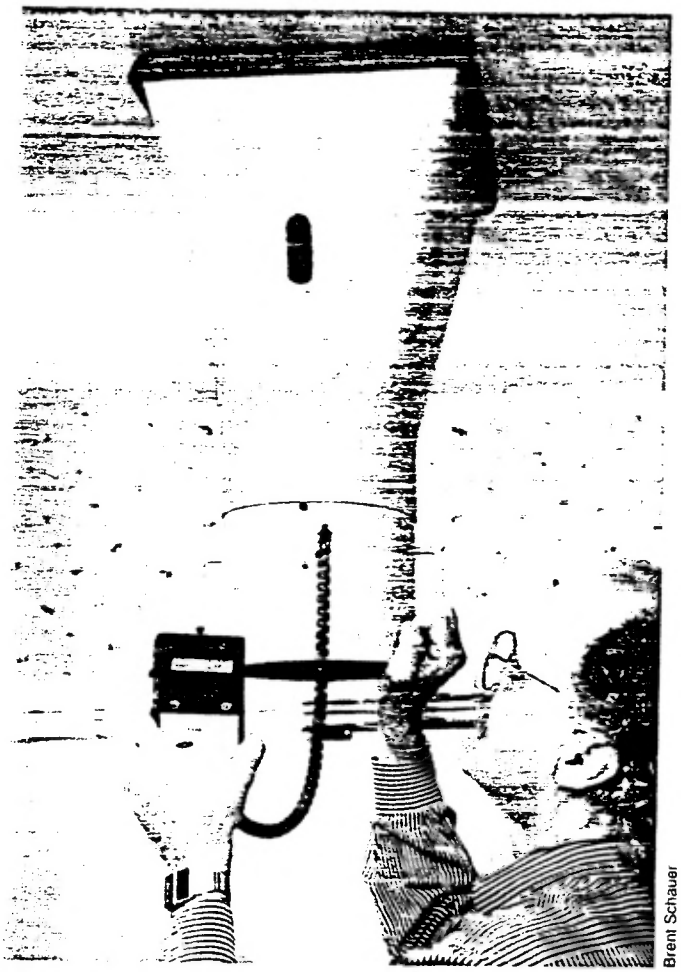
The best policy, however, is to reduce the pressure differentials caused by closed interior doors and duct leaks. Once these are fixed, there's no need to modify the BTL values. Since most indoor air quality problems occur during mild weather when the heating system runs the least, there may not be a need to modify the BTL values anyway.

Attic Moisture Problems

It may be necessary to seal attic bypasses, and so air tighten, even in cases where the tightening will reduce the house's measured cfm_{50} value below the BTL. Solving a serious attic moisture problem may create an indoor moisture problem or other indoor air quality problem since the air sealing will likely raise the humidity. One option is to overtighten and install mechanical ventilation.

Bathroom and Kitchen Exhaust Fans

No changes should be made in the BTL values based on whether a bathroom or kitchen fan exists and is used. They help control moisture, but generally do not affect the overall ventilation rate. They are not always used, and do not run very long. There are no clear guidelines for whether a bathroom exhaust fan (or general ventilation) should be installed if none exists and the house is over tightened. The best approach is to carefully inspect for an indoor air pollution problem. If one is found, a fan may be warranted. Portable dehumidifiers can also provide good results.



Brent Schauer

The flow hood, used here on an exhaust fan, is another useful air measurement tool. Used in bathrooms and kitchens, flow hood measurements can provide some idea of air flow rates and ventilation inside a building.

Use Common Sense

Since the tables do not indicate whether any or all of the air sealing is cost effective, before and during air tightening, cost effectiveness should be determined.[3] Furthermore, if a house is already close to the BTL, it makes little sense to spend lots of time looking for large leaks. There's also no point in caulking small cracks in a leaky building when the budget may not allow for fixing all of the bigger holes. It's best to go after the big leaks first.

The BTL guidelines are a reasonable and relatively easy way to help avoid indoor air quality problems when weatherizing existing homes. Keep in mind, though, they *do not* guarantee satisfactory air quality, especially from large pollutant sources. An alternative approach is to tighten the building as much as economically possible—often well below the tightness limits presented here—and then install a controlled mechanical ventilation system. A lack of practical experience and relatively high costs limit this option at present. Dehumidification may also be required, especially in small dwellings with a large number of occupants during mild weather.

The author would like to thank the Montana Department of Social and Rehabilitation Services for supporting the initial development of these building tightness guidelines. Special thanks

go to Dave Legg of MassSave for providing the first BTL tables used in Massachusetts. Finally, the author is indebted to Gary Nelson of The Energy Conservatory in Minneapolis who years ago developed the first BTL tables and helped with the initial development of these guidelines for Montana, and whose consultation and advice has been invaluable. ■

Endnotes

1. DOE's 1992 grant guidance document in its Health and Safety section (IV. Policy, Program Guidance, and Regulatory Changes) states that grantees must have in their programs procedures to determine the minimum number of air changes that will occur in dwellings following weatherization. Support offices are asked to encourage grantees to include in the state plans information that describes their target level for minimum air change rates and how subgrantees will test to determine that level.
2. An invaluable, detailed, step-by-step procedure for all necessary combustion safety tests is provided in the October 1992 *Minneapolis Blower Door Manual*, available from The Energy Conservatory, 5158 Bloomington Ave. S., Minneapolis, MN 55417. Tel: (612)827-1117; Fax: (612)827-1051. Another good source of information on this subject is the *Chimney Safety Tests Users' Manual*, 2nd ed., prepared for Canada Mortgage and Housing Corp. by Scanada-Sheltair Consortium Inc., 1988. It is available free from C.M.H.C., Publications Section, Montreal Rd., Ottawa, ONT K1A 0P7. Tel: (613)748-2367.
3. Methods for determining whether a particular air sealing weatherization action is cost-effective are presented in the *Minneapolis Blower Door Manual*. (Also, see "Blower Door Guidelines for Cost-Effective Air Sealing," *HE*, Mar/Apr '90, p. 34.)

User-Friendly Pressure Diagnostics

by Jim Fitzgerald, Robert Nevitt, and Michael Blasnik

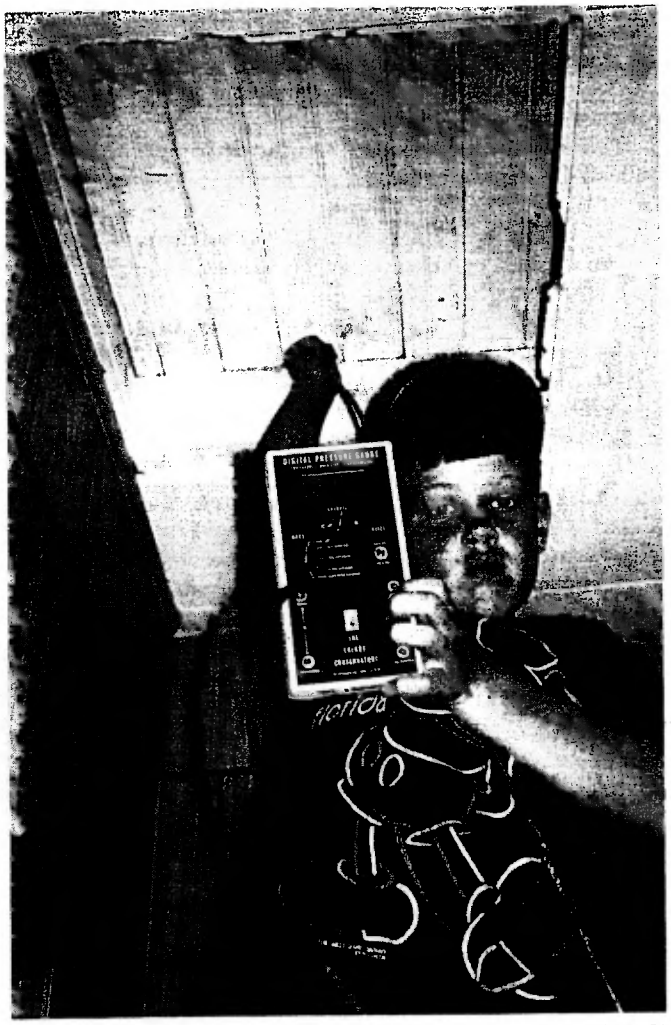
Here is an easy-to-understand explanation of pressure diagnostics. The "user friendly" approach focuses on measuring pressures rather than just leakage to help you quickly determine which weatherization treatments a home needs. Know what you're measuring before you start work.

Using pressure measurements to find and quantify air leakage in houses has been a hot topic over the past two years. Packed sessions at recent conferences are testimony to the intense interest these techniques are generating in the weatherization community. Advanced pressure-diagnostic techniques have greatly furthered our understanding of the complicated nature of air movement through building cavities and chaseways (see "In Search of the Missing Leak," *HE* Nov/Dec '92, p.27). This new understanding is helping answer many questions about why some houses respond well to weatherization treatments while others provide disappointing results.

Unfortunately, transferring these new diagnostic techniques to the field can be a difficult and even intimidating task. The graphs and mathematical formulas associated with the techniques have been known to create math anxiety in many a crew member, while others complain that performing all the tests adds too much time to the house inspection. Yet it has become increasingly clear that we need a better process to guide us in developing treatment plans for houses. In many programs, "lost opportunities" abound even in fully treated houses.

So how do we choose from the growing list of diagnostic tests and treatment options available? If our goal is improving program results, and not doing research, then not every test procedure and treatment option is appropriate for every house. We want the minimum testing to help make the right choices fast, and the minimum treatment to achieve the desired results.

Here is an easy-to-understand explanation of pressure diagnostics plus some simple examples of pressure tests. With this information, you should have a better understanding of when these techniques may be appropriate and how they can be quickly incorporated into your diagnostic procedures.



Jim Fitzgerald

Who says pressure diagnostic tests are too difficult to perform?! This young man demonstrates one basic technique used to make many of the readings.

Jim Fitzgerald is a Minneapolis-based trainer and consultant. Robert Nevitt is business manager of the Energy Conservatory in Minneapolis. Michael Blasnik is research director of GRASP, a Philadelphia-based nonprofit, but is joining Proctor Engineering Group in its new Boston office.

Thermal and Pressure Boundaries

One of the most important pieces of information we need to make informed treatment decisions for a house is the location of thermal and pressure boundaries.

Insulation is normally installed to reduce conductive heat loss between conditioned and unconditioned spaces. This surface is called the thermal boundary, or thermal envelope, and is typically used by auditors and crews to determine the "intentionally conditioned" area of the house. Conventional wisdom tells us that thicker insulation along the thermal boundary or a smaller boundary surface area produces better thermal performance and energy savings.

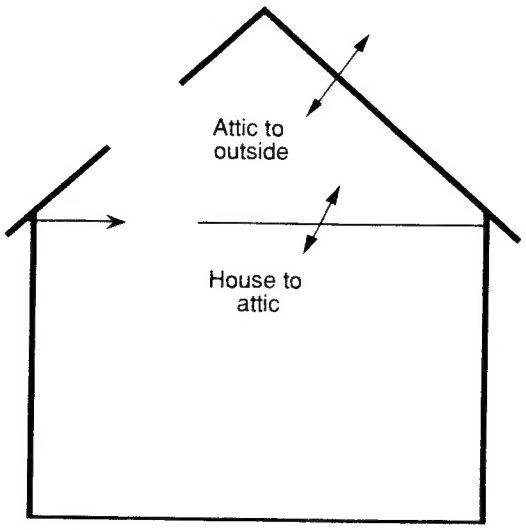
Plywood, gypsum board, weatherstripping, foams, and other air-barrier materials, on the other hand, all serve to slow the exchange of conditioned air with outside air. While some insulations (such as rigid foam board and dense-packed cellulose) can act as an air barrier, typical insulation applications do little to impede air movement. The location of the actual block between the inside and outside air is called the pressure boundary. Conventional wisdom tells us that sealing holes in the pressure boundary will also produce energy savings.

Blower-door tests are routinely used to measure the airtightness of this pressure boundary and to measure changes in the boundary from airsealing work. Most experts would agree that the advent of blower-door tests has greatly aided crews in directing cost-effective airsealing treatments. Unfortunately, a blower-door test by itself does not tell us the actual location of the pressure boundary. And it is this key piece of information that can make or break a treatment plan.

MICA

The author peering down through the ceiling shows that the roof is the pressure boundary in this house. When the boundary is less obvious, however, pressure diagnostic tests are an important asset.

It is not uncommon for the pressure boundary and the thermal boundary of a house to be in different locations. For instance, the pressure boundary in a house may actually be the roof boards rather than the insulated attic floor. Misalignment of these boundaries can create numerous problems with conventional treatment decisions. First, when the two boundaries are not aligned, the actual conditioned space of the house may be significantly greater than you assumed in your audit. Misalignment can also dramatically increase the surface area over which heat loss can occur. This can happen by unintentional heating of "unconditioned spaces" like attics, or convective looping occurring within interior walls.



Katherine Falk and Jim Fitzgerald

Figure 1. The table below gives the relative size of the leakage rates. However, you need to know the actual size of one side of the leakage path (house-to-attic or attic-to-outside) to determine if the leakage path is significant.

Relative Size of Leakage Rates		Measured Pressures*	
House-to-Attic	Attic-to-Outside	House-to-Attic	Attic-to-Outside
2	1	–12	–38
1	1	–25	–25
1/2	1	–37	–13
1/3	1	–41	–9
1/4	1	–45	–5
1/8	1	–48	–2
1/13	1	–49	–1

* with the house depressurized by 50 Pa.

Just as importantly, when the boundaries are misaligned, the house may not respond to treatments as expected. For example, crews may waste time and money by sealing only visible air leaks in houses which are dominated by hidden cavity leakage. This can result in no reduction in house airtightness, despite the crew's plea that several hours were spent sealing attic bypasses.

Finally, since most residential insulations require "still air" to function properly, houses tend to perform better when the pressure boundary lines up with the thermal boundary. When the boundaries are aligned, we are less likely to have air movement through insulation, which causes R-value degradation.

Finding the Pressure Boundary

Simple pressure tests can help us determine which houses will respond more predictably to treatments and can also reinforce training goals. We do this by learning which part of the house structure is really inside the pressure boundary, which part is outside, and which parts are a mixture of the two. We can no longer assume every house behaves like a simple box with holes. Using the right pressure test, fast production houses can be quickly differentiated from the complicated house having multiple interconnected leaks with connections to ducts, side attics or porches.

Let's look at three examples of simple pressure measurements and how they help us decide on treatment options. Before we begin, we need to set some ground rules. First, our pressure tests are always conducted with a blower door depressurizing the house by 50 Pa with respect to (WRT) outside. This means that all exterior windows and doors in the house are closed, interior doors open, and the blower door is blowing air out of the house, creating a lower pressure inside the house than outside.

If the house has a forced-air duct system, we need to decide whether the duct system should be considered "outside" the house, with high savings potential, or "inside" the house, with low savings potential. Set up the house for the test accordingly (see Figure 2). Clearly decide, and leave no in-between "semi-conditioned" areas. Safety testing must be done after the exterior-interior boundary is repaired, because HVAC systems cannot create pressure imbalances if no effective pressure boundary exists before treatment. Also, if there is no effective pressure boundary between the basement and the upstairs, or between rooms, then no pressure problems are created by duct leaks to the inside that remain after treatment.

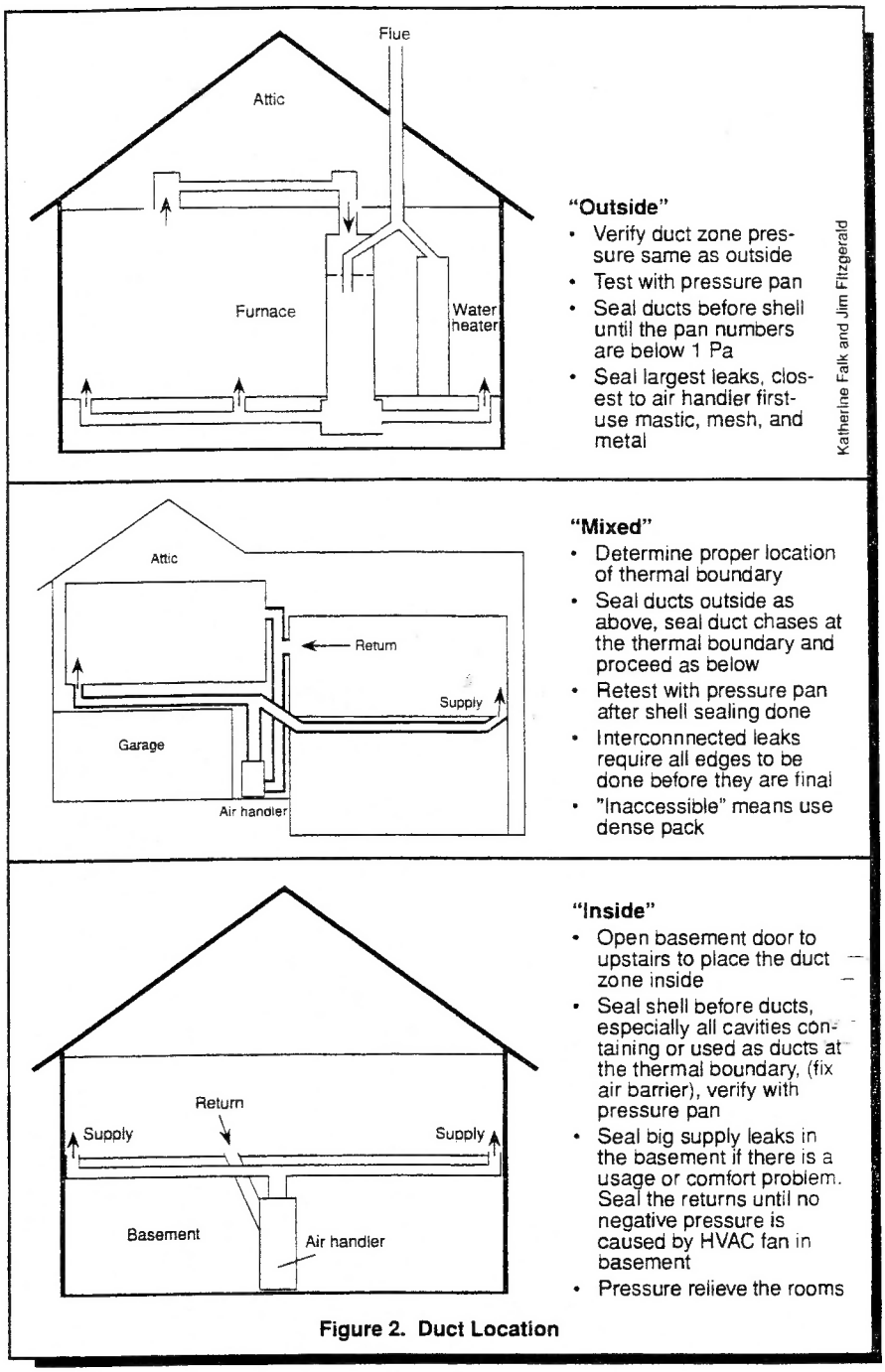


Figure 2. Duct Location

Our simple tests will include two or more of the following pressure measurements taken with the blower door operating:

- Pressure in the house WRT the outside
- Pressure in the house WRT the attic
- Pressure in the house WRT the duct system (using a pressure pan)
- Pressure in the house WRT an interior building cavity which contains ducts or plumbing

In all cases, take the measurements while standing inside the house. If you are using a digital pressure gauge, leave the input tap on the gauge open to the house, connect a hose to the reference tap and run it to the zone you are measuring with respect to. If using a pressure pan, connect the reference tap to the pressure pan. All readings from the digital gauge will now display as negative. If you are using a magnehelic gauge, connect a hose to the top tap on the gauge and run it to the zone you are measuring (or to the pressure pan), while leaving the bottom tap open to the house. All readings from our magnehelic gauge will show as positive.

Before turning on the blower door, place a pressure hose through the attic hatch so that one end is in the attic

and the other can be reached from inside. Place it 2–3 ft past any direct leaks. If you have a digital gauge, use it for all the readings, or use the same gauge to measure house-to-attic pressure and house-to-outside pressure. Detach the blower door gauges and use the top (0–60 Pa) gauge for all the measurements; leave the fan running to maintain an even –50 for all the tests.

Pressure and Air Leakage Rates

Before we go any further, let's take a quick look at the relationship between leakage rates and pressures.

Figure 1 shows 7 examples of how leakage rates between a house and attic and between the attic and outside relate to simple pressure readings taken with the house being depressurized by a blower door by 50 Pascals (Pa).

For example, if you measured a house to attic pressure of –12 Pa and an attic to outside pressure of –38 Pa, the leakage rate from the house to the attic would be twice the leakage rate from the attic to outside. As the ceiling air pressure boundary is tightened (for instance by sealing attic bypasses), the house-to-attic pressure moves closer to –50 Pa, and the attic-to-outside pressure gets closer to zero. By the time most of the attic leaks have been sealed and the house to attic pressure reaches –48 Pa, the leakage rate between the house and the attic is ⅛th the attic-to-outside leakage rate.

Importantly, Figure 1 only gives the relative size of the leakage rates. You need to know the actual size of one side of the leakage path (house-to-attic or attic-to-outside) to determine if the leakage path is significant. Fortunately, attic vents can often be used to estimate the attic-to-outside leakage rate. For example, let's consider a house with a tight roof and one single attic vent installed. A single common attic vent has an effective leakage area of about 25 in^2. Therefore, if we measure a house to attic pressure of –12 Pa, we can estimate from Figure 1 that the house-to-attic leakage area is about 50 in^2 (twice the attic to outside leakage area). If we seal the attic until the house-to-attic pressure equals –48 Pa, we estimate that only 3 in^2 of house-to-attic leakage remains (one eighth the attic-to-outside leakage area). Our attic pressure measurement tells us that this bypass job will now pass any inspection.

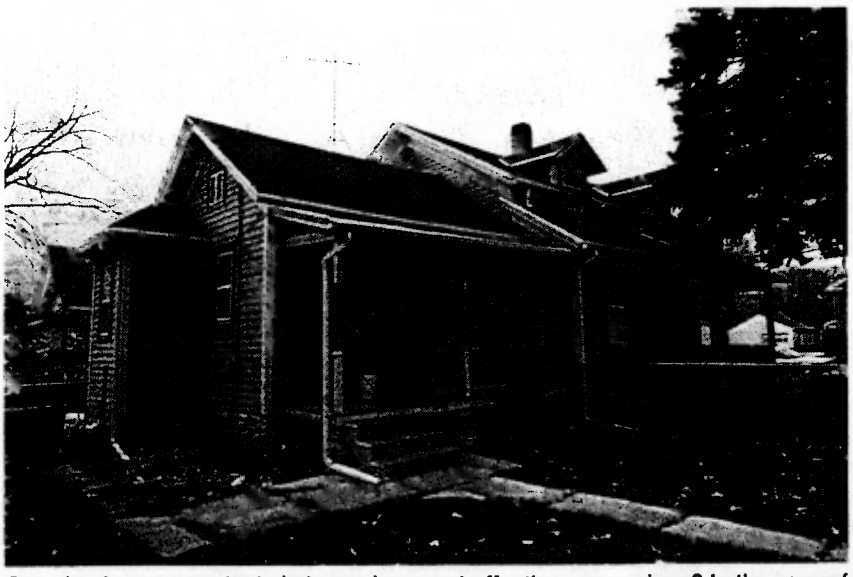
On the other hand, if you are working on a house with loads of attic venting, an attic pressure of –48 or –49 before work begins may still mean plenty of unsealed attic bypasses. For a house with 600 in^2 of attic venting, a house-to-attic pressure of –48 Pa means there is roughly 75 in^2 of bypass area unsealed; plenty of work left to be done—about 750 CFM_{50}.

House #1: Leaky Interior with Tight Exterior

House #1 has an insulated attic with large attic bypasses, a very tight roof with no attic venting, and leaky supply ducts running in the attic. With the house depressurized by 50 Pa (for example, the digital gauge reads –50 Pa of house pressure WRT outside), we measure the pressure of the house WRT the attic. Our digital gauge reads close to 0. Now we take a pressure pan reading on a ceiling supply register. The pressure pan reading is also close to zero, even though we know there are leaky ducts in the attic. What do these readings tell us?

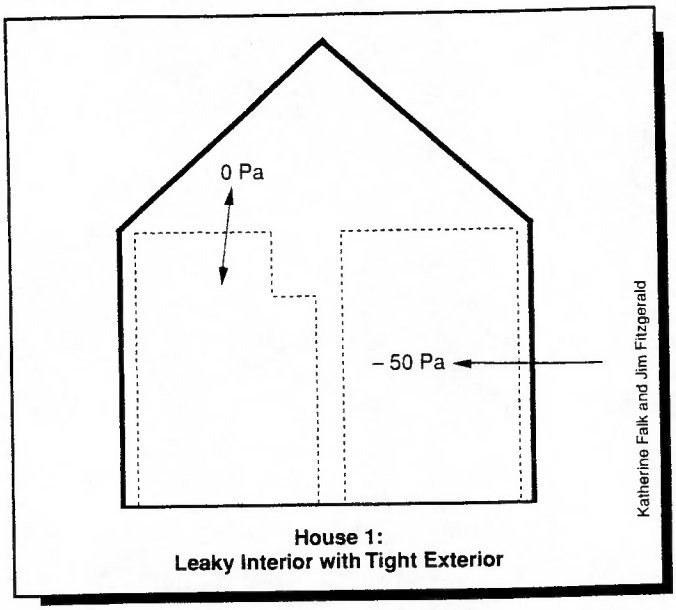
In this case, the pressure boundary (the roof) is above and outside of the thermal boundary (the attic floor). Since the house ceiling is very leaky to the attic, the ceiling can not hold pressure and act as a pressure boundary. The roof is the tightest air barrier so becomes the pressure boundary by default. Conditioned air moves through and above the insulation in the attic floor lowering the effective attic R-value and increasing the envelope surface area and overall heat loss.

The leaky supply ducts in the attic do not show up in our pressure pan readings, then, because the duct leaks are located within the house pressure boundary. The misaligned pressure boundary effectively hides the duct leaks from the pressure pan. Because the pressure boundary is the roof and not the attic floor, the cost and savings potential for this house will not be well-correlated with before-treatment CFM_{50} measurements. Although we think this house badly needs attic air-sealing, the blower door by itself will not provide good crew feedback on air-sealing effectiveness, because it is measuring the airtightness of the roof and



David Heilman

Can simple pressure tests help produce cost-effective gas savings? In the case of this Wisconsin home, the first priority was realigning the pressure boundary by sealing the top attic bypasses, and using targeted dense-pack cellulose to seal the ceiling joist connections to the many side porches. The needs of this house and its savings potential did not require other work. The pre-CFM_{50} of 3,900 was barely higher than the post-CFM_{50} of 3,850, but nonetheless savings were 30% (370 therms) at a cost of $850 for improvements.



House 1:
Leaky Interior with Tight Exterior

not of the attic floor. As a result, although sealing the attic bypasses will result in little CFM_{50} reduction, it should produce significant energy savings. Instead of relying on the CFM_{50} measurement alone for feedback, then, crews will also need to look at the house-to-attic pressure.

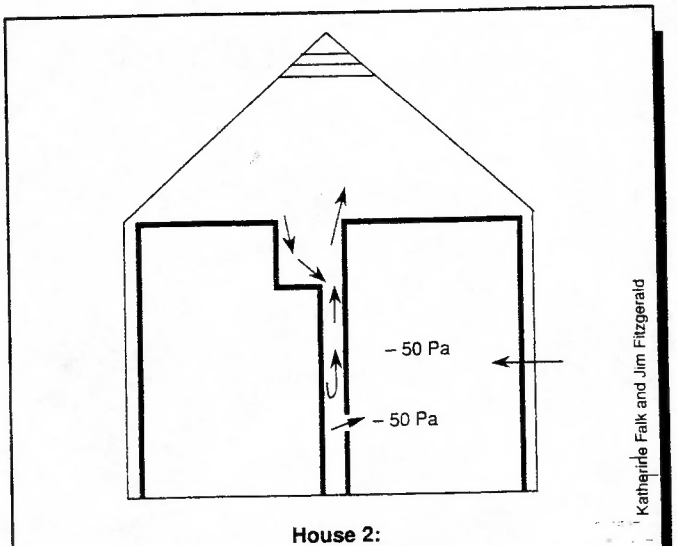
Recommended Action

First install one roof vent and re-measure house-to-attic pressure, to estimate the leakage rate to the attic using Figure 1. If the house-to-attic pressure becomes much closer to –50 Pa with the addition of one small roof vent, then we know that the house-to-attic leakage is relatively small and not worth a lot of time. Assuming that the house-to-attic pressure doesn't increase greatly, seal attic bypasses until house-to-attic pressure is close to –50 Pa, then check attic ducts with a pressure pan and continue duct-sealing until pressure pan readings are less than –1 Pa. Now add the remainder of attic vents needed and re-insulate the attic as necessary. By sealing the attic bypasses and venting the attic, we re-align the pressure boundary with the thermal boundary. You can expect an increase in energy use and CFM_{50} reading for the house by adding roof vents without airsealing the attic well.

House #2: Leaky Exterior with Tight Interior

House #2 was heavily vented and air-sealed years ago using the old technique of sealing all interior baseboards, wall outlets, and other wall/ceiling joints. With the house depressurized to 50 Pa, we measure a house-to-attic pressure of –50, and a house-to-interior wall cavity of –50. The interior wall cavity pressure of –50 tells us that a significant part of the pressure boundary is below and inside of the thermal boundary. The pressure boundary is the interior sheetrock, and not the attic floor. Interior wall volumes, including the plumbing wall and fireplace chase, appear to be open at the top to the vented attic and are actually acting as if they were outside (greatly increasing heat loss surface and energy use through convective looping). If there were ducts running through interior wall cavities, duct leakage to the outside would be significantly greater than if the pressure boundary was aligned properly.

Once again this house is a good candidate for air-sealing. But because of the misaligned boundaries, air-sealing may have little effect on blower door CFM_{50} readings, even though large energy savings are available. The energy-savings potential for this house may not be well-correlated with before-treatment CFM_{50} measurements. As with House #1, crews may need to use pressure to get feedback on their progress, rather than CFM_{50} alone. If there are ducts running through interior cavities, a reduction in duct leakage (indicated by the pressure pan) may show up with attic air-sealing, because the interior cavities will be sealed off from the outside.



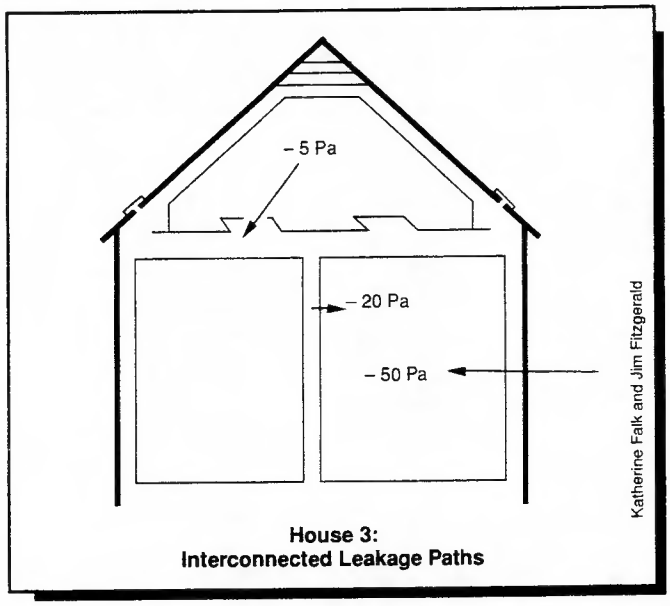
House 2:
Leaky Exterior with Tight Interior

Recommended Action

Seal the tops of walls and chaseways until the house-to-interior chaseway pressure moves closer to zero. If ducts are running through chaseways, check the new pressure pan readings and continue to seal exterior leaks to the chase until the pressure pan reads close to zero (exterior duct sealing merits the extra detail). By sealing the attic-floor level, we re-align the pressure boundary with the thermal boundary.

House #3: Interconnected Leakage Paths

This one-and-a-half-story house has interconnections between the basement, sidewalls, and interior wall cavities to the first-floor ceiling joists, kneewall attics, and the peak attic. This house also uses a first-floor ceiling joist as a return duct for the upstairs. With the house depressurized to 50 Pa, we measure –5 Pa at a second floor register using a pressure pan and –20 Pa between the house and a first-floor interior building cavity.



House 3:
Interconnected Leakage Paths

Based on the construction details of this house, we suspect that many of the leakage paths may be interconnected so we conduct one more set of tests. We open an access door between the house and the side attic. Then we readjust the blower door to depressurize by 50 Pa and remeasure the duct and interior cavity pressures. We now find the duct pressure is –3 Pa and the interior wall cavity pressure is –11 Pa.

Because the duct and cavity pressures changed after we opened the attic access, we know that the interior cavity and ceiling duct chases are interconnected to the side attic. The pressure boundary in this house is complex—it's partially above the thermal boundary at the roof, partially below the thermal boundary at the interior finish level, and partially located in the resistance to air flow through the spaces between floors and walls. It is everywhere except where it belongs. Neither the attic or the interior wall and floor volumes function as completely "inside" or "outside." Weather, wind direction, and duct operation all affect the mix of conditioned and unconditioned air in these volumes. Increased heat loss and comfort problems in this house may be more important than air leakage.

Importantly, when sealing leaks on interconnected complicated houses, all pathways for the leak must be sealed before you will see a reduction in measured house airtightness using a blower door. Sealing off only one of multiple pathways to the outside simply redirects air flow; it does not reduce air flow. Only when the last part of the interconnected leak is sealed does the blower door respond. In this type of house it is not uncommon for 50 ft^2 of air barrier to be installed to reduce measured leakage by 500–1,000 CFM_{50} (roughly 50–100 in^2 of equivalent leakage area).

Recommended Action

Install dense-pack cellulose under all roof cavities that contain open walls, and all kneewalls, to effectively seal off side attics from interior cavities. This will reduce conduction losses by reducing surface area to the outside, reduce convective looping in interior floor and wall cavities, and reduce duct leakage to the outside by sealing leaky floor cavities (used as a return run) from the outside. Measured duct and interior cavity pressures should be close to zero when the job is complete.

This type of house often presents the largest savings potential, because one well-placed treatment can fix multiple problems. It is also the riskiest type of house, because failure to completely seal all leakage pathways will result in the house showing little or no savings.

Cautions

Be careful interpreting single-point pressures. Simple pressure measurements are an aid to the blower door and other diagnostic tests. They are not a stand-alone substitute for infrared scanning, visual inspections, and plain common sense. Cost-effective work requires looking at actual utility, structural, and treatment costs. No one measurement can tell us everything.

We recommend against testing single closed cavities like walls or individual floor joists, unless they are obviously connected by a lowered ceiling, ductwork, or plumbing to a pathway with significant air flow. Larger volumes like attics, garages, and duct chases are less likely to be perfectly airtight, so measurements are easier to interpret. Good luck! ■

Jim Fitzgerald

The "Magnificent Seven" from the Pacific Northwest say, "We can do this!" after a pressure and dense-pack training session.

PRESSURE PAN TEST

OBJECTIVE OF TEST:

- TO DETERMINE LOCATION AND MAGNITUDE OF DUCT LEAKS TO OUTDOORS.

SETUP CONDITIONS:

- HOUSE AT 50 Pa DEPRESSURIZED.
- INTERIOR DOORS OPEN.
- DOOR TO BASEMENT (FURNACE AREA) OPEN.
- CONSIDER HEALTH AND SAFETY ISSUES.

TEST METHOD:

- START AT BLOWER DOOR LOCATION.
- FACING B/D, MOVE CLOCKWISE THRU HOUSE.
- TEST REGISTERS & GRILLES IN ROOM CLOCKWISE ALSO.
- RECORD READINGS ON AUDIT FORM, BEFORE & AFTER Wx.

POSSIBLE RESULTS:

- TIGHT SYSTEM IF ALL READINGS ARE LESS THAN 1.5 Pa AND NOT MORE THAN 2 READINGS ARE MORE THAN 1 Pa.
- LEAKY SYSTEM IF 3 OR MORE READINGS MORE THAN 2 Pa.
- GRAY-AREA SYSTEM IF FALLS BETWEEN "TIGHT" AND "LEAKY."

ACTION:

- IDENTIFY AND REPAIR DUCT RUNS WITH READINGS HIGHER THAN 1.5 Pa, STARTING WITH THE HIGHEST FIRST. TAKE MID-REPAIR READINGS, IF APPROPRIATE.

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ROOM-BY-ROOM TEST METHOD

OBJECTIVE OF TEST:

- TO MEASURE THE PRESSURES IN EACH ROOM W/ A DOOR CAUSED BY THE AIR HANDLER (A/H) FAN OPERATION.

SETUP CONDITIONS:

- B/D OFF WITH "NO-FLOW" PLATE INSTALLED.
- ALL HVAC FILTERS IN PLACE AND CLEAN.
- ALL INTERIOR DOORS CLOSED.
- ALL EXHAUST FANS AND DRYER OFF.
- A/H FAN ON.
- CONSIDER HEALTH AND SAFETY ISSUES.

TEST METHOD:

- MOVE FROM ROOM TO ROOM W/ PRESSURE GAUGE, MOVING CLOCKWISE WRT THE BLOWER DOOR (1st FLOOR, THEN 2nd FLOOR, 3rd FLOOR, & BASEMENT/CRAWLSPACE LAST).
- W/ GAUGE IN MAIN BODY OF HOUSE, PLACE HOSE UNDER ROOM DOOR.
- MEASURE PRESSURE OF EACH ROOM WRT MAIN HOUSE.
- ENTER VALUES BEFORE AND AFTER Wx ON AUDITOR FORM.

• *ACTION:*

- CONSIDER PRESSURE RELIEF FOR ROOMS PRESSURIZED OR DEPRESSURIZED BY MORE THAN 3 Pa.
- IF FIREPLACE OR WOODSTOVE ZONE IS DEPRESSURIZED BY MORE THAN 3 Pa WRT OUTDOORS, PRESSURE RELIEF IS NEEDED. (TO FIND ROOM WRT OUTDOOR PRESSURE, TAKE ROOM PRESSURE WRT MAIN HOUSE BODY AND ADD IT TO "ALL INTERIOR DOORS CLOSED" VALUE. FOR EXAMPLE, IF THE WOODSTOVE ROOM MEASURED 3 PASCALS NEGATIVE WRT MAIN HOUSE BODY, AND DURING "ALL INTERIOR DOORS CLOSED" TEST YOU MEASURED MAIN HOUSE BODY TO BE 4 PASCALS NEGATIVE WRT OUTDOORS, THE WOODSTOVE ROOM IS 7 Pa NEGATIVE WRT OUTDOORS).

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Assessing the Integrity of Electrical Wiring

Dense-pack cellulose insulation is a very useful and cost-effective technique for lowering both conductive and convective heat losses in a variety of housing types. In row homes, for example, GRASP in Philadelphia has found dense-pack cellulose to be very effective in treating attic bypasses that can be reached only by a hose. In areas where the distance between the ceiling and the roof deck is small (12 in or so), insulation is blown so that there is virtually no empty space between the ceiling and the roof deck. These areas tend to be in the rear of row houses, where there may be a master bedroom lit by a fixture hanging from the ceiling.

Half a dozen smoldering fires have been associated with these jobs, and although no serious damage or injury has yet resulted, there is cause for concern. Most people believe that the fires are caused by defective wiring, which is common in Philadelphia's housing stock. It is also possible that the action of the hose installing the insulation, or the movement of the insulation itself, could damage wiring that has been on the grim edge of safety for decades. The fact that thermal insulation allows heat to concentrate, rather than being dissipated by convective air movement, may worsen the situation.

The Philadelphia Housing Development Corporation's (PHDC) first response was to require visual inspections of wiring before installing insulation. Of course, such visual inspection is often difficult or even impossible, shy of radical surgery. And even a close look doesn't always reveal corroded connections, which may have high resistance. Roof insulation was not installed in many of these homes pending a solution to the wiring problem, resulting in lost opportunities for much-needed energy conservation.

Now PHDC has found what appears to be a practical solution to the problem. Their insulation contractors use a clever technique to test for the integrity of wiring quickly, accurately, and safely, without the need for extensive visual inspection. According to Jeff Allegretti, PHDC's director of Home Improvement Programs, there have been no fires in the 2,500 plus houses insulated since the wiring integrity testing technique was instituted two years ago.

Measuring Technique

Fire requires heat, and heating of electric wiring in a circuit can only occur when current is drawn. Accordingly, it is desirable to have a simple procedure to measure the extent of heating likely to result from placing a substantial (and known) load on a circuit.

Imagine a simple circuit like the one shown in Figure 1, where a load can be switched in or out, reading the line voltage in both circumstances. A large percentage difference in the two readings indicates an unsafe condition in the wiring, probably somewhere between the service entry and the point of measurement.

The diagram shows the line voltage at the service entry (V_S) and downstream at the end of a branch circuit (V_L). The sum of the resistance of the wire and sundry connections between the service entry and the point of testing the branch circuit is represented by R_W. As shown in the diagram, when there are no other loads on the circuit and the switch is in the open position, the voltage at the load, V_L, equals the voltage at the service entry, V_S. (Since there is no current flow, there is no voltage drop across R_W.) However, when the switch is closed, the voltage measured is dropped in proportion to current drawn, I, and the amount of the resistance of the wiring, R_W. The difference between the two readings is the voltage

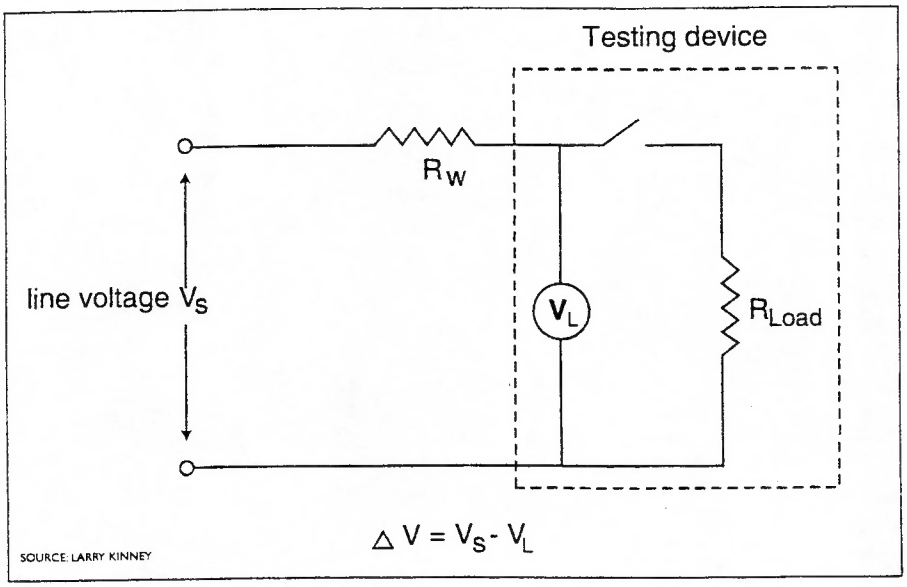

Figure 1. Schematic of a branch circuit wiring analyzer.

drop across R_W. Thus, if one knows the current draw causing this voltage drop, it is possible to calculate R_W from the expression $R_W = (V_S - V_L)/I$.

The power dissipated by R_W is given by I^2R_W watts. This expression times 3.4 is the heat produced (in Btu/h) by the wiring over one hour of operation at a given current draw. Once R_W is determined by this methodology, one can calculate the rate of heat production by the circuit under any condition of load.

The heating of the circuit wiring varies directly with its resistance and the *square* of the current flow. This means that if a marginal circuit that operates satisfactorily when illuminating a 60W bulb and running a radio is suddenly used to power a space heater or an iron, at least one hundred times more heat is dissipated on the line. If the high resistance is at a single bad connection—and the heat cannot dissipate—a fire can result.

A Practical Tool

To test for the integrity of a circuit, it's simple to build a device that uses an electric resistance heater, a digital voltmeter, and a switch. Fortunately, a much more elegant device is available that runs this test and others, yet fits in the palm of the hand. Called the SureTest® ProPlus Branch Circuit Wiring Analyzer, this device has a built-in microprocessor, which switches in a 15-amp load on the circuit being tested for a small fraction of a second. This is enough to measure the voltage of the circuit with and without the load. The digital display alternates between showing the voltage measured under no load and the percentage by which the voltage drops under a 15-ampere load. According to the National Electrical Code, if the drop in voltage is greater than 5%, the branch circuit may be defective.

For example, if under no load a branch circuit measures 120 V, then drops 5% under a 15-amp load, the resistance of the wiring is 0.4 ohms. If a 1,200W heater is hooked up to the circuit, 37 W (130 Btu/h) will be dissipated along the wire. If most of the resistance is at a single bad connection, this amount of heat could cause a large temperature rise.

Field Use

The SureTest (or a similar device) offers a way to check the integrity of a circuit in only a few seconds. However, since the procedure merely measures the potential for heating of the line between the point of measurement and the service entry, one cannot determine precisely where the problem may lie between those two points. But with multiple tests on a circuit and a little common sense, one can narrow it down considerably.

Since the test is simple and quick—and the problems it can identify are potentially quite serious—it's wise to employ it both before and after installing insulation. The pretest can verify the integrity of the wiring before work is begun, and the posttest can confirm that no harm was done during the installation.

All of the insulation contractors working on retrofit projects for the City of Philadelphia are now required to use this technique to test circuits associated with wiring in the attic before and after insulating. They use a 10% current drop threshold for the test, and Jeff Allegretti reports that approximately 25% of the jobs flunk at the initial audit. (They initially used a 5% threshold, but more than 70% flunked, with a cluster around 6%. PHDC adopted the 10% threshold in the interest of practicality, and this seems to leave an ample safety margin.) PHDC's solution for circuits that flunk is to have an electrician replace the entire circuit by running new wiring from the offending light or plug directly back to the fuse box at the service entry. Other weatherization programs may choose less extensive repairs, since many wiring problems can be solved by merely checking and tightening accessible connections.

Of course, the usefulness of the circuit-testing tool goes beyond row houses. It's clearly helpful when wall insulation is to be blown, where there's evidence of aluminum wiring (which can corrode in contact with copper and has a greater tendency to develop bad connections over time), and whenever a visual inspection raises doubts about the safety of the wiring in a dwelling.

The SureTest ProPlus costs about $200. It is available through Industrial Commercial Electronics Incorporated, 2421 Harlem Road, Buffalo, NY 14225. Tel: (800) 442-3462; Fax: (716) 892-0113.

—Larry Kinney

Larry Kinney is president of the Synertech Systems Corporation in Syracuse, New York.

LARRY KINNEY

This wiring analyzer helps contractors to check the integrity of wiring in a building before insulating.

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2.
A Protocol for the Testing of all Combustion Appliances for Carbon Monoxide Emissions

Background Information

☐ Carbon monoxide is produced from combustion in two ways:

1) The ratio of fuel to oxygen is too high to permit complete combustion. In other words, the amount of oxygen is too low for the fuel being burned. This is the means of carbon monoxide production that most people are familiar with.

2) The temperature of the fuel is too low to permit oxidation (combustion) to occur. Many people are unfamiliar with this means of carbon monoxide production. It can occur as a result of flame impingement (flame in contact with metal or other materials) because parts of the flame are cooled—quenched—below the burn temperature of the fuel. On a gas range burner, flame impingement always occurs when a pot is on a burner. As the pot becomes hotter, the carbon monoxide production decreases because the flame is not cooled as much by the impingement. This makes measurement of carbon monoxide difficult; as impingement surfaces change temperature, the carbon monoxide emissions change.

Quenching of a flame can also occur if air blows across a flame rapidly enough to cool it to below its burn temperature. This is a major reason that a defective heat exchanger in a furnace is a hazard; rapidly moving air from the distribution blower moves into the combustion area through the defect in the heat exchanger, quenching flames and producing carbon monoxide.

☐ Gas- and oil-fired appliances, except for gas ovens and range burners, can be tuned to burn without producing carbon monoxide; just the right amount of oxygen can be supplied and the flames can be adjusted so no impingement occurs.

☐ Gas ovens and range burners are extremely difficult to tune for zero carbon monoxide emissions because impingement is a characteristic of the design and operation.

☐ Wood and coal burning always emit carbon monoxide because of the solid characteristic of the fuels. Proper amounts of oxygen are never able to get to all the combusting fuel, so complete combustion cannot occur.

☐ Smoke is a by-product of combustion, usually incomplete combustion. Smoke from food preparation can contain carbon monoxide; smoke from burning toast is a result of incomplete combustion. These short lived occurrences are probably not hazardous. However, cleaning ovens with high temperatures (self-cleaning feature) can emit large amounts of smoke and high levels of carbon monoxide. Carbon monoxide levels of over 2000 ppm have been measured at the vent port of an *electric* oven during self-cleaning! During the self-cleaning process, levels of carbon monoxide in a kitchen can exceed 200 ppm if the oven is quite dirty.

☐ Carbon monoxide is a cumulative poison. It can slowly build up in the blood during the time of exposure. In the blood stream it combines with blood hemoglobin, replacing oxygen until there is too little oxygen in the blood stream to support life.

☐ Some of the symptoms of carbon monoxide poisoning are headache, dizziness, tiredness, fatigue, feelings of disorientation, and nausea. It is common for carbon monoxide poisoning to be confused with the symptoms of influenza or the common cold.

☐ The best way to test for carbon monoxide poisoning is a blood carboxyhemoglobin test.

☐ Carbon monoxide is often measured on an "air-free" basis. Air-free actually means oxygen free. If the carbon monoxide in the vent connector of a gas furnace is measured to be 20 ppm and the oxygen content in the same vent gas is 10%, the air-free carbon monoxide level is 38 ppm. For the same example, if the oxygen percentage in the vent gas is zero, the air-free carbon monoxide level is 20 ppm, the same as the measured value. Air-free carbon monoxide levels allow for a basis of comparison of measurements, however, the measurement process sometimes takes longer because the combustion vent sample must also be measured for the percentage of oxygen. Equations for determining air-free carbon monoxide ppm is:

$$CO_{AFppm} = \frac{CO_{ppm}}{[1-4.78(O_2)]}$$ For ***any fuel***, using measured CO and O_2

$$CO_{AFppm} = \left(\frac{0.209}{0.209-O_2}\right) \times CO_{ppm}$$ For ***any fuel,*** using measured CO and O_2

$$CO_{AFppm} = \left(\frac{15.3}{co_2}\right) \times CO_{ppm}$$ For ***#2 fuel oil***, using measured CO and CO_2

$$CO_{AFppm} = \left(\frac{14}{co_2}\right) \times CO_{ppm}$$ For ***propane (LPG)***, using measured CO and CO_2

$$CO_{AFppm} = \left(\frac{12.2}{co_2}\right) \times CO_{ppm}$$ For ***natural gas***, using measured CO and CO_2

Where: CO_{AFppm} = Carbon monoxide, air-free, ppm.
CO_{ppm} = As-measured combustion gas carbon monoxide, ppm.
O_2 = Percentage of oxygen in combustion gas, *as a decimal.*
CO_2 = Percentage of carbon dioxide in combustion gas, *as a percentage.*

General Procedure

☐ For testing, use an electronic carbon monoxide meter with a range of 0 ppm - 2,000 ppm and a resolution of 1 ppm, such as the Bacharach Monoxor® II. Older non-electronic meters or diffusion tubes are not suitable.

☐ Zero the carbon monoxide meter before any testing. This is typically done outdoors in a rural or unpolluted area

☐ Calibrate the meter with 500 ppm calibration gas about once every six months or as often as the manufacturer recommends.

☐ If your carbon monoxide meter is drifting (readings moving up and down from a stable source of carbon monoxide), have it checked by a qualified technician.

Carbon Monoxide Detector/Alarm

☐ In homes having combustion appliances, install one approved carbon monoxide detector/alarm per house level, excluding the basement (unless the basement is living space). An approved carbon monoxide detector shall meet Underwriter's Laboratory standards and shall be approved by Maine State Housing Authority.

☐ The carbon monoxide detector shall be installed according to the manufacturer's specifications.
☐ If the house has a gas oven/range, install the detector/alarm in the kitchen at least five feet away from the oven/range and about five feet above the floor.
☐ Locate a detector/alarm in a common hall serving bedrooms, about five feet from the floor but never closer to a ceiling than six inches.
☐ Do not install alarms closer than five feet to a combustion appliance.
☐ Make sure that the client(s) will be able to hear the alarm sound from all sleeping areas.
☐ Do not install a detector/alarm in a basement unless the basement is an occupied a living space.
☐ Do not install the detector/alarm in an area characterized by stagnant air, such as cathedral or vaulted ceilings, where carbon monoxide might not reach the detector/alarm in time to provide early warning of high concentrations in occupied areas.
☐ Do not install the detector/alarm in turbulent air from ceiling fans, heating or cooling registers, or doors and windows. Rapid moving air might disperse carbon monoxide before the detector/alarm can sense it.
☐ Make sure the detector/alarm is not covered by curtains or other materials that might render it ineffective.
☐ You might choose to give the client a copy of "Effects of Carbon Monoxide" and "CO Concentrations and Symptoms Developed" charts. The first chart expresses the cumulative effect of carbon monoxide poisoning. The second chart lists the toxic limits of the gas. These appear on page 6.

Diagnostic Questions for Client's Health[1]

☐ What types of combustion appliances are in the home?
☐ Are all combustion appliances vented to the outdoors?
☐ Are clients or family members exhibiting influenza-like symptoms during the heating season? Are they complaining of watery eyes, coughing, or headaches?
☐ Is the client aware of an odor when combustion appliances are in use?
☐ Are any of the combustion appliances in disrepair or misused?
☐ Is a gas range used as a space heating appliance?
☐ Does the dwelling have an attached garage where motor vehicles may idle?
☐ Is charcoal being burned indoors?

Customer/Client Education

☐ Explain that a gas oven/range should never be used as a space heater.
☐ Oven cleaning with high temperatures (self-cleaning ovens) can produce extremely high concentrations of carbon monoxide, in gas *and* electric ovens. Explain that exhaust fans should be on, windows should be opened, and occupants should stay out of the kitchen, whenever gas or electric ovens are cleaned with high temperatures.
☐ Explain that dirty (smoking) gas ovens will usually give off more carbon monoxide than clean ovens when used for normal baking or broiling. Dirty (smoking) electric ovens can give off significant amounts of carbon monoxide when used for normal baking or broiling. Generally, smoke is a by-product of incomplete combustion; incomplete combustion produces carbon monoxide.
☐ Explain that a carbon monoxide detector/alarm is not a smoke alarm. A carbon monoxide detector/alarm serves a specific function and does not take the place of a smoke alarm.

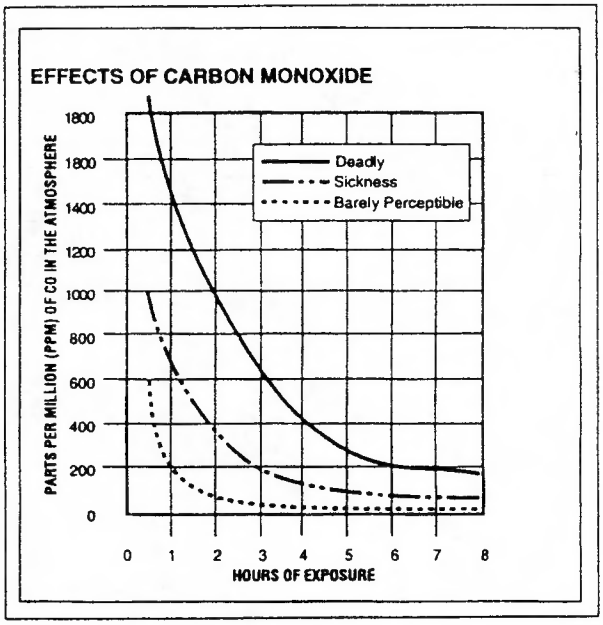
[1] U.S. EPA, *Indoor Air Pollution: An Introduction for Health Professionals*, 1994, p. 7.

☐ Explain that neither a carbon monoxide detector/alarm nor a smoke alarm sense the presents of natural gas, propane, butane or other combustible gases.

☐ Explain that one should never leave an automobile running in a garage when the garage door is closed. Never let the door from the house to the garage stay open when the automobile is running.

☐ Explain that automobiles are a common source of carbon monoxide. Automobiles running in attached garages or just outside of a dwelling can be hazardous to those in the dwelling.

☐ Explain that cigarette smoking can emit high levels of carbon monoxide and can cause high detector/alarm readings.



☐ Explain how the carbon monoxide detector/alarm works.

- When the electrical power is off, plug-in or hard-wired detectors will not function.
- Read the carbon monoxide detector/alarm instruction manual, explain operation to client(s).
- Leave the instruction manual behind with the client(s). Ask the client(s) to read the instruction manual.

☐ Explain how the carbon monoxide detector/alarm should be maintained.

- Vacuum dust away from detector/alarm vents each spring and fall.
- Test the unit at least once every month.

☐ Explain the carbon monoxide safe-level chart to client. Ask them to post it near the detector/alarm. If carbon monoxide levels are above 9 ppm for an 8 hour period, 35 ppm for a one hour period, or 200 ppm at any time, the client(s) should be instructed to turn off combustion appliances or automobiles in

CARBON MONOXIDE CONCENTRATIONS AND SYMPTOMS DEVELOPED

Concentration of CO in Air	Inhalation Time and Toxic Symptoms Developed
9 ppm (0.0009%)	Maximum allowable concentration for short term exposure in a living area, according to ASHRAE.
35 ppm (0.0035%)	Recommended highest concentration for continuous exposure in any 8-hour period, according to NIOSH.
50 ppm (0.005%)	Maximum allowable concentration for continuous exposure in any 8-hour period, according to OSHA.
200 ppm (0.02%)	Maximum CO exposure at any one time (OSHA). Slight headache, tiredness, dizziness, nausea after 2-3 hours.
400 ppm (0.04%)	Frontal headaches within 1-2 hours, life-threatening after 3 hours.
800 ppm (0.08%)	Dizziness, nausea and convulsions within 45 minutes. Unconsciousness within 2 hours. Death within 2-3 hours.
1,500 ppm (0.15%)	Headache, dizziness and nausea within 20 minutes. Death within 1 hour. This is the NIOSH IDLH level (Immediately Dangerous to Life or Health)
3,200 ppm (0.32%)	Headache, dizziness and nausea within 5-10 minutes. Death within 25-30 minutes.
6,400 ppm (0.64%)	Headache, dizziness and nausea within 1-2 minutes. Death within 10-15 minutes.
12,800 ppm (1.28%)	Death within 1-3 minutes.

- *10,000 ppm (parts per million) = 1% by volume.*
- NIOSH, National Institute for Occupational Safety and Health.
- OSHA, Occupational Safety and Health Administration.
- This chart relates to the exposure or healthy adults. Pregnant women, unborn children, the elderly, persons with heart or respiratory problems, children and smokers may experience symptoms at lower levels of exposure than noted.
- Standards cited are as of February, 1996.

attached garages and get fresh air into the building as soon as possible. A qualified technician should be called to fix the problem before any combustion appliances are turned back on.

Gas-Fired Furnaces

☐ The gas-fired furnace must be properly vented according to NFPA 54.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft gas-fired furnaces shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft furnaces may be tested from the inside of the building, as described below.

- Most gas atmospheric furnaces in the field today have draft diverters rather than draft hoods (a bell-shaped fitting). All tests for carbon monoxide must be done before—upstream of—the draft diverter or draft hood. If the unit has a draft diverter, the probe of the carbon monoxide tester must be inserted into the draft diverter area and then into each of the heat exchanger sections. If the unit has a draft hood, the probe of the carbon monoxide tester must be inserted into the draft hood and into the vent pipe below the draft hood.
- If the heating unit has a draft diverter, check each of the heat exchanger sections in a multi-burner heating unit. The section with the highest reading shall be the recorded carbon monoxide reading for the unit.
- A change in the carbon monoxide reading of more than 25 ppm when the distribution blower fan turns on might indicate a defective heat exchanger section.
- **The carbon monoxide reading must be 50 ppm or less when the distribution blower fan is running.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Oil-Fired Furnaces

☐ The oil-fired furnace must be properly vented according to NFPA 31 and NFPA 211.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft oil-fired furnaces shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft furnaces may be tested from the inside of the building, as described below.

- Check for carbon monoxide at the hole used to test for furnace efficiency. This hole should be before—upstream of—the barometric damper near the breeching, about twelve inches from the heating unit. If it is not possible to drill a hole in the vent connector, insert the

probe of the carbon monoxide tester in the barometric damper and push the end of the probe into the vent connector in the direction of the heating unit (Note: This practice might have an impact on the draft of the unit and thereby affect the carbon monoxide reading. Therefore, it is preferred to drill a hole in the vent connector for insertion of the carbon monoxide tester probe.)

- A change in the carbon monoxide reading of more than 25 ppm when the blower fan turns on might indicate a defective heat exchanger.
- **The carbon monoxide reading must be 50 ppm or less when the distribution blower fan is running.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Gas-Fired Boilers

☐ The gas-fired boiler must be properly vented according to NFPA 54.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft gas-fired boilers shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft boilers may be tested from the inside of the building, as described below.

- Check for carbon monoxide at the hole used to test for boiler efficiency. This hole should be before—upstream of—the draft hood near the breeching. If it is not possible to drill a hole in the vent connector, insert the probe of the carbon monoxide tester in the draft hood and push the end of the probe into the vent connector in the direction of the heating unit.
- When the circulator pump is running, the carbon monoxide reading will be different—most likely higher—than when the circulator is not running.
- **The carbon monoxide reading must be 50 ppm or less when the circulator is running.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Oil-Fired Boilers

☐ The oil-fired boiler must be properly vented according to NFPA 31.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft oil-fired boilers shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft boilers may be tested from the inside of the building, as described below.

- Check for carbon monoxide at the hole used to test for boiler efficiency. This hole should be before—upstream of—the barometric damper in the breech of the vent connector, about twelve inches from the heating unit. If it is not possible to drill a hole in the vent connector, insert the probe of the carbon monoxide tester in the barometric damper and push the end of the probe into the vent connector in the direction of the heating unit (Note: This practice might have an impact on the draft of the unit and thereby affect the carbon monoxide reading. Therefore, it is preferred to drill a hole in the vent connector for insertion of the carbon monoxide tester probe).
- When the circulator pump is running, the carbon monoxide reading will be different—most likely higher—than when the circulator is not running.
- **Carbon monoxide reading must be 50 ppm or less when the circulator is running.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Gas-Fired Water Heaters

☐ The gas-fired water heater must be properly vented according to NFPA 54.

☐ Allow the unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft gas-fired water heaters shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft water heater units may be tested from the inside of the building, as described below.

- Insert the probe of the carbon monoxide tester into the bottom section of the draft hood (bell-shaped fitting) and push the probe down into the internal water heater vent pipe.
- Check for carbon monoxide on each side of the internal vent pipe baffle (turbulator). The side with the highest reading shall be the recorded carbon monoxide reading for the unit.
- If water is drawn from the water heater during your test, you might notice a change in carbon monoxide ppm.
- **Carbon monoxide reading must be 50 ppm or less.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Oil-Fired Water Heaters

☐ The oil-fired water heater must be properly vented according to NFPA 31.

☐ Allow the unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft oil-fired water heaters shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft water heater units may be tested from the inside of the building, as described below.

- Check for carbon monoxide through a hole drilled in the vent connector. This hole should be before—upstream of—the barometric damper in the breech of the vent connector, about twelve inches from the water heating unit. If it is not possible to drill a hole in the vent connector, insert the probe of the carbon monoxide tester in the barometric damper and push the end of the probe into the vent connector in the direction of the water heating unit (Note: This practice might have an impact on the draft of the unit and thereby affect the carbon monoxide reading. Therefore, it is preferred to drill a hole in the vent connector for insertion of the carbon monoxide tester probe.)
- If water is drawn from the water heater during your test, you might notice a change in carbon monoxide ppm.
- **Carbon monoxide reading must be 50 ppm or less.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Gas Clothes Dryers

☐ The gas clothes dryer must be properly vented to the outside according to NFPA 54 before the carbon monoxide test is performed.

☐ Empty the dryer of all clothes before turning it on for the test.

☐ For testing, use a hot air cycle, not the air dry cycle.

☐ Allow gas dryer to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Insert the probe of the carbon monoxide tester into the dryer vent assembly on the outside of the dwelling.

☐ **The carbon monoxide reading must be 50 ppm or less when no clothes are in the dryer.**

☐ If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Vented Gas-Fired Space Heaters

☐ Gas-fired space heaters must be properly vented according to NFPA 54.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft gas-fired space heaters shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft space heater units may be tested from the inside of the building, as described below.

- Insert the probe of the carbon monoxide tester into the bottom section of the draft hood (bell-shaped fitting) and push the probe down into the water heater internal vent pipe.
- **Carbon monoxide reading must be 50 ppm or less. If the space heater has a distribution fan, the carbon monoxide reading must be taken when this fan is operating.**

- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Vented Oil-Fired Space Heaters

☐ Oil-fired space heaters must be properly vented according to NFPA 31.

☐ Allow heating unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft oil-fired space heaters shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft space heater units may be tested from the inside of the building, as described below.

- Check for carbon monoxide through a hole drilled in the vent connector. This hole should be before—upstream of—the barometric damper in the breech of the vent connector, about twelve inches from the water heating unit. If it is not possible to drill a hole in the vent connector, insert the probe of the carbon monoxide tester in the barometric damper and push the end of the probe into the vent connector in the direction of the water heating unit (Note: This practice might have an impact on the draft of the unit and thereby affect the carbon monoxide reading. Therefore, it is preferred to drill a hole in the vent connector for insertion of the carbon monoxide tester probe).
- **Carbon monoxide reading must be 50 ppm or less. If the space heater has a distribution fan, the carbon monoxide reading must be taken when this fan is operating.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Wood- and Coal-Burning Appliances

☐ All wood- and coal-burning appliances shall be vented and installed according to NFPA 211.

☐ Combustion gases shall not be tested for carbon monoxide concentrations.

☐ Check for carbon monoxide at all joints and gasketed seams of the wood- or coal-burning appliance by slowly moving the probe of the carbon monoxide tester along these joints and seams.

☐ Ambient air testing shall be performed on all wood- and coal-burning appliances.

☐ Wood- and coal-burning appliances are usually shut down during the weatherization audit process. It is recommended that the client be requested to start the appliance after the blower door and other depressurization testing is completed. If possible, test the appliance for ambient carbon monoxide and emission of carbon monoxide from the joints and seams before leaving the site.

Unvented Gas-Fired Space Heaters or Fireplaces

☐ If the house has an unvented space heater or fireplace, the house should not be air-sealed in any way.

Unvented Oil-Fired Space Heaters

☐ If the house has an unvented space heater, the house should not be air-sealed in any way.

Gas Logs, Gas Fireplaces, Gas Fireplace Inserts, and Stand-Alone Gas Fireplaces

☐ Gas appliances must be properly vented according to NFPA 54.

☐ Allow unit to reach a stable temperature before testing for carbon monoxide. This usually requires about five minutes of run-time.

☐ Direct vent and forced draft units shall not be tested from the inside of the dwelling. If the exhaust gas vent is accessible on the outside of the building, it is recommended that the combustion exhaust gases be tested for carbon monoxide concentrations by inserting the probe of the carbon monoxide tester into the exhaust gas opening. The carbon monoxide reading must be 50 ppm or less. If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

☐ Natural draft and induced draft units may be tested from the inside of the building, as described below.

- On draft-hood equipped appliances, insert the probe of the carbon monoxide tester into the bottom section of the draft hood (bell-shaped fitting) and push the probe down into the vent connector pipe.
- On appliances without draft hoods, such as gas logs, measure the carbon monoxide eight inches above the gas logs near the vertical center of the gas log assembly.
- **Carbon monoxide reading must be 50 ppm or less.**
- If the reading is more than 50 ppm, no house tightening should be done until the situation is remedied.

Gas Range Burners (Governed by ANSI Z21.1)

☐ Test the range-top burners before the gas oven is turned on for testing.

☐ All testing shall be done with the burner grates in place. If any burner grates are missing, they must be replaced before carbon monoxide testing and any house tightening is done.

☐ Range-top burner testing shall be performed with the calibrated CO HOT POT™, a tool for the standardized testing of carbon monoxide emissions from gas range burners, made by WxWare Diagnostics. The CO HOT POT™ tester shall *not* be filled with water for the testing.

- Heat the CO HOT POT™ on one of the burners until sections of the stainless steel pan resting on the burner grate are red-hot.
- Turn the burner off.
- Without delay, move the CO HOT POT™ to the first burner to be tested.[2] Center the tester on the burner grate, insert the probe of the carbon monoxide tester in the hole in the side of the CO HOT POT™, and then through the eye of the eye bolt at the center of the CO HOT POT™ housing. The probe should extend about one-half inch beyond the eye of the eye bolt.

☐ Turn the burner on.

☐ *Take care not to burn your hands or parts of the carbon monoxide tester on hot parts of the range top or CO HOT POT™.*

☐ Watch the carbon monoxide ppm reading. It will rise and then start to fall. When it stops falling and stabilizes (the stabilized low level), record the reading.

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[2] The purpose of this preliminary warm up is to heat up the CO HOT POT™ so that the temperature of the tester will be approximately the same for the first burner tested as for the last burner tested. The temperature of the tester affects the carbon monoxide reading.

☐ Move the CO HOT POT™ to the next burner, center it over the next burner, insert the probe of the carbon monoxide tester and turn on the burner. Record the reading as instructed above.
☐ Continue this procedure until all the burners have been tested.
☐ **The carbon monoxide reading must be 30 ppm or less at the low stabilized level, measured with the calibrated CO HOT POT™ (dry test).**
☐ If any of the range-top burners have carbon monoxide readings of more than 30 ppm, delay weatherization work until the appliance has been adjusted and is producing 30 ppm or less of carbon monoxide.
☐ Continue with the testing of the gas oven.

Gas Ovens (Governed by ANSI Z21.1)

☐ Test the oven ***after*** the gas burners on the range top have been tested. Turning on the oven before the range burners are tested for carbon monoxide emissions might have an impact on the burner readings.
☐ Make certain that all baking utensils and other materials other than oven parts are removed from the oven before turning it on.
☐ If aluminum foil is lining the oven bottom, it should be removed or perforated along its edges so the air holes in the oven bottom are not blocked. This blockage can be a major cause of high carbon monoxide emissions.
☐ Determine whether the oven has one or two oven burners.
☐ If the oven has one burner, it will be located at the bottom of the oven enclosure, the bake/broil burner. These ovens will have a broil tray under the oven baking area. Bake temperatures up to 550°F and broil temperatures of 575 to 600°F are usually available. Some oven burner controls hold oven temperature by flame modulation, others turn the burner off and on, and some use both methods.
☐ If the oven has two burners, one will be located at the bottom of the oven enclosure—the bake burner—and one at the top will be at the top—the broil burner. (Self-cleaning gas ovens have two burners.) The bottom bake burner is on for baking up to 550°F and the top broil burner is on during "BROIL" (575 to 600°F). The two burners are never on simultaneously. Both burners should be tested for carbon monoxide emissions. Some oven burner controls hold oven temperature by flame modulation, others turn the burner off and on, and some use both methods.
☐ Insert the carbon monoxide meter probe tip well into the oven exhaust vent. The intent is to monitor the exhaust gases before they are diluted with air outside the oven.
☐ Turn the meter on and then turn the oven on to the highest temperature on the oven dial, making sure not to set the oven for "BROIL" The oven door should be closed.
☐ **If the oven has two burners, a bake and a broil burner, test the broil burner also by doing a separate test on the broil burner (unless the bake and broil burners operate simultaneously). Turn the oven control to "BROIL" and follow the guidelines below.**
☐ The oven door should be closed.
☐ Make certain the oven burner(s) do not automatically shut off during the entire test period.
☐ Watch the carbon monoxide meter reading rise and record the peak or maximum reading. It should typically reach a peak within about three to five minutes.
☐ Record this peak carbon monoxide level.

☐ Continue the test until the carbon monoxide emissions stabilize at a low level. This might take from five to ten minutes. During this time do not operate a blower door or open an outside door, or engage in any other activity that might effect ambient kitchen carbon monoxide levels.
☐ Record this lowest stabilized level. Of the two measurements—peak and stabilized low—the stabilized low level is the most important.
☐ **The stabilized low level carbon monoxide reading must be 30 ppm or less.**
☐ If the oven is producing higher levels of carbon monoxide, it needs to be cleaned, tuned, or adjusted before or in conjunction with any air tightening of the dwelling.
☐ Most ovens can be satisfactorily tuned in the field to a stabilized low carbon monoxide level of 30 ppm or less.
☐ This testing procedure does not apply to convection ovens.
☐ Some older gas ovens are vented into a chimney. In these cases, the probe of the carbon monoxide tester must be inserted into a hole drilled in the vent connector. **The carbon monoxide reading must be 50 ppm or less after ten minutes of operation.**
☐ Continue with the testing of ambient air in the kitchen area. (Note: In extreme cases, it may be advisable to measure the maximum stabilized high level of carbon monoxide level in the kitchen air. After oven start-up it typically takes at least an hour to reach that level in loose dwellings and may take upwards of 8 to 10 hours in very tight homes.)

Ambient Carbon Monoxide Measurements

☐ Carbon monoxide limits in the U.S. are recognized to be 9 ppm for an 8 hour period, 35 ppm for a one hour period, or 200 ppm at any moment. Moreover, a person in a place of work is not to be exposed to any of these conditions more than once each year.
☐ ASHRAE Standard 62-1989 recommends an exposure limit of no more than 9 ppm in a living space.
☐ In some kitchens the ambient level of 9 ppm will be exceeded when a gas oven and range-top burners are operating. Usually soon after the oven and burners are shut down, the carbon monoxide level will fall to below 9 ppm quickly.
☐ All combustion appliances shall be tested for ambient levels of carbon monoxide, including direct vent space heaters and direct vent central heating combustion equipment located within the occupied space of a building.
☐ **Ambient levels of carbon monoxide measured at a distance of five feet above the floor and five feet horizontally from any combustion appliance, except a gas oven/range, must be 9 ppm or less immediately after the appliance has been tested for carbon monoxide in the flue gas or after the appliance has been in operation for at least five minutes.**
☐ If the level of carbon monoxide five feet from any combustion appliance exceed 9 ppm, the source of ambient carbon monoxide shall be determined and the hazardous situation shall be remedied before any house tightening is done.
☐ **Ambient levels of carbon monoxide measured at a distance of five feet above the floor and five feet horizontally from any gas range/oven must be 15 ppm or less immediately after all range-top burners and oven(s) have been tested for carbon monoxide in accordance to this protocol.**
☐ If the level of carbon monoxide five feet from any oven/range exceed 15 ppm, the hazardous situation shall be remedied before any house tightening is done.

Glossary

Air-Free. A carbon monoxide reading taken in an oxygen-free environment or, more commonly, a carbon monoxide reading taken in an environment containing oxygen but then adjusted to simulate oxygen-free conditions.

Breeching. The collar to which the vent connector is attached on an appliance.

Boiler. A central space heating appliance using hot water or steam for heat distribution.

Direct Vent Appliance. Appliances that are constructed so that all combustion gases are vented to the outside and all combustion supply air is directed to the appliance from the outside through a dedicated pipe.

Emissions-Containing Device. Any device that contains the emissions from combustion in a manner that allows the accurate measurement of the emissions. Examples are vent connectors on combustion heating systems, gas dryer exhaust vents, and gas oven vent ports.

Forced Draft. Positive draft in the vent connector developed by a fan installed at the appliance.

Furnace. A central space heating appliance using forced air for heat distribution.

Gas Fireplace. Similar to wood burning fireplace, but includes gas-fired logs. May be conventionally vented (natural draft) or mechanically vented. Provides radiant heat and might provide some convective heat.

Gas Logs. Venting in existing fireplace with damper fixed in open position. If glass doors are present, they must be open while the gas-log appliance is operating. Do not provide much heat.

Gas Fireplace Insert. A complete unit that fits into an existing fireplace opening and includes gas-fired logs. May be conventionally vented (natural draft), mechanically vented, or direct vented. Provides radiant heat and might provide some convective heat.

Induced Draft. Negative draft in the vent connector developed by a fan just inside or outside the building envelope wall.

Mechanically Vented Appliance. A broad term used to indicate the venting of combustion gases is assisted in some fashion with an electrically operated fan. Examples are forced draft and induced draft appliances.

Natural Draft. Negative draft in the vent connector developed by differences in temperature.

Peak Level. Carbon monoxide emissions from a combustion appliance that have reached a maximum level during any one emissions test. Emissions usually rise just after the combustion process in a combustion appliance begins. A peak level is reached, then the emissions begin to fall, and eventually they reach a stabilized low level.

ppm. Parts per million. 1,000,000 is equal to 100% concentration by volume, 100,000 is equal to 10%, 10,000 ppm is equal to 1%. 200 ppm is equal to 0.02%, 35 ppm is equal to 0.0035 %, and 9 ppm is equal to 0.0009% concentration by volume.

Single Wall Vent Connector. Single-wall vent connector made of galvanized sheet metal.

Space Heater, Vented. A vented, self-contained, freestanding, non-recessed, fuel burning appliance for furnishing warm air to the space in which it is installed, directly from the heater without duct connections.

Stabilized Low Level. Carbon monoxide emissions that have reached a stable low (minimum) level during any one emissions test. Emissions usually rise just after the combustion process in a combustion appliance begins. A peak level is reached, then the emissions begin to fall, and eventually they reach a stabilized low level.

Stand-Alone Gas Fireplace. Freestanding, like a wood or coal stove, and includes gas-fired logs. May be conventionally vented (natural draft) or mechanically vented. Provides radiant heat and might provide some convective heat.

Type B, Double Wall Gas Vent Connector. Double-wall vent connector, usually aluminum on the inside and galvanized sheet metal on the outside layer.

Vent Connector. The pipe that connects a combustion appliance to a vent or chimney.

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HEATING SYSTEM SAFETY TESTS
for homes with natural draft wood, gas or oil appliances
Note: these tests cannot be done in windy conditions.

AIR FOR COMBUSTION AND VENTILATION

Combustion appliances should comply with requirements as described in NFPA31 for Oil, NFPA54 for Gas and NFPA211 for Solid Fuel Burning Appliances.

WORST CASE DEPRESSURIZATION TEST - Determines possibility of exhaust fans overpowering chimney of natural draft combustion appliances.

Prepare house as follows:

- Close all exterior doors and windows
- Open all doors between furnace room and rooms with exhaust fans (i.e., bathrooms, laundry, furnace room/basement doors).
- Close ventilation system passive fresh air inlets (wall or window inlets) if present.
- Close fireplace/wood stove damper and doors; close combustion air inlet.
- Turn on ventilation system; do not seal powered ventilation system exhaust hoods.

Turn on all exhaust fans to high:

- Bathroom fans
- Kitchen range exhaust fans (recirculating range hoods do not need to be operated)
- Clothes dryer
- Ventilation system

Measure depressurization in furnace room created by exhaust fans. Should not exceed 5 pascals.

If any exhaust fan is in the same room as a furnace or water heater (i.e., dryer) repeat test with furnace room door closed.

If forced air heating system, repeat test with furnace room door closed and furnace blower on.

If greater than 5 pascals in any test situation, house has potential for pressure-induced spillage.

Leave exhaust fans on and continue with Spillage Test below.

SPILLAGE TEST - Identifies exhaust gas spillage into house from natural draft combustion appliances.

- Turn all exhaust fans on (as in Worst Case Pressurization Test above).
- Turn thermostat high enough to fire furnace/boiler and/or water heat (test each separately).
- Hold smoke at draft diverter/barometric damper and watch direction of smoke for 30 seconds.
- If draft is not established within 30 seconds, spillage is excessive. Continue with next step.
- If draft is established within 30 seconds, venting system is satisfactory.

Determine if spillage problem is caused by venting system or due to competing pressures:

- Open window near furnace or water heater and retest with smoke.

If spillage continues, the problem is in the venting system for the appliance.

If spillage is reduced, there is a pressure induced spillage problem.

Repair and retest or note problem and return building as found.

COMBUSTION EFFICIENCY AND/OR DRAFT TESTING

In Maine, persons performing combustion or draft testing are required by law to be licensed by the Oil and Solid Fuel Board. Sub-grantees not having a licensed technician on staff must rely on auditor experience and observation to determine the necessity of efficiency testing in each individual client home. If a Clean, Tune & Evaluation (CT&E) is not ordered the reason must be entered in the Primary and/or Secondary Heating test result area of the MEAFF.

SECTION B

HEALTH AND SAFETY

SECTION B

HEALTH AND SAFETY

MAINE WEATHERIZATION ASSISTANCE PROGRAM
HEALTH AND SAFETY STANDARDS 1999

In response to an ongoing and increasing concern for health and safety issues, and to comply with regulations described in The Department of Energy's CFR Section 440.16, 440.18, and 440.21, Maine State Housing Authority has established the following health and safety guidelines for the Weatherization Program.

I. 440.16 Minimum Program Requirements

The primary goal for Maine's Weatherization Program is to implement cost effective weatherization procedures to conserve energy and to assess and correct related health and safety hazards as listed on the "Hazards Chart" Pages 69-70, for the well being of clients and weatherization personnel. Materials used for the abatement of such hazards not listed in Appendix A of 10 CFR Part 440 must meet all standards incorporated by reference and made a part of Part 440.

Consequently sub-grantees will be allowed to expend program funds for the abatement of energy related health and safety hazards up to 10% of the annual per dwelling allowable average. Realizing that there is a wide variety of energy related hazards with an equally varied cost factor, a cap of $400.00 per unit has been set. Exceptions to exceed this limit will be made only after careful evaluation of a written waiver request submitted by the Subgrantee. This will allow flexibility to shift funds from homes that need little or no hazard abatement or have benefitted from other leveraged monies, to homes that have no other resources. It will be the responsibility of the Subgrantee to manage Health and Safety expenditures. The Health and Safety costs are excluded from the cost effective calculations of the remaining unit expenditures and must be tracked separately. Any Health and Safety measures that have an energy savings factor do not have to be tracked separately and should be included with the energy conservation measures. Any non cost effective tested Health and Safety measures will be reported as a separate line item on the Weatherization Reporting Form.

II. 440.18 Allowable Expenditures

The Cost of eliminating health and safety hazards, elimination of which is necessary before, or because of, installation of weatherization materials. Realizing that these monies are non cost effective tested but do come out of the DOE dwelling average, use of the health and safety funds does reduce the subgrantees's ability to conserve energy. Subgrantees will be encouraged to leverage other funds whenever possible when addressing non cost effective tested items. Problems with the dwelling unit that have no connection with Weatherization activities can only be addressed with other funding sources. A list of potential funding sources includes:

THE CENTRAL HEATING IMPROVEMENT PROGRAM
CDBG
MSHA HOUSING PROGRAMS
CITY OR TOWN WELFARE

RURAL ECONOMIC DEVELOPMENT (FORMERLY FHA)
HUD
LOCAL CHURCH AND COMMUNITY GROUPS
BUILDING MATERIALS BANK
HABITAT FOR HUMANITY
DONATIONS FROM LOCAL BUSINESSES
LANDLORDS

III. 440.21 Standards and Techniques for Meeting Health and Safety Program Requirements

Energy-related health and safety concerns are those hazards that are necessary to be abated before or because of, installation of weatherization materials. Therefore health and safety hazards associated with weatherization activities that are energy related are allowed to be abated with DOE funds.

A. CLIENT EDUCATION

The client education component of The Health and Safety program is part of the overall Client Educational Component of the WAP. The auditor's education duties include integrating pertinent information received from the client application and the audit interview with the assessment of the dwelling and using it to formulate a cooperative plan of action with the client. Health & Safety issues should be addressed as part of the process both verbally and by distributing educational pamphlets during the audit "walk-through". This can be particularly effective as the auditor notices and discusses potential hazards.

Some of the educational pamphlets discussing Health and Safety Issues include but are not limited to:

Maine Woodburning Guide
A Citizen's Guide To Radon
Lead Free
Protect Your Family from Lead in Your Home (As of 9/00, this EPA publication **must** be given to clients at least 10 days prior to the commencement of weatherization activities which will disturb lead-painted or presumed lead-painted surfaces in the home.)
Combustion Appliances and Indoor Air Quality
Combustion Pollutants in Your Home
Safe Homes: Suggestions for Reduction of Pollutant Sources in private Homes
The Inside Story- A guide to Indoor Air Quality
Indoor Air Quality And Your Health
Background Understanding Indoor Radiation
Indoor Air Pollution - An Introduction for Health Professionals
Managing Indoor Air Quality

There are also energy conservation educational videos available that discuss health and safety issues.

The auditor completes a checklist of which topics were discussed with the client and has the client sign the sheet as an acknowledgment of receiving the information. Client Education continues throughout the entire process as the home is being weatherized. Crews, contractors, inspectors and other qualified personnel explain various related concepts as the work progresses. Clients are always encouraged to contact appropriate agencies after weatherization if they have any questions, concerns, or wish to report feedback on the conservation efforts.

* See Client Educational Pamphlet Checklist

B. WALK-AWAY POLICY

When conditions are discovered that are too hazardous for the client or weatherization personnel for weatherization procedures to commence, a walk-away policy has been developed. "Walk-away" does not necessarily mean that the client will not receive weatherization services but that until the conditions are rectified, the weatherization services are temporarily postponed. Subgrantees must utilize all resources available to rectify the situation so that the home can be weatherized. Unfortunately there may be extreme cases where the problem is beyond the scope of the available funding and/or a case where the client is not willing to cooperate. In either case an agency must determine what is in the best interest of all concerned and proceed accordingly, providing appropriate documentation in the client file.

* See Notice of Postponement of Services Form

C. GRANTEE HEALTH AND SAFETY

Grantee health and safety related costs will be charged to either the administrative or training and technical assistance cost category. The Grantee is responsible for following all OSHA safety regulations, National, State and Local codes as further described under Agency/Contractor Safety.

D. AGENCY/CONTRACTOR SAFETY

Sub-grantees must comply with Occupational Safety and Health Administration (OSHA) requirements in all weatherization activities. When contractors are employed by local agencies those contractors are expected to comply with OSHA requirements as well. The contractor costs to comply with OSHA, as applicable, are part of the bid price. Related costs for Sub-grantees to comply with OSHA requirements may be charged under 440.18 as health and safety, tools and equipment, incidental repairs, etc.

The State Weatherization Program expects the crews, contractors, and other field personnel to be able to work under conditions that do not jeopardize their own health and safety. Weatherization personnel shall be properly trained in workplace safety and will be provided with necessary protective equipment.

Sub-grantees and contractors are expected to follow the requirements of CONSTRUCTION INDUSTRY OSHA SAFETY AND HEALTH STANDARDS (29 CFR 1926/1910). Some of the standards include but are not limited to:

How to prepare for Emergencies in the workplace
Employees guide to: Respirator Safety
Personal Protective Equipment
Machine Guarding and Hand and Power Tool Safety
Hazardous Waste and Emergency Response
Hazard Communication Standard
Lead in Construction Standard
Ladders 1926.1053
Scaffolds 1910.28
Electrical Safety

Sub-grantees must comply with OSHA Hazard Communication "Right To Know Program". The program requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels, and other forms of warning, material safety data sheets, and information and training.

Sub-grantees must follow the record keeping requirements for Occupational Injuries and Illnesses under the Occupational Safety and Health Act of 1970 and 29 CFR 1904 using the #200 form.

Sub-grantees are responsible for maintaining agency vehicles so that they are in safe and proper operating condition.

Sub-grantees are responsible for ensuring all work performed in client homes abides by federal, state, and local codes and regulations.

E. CLIENT HEALTH AND SAFETY

Client Health and Safety has always been a priority for Maine's Weatherization Program. Through Doe trainings, other related national trainings and field training performed by Grantee Technical Program Officers, Maine has developed a comprehensive plan to ensure safety in energy related areas. Maine will ensure that Subgrantees obtain the appropriate equipment and training to perform the necessary assessments.

The Housing Council's Building Technology Committee meets on a monthly basis to discuss all energy related aspects of the weatherization program. The committee consists of a technical representative from each subgrantee. Through this vehicle subgrantees are constantly updated with information and techniques regarding energy conservation and health and safety issues. This system ensures that all subgrantees are receiving the same information and creates consistency for a quality program across the state.

The Central Heating and Improvement Program (CHIP) also has a technical committee for the same purpose. A representative from each subgrantee, experienced in heating system technology attends periodic meetings. All different aspects of heating systems are discussed including health and safety issues. The Weatherization and CHIP programs work in unison to achieve "A HOUSE AS A SYSTEM" approach for the Weatherization Program.

V. TYPES OF HAZARDS AND CORRECTIVE PROCEDURES

All sub-grantees have blower doors, digital manometers, CO testers, heating system efficiency testers, and hygrometers, as well as other test equipment. All weatherization personnel must participate in training in energy related health and safety issues and indoor air quality problems. Testing and corrective procedures requiring special licensing on a State level will be referred to the appropriate authority.

a. See Hazards Chart Pages 69-70.

The chart is a quick reference of a majority of conditions that the State regards as hazardous. In all cases these conditions will indicate the course that weatherization will take. The chart outlines the hazard, the importance of correction, if postponement of weatherization services is necessary, types of testing, and corrective procedures for each hazard.

b. Asbestos

"Asbestos" describes six naturally occurring fibrous minerals found in certain types of rock formations. When mined and processed, asbestos is typically separated into very thin fibers that are normally invisible to the naked eye. They may remain in the air for many hours if released from asbestos-containing material (ACM) and may be inhaled at this time. Three specific diseases-asbestosis (a fibrous scarring of the lungs), lung cancer, and mesothelioma (a cancer of the lining of the chest of abdominal cavity)-have been linked to asbestos exposure. It may be 20 years or more after the exposure before symptoms of these diseases appear; however high levels of exposure can result in respiratory diseases within a shorter period of time.

According to the EPA's "Building Air Quality" guide, the mere presence of asbestos in a building does not mean that the health of a building occupant is endangered. Asbestos-containing material (ACM) which is in good condition, and is not damaged or disturbed, is not likely to release asbestos into the air.

In residential homes asbestos was generally used as an insulating material on heating systems, steam and hot water pipes, and duct work. Asbestos usually appears as a white-caulk type of substance used in a plaster form or contained in corrugated insulation sleeves.

General asbestos removal is not approved as a health and safety weatherization cost. Major asbestos problems should be referred to the appropriate State agency and/or EPA.

Where permitted by code or EPA Regulations, less costly measures that fall short of asbestos removal, such as encapsulation, may be used. Removal and replacement of asbestos siding for purposes of wall cavity insulation is permissible if allowed by State and local codes.

CLIENT EDUCATIONAL PAMPHLET/CHECKLIST

	RECEIVED
AIR POLLUTION IN YOUR HOME	_____
THE INSIDE STORY (A Guide to Indoor Air Quality)	_____
TIPS FOR ENERGY SAVINGS	_____
HOW TO REDUCE RADON LEVELS IN YOUR HOME	_____
A CITIZEN'S GUIDE TO RADON	_____
WEATHERIZE YOUR HOME	_____
CUT THOSE ENERGY BILLS	_____
HOME ENERGY AND COMFORT	_____
INDOOR AIR QUALITY AND YOUR HEALTH	_____
MAINE WOOD BURNING GUIDE	_____
MAINE'S RESIDENTIAL ENERGY STANDARDS	_____
PROTECT YOUR FAMILY FROM LEAD IN YOUR HOME	_____
OTHER SERVICES OFFERED BY THE COMMUNITY ACTION PROGRAM	_____

I ACKNOWLEDGE RECEIPT OF THE ABOVE INFORMATION WHICH MAY OR MAY NOT APPLY TO MY HOME AND UNDERSTAND THAT IT IS PROVIDED TO ME AS A GUIDE ONLY.

_____ _____
(Client Signature) **(Date)**

_____ _____
(Agency Personnel Signature) **(Date)**

MAINE'S WEATHERIZATION PROGRAM
NOTICE OF POSTPONEMENT OF SERVICES

Agency _____ Auditor _____

Phone # _____ Date of inspection _____

During a preliminary inspection by a Maine Weatherization Provider, the following Health and Safety problem(s) were noted:

1)_____

2)_____

The problem(s) listed above do not exclude your household from receiving the benefits of the Weatherization program. When the above condition(s) are rectified, your household will still be eligible for weatherization services, providing the household is still eligible and there is available funding.

_____ I (The client) understand that the above condition(s) prevent my home from being weatherized at this time.

_____ It is my (The client) responsibility to contact the agency when the problem has been corrected.

_____ It is my (The agency representative) responsibility to contact alternative funding sources.

If a request for alternative funding sources is checked, list the possible sources and contact persons that will be working on the case:

Source_____ Contact Person_____ Date_____

Source_____ Contact Person _____ Date _____

I (The Client) clearly understand that the condition(s) outlined above prevent my home from weatherized. I also understand the responsibilities of all parties involved, including my responsibilities. By signing this document, I understand that I am not giving up my rights to my benefits provided by the weatherization Program, but it is in the best interest of all parties involved that weatherization not take place until the problems(s) are resolved.

_____ _____
(Client Signature) **(Date)**

_____ _____
(Agency Representative) **(Date)**

Weatherization personnel are advised to identify and asses the condition of asbestos during the audit process and to take all precautions not to disturb asbestos containing products throughout the weatherization process.

c. Biological

Removal of mold, odors, viruses, bacteria, unsanitary conditions and rotting wood is not a weatherization responsibility, however, program workers frequently encounter these conditions. DOE funds may be used if these conditions must be mitigated to allow effective weatherization work and/or to assure the immediate or future health of workers and clients. Building tightness limit guidelines pertain only to fresh air for people to breathe in normal living conditions. Factors such as biologicals may affect an agency's air tightening procedures in any given home if the source of the biological cannot be mitigated.

d. Moisture

A thorough moisture assessment of the client home is done during the audit process and conditions are noted on The Maine's Building Test Data Information Sheet.

The Usual Sources of Moisture Problems are:

a. Interior moisture generated by client behavior (showering, cooking, floor washing, use of unvented combustion appliances, etc.)

b. Interior moisture migrating up through the house from damp basements or dirt crawl spaces.

c. Bulk moisture entering from the exterior of the house from shell problems.

The more air tight a house is, the less air changes per hour occur, consequently lessening the ability to dry out the humid indoor air. Although a tight home is good for energy conservation purposes, it can be a problem if there is no way to exhaust the moisture that is produced and trapped inside the house. In colder climates, interior moisture that escapes through holes or bypasses can cause structural degradation by condensing on cold outer surfaces, slowly rotting the wood. Moisture can condense on cold interior surfaces that are not insulated properly or that are deprived of heat circulation. This is generally the root of the biological problems and structural problems relating to weatherization activities.

The Assessment Process is as Follows:

a. The Client Interview: The auditor asks a series of questions about household activities, client health, landscape problems, and structural problems that may indicate moisture problems.

b. A Visual Inspection: The auditor starts the assessment process upon driving up to the house. Condensation on windows, a buckling roof, lack of gutters, groundsloping towards the house, and peeling paint are just some of the indications of trouble. Inside the house, musty smells, mold and mildew, blackening roof sheathing, plumbing leaks, and damp basements are additional signals of moisture problems for the auditor to make note of.

c. Measuring Humidity Levels: The auditor uses either a sling psychrometer or a digital hygrometer to measure humidity levels in different portions of the house.

d. Blower Door Testing: A Blower Door Test is done to determine the tightness of the house as well as assessing leakage areas. Maine has adopted George Tsongas's procedures for Building Tightness Limits as delineated in an article in The Home Energy Magazine March/April 1993 issue. The article in its entirety is reprinted in Section A, Part II of this manual. The article is to be used as a guide only. It is understood that the chart and the formulas quantify tightness limits to ensure adequate fresh air for people to breathe in normal living conditions. The limits do not allow for poor indoor air quality or guarantee adequate combustion air for appliances.

Corrective Procedures and recommendations:

a. Client Education

b. Eliminate/Reduce Source: utilizing moisture control activities ground-covers, sealing shell bypasses, diverting bulk moisture, sump pumps, etc.)

c. Mechanical ventilation - exhaust only, fresh air intakes, balanced mechanical whole house ventilation systems.

e. Combustion Appliances and Combustion Gases:

Maine State Housing Authority recognizes that combustion gases pose the most serious hazard found in homes. As a result, we have adopted a comprehensive plan to achieve safe operation of combustion appliances and to make sure that weatherization procedures do not contribute to the problem.

Some of the harmful products of combustion are dust, nitrogen oxides, and carbon monoxide. While all of these products are harmful, Carbon monoxide (CO) is of most concern because it is deadly. Carbon monoxide is a highly toxic, lighter than air gas, that is produced when there is insufficient oxygen to allow for complete combustion of the fuel in use. Carbon monoxide is very dangerous because it is colorless, odorless, tasteless, and non-irritating and virtually impossible to detect without test equipment. Carbon monoxide is a cumulative poison and can slowly build up in the bloodstream. CO combines with blood hemoglobin and replaces the oxygen in the bloodstream until there is too little oxygen to support life.

MSHA views any ambient level of CO as potentially dangerous and will be considered a warning signal that a problem exists. ASHRAE Standards (62-89) states that in a residential setting, the maximum allowable concentration for <u>short term exposure</u> is 9 ppm.

* Caution: Test results may vary during different seasons of the year and different weather conditions. Low levels of CO measured in the exhaust stream of the combustion appliance does not guarantee that there will not be a problem under different conditions.

1. Client Education: Informational pamphlets are distributed and verbal discussions take place on a case by case basis concerning combustion appliances.

2. Test Equipment: Bacharach's Monoxer II CO Tester
   Various Heating System Efficiency Test Kits
   Digital Manometer
   Pressure Pan
   Smoke Gun

3. Testing Procedures: All houses with combustion appliances and/or fireplaces, will be tested when possible and results will be noted on the Building Data and Test Sheet. All Test procedures are delineated in Section A, Part II of this Manual.

   a. CO in Flue - Houses where CO levels in the flue of combustion appliances (with the exception of wood and coal) is higher than 50ppm, will not be weatherized until system is evaluated by a licensed technician. At present unlicensed persons are banned from CO testing of oil fired appliances. If you suspect dangerous levels of CO are being produced by an oil fired appliance, have the system evaluated by a licensed technician. All other combustion appliances should be tested for CO production.

   b. Ambient CO - Houses where ambient levels of CO are higher than 9ppm, will not be weatherized until the source is eliminated. If, for whatever reason, the auditor is unable to test for ambient CO, it is permissible to follow the individual appliance CO test procedures delineated in the *Maine Auditor/Estimator Health and Safety Field Guide* which is incorporated into this manual by reference. Be certain that all ventable appliances are vented as per code or manufacturer's instructions. Cook stoves can be dangerous. Burners and ovens combined producing greater than 15ppm should be cleaned or serviced. If necessary, unit replacement is permissible within the H&S expenditure limits. Kitchen ventilation should be installed if possible. Installing a CO alarm is often wise. Remember, building tightness limits are influenced by cigarette smokers, as per George Tsongas's article referenced above.

   c. Backdraft Test(Worst Case)

   d. CTE

   e. Pressure Balancing

4. Corrective Procedures: Corrective procedures requiring special licensing to be referred to appropriate authority.

   a. Client Education
   b. Postponement of Services
   c. Refer heating system problems to the C.H.I.P. program.
   d. Repair Appliances
   e. Correction of draft problems
   f. Combustion Air Evaluation and correction
   g. Pressure Balancing

5. CO Alarms- May be installed in situations that an auditor has determined questionable or in situations that an unvented gas cook stove cannot be vented. A CO alarm should provide warning to home occupants whenever CO levels are harmful. Installing a CO alarm will not remove the requirement to vent any appliance if venting is required by code or manufacturer's instructions.

6. Other Funding Sources- A majority of the heating system work will be referred to the Central Heating System Improvement Program. Other funding sources such as the programs mentioned in section II. of this outline should be utilized when possible. DOE Health and Safety monies, keeping with the allowable averages, can be used as necessary.

f. Formaldehyde and Volatile Organic Compounds (VOCs)

Curing existing formaldehyde and VOC problems is not a weatherization responsibility; but avoid excessive air tightening in such homes so as not to exacerbate the existing problem. Formaldehyde vapors may be slowly released by some new carpets, waferboard, plywood etc. VOCs are emitted by some household cleaning agents.

g. Existing Occupant Health Problems

Sub-grantees are advised that certain weatherization procedures may aggravate some existing health problems that clients may have. The Auditor will identify such conditions during the client interview and make special arrangements if necessary to accommodate the client's situation.

h. Lead Paint

Lead paint abatement is not an allowable activity under the weatherization program. However, where precautions need to be taken when drilling or sawing through walls or floors to insulate or implement other weatherization measures, incurred costs may be charged to the weatherization activity. General Lead paint problems will be referred to the appropriate authority.

All weatherization work performed in structures built before 1979 whenever more than two square feet of lead-painted or presumed lead-painted surfaces are to be disturbed will be done using lead-safe weatherization practices. Additional incurred costs may be charged to the weatherization activity.

i. Radon

Radon is a radioactive gas produced by the decay of radium. It occurs naturally in almost all soil and rock. Radon migrates through the soil and groundwater, and can enter the building through cracks or other openings in the foundation. Radon's decay products can cause lung cancer, and is second only to smoking as a cause for lung cancer in America.

General weatherization procedures, such as reducing stack effect and relieving negative pressures in the combustion appliance zone(usually the basement), are beneficial for reducing the entry of radon gases. Negative pressures in the basement relative to outdoors will draw any gases, water, water vapor and cold air, into the basement. Program testing procedures and corrective measures outlined in the procedures manual describe corrective steps to take when faced with negative pressures in the combustion appliance zone.

Identification of radon levels through appropriate testing will be allowed with DOE Health and Safety monies in areas that the potential for Radon is high. Radon concentrations vary greatly across Maine. Consequently, Subgrantees will be encouraged to develop procedures for their area that will allow for the identification of unsafe Radon levels.

j. Unvented Space Heaters

Operation of unvented gas and liquid fueled space heaters can negatively impact indoor air quality through indoor air pollution. Indoor pollutant concentrations resulting from the use of unvented space heaters can vary significantly from house to house depending on the operation of the space heater and the infiltration/ventilation rates of the residential structure in which it is placed. Poorly adjusted heaters produce substantially greater quantities of carbon monoxide (CO), aldehydes and particulates than properly adjusted units. Inadequate ventilation may result in rapid buildup of all pollutants including harmful levels of CO.

In addition to the production of toxic by-products, unvented space heaters release water vapor equivalent to 8 to 11 gallons of water into the into the heated space for each million BTU of energy delivered. Water vapor condenses upon contacting cool surfaces, creating a source of mold growth and contributing to premature rotting of building materials. Eliminating the source of water vapor, providing adequate ventilation, raising surface temperatures by proper insulation techniques and/or by circulating conditioned air could solve the problem.

MSHA policy for unvented space heaters is as follows. A home that is utilizing an unvented space heater will not be weatherized. Client Education will be used to explain the consequences of space heater use. The postponement of services form must be used. Once the client has agreed that they understand the policy and will not use the heater, weatherization can commence. Cases where space heater usage is necessary being the only heat source or to compensate for inadequate distribution of heat by a central heating system, should be referred to the CHIP program or other fund source to correct.

k. Building Structure

Subgrantees will ensure that weatherization-related work will be in conformance with the applicable codes in the jurisdiction where the work is being performed.

1. Knob and Tube Wiring (KTW) - A Memorandum issued by DOE 10/21/1988 which supersedes DOE guidance on KTW dating 7/25/1983 and 7/13/1988 states that work is to be in conformance with the applicable codes in the jurisdiction where the work is being performed.

2. Circuit Overloading - Now that it has been confirmed that overloaded wires imbedded in cellulose can cause structural fires (See *Assessing the Integrity of Electrical Wiring, Home Energy, Sept/Oct 1995* which is reprinted in Section A, Part II of this manual) auditors and installers must be certain that weatherization efforts do not create potential fire hazards in client homes. Evaluating potentially affected wires by means of a circuit tester such as the *SureTest Pro* is strongly encouraged. Circuits which fail the test can be "fusestated" to a safe amperage to prevent overloading, replaced or discontinued. If you chose not to test, it is permissible to leave bays containing suspect circuits uninsulated or to dam insulation away from them. Remember that insulation voids - intentional or not - seriously compromise the overall effectiveness of the installed insulation while possibly invalidating the MEADOW SIR estimate. To the extent that these situations prevent adequate weatherization, the postponement of services form should be filled out and weatherization deferred until necessary repairs are completed.

3. Other Miscellaneous Wiring Hazards - Use common sense.

l. Exceptions

Diagnostic Equipment or test procedures should not be used in or on dwellings where such equipment or testing could exacerbate existing problems or pose a threat to the health of occupants. In all cases, it is the auditor's responsibility to determine if a condition exists which could cause <u>any</u> diagnostic equipment or test procedure to be potentially harmful to clients or sub-grantee personnel. If the potential exposure can be eliminated by varying the test procedure while still achieving viable results, doing so is permissible and encouraged, i.e. in a home with possible air borne pathogens, pressurizing as opposed to depressurizing during the blower door test should garner the necessary data safely. If no viable alternate test procedure exists elimination of the test in question is allowable in the subject home. Documentation in the MEAFF is required.

HAZARD CHART

HAZARD	IMPORTANCE OF CORRECTION	POSTPONEMENT OF SERVICES NECESSARY	TYPES OF TESTING	CORRECTIVE PROCEDURE	APPROX. COST - $
Cracked Heat Exchanger	Immediate Action	Yes	Lysol Test Leak Seak Test Kit Pressure Test Bacharach Monoxer II CTE	Replacement of exchanger Replacement of Heating System	(#1) (#1)
Backdrafting	Immediate Action	Yes	Backdraft Test	Check Chimney Pressure relieving combustion appliance zone Introduce outside air to appliances	— 10 100
Spillage	Immediate Action	Yes	Spillage Test	Check Chimney	—
Lack of Combustion Air for Combustion Appliances	Immediate Action	Yes	NFPA 211 National Gas Code	Introduce outside air to space Introducing outside air to appliance	10 100
Poor Draft	Immediate Action	Yes	Pressure Test Smoke Test	Check Chimney Check Flue Pipe	— —
Levels of CO in Flue of Combustion Appliance - over 50 ppm	Immediate Action	Yes	Monoxer II	CTE Check adequacy to combustion air supply	75 —
Ambient levels of CO in excesss of 9 ppm	Immediate Action	Yes unless source is cigarette smoke	Monoxer II	Elimate source Client Education Ventilation	— — 100
Unvented combustion appliance/space heater	Immediate Action	Yes	Visual Inspection	Client Education Remove or discontine use of appliance Vent appliance Upgrade Central heating system Install a properly vented appliance	— — 100 (#1) (#1)
Building tightness limit exceeded prior to weatherization	Immediate Action	Yes	Blower Door CO2 Monitor Ashrae Assessment	Client Education Exhaust fans Fresh Air Inlets Whole house ventialation Air to Air Heat exchanger	— 100 30 250 Not Allowed
National-Local Code Violations	Depends on relationship to Weatherization	Depends on relationship to Weatherization	As necessary	Refer to appropriate authority	—

(#1) - Refer to CHIP
(#2) - Depends on circumstances
(#3) - Included in Weatherization

HAZARD CHART CONTINUED

HAZARD	IMPORTANCE OF CORRECTION	POSTPONEMENT OF SERVICES NECESSARY	TYPES OF TESTING	CORRECTIVE PROCEDURE	APPROX. COST - $
Unsafe levels of Radon	Levels above 4pCi/L mitigation recommend	Only Weatherization activities that would be exacerbate radon levels	Varied	Mitigation	Mitigation not allowed
Lead	Depends on realtionship to Weatherization	Affected measures only	Assume presence by age of structure	Follow Lead Safe Weatherization Practices	Mitigation not allowed
Moisture	Depends on Severity	Relative to level of Severity	Visual Client interview Hygrometer	Client Education Ground Covers Shell Renovation Ventilation Effective Air Sealing	— 50 (#2) 100 (#3)
Mold and Mildew	Immediate Action	Yes	Client interview Visual Inspection	Client Education Remove moisture source Insulate Ventilation Improve heat distrubution	— (#2) (#3) 100 50
Asbestos Containing Material (ACM)	Relative to condition of ACM	Relative to condition of ACM	Visual inspection	Encapsulation Abatement by a qualified technician	(#2)
Gas /Fuel Leak	Immediate Action	Yes	Gas leak detection equipment/visual inspection	Notify appropriate technicians	(#1)
Disconnected Sewer Lines	Immediate Action	Yes	Visual inspection	Notify appropriate technicians	(#1)
Structural Problems	Depends on Severity	Depends on Severity	Client interview Visual inspection	Utilize available resources to correct	(#2)
Poor IAQ	Depends on Severity	Depends on Severity	Varied depending on pollutant	Eliminating pollutant source dilution	(#2)
Client Health Problems	N/A	Depends on Relationship to Weatherization	N/A	Client education/negotiation	—
Hazardous Electrical Wiring	Immediate Action	Yes	Visual inspection Client interview	Refer to qualified technician	(#2)
Unsanitary Living Conditions	Depends on Severity	Depends on Severity	N/A	Client Education Refer to appropriate authority	— —
VOC'S	Depends on Severity	Depends on Severity	Client interview Visual inspection	Client Education Refer to appropriate authority	— —

(#1) - Refer to CHIP
(#2) - Depends on circumstances
(#3) - Included in Weatherization

SECTION C

MOISTURE CONTROL ACTIVITIES

SECTION C

MOISTURE CONTROL ACTIVITIES

A. DEFINITION: Actions taken by the installer and client that will prevent or correct excessive moisture conditions that adversely affect the client's dwelling and health.

B. Material Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Thoroughly review the booklet, "Moisture and Home Energy Conservation". (DOE/CE/115095-4). The Home Energy article, "Assessing and Solving Moisture Problems in Houses" by George Tsongas is also a good reference.

2. Use the methodology described in these publications to assess, correct and prevent excessive moisture problems, unless stated otherwise in these standards.

3. Prior to initiating any weatherization activity which will impact the drying capability of the client home, all necessary moisture control activities must be completed.

4. In exceptional dwelling units, technically and economically feasible moisture control activities may not correct or prevent excessive moisture conditions. Such units shall not be weatherized until corrective action is taken.

5. Additional mobile home moisture control activities are listed in the Mobile Home Section.

PRE-INSTALLATION PROCEDURE:

1. Examine all plumbing, including drains, for leaks.

2. Examine all gas water and space heaters to determine if they are vented to outside of structure.

3. Determine the ventilation system used in all bathrooms.

4. Examine all mechanical ventilators and other ducted systems to determine if all ducts are sealed and vented to outside the structure.

5. Examine all structural systems (roof, wall, floor, doors, windows) for rain and ground water penetration.

6. Examine all dryers to determine if all ducts are sealed and vented to outside the structure.

7. Examine all ceiling, wall, roof and floor systems with existing insulation to determine current vapor retarder and ventilation status.

8. Examine all existing crawl spaces to determine current ground cover vapor retarder and ventilation status.

9. Survey the entire dwelling unit for the following symptoms of moisture problems:

   a. Musty odors
   b. Damp sensation
   c. Mold and mildew
   d. Discoloration, staining and texture changes
   e. Rot and decay
   f. Standing water
   g. Condensation on double-glazed windows
   h. Sweating pipes and dripping
   i. Frost on interior surfaces
   j. Ice dams
   k. Unusual corrosion
   l. Deformed wood surfaces
   m. Concrete and masonry efflorescence, chipping and spauling

INSTALLATION PROCEDURES

Mandatory Measures:

A. Repair plumbing leaks.

B. Install dryer vents – must vent to the outside of structure.

C. All bathrooms shall have ventilation provided by either an operable window or mechanical ventilation system. If this requirement is not met prior to weatherization, install a mechanical ventilation system.

D. Seal mechanical and non-mechanical exhaust ventilation ductwork and ensure that it vents to outside the structure.

E. Repair roof leaks, meeting the requirements of the Repairs Section.

F. Vent unvented gas hot water heater by whatever method is most cost effective for the client, including moving the tank. Replacement of unventable gas tank with electric tank is allowable. Keep in mind doing so will in all probability significantly increase the client's total energy cost.

G. Air seal attics from heated spaces and basements to the greatest degree possible in order to prevent moisture migration to attics and resultant moisture damage.

H. Existing crawlspaces and areas confined by skirting shall, as close as technically possible, meet the groundcover vapor retarder requirements of Section C and Section H.

I. Install poly or equivalent ground cover if needed.

J. Remove existing improperly installed vapor retarders.

K. Ensure adequate kitchen and/or bathroom ventilation capabilities.

L. Leave operable at least two (2) existing basement windows. Whenever possible, the operable windows shall be located so as to provide cross ventilation.

Further Measures:

The survey required in the pre-installation procedures above may detect one or more current moisture problems. It may also detect potential moisture problems that would be created or aggravated by proposed weatherization activities. In such cases use the methods described in "Moisture and Home Energy Conservation" or the Home Energy article, "Assessing and Solving Moisture Problems in Houses" by George Tsongas is also a good reference to determine which of the following procedures are required.

A. Client education.

1. Remove firewood from structure.

2. Proper use of pot and pan covers.

3. Dry clothes outdoors.

4. Remove inordinate number of houseplants.

5. Cover aquarium(s).

6. Use of mechanical ventilation systems.

7. Avoid humidifier use.

B. Repair or install bathroom mechanical ventilation. New fans shall be capable of providing an actual minimum of 50 CFM. Install according to manufacturer's instructions. If a new fan is installed, it shall exhaust to the outside.

C. Repair or install kitchen mechanical ventilation. New fans shall be capable of providing an actual minimum of 50 CFM. If a gas stove is used, minimum fan size shall be 100 CFM. Install according to manufacturer's instructions. If a new fan is installed, it shall exhaust to the outside.

D. Install gravity basement drain.

E. Install, according to manufacturer's instructions, a sump pump.

F. Install ground cover vapor retarder on basement floor according to the specification in Section D Floor Insulation. Ground covers in traffic areas may be either six-mil poly protected by sand or saturated and coated rolled roofing.

G. Install operable basement vents.

H. Create air barriers necessary to confine air-transported moisture.

POST-INSTALLATION REQUIREMENTS:

1. Ensure all measures taken meet the standards of this publication, manufacturer's instructions and applicable trade standards.

2. Re-survey the dwelling (see pre-installation requirement # 9) to ensure that any measures undertaken have controlled excessive moisture conditions. Perform additional optional measures as necessary.

3. If applicable, instruct the client/landlord to re-survey the dwelling during the next heating season and report and results to the program operator for possible follow-up action.

SECTION D

INSULATION

SECTION D

INSULATION

General Information

1. The Maine State Housing Authority recommends the use of loose fill cellulose insulation whenever possible as it is less expensive per R, is a locally produced recyclable product and when properly installed contributes significantly to infiltration reduction. Should it be necessary to use batt fiberglass it must be carefully cut to fit and installed in order to minimize the chance of thermal bypasses and looping and to achieve a uniform R-value over the entire area to be insulated. (See Fig. 1; Sec. D)

2. In the event that sheetrock is being installed over either newly installed or existing insulation MSHA recommends the installation of a poly vapor retarder as it acts as an air barrier and will enhance the value of the insulation and reduce moisture penetration, thereby extending the life of the insulation and the structure.

3. If sheetrock is installed it must be taped and mudded one coat.

ATTIC INSULATION

DEFINITION: A material or assembly of materials, primarily designed to resist heat flow, which is installed between the conditioned area of a building and an unconditioned attic. Where the conditioned area of a building extends to the roof, the term attic insulation also applies to material used between the underside of the roof and the ceiling of the attic.

A. Material Specifications: See Appendix A for all material types.

B. Requirements:

1. Insulate all finished and unfinished attic areas to the maximum extent possible up to a maximum of R-38. When filling a cavity, MSHA recommends using the dense blow tube method. If the decision is made to insulate an inaccessible cavity (i.e., dormer or bay window, ceiling, etc.) always use the dense blow method in order to reduce the possibility of air transported moisture penetration.

2. Insulate all attic entry ways, such as scuttle holes, walk-up stairways, and pull-down stairs. These shall be insulated to the same R-value as the attic or to the fullest extent practicable. Weatherstrip hatches, doors, scuttle holes.

3. Safety precautions: During installation, do not smoke in the attic or in any truck or van used for installation. MSHA recommends the use of appropriate dust masks as recommended by material data sheets.

INSULATIONS

FORM AND TYPE	AVE R/IN	REL. COST	CHARACTERISTICS[3]
BLANKET AND BATT			
Fiberglass (spun glass fibers)	3.2	low	Non-combustible except for facing.
Rockwool (expanded slag)	3.4	low	Non-combustible except for facing.
LOOSE FILL[1]			
Fiberglass (shortfiber) attic / wall	2.7 / 4.0	med	Non-combustible. Good in irregular spaces.
Fiberglass (longfiber) attic / wall	2.2 / 3.3	low	Non-combustible. Good in irregular spaces.
Rockwool attic / wall	2.9 / 2.9	med	Non-combustible. Good in irregular spaces.
Cellulose (paperfiber) attic / wall	3.7 / 3.3	low	Spec. "Class 1, non-corrosive. Good air barrier. May be damaged by water.
Perlite (glass beads)	2.5-3.7	high	Non-combustible. Expensive.
Vermiculite (expanded mica)	2.4-3.0	high	Non-combustible. Expensive.
RIGID BOARDS[2]			
Molded Polystyrene (bead board)	4.0	med	Combustible, cover with 15 min. fire-rated material. Do not use below grade.
Extruded Polystyrene ("Styrofoam")	5.0	high	Combustible, cover with 15 min. fire-rated material. May use below grade in contact with soil.
Polyurethane or Poly Isocyanurate	5.6-7.7	high	Combustible, cover with 15 min. fire-rated material. Do not use below grade.
Phenolic Foam	8.0	high	Non-Combustible, do not use below grade.
High-Density Fiberglass	4.4	high	Non-Combustible.
SPRAYED-IN-PLACE			
Cellulose (wetspay)	3.9	high	Usually used in walls. All good in irregular spaces. Special installation techniques required. Many different types available.
Fiberglass ("BIBS")	4.0	high	
Rockwool ("BIBS")	3.7	high	
FOAMED-IN-PLACE			
Urethane	6.2	high	Combustible, cover with 15 min. fire-rated material. Do not use below grade.
Urea Formaldehyde	4.2	high	May exude formaldehyde gas while curing. May shrink while curing. Used in walls only.
REFLECTIVE FOIL/PAPER Radiant Barrier System	Vari-able	med	The insulating value is dependent on where and how it is used.

NOTES:

[1]All loose fill insulation must be installed at manufacturer's recommended densities to insure proper performance.

[2]All rigid boards, except phenolic foam and fiberglass, are combustible and must be covered with 1/2" drywall or equivalent 15-minute-fire-rated material when used on interior.

[3]Most data taken from *An Assessment of Thermal Insulation Materials and Systems for Building Applications*, Brookhaven National Laboratory, June, 1978; GPO Stock No. 061-000-00094-1.

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PRE-INSTALLATION PROCEDURES (attic preparation)

Complete the following prior to the installation of insulation:

1. Identify all recessed lighting fixtures, including wiring, compartments and ballasts, vents, chimneys and other heat-producing devices in all areas where insulation is to be installed. Block off recessed light fixtures with a sheet metal barrier or other commercially available products. Install all blocking at least as high as the height of the finished insulation and in a manner that ensures all devices which may require maintenance or service remain accessible after the insulation is installed. Maintain a 3 inch minimum clearance between the fixture and the insulation. In addition, do not cover recessed light fixtures unless they are plainly marked as U.L. approved to do so. Covering entraps heat and/or prevents the free circulation of air.

   It is permissible to remove recessed light fixtures with client permission if it is the most practical method of air sealing. Be certain to observe all applicable codes.

2. Chimney preparation procedures are crucial for effective insulation performance. Such preparation serves three (3) purposes: to reduce thermal bypasses; to provide a fire-stop; to maintain the required 2 inch chimney clearance from combustible materials.

   a. Install a fire-stop and air barrier at all chimney penetrations; cellar through first floor and the attic using flashing consisting of 26 gauge sheetmetal strips fastened in place with screws and sealed with high temperature caulk. For installation ease, the 26 gauge sheetmetal should be bent to form an ell (90°). (See Fig. 2; Sec. D)

   b. Maintain the required chimney clearance of 2 inches from any combustible materials by preventing cellulose contact with the chimney. Wrap unfaced R-11 fiberglass completely around the chimney and secure with baling or mechanics wire. Ensure that the fiberglass wrap extends above the insulation to a maximum of 4 inches. A second method is to box the chimney out, maintaining the 2 inch clearance. Ensure that the boxing extends no more than 4 inches above the insulation. In addition, there are commercially available systems for maintaining the necessary clearance.

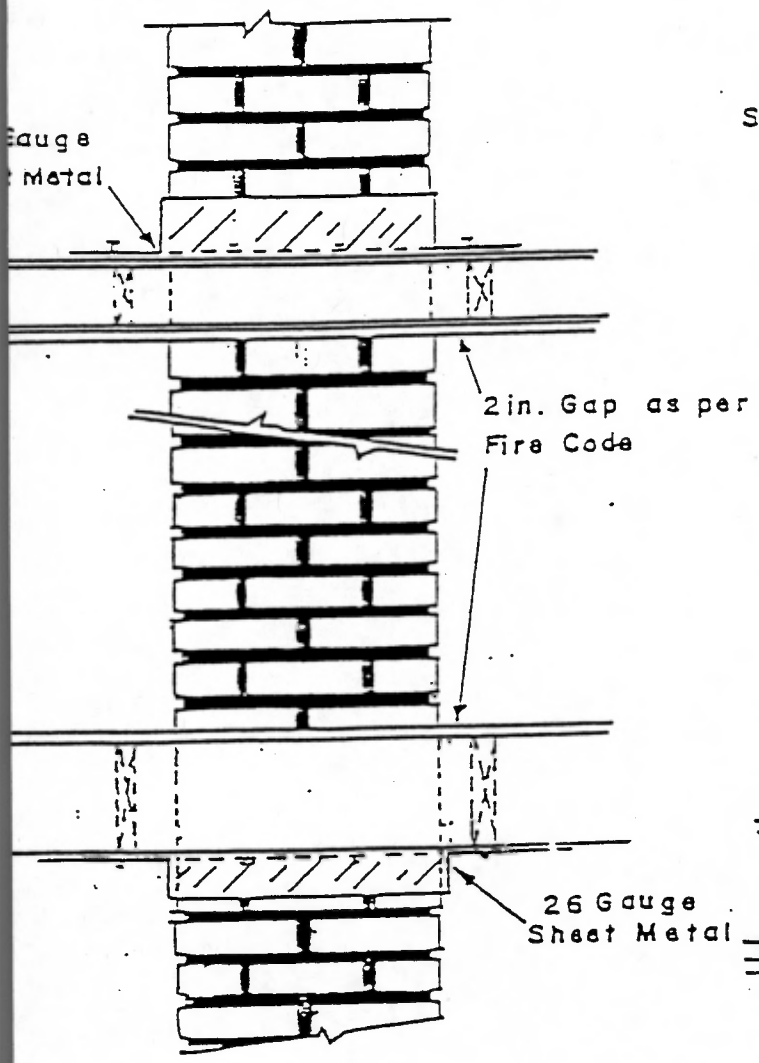
      NOTE: If a fiberglass wrap is used, do not stuff or compress the fiberglass into the framing cavity.

3. Locate and air seal pipe chases, wire chases, open framed interior partitions and any other thermal bypass from the conditioned space into the unconditioned attic.

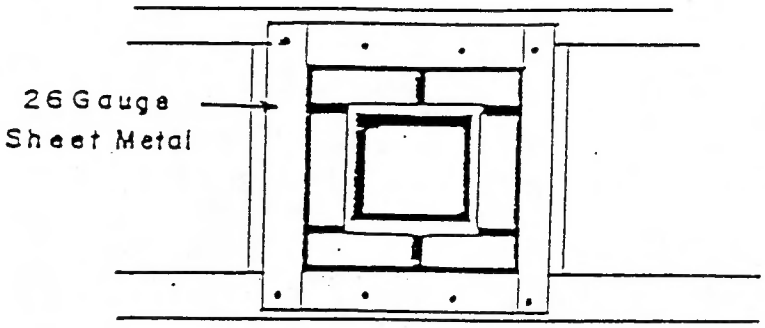
4. Inspect the roof, ceiling, and attic floor to identify areas where a previous moisture Problem caused paint peeling, warpage, stain, visible fungus growth, rotting, or other structural damage. Do not install insulation in such areas until the resident is informed of inspection results and conditions are corrected and source eliminated.

Detail for Sealing Thermal Bypass Around Chimney

Side View



Top View/Bottom View



Side View /Finished Ceiling

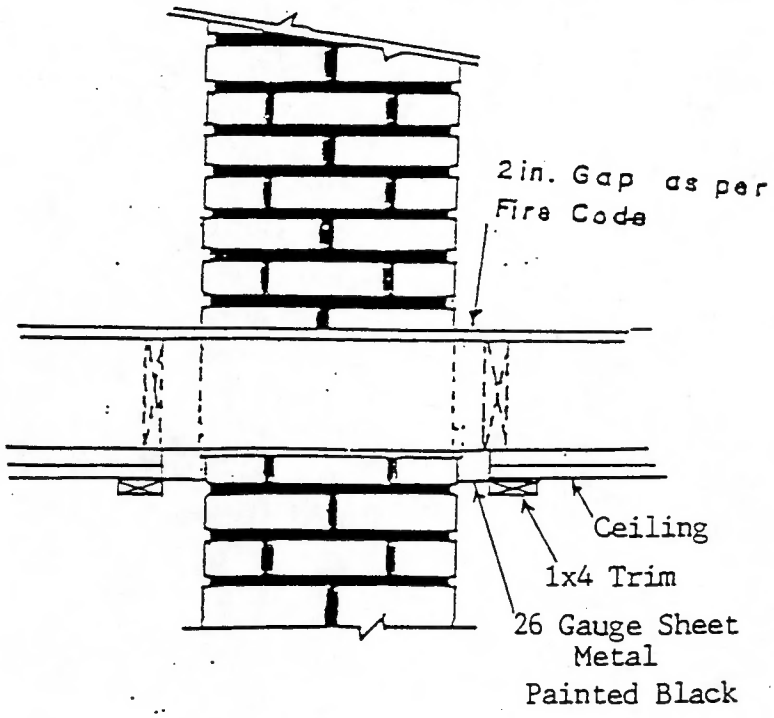


Fig 2; Sec D

5. Cover drop ceiling cavities to prevent filling these areas with cellulose.

6. Determine if knob and tube wiring is present; if so, proceed as follows:

Method A:

a. Knob and tube wiring is suspected as a potential hazard because it is generally found in older homes (constructed prior to 1920), and these structures were usually wired with a lower electrical service than is customary for the requirements of today's households. However, it is now felt that insulation can be safely placed over knob and tube wiring provided that:

   1) The wiring is in good condition; and the circuits do not carry an amperage greater than the rated current for that size wiring.

b. In all cases before insulating over knob and tube wiring is approved, personnel authorizing work orders or contracts will arrange for or conduct a thorough inspection of the areas to be insulated and gain assurance that:

   1) All wiring to be covered is examined and pronounced safe and in good condition, and

   2) The electrical system has protective devices matched to the wire sizes which discontinue the flow of electrical current if the circuits are overloaded.

c. Strictly adhere to the following fuse sizes:

   - 15 amp fuses for #14 wire
   - 20 amp fuses for #12 wire

d. Check to determine if there is evidence of cracked or frayed electrical insulation or exposed conductors. Installers of the insulation should be cautioned to use care not to damage the old wiring as the insulation is installed.

e. Installation of type "S" fuses is required in fuse boxes in homes where knob and tube wiring systems are used. Type "S" fuses insure against overloading by making it impossible to put in a larger rated fuse. Obtain prior client approval before modifying the fuse box. If the resident does not consent, the insulation cannot be installed.

f. Sub-grantee personnel who authorize work should be aware that in some cases, when older homes have been rewired the knob and tube system has been left in place. An inspector may see only the abandoned wiring and take inappropriate action. Wiring inspectors will verify that knob and tube systems are in fact in service before disqualifying homes.

Method B:

a. Using fiberglass make continuous dams leaving at least 2 inch clearance from the wires, or simply do not insulate the bays with knob and tube wiring.

7. A certificate of insulation is required.

ATTIC ACCESS

Installation Procedure

1. Install attic accessways, either in kneewalls or ceilings, so that they may be readily removed for post-inspection purposes by sub-grantee or grantee personnel.

2. Whenever possible the access opening will be at least 4 sq. feet, ideally 2' x 2', and in a readily accessible location. When installed between ceiling joists that do not protrude above the insulation, install blocking strong enough to hold a person completely around the opening in a manner which will prevent insulation from falling into the living area when the hatch is opened. (See Fig. 7; Sec. D)

3. To construct a simple hatch fit a piece of plywood neatly into the box created by the insulation blocking (above). Install a collar around the lower edge of the blocking with an appropriate weatherstrip for the lid to rest on. Include fasteners such as hooks and eyes to hold the lid securely in place. Trim to match the home as closely as possible. Reinforce the lid if necessary to create a tight seal at weatherstrip. Insulate the lid to approximately the same R value as the attic flat either by gluing layers or rigid board or permanently fastening other appropriate insulation to it. (See Fig. 7; Sec. D)

4. In the event the home has a pull down attic stairway or an open stairwell into an attic, one recommended treatment is as follows:

   a. Construct a barrier entirely around the opening using suitable material. The barrier shall be constructed high enough to clear the folding stair and prevent attic insulation from falling into the stairwell.

   b. Construct a lid of 1/2 inch plywood reinforced with a 1 x 3 inch collar and attach it to the barrier with at least 2 hinges and 2 hooks and eyes or other secure mechanical locking devices. Counterweight the entire assembly for operational ease.

   c. Neatly caulk all seams.

   d. Install door type weatherstrip.

   e. Insulate sides and top of box to same R-value as attic, or to the fullest extent technically practicable.

Methods of venting

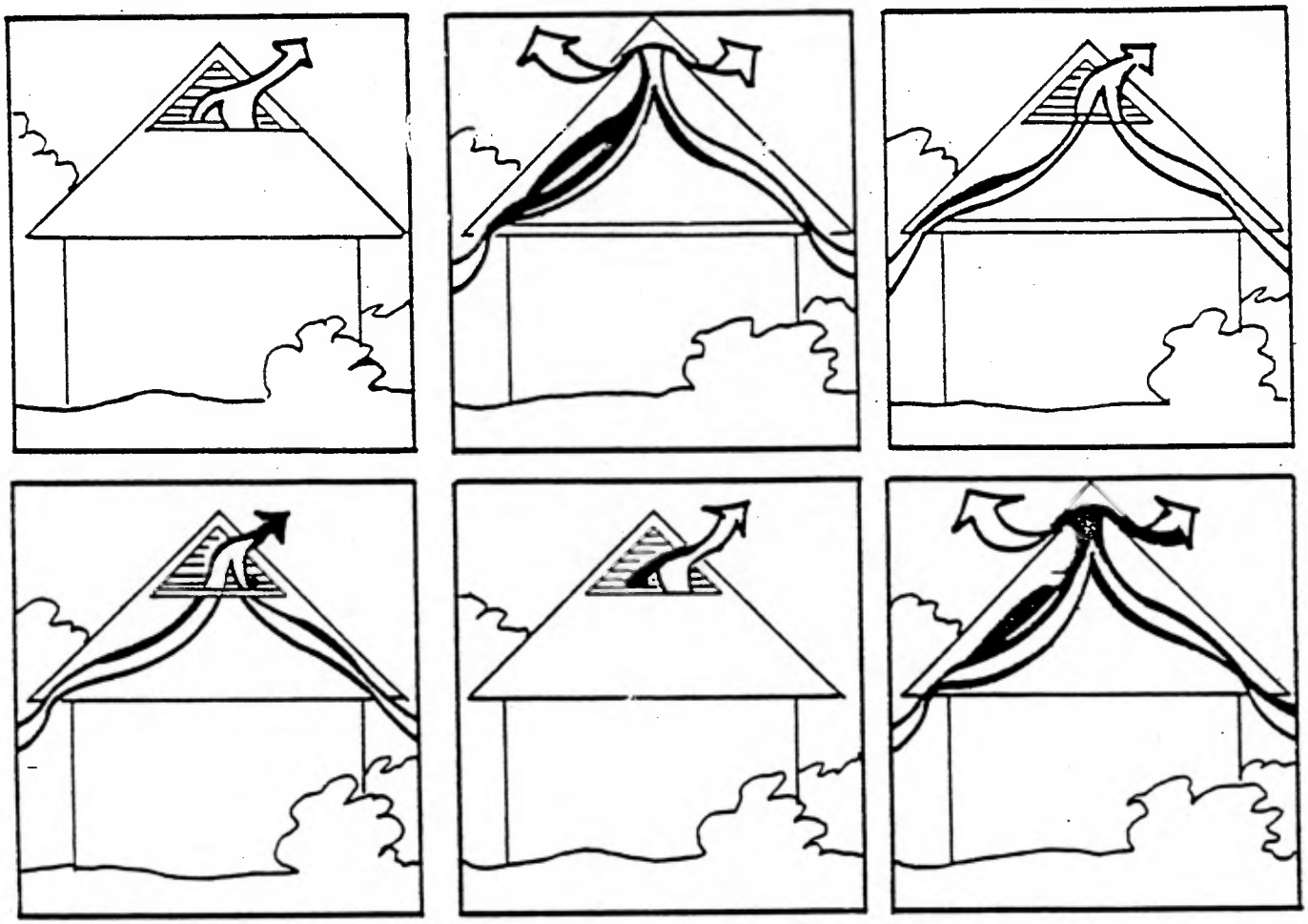
Attics with a ceiling vapor barrier shall be ventilated with one square foot of vent area for each 300 square foot of ceiling.

Attics without a ceiling vapor barrier shall be ventilated with one square foot of vent area for each 150 square feet of ceiling.

With vapor barrier
1 square foot of Gable vent for each 300 square foot of ceiling. Install one half in each end of gable

With vapor barrier
1 square foot of Roof or Ridge Vent and 1 square foot of Eave vent for each 600 square feet of ceiling.

With vapor barrier
1 square foot of Gable vent and 1 square foot of Eave vent for each 600 square feet of ceiling.



Without vapor barrier
1 square foot of Gable vent and 1 square foot of Eave vent for each 300 square feet of ceiling

Without vapor barrier
1 square foot of Gable vent for each 150 square feet of ceiling. Install one half in each end of gable.

Without vapor barrier
1 square foot of Roof or Ridge vent and 1 square foot of Eave vent for each 300 square feet of ceiling.

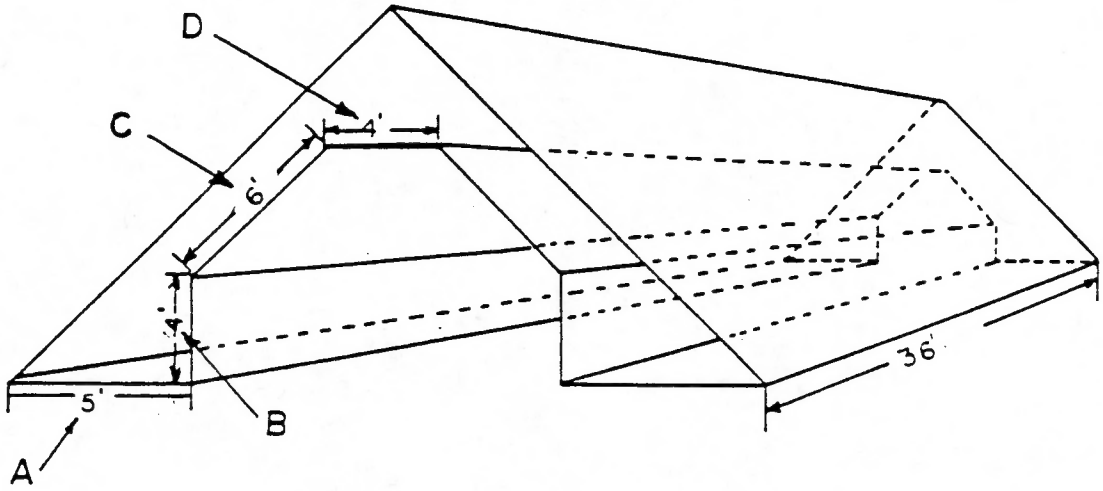
NOTE: Ridge, roof or gable vent must be at least 3' above the eave vents
The vents sizes recommended above are for unobstructed vents

Source: Owens Corning Fiberglas[R]
Guide to Constructing an Energy Efficient Home

Fig 3; Sec D

Finished Attic Diagram

- No Vapor Barrier
- Soffit & Gable End Vents
- Therefore, Appropriate Vent Ratio is $\frac{1}{300}$.



A – Kneewall Floor

Area = 36' x 5' = 180 sq.ft. each

B – Kneewall

Area = N/A

C – Slope

Area = 36' x 6 = 216 sq.ft. each

D – Flat Ceiling

Area = 36' x 4 = 144 sq.ft.

To Find Required "Free Vent Area" (FVA).

FVA = $\frac{1}{300}$ x 936 = 3.12 sq.ft.

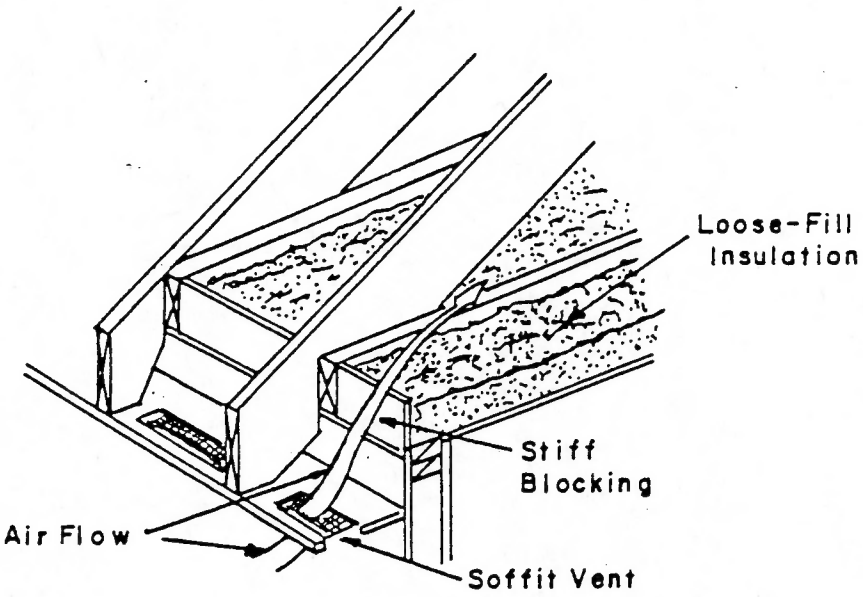
3.12 sq.ft. ÷ 2 = 1.5 sq.ft. High Venting – 1.5 sq.ft. Low Ventin

.75 sq.ft. in each soffit – Low Venting

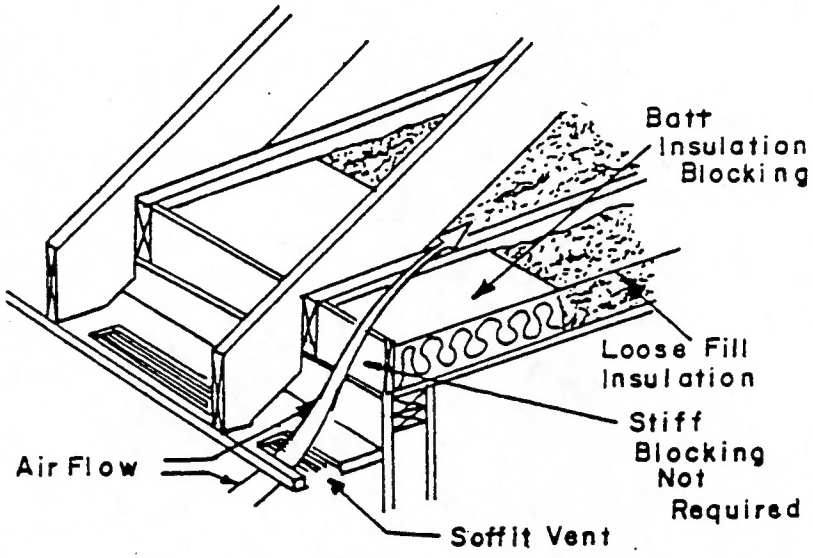
.75 sq.ft. in each of 2 gable vents (one each end).

Fig 4; Sec D

Recommended Procedure to Ensure Vent Performance



Blocking at Soffit Vent Using Rigid Baffle.

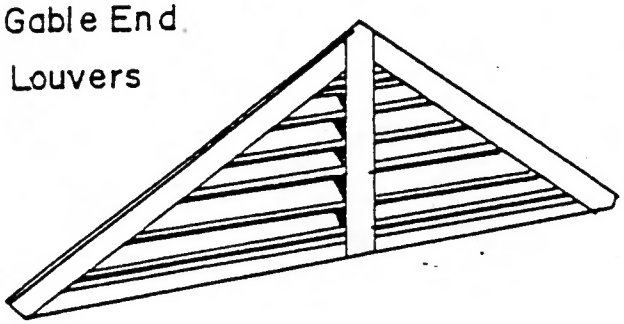


Blocking at Soffit Vent Using Insulation Batt.

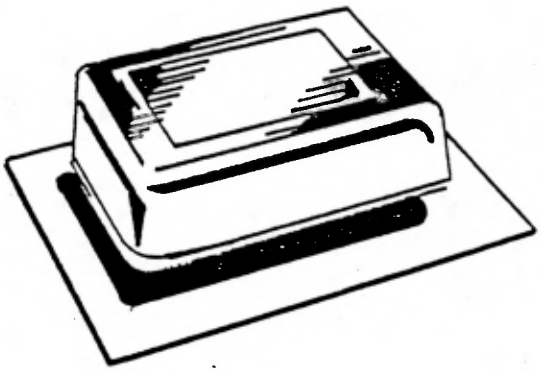
Fig 5; Sec D

Ventilator Types

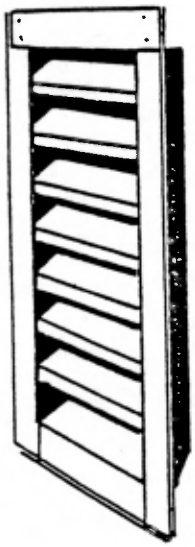
Gable End Louvers

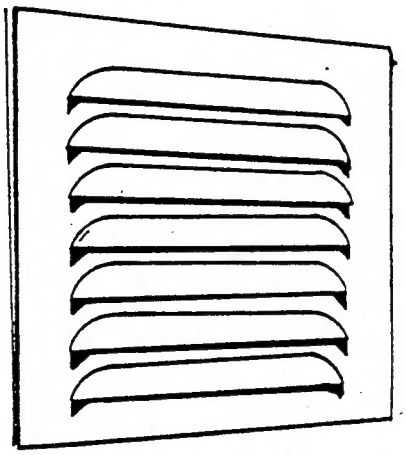


Roof Louvers

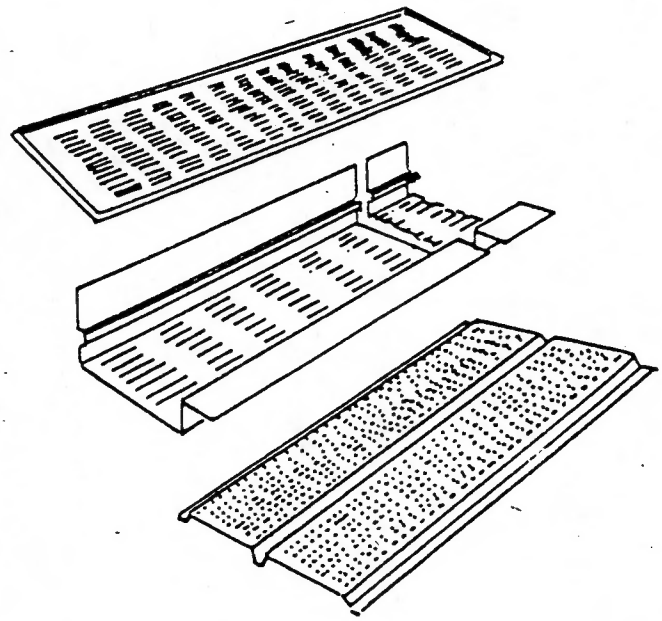


Rectangular Louvers





Soffit Vents



Ridge Vent

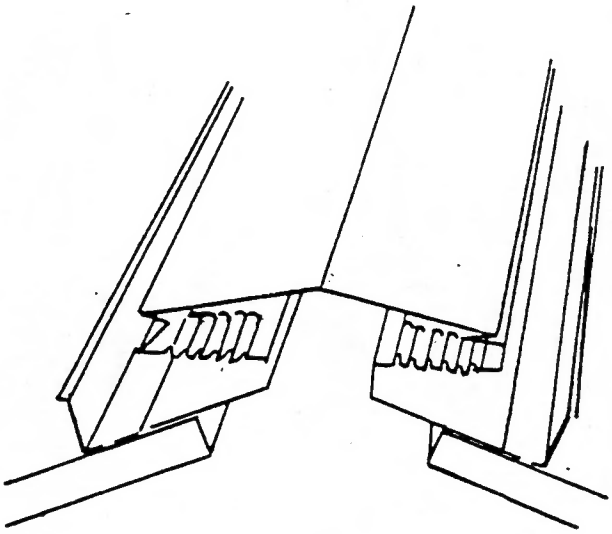
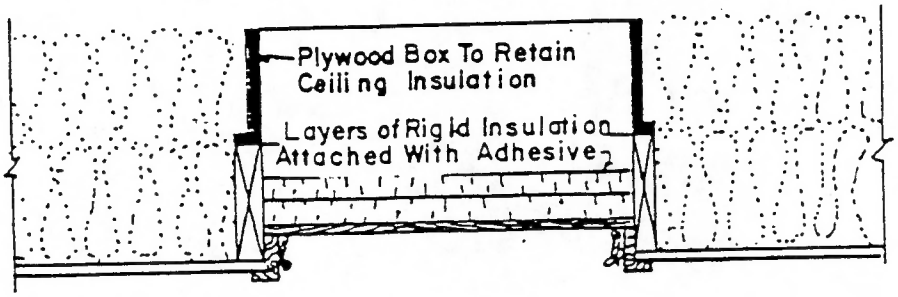


Fig 6; Sec D

Attic Hatch Construction Methods



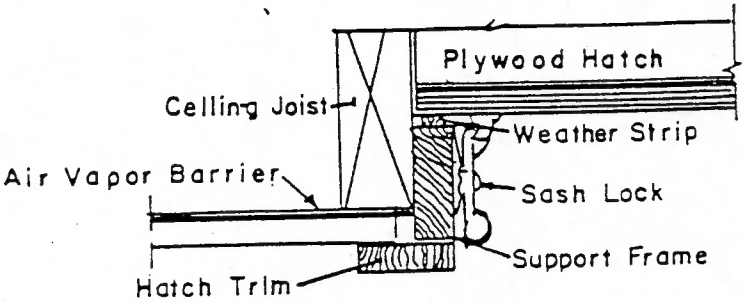


Fig 7; Sec D

f. Constructing an upside down box of rigid board insulation which fits over the folding stair is also permissible. Glue securely and attach a weatherstrip to the lower edge where it rests on the attic floor.

5. For access into a kneewall area construct a door type entry, either hinged or held in by turn buttons. Weatherstrip and insulate it to the same R as the surrounding wall.

6. Trim out access panels to match the home's interior and caulk where necessary to prevent infiltration/exfiltration.

7. Alternate methods for all the above procedures are acceptable as long as they achieve the same end result cost effectively.

8. In the very few cases where an access panel can not be installed ensure that the area insulated is inspected by an appropriate sub-grantee representative prior to the permanent sealing of such accessway. This may be the case when a roof or gable end vent opening is utilized as access to an attic or ceiling area. MSHA reserves the right to open a sealed accessway in the course of normal program monitoring.

WALL INSULATION

A. DEFINITION: A material or assembly of materials, which is designed primarily to resist heat flow installed in the wall cavity of a dwelling between conditioned and unconditioned space.

Installation Procedures

1. Fully insulate wall enclosed cavities. Insulate open studding to R-19 or capacity.

2. If faced insulation is used, the vapor barrier must always face the winter warm side. (Conditioned space)

   a. Cover all fiberglass installed in living quarters to ensure that:

      1) No damage to insulation will occur due to client lifestyle habits.

      2) Insulation will remain intact and perform as functionally intended.

      3) No potential health hazard will be created as a direct result of Weatherization activities.

   b. Cover vapor barriers with a 15 minute fire rated material, such as 1/2 inch drywall.

   c. If gypsum board is used to cover the fiberglass it shall be taped and mudded one coat.

3. Either the "two-hole," or "dense blow" method is acceptable. If using the two-hole method, never blow more than four feet down or 18 inches up. (See Fig 8; Sec. D)

4. MSHA requires that the siding be removed prior to drilling and, if necessary, replaced with siding to match the existing condition.

5. A Certificate of Inspection is required.

Recommendations:

Accessible Wall Cavity: The Maine State Housing Authority recommends the use of unfaced fiberglass with polyethylene vapor barrier, or faced (kraft or foil) fiberglass batts. Cover vapor barriers with a 15 minute fire rated material, such as 1/2 inch drywall.

Inaccessible Wall Cavity: Dense blow cellulose is recommended.

Buildings which cannot be insulated from the exterior may be done from the interior. It is permissible to drill plaster or sheetrock walls if the holes are corked, spackled and painted to match or if base boards, window and door trim, etc. are removed and holes drilled behind them. Obtain client permission prior to proceeding.

KNEEWALL AND SLOPE INSULATION

A. Definition: A material or assembly of materials, which is designed primarily to resist heat flow installed in the kneewall or slope ceiling cavity of a dwelling.

Installation Procedures

1. Insulate to R-19 whenever possible.

2. If faced insulation is used, the vapor barrier must always face winter warm side. (Conditioned space)

BASEMENT PERIMETER INSULATION

A. DEFINITION: A material or assembly of materials, which is designed primarily to resist heat flow through basement walls.

Installation Procedures

1. Perimeter insulation must be a minimum of R-10, installed on the interior excepting situations where rigid foam is used.

2. If faced insulation is used, vapor barrier must always face winter warm side. (Conditioned space)

3. A Certification of Insulation is required, as specified under the requirements for Attic Insulation.

4. If fiberglass is used and if the basement is considered a "lived in area" cover the insulation. Gypsum wallboard is recommended.

5. Insulate walls to two feet below grade, if technically feasible.

6. Seal the insulation to the wall at the bottom to prevent exfiltration.

Recommendations:

The Maine State Housing Authority recommends the use of vinyl faced fiberglass for below grade insulation.

SILL POCKET INSULATION (Band Joist)

A. DEFINITION: A material or assembly of materials, which is designed primarily to resist heat flow installed in the sill pockets or band joist of a dwelling.

Installation Procedures

1. Sill pocket insulation must be a minimum of R-11.

2. Carefully fit the insulation to prevent conditioned air from circulating around it. (Exfiltration)

Recommendations:

MSHA recommends the use of faced R-19 insulation for this activity.

FLOOR INSULATION

A. DEFINITION: A material or assembly of materials, primarily designed to resist heat flow, installed between the first level conditioned area of a building and an unconditioned basement or crawl space.

Installation Procedures

1. Floor insulation must be a minimum of R-11, a maximum of R-19. (See Fig. 10; Sec. D)

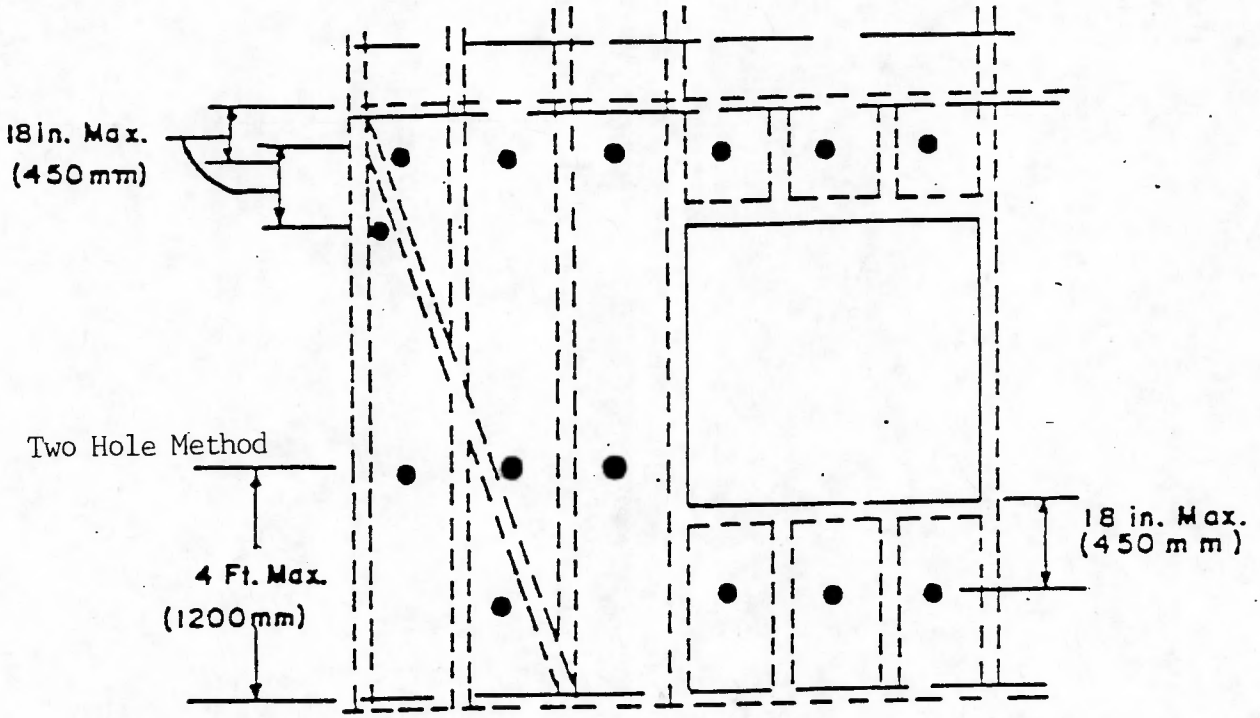
2. If using kraft or foil-faced fiberglass batts, the facing must be installed toward the conditioned area (upward).

3. Where insulation is to be installed beneath floors over crawl spaces:

   a. Cover the ground surface with a ground cover (polyethylene sheeting or, if the area is subject to foot traffic, 45 lb. roll roofing). Overlap the ground cover 1 foot at joints and carry it up the walls 6 inches. To prevent ground cover displacement, secure it with weights.

4. Provide one square foot of net free ventilation for every 1500 square feet of ground area with a ground cover. Install a minimum of two vents, located to allow cross ventilation.

Drill Pattern for Installation of Loose Fill Wall Insulation



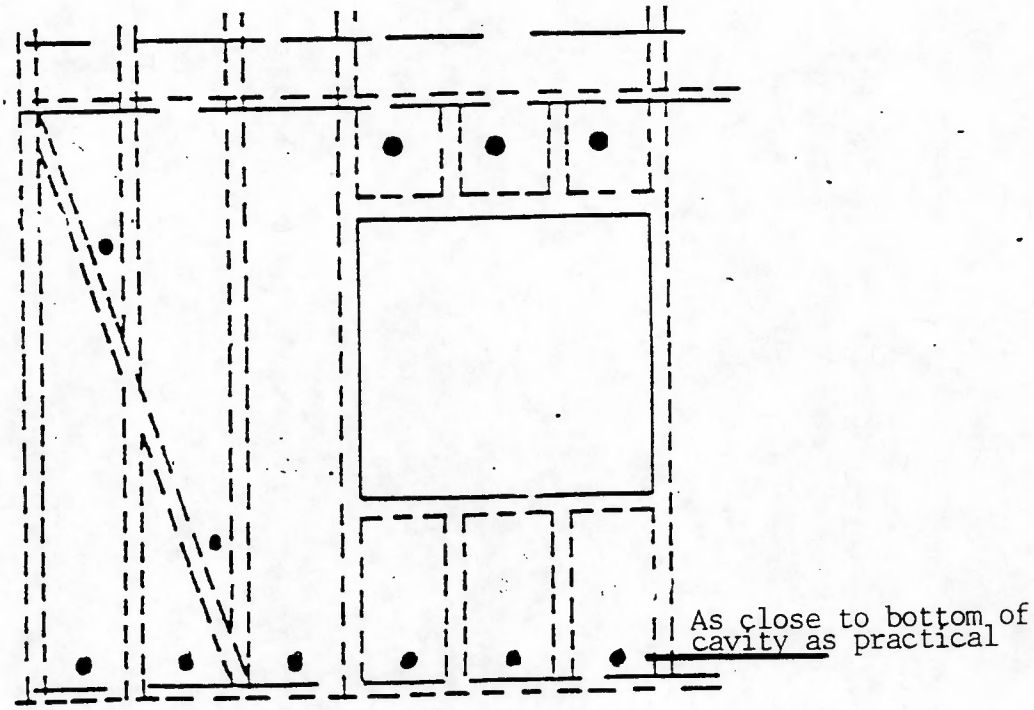


Fig 8; Sec D

5. Provide one square foot of net free ventilation for every 150 sq. feet of ground area not covered with a ground cover. Install a minimum of two vents, located to allow cross ventilation.

6. If the floor is insulated, insulate all space heating ducts and all hot/cold water pipes located in the unconditioned areas. Prior to insulating ducts seal all joints.

Recommendation:

MSHA recommends the use of vinyl mesh to hold the insulation in place.

RIGID BOARD INSULATION

A. Requirements:

1. Cover Rigid Board Insulation installed in living spaces with 1/2 inch sheetrock, taped and mudded one coat.

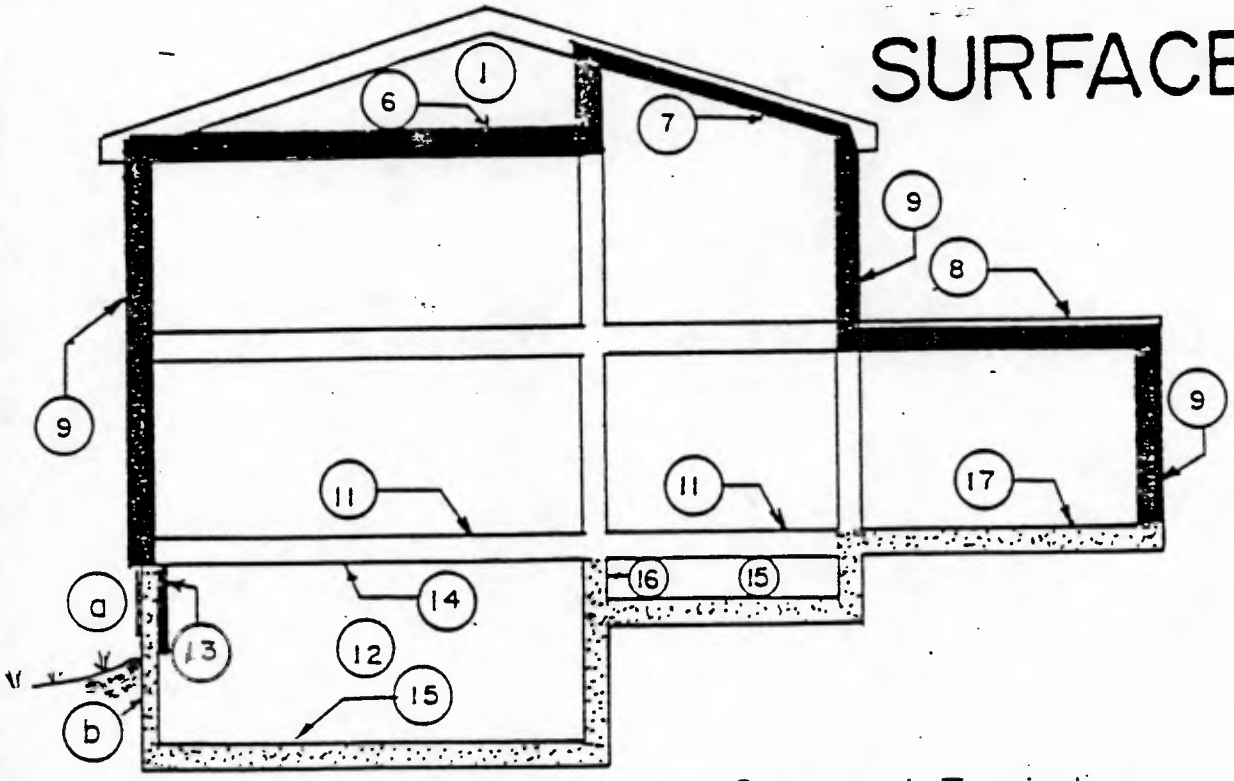
2. Protect Rigid Board Insulation from direct sunlight.

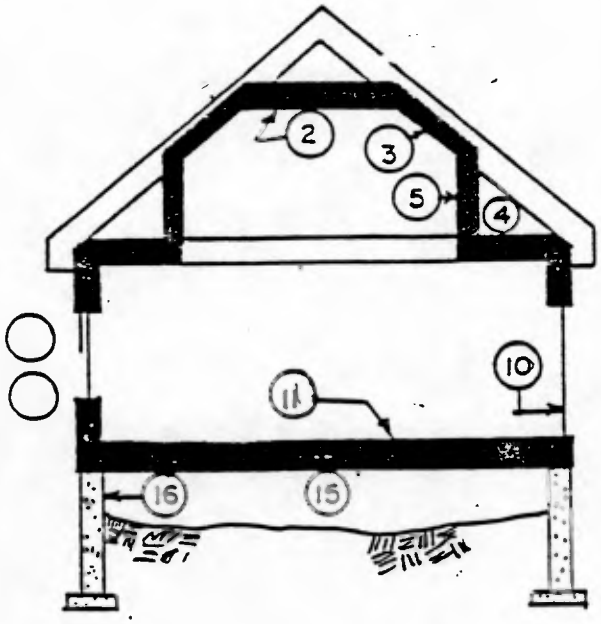
3. Glue Rigid Board Insulation with appropriate adhesives or otherwise securely fasten it in place.

Recommendations:

Rigid Board Insulation is most practically used to insulate unventable slopes or ceilings, on foundations or in sandwich type doors. As it is expensive per R, do not use it when other less expensive products or systems could be employed.

AREAS AND SURFACES





Suggested Terminology
Areas and Surfaces

1. ATTIC
2. ATTIC FLAT
3. ATTIC SLOPE
4. ATTIC CRAWL / Kneewall floor
5. KNEEWALL
6. ATTIC FLOOR
7. CATH. CEILING
8. FLAT ROOF
9. EXTERIOR WALL
10. EXTERIOR DOOR
11. FLOOR
12. BASEMENT
13. BASEMENT WALL
    a. Above grade wall
    b. Below grade wall
14. BASEMENT CEILING
15. CRAWL SPACE
16. CRAWL WALL
17. SLAB

Fig 10: Sec D

FLOOR INSULATION

Unconditioned Basement or Crawl Space

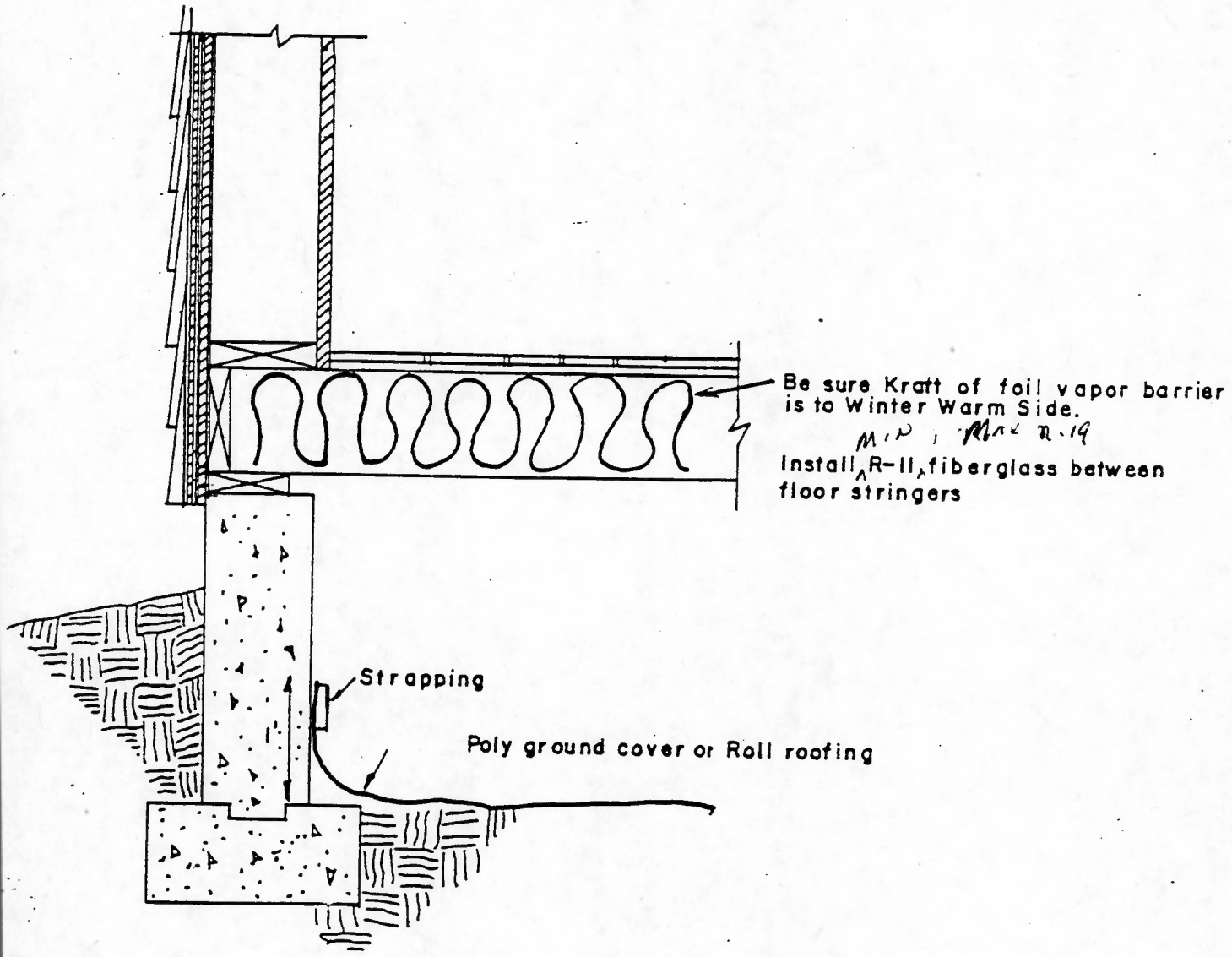


Fig 11; Sec D

INSULATION ON DOMESTIC HOT WATER HEATERS

A. SCOPE

1. This practice covers the installation of insulation around gas-fired, oil-fired, and electric resistance water heaters.

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.

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.

   NOTE: Some newer domestic hot water heaters have labels affixed that recommend no further insulation be added. Do not risk voiding the warranty by adding insulation.

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.

B. DEFINITIONS

1. Water heater insulation - a material designed to resist conductive heat loss, applied to the casing on the exterior of a water heater.

2. 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.

3. 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.

4. 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.

5. 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 reaches a certain point.

6. 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.

7. Vent pipe - an exhaust pipe carrying products of combustion from oil-fired and gas-fired water heaters to the outside environment.

8. Vent damper - a device which automatically closes the vent on design gas-fired appliances to prevent the escape of heat through the vent pipe when the main burner is not operating.

C. MATERIALS SPECIFICATIONS: See Appendix A

Pre-Installation Procedures

1. Determine the fuel type (gas, electrical, oil) of the water heater.

   a. The installation criteria differ with fuel type used.

Electric Resistance Water Heater

1. Determine the location of the pressure relief valve, thermostat control, and hi-limit switch (See Fig. 12; Sec. D)

2. Leave the pressure relief valve exposed to assure its proper functioning. The thermostat control and hi-limit switch need access for adjustments. Leave minimum three inch clearance where wire enters heater jacket. Leave the drain valve exposed so that the heater can be drained periodically.

Gas-Fired Water Heater

1. Determine whether the gas-fired water heater is equipped with a vent damper. Do not insulate gas-fired water heaters so equipped. (See Fig. 12; Sec. D)

2. Insulation of water heaters equipped with vent dampers may contribute 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.

3. Determine the location of the pressure relief valve and draft hood on the water heater (See Fig 12; Sec. D)

4. Leave the pressure relief valve 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.

5. Determine the location of the burner air inlet, pilot light access plate, and drain valve (See Fig. 12; Sec. D)

6. Care must be exercised not to cover the burner air inlet since this would interfere with proper combustion and lead to safety hazards. Covering the pilot light access plate would require removal of insulation whenever the pilot needs to be relighted. Leave the drain valve exposed so that the heater can be drained periodically.

Oil-Fired Water Heater

1. Determine the location of the pressure relief valve, vent pipe, and barometric draft regulator (See Fig. 12; Sec. D)

2. Leave the pressure relief valve exposed to assure its proper functioning; identify the vent pipe to determine whether the top of the heater can be insulated; leave the barometric draft regulator exposed for proper functioning and adjustment.

3. Determine the location of the thermostat control, peep sight, and drain valve (See Fig. 12; Sec. C)

4. Leave the thermostat control exposed for proper functioning and adjustment. Leave the peep sight accessible for inspection and the drain valve exposed so that the heater can be drained periodically.

Installation Procedure

NOTE: The procedures pertain to all types of water heaters except where noted.

1. Handle insulation in accordance with manufacturer's instructions. Keep it dry and free of extraneous materials.

2. Prepare the section(s) of insulation in accordance with the insulation manufacturer's instructions. If no instructions are available, the following procedure is recommended:

   a. Cut the insulation such that the finished height is 4 inches less than the distance from the floor to the top of the water heater and the length is 7 inches greater than the circumference (distance around) of the water heater.

   b. 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.

   c. Apply the insulation to the water heater with the facing to the outside. The facing is designed to protect the insulation from damage.

   d. Secure the sections of insulation to the water heater using a tape or alternative materials of the size and type recommended by the insulation manufacturer.

   e. Use vinyl duct tape 3 inches or wider unless the insulation manufacturer specifically recommends another product.

f. Ensure that the insulation is secured to the tank to minimize the likelihood of the insulation slipping down.

3. Do not install insulation over the water heater operating instructions and other components identified below.

4. 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.

Electric Resistance Water Heater

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.

2. Install insulation on the sides and top plate of the water heater. (See Fig. 12; Sec. D)

3. Cut the insulation to leave holes for the pressure relief valve, thermostat control, hi-limit switch, plumbing pipes, and other necessary access plates. Remove these cut-outs from the premises. This will provide the needed access for servicing the water heater after insulation installation, and for proper operation of the water heater.

   a. Leave a 3 inch hole in the insulation around the electrical cable.

4. Secure measured sections of insulation to the exterior of the water heater using mechanical fasteners (wire and/or staples) or manufacturer supplied straps to prevent loosening and slipping of the insulation. Use tape to cover any exposed insulation.

5. Insulate the first 3 feet of hot and cold water lines emerging from the tank, where accessible.

Gas-Fired Water Heater

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 gas-fired water heaters.

2. Do not install insulation on the top plate of gas-fired water heaters.

3. 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.

4. 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.

5. Reduce gas water heater temperature by turning burner control dial to a setting between warm and hot. Client permission must be obtained prior to reducing the temperature.

6. Apply measured insulation to the exterior sides of gas fired water heaters with the vapor barrier facing outward.

7. Gas fired water heaters with top mounted vent pipes will not be insulated on the top of the tank.

8. Insulate gas fired water heaters with side mounted vent pipes on the top and sides of the tank maintaining a 3 inch clearance between insulation and vent pipes.

9. Apply water heater insulation on gas units to cover only the water storage tank leaving the bottom burner access totally uninsulated.

Oil-Fired Water Heater

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.

2. If the vent pipe is top mounted, do not install insulation on the top plate of the water heater.

3. Flue pipe temperatures may range from 370°C to 430°C . 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 4 inch clearance requirement makes the insulation of the remaining top impractical and not cost-effective.

4. If the vent pipe is side mounted, maintain the minimum vent connector clearances specified in the latest edition of NFPA 211.

5. 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.

6. 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.

7. 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. Reduce fuel oil water heater temperature by turning bottom burner control to a setting between warm and hot. Client permission must be obtained prior to reducing the temperature.

9. Apply measured insulation to the exterior sides of fuel oil water heaters with the vapor barrier facing outward.

10. Do not apply insulation to the top of fuel oil water heaters with top mounted vent pipes.

11. Insulate fuel oil water heaters with side mounted vent pipes on the top and sides of the tank maintaining a 3 inch clearance between insulation and vent pipe.

12. Apply water heater insulation to oil units to cover only the water storage tank leaving the bottom burner access area totally uninsulated.

13. Cut but do not remove insulation over upper limit switch cover plate so as to provide a flap access to limit switch.

14. Cut insulation to allow pressure relief valve, plumbing pipes, burner control cover and drains to remain exposed after insulation is installed.

15. Secure measured sections of insulation to the exterior of the water heater using mechanical fasteners (wire and/or staples) or manufacturer supplied straps to prevent loosening and slippage of the insulation. Use tape to cover any exposed insulation.

16. Insulate, where accessible, the first 3 feet of hot and cold water lines emerging from the tank.

Post-Installation Procedures

1. Ensure that the insulation is securely attached to the water heater.

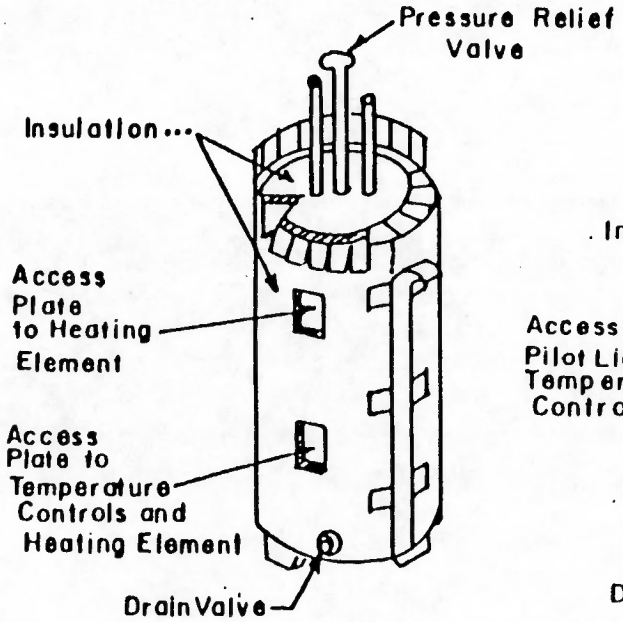
2. Inadequate attachment may allow the insulation to slide down or to the floor, or off the appliance entirely. This will reduce the effectiveness of the insulation. If the insulation slips down over the burner air inlets on gas and oil-fired appliances, it will interfere with proper combustion and reduce efficiency, and may cause the release of toxic combustion products.

3. 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.

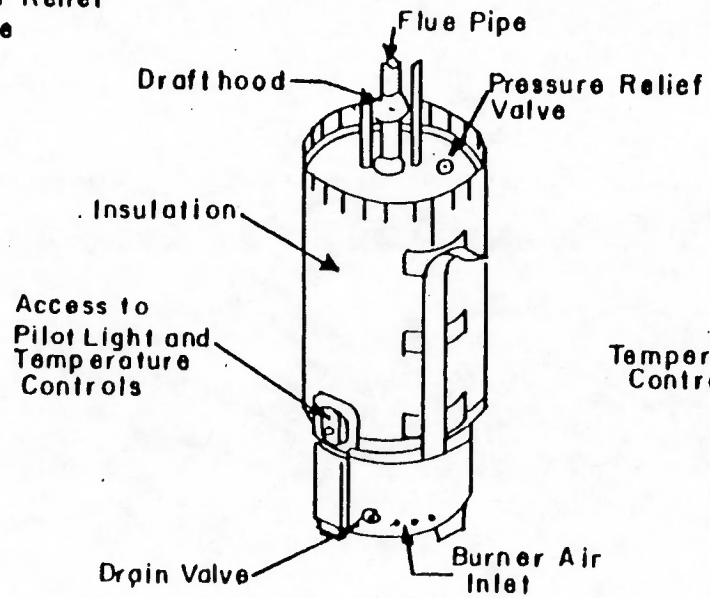
4. Ensure that air inlets, access plates, drain valves, temperature controls, and pressure relief valves are not covered by insulation.

5. Remove insulation cutouts and waste from premises.

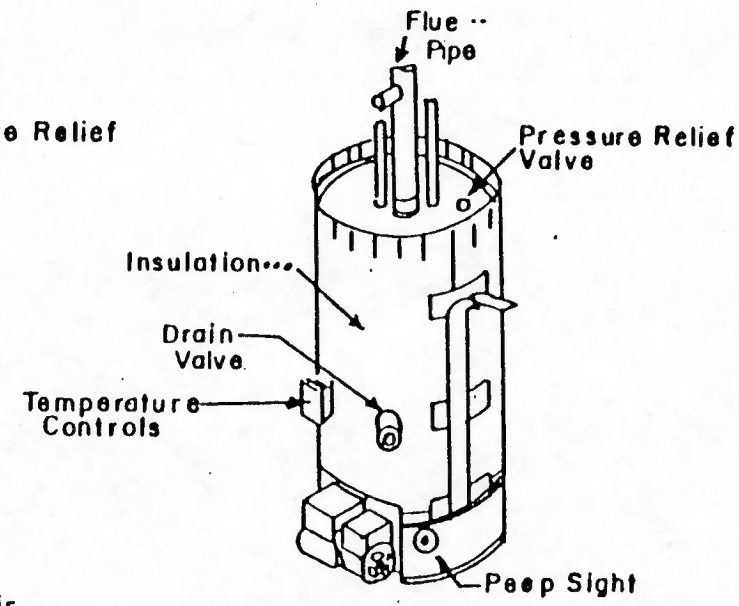
Insulation Techniques For Domestic Hot Water Heaters



Electric Water Heater



Gas-Fired Water Heater



Oil-Fired Water Heater

• Only found on water heater with two heating elements.

•• The pipe may be side mounted

••• Top insulated on all electric water heaters and oil-fired water heaters with side-mounted flue pipes

SECTION E

AIR LEAKAGE CONTROL

SECTION E

AIR LEAKAGE CONTROL

Air leakage control activities are divided into six categories for your convenience.

Section E - Part I - Sealing Major Air Leaks in Walls

Section E - Part II - Duct Sealing and System Balancing

Section E - Part III - Caulks and Sealants

Section E - Part IV - Weatherstripping

Section E - Part V - Door Treatments

Section E - Part VI - Window Treatments

Because it is extremely difficult not only to locate leakage paths but also to determine which air leakage/pressure difference control methods are cost effective without the use of proper technical equipment, i.e., blower door, digital manometer, etc., the Building Technical Committee recognizes that all weatherized homes must receive such testing prior to air leakage measures determination. Beyond this the Technical Committee also recognizes that conductive weatherization measures contribute significantly to air change reduction making post testing necessary in order to evaluate post weatherization air quality and combustion appliance safety. Additionally: As the Maine system of assigning energy saved values for air leakage/ pressure difference control measures only applies to blower door determined air change reductions any measures undertaken without pre and post blower door testing of the unit will adversely affect the SIR equation.

SECTION E

Part I

The following is excerpted from *Fixing the Building Shell; Gautam Dutt, Gary Nelson, Jim Fitzgerald & Lester Shen*

Obviously, you will not see the leakage reductions if the opportunities do not exist in the house. If the cavity isn't leaking, it won't tighten with filling. Very tight construction does not release air and voids occur when air back-pressure prevents the flow of material. High density blowing works better on leakier houses. We have found that the houses that show the greatest impact are those that have a pre-weatherization blower door reading (in cfm50) that is greater than the above ground surface area of the house (in ft2). In these houses the insulation takes care of many small air leaks through the walls and greatly reduces the effect of later air sealing.

Settling of insulation is not an issue at 3.5 to 4 lb/ft3 density; however blowing off the wall is a concern. The higher air pressure required to pack insulation tight enough to stop air leaks is sometimes too much for wall plaster and paneling. This is disastrous occasionally and will continue until the crew learns vigilance. If you crack a wall, please don't continue to fill the entire room. Cleaning and patching are unfortunate facts of life with wall filling, but need not be a part of many jobs. We strongly encourage proper training in the field.

Air leakage reductions will not be realized if a leaky cavity is filled with low-density insulation. Conductive losses will not be minimized if the density is low and there are voids. MWX90 calls for a "no leaks - no voids" attitude to wall insulation.

STEP 2: SEALING MAJOR AIR LEAKS IN WALLS

Insulation is expected to seal small air leaks through the wall, but large air leaks need special attention. We have noted that the insulator should be on the lookout for these major defects. Here we describe what they are and how they are best fixed.

Porch Attached to the House

This is a common situation that permits significant heat losses. Figure 6-3 shows the cross section through a typical porch-house connection. The porch in this case is totally open. We define the thermal boundary to be at the outside wall between the house and the porch and, therefore, the porch roof cavity is outside of the thermal boundary. There is no siding on the part of the wall hidden behind the porch roof (unless the porch was added on later), and the sheathing is either leaky or completely missing (Figure 6-3). Cold air from the porch roof cavity can get into the space between the two heated floors of the house, increasing heat losses. If there is any plumbing near the porch connection, the cold air penetration can cause pipes to freeze in cold climates. There are several ways this can be fixed.

One way to seal the leaks is by blowing insulation at high density from above and below. It is important to measure carefully to make sure that the insulation not only covers the first and second floor walls but also the space between the floors. If there is no sheathing at all, there will be nothing to keep the insulation in place. It is best to open up a part of the porch ceiling to look at the situation. If there is no sheathing, fiberglass insulation batts should be inserted a foot or so into the space between the floors and insulation should be blown tightly against it to stop the leak. Alternatively, cellulose can fill the entire void if it is blown at high pressure initially (Figure 6-4).

Blowing into the space between the floors is particularly difficult when there is a window that ends close to the porch ceiling on the lower floor, or a second floor window that comes down close to the porch roof, or both. Again, opening the porch ceiling is one

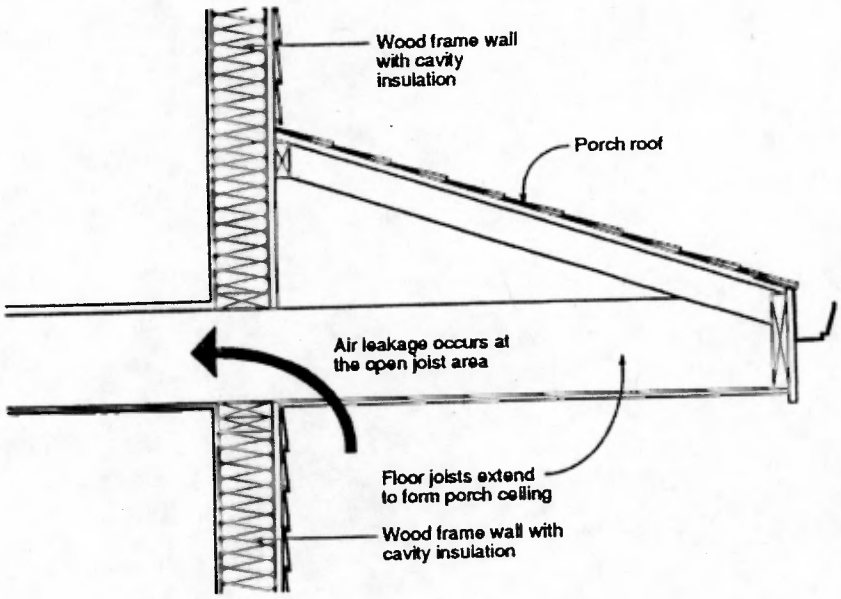


Figure 6-3: Cross section of a typical porch/roof connection illustrating air leakage through the rim joist.

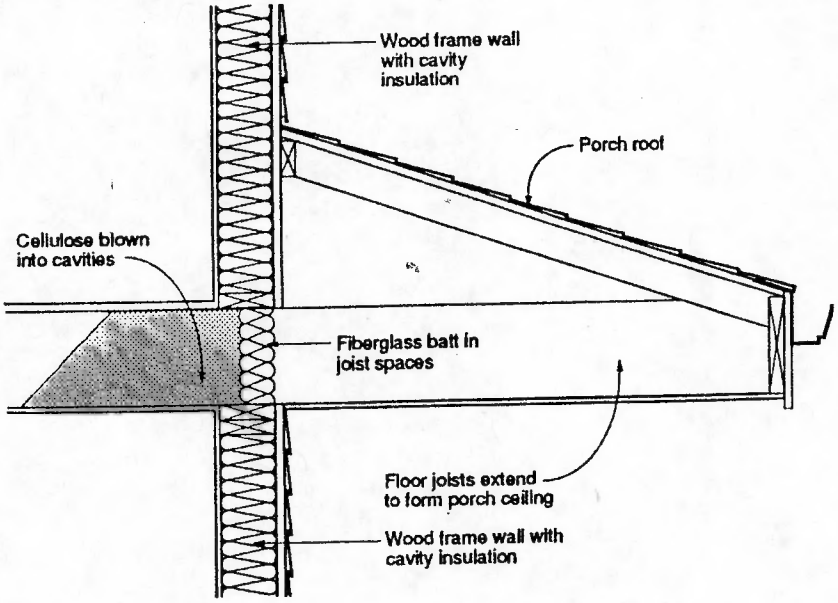


Figure 6-4: The air leakage path through the rim joist at a porch roof can be treated by packing cellulose insulation into the voids and covering with fiberglass batts to hold the cellulose in place.

way to gain access. Alternatively, an appropriate molding may be removed and the space blown with insulation using a smaller tube.

Bathtub on an Exterior Wall

Even without a porch or cantilever, a bathtub on an exterior wall is often a big air leak that can lead to freezing pipes. The reason is that interior drywall, and possibly the sheathing, may be missing where the bathtub is against the outside wall. Additional siding may have to be removed to inspect the situation. Then, fiberglass batts may need to be installed in the cavity around the tub, a foot or so in from the exterior, so that insulation can be blown tightly into the wall cavity where the bathtub is located.

Second Floor Overhangs

Sometimes the entire second floor is cantilevered over the first floor (Figure 6-5). The overhang is usually very leaky. Since it is an enclosed space, the leakage can be stopped by blowing tightly with insulation (Figure 6-6).

Sometimes only a closet or bay window in the second floor overhangs the first floor wall, but by a bigger amount. This leak, which invariably causes cold floors upstairs, is also readily sealed by blowing tightly with insulation.

Combined Second Floor Overhang and Porch Roof

Life gets more complicated when the second floor overhang gets combined with a porch roof cavity. There is a much larger opening for cold porch air to enter the space between the floors, leading to bigger heat losses (and colder floors) than in the case where there is no cantilever. If there is no sheathing where the wall is enclosed by the porch roof, parts of the wall will need to be insulated with fiberglass batts, since there is nothing to hold blown insulation in place.

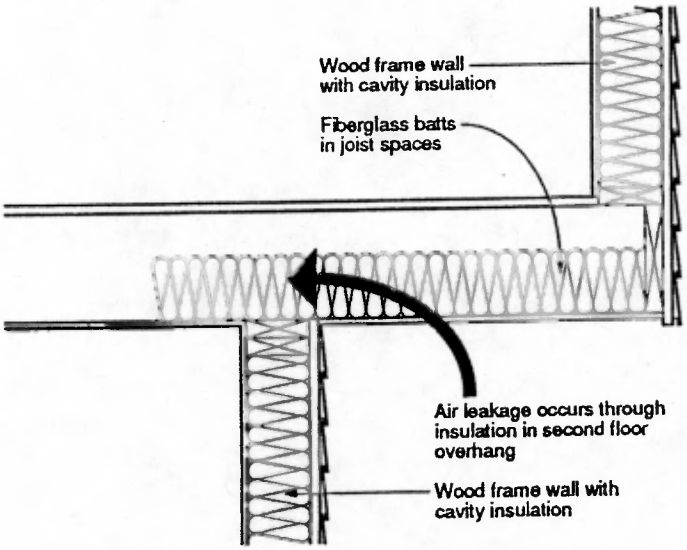


Figure 6-5: Cross section illustrating air leakage through the joist spaces of an overhanging second floor.

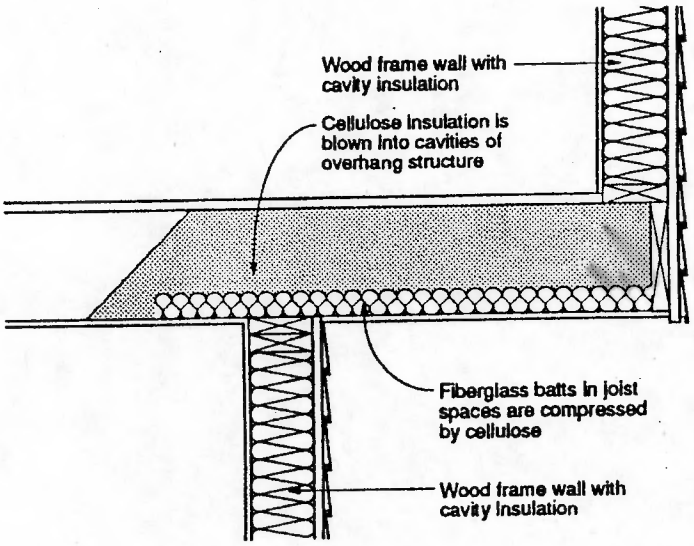


Figure 6-6: The air leakage path through the overhang area can be treated by packing cellulose insulation into the joist cavities. The existing fiberglass insulation is compressed by the cellulose.

Soffited Ceiling on an Exterior Wall

A similar situation occurs where there is a soffited ceiling on an outside wall in the first floor. The drywall is likely to be missing at the soffit, allowing air to leak into the space between the floors (Figure 6-7). If the walls are being insulated, it is easiest to fill the soffit with insulation (Figure 6-8)—unless there is a recessed light in it. A soffit with a recessed light should not be blown with insulation as this could cause the light to overheat, resulting in a fire hazard. Read the label inside the light, if it is IC, blowing is safe.

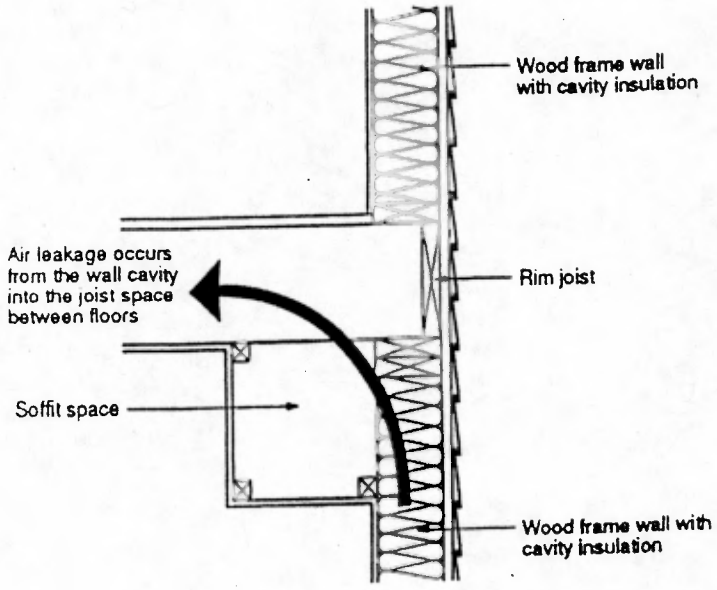


Figure 6-7: Cross section illustrating air leakage from the exterior wall through an open soffit and into the floor joist spaces.

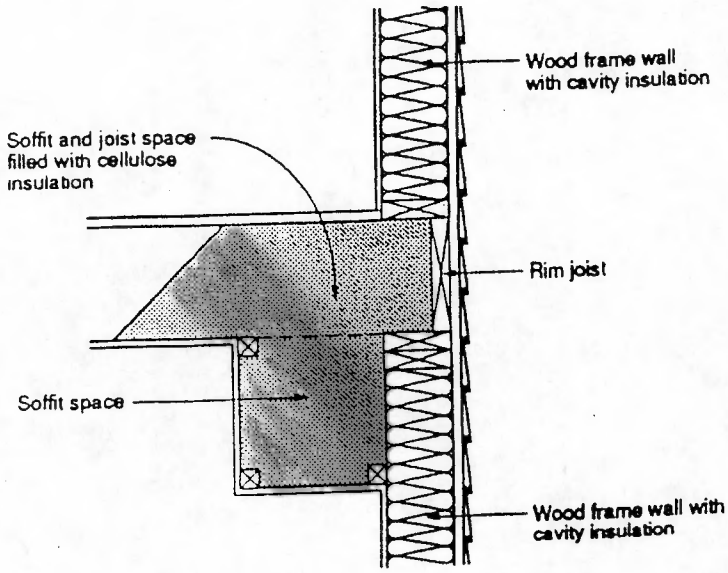


Figure 6-8: The air leakage path through the soffit area can be treated by packing cellulose insulation into the soffit area and joist cavities at the perimeter.

If it is not IC-rated, however, it must be protected from overheating, or replaced with a flush mount or IC-rated fixture. Before blowing near a non-IC rated fixture in a soffit, first drop the fixture down out of it's holder. Usually this requires loosening 3 or 4 screws or a couple springs. Stuff batting in the hole. Blow the soffit tight. Then push back the blown insulation with fg batt so no insulation comes within 3" of the fixture. Check every recessed light that can possibly become covered. Install a rigid barrier or remove it if it can't be isolated from the insulation.

Heating and Cooling Ducts on Exterior Walls

This condition can also cause trouble. The space taken up by the ducts greatly reduces the space left for adding insulation, where it is most needed. Drilling should be done carefully to avoid damaging the ducts. The air in a supply duct is at a higher pressure

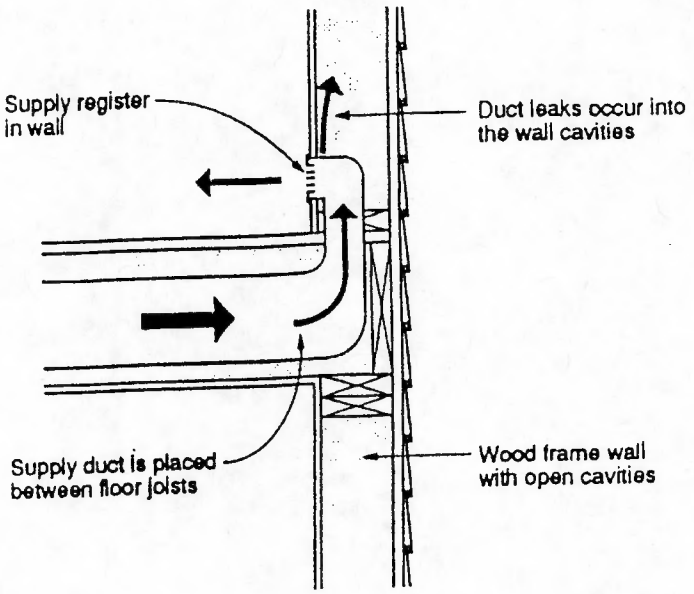


Figure 6-9: A supply duct in an exterior wall can lead to several problems: there is less space for insulation in the exterior walls, duct leaks result in heated air escaping out of the house, energy waste , and possibly house depressurization.

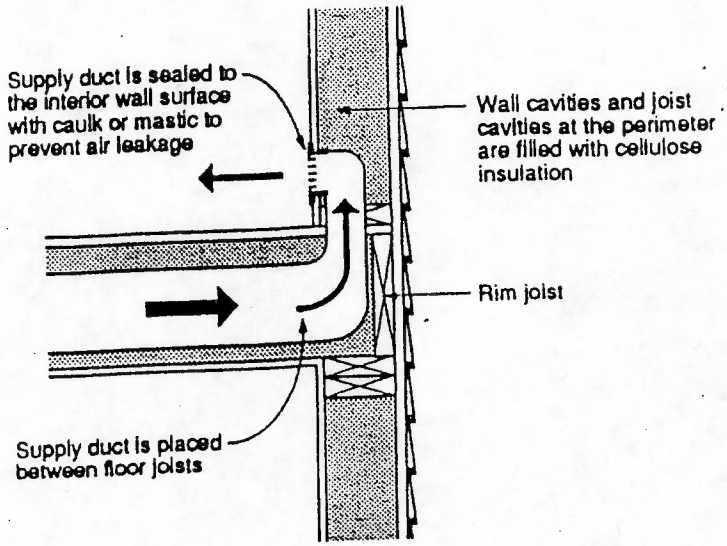


Figure 6-10: Problems associated with leaky supply ducts can be controlled by sealing ducts to prevent leaks and filling exterior wall cavities around the ducts with cellulose insulation.

than the air outside and any duct leaks cause air to leak into the wall cavity (Figure 6-9). The wall cavity above the duct should be tightly blown with insulation to reduce the loss of conditioned air directly to the outside (see Figure 6-10).

The reverse happens when joist spaces are used as return plenums. Now the spaces get depressurized relative to the surroundings and tend to draw in cold outside air into the house through cracks in the outside wall (Figure 6-11). If accessible through a return register, these joist spaces should be carefully sealed to keep outside air from getting in. Figure 6-12 shows sheet metal carefully sealed to block this air bypass.

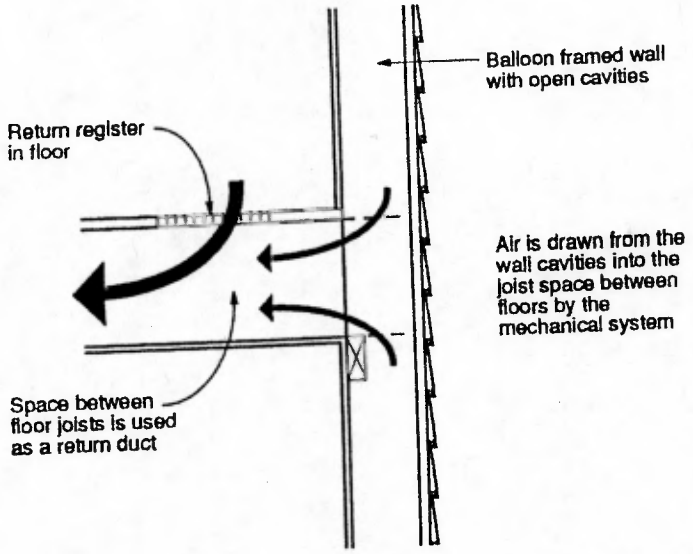


Figure 6-11: Often, return air ducts are formed in floor joist spaces. With balloon frame construction, this can draw air from the exterior wall assembly.

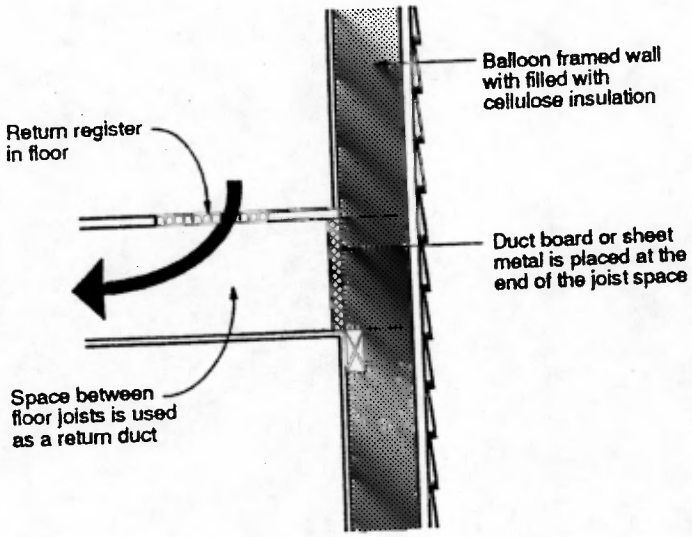


Figure 6-12: The air leakage paths created by return air ducts can be minimized by placing metal or duct board at the end of the joist space and filling exterior wall cavities with cellulose.

Check with Infrared Viewer

If an infrared viewer is available, it should be used to make sure that these large air leaks, which can bypass the benefits of the wall insulation, have been effectively sealed. For an infrared inspection, turn on the blower door to depressurize the house to about 15 or 20 Pascals. Scan the exterior walls for voids. Then inspect the first floor ceiling to see if it turns cold (assuming winter conditions) as outside air leaks through any hidden leakage paths into the space between the floors.

When an infrared viewer is not available, a test can also be done using a blower door alone. With the blower door set to depressurize the house, any leakage into the space between the floors may show up as leaky floorboards upstairs or as air coming out of openings in the first floor ceiling. Without the infrared viewer, it will not be obvious where the air is leaking through, and additional checking with the smoke pencil may help to identify the air leakage path. A sure way is to open and look into porch roof cavities or removing additional siding to look for places where sheathing may be missing or very leaky.

SEALING WALL AIR LEAKS FROM THE INSIDE

We have seen how insulation is blown tightly to take care of many wall air leaks and how certain large air leakage paths through the walls are sealed from the outside. This leaves relatively few air leaks through the walls and these can be sealed from the house interior. Except for the so-called straight-through leaks, the place where the air leaks into the wall cavity from the outside is not the same as where it leaks from the cavity into the house interior (see Figure 6-13). Air coming in through a wall leak may come into the house interior at an interior partition or floor. This is not the location of the thermal boundary. To maximize energy savings, every attempt should be made to seal the leaks at the thermal boundary.

Below we will first consider relatively larger leak and, then smaller leaks from the wall cavity to the inside. Following that we will consider doors, windows, and other straight-through leaks. Finally, we will look at the problems associated with attached garages and sheds. These leaks are sealed using the blower door as a guide to determine the relative importance of the various leakage paths. The leaks are then sealed in order of ease and importance until the air-sealing is no longer cost-effective or the blower door readings show us we're approaching a natural ventilation limit. These limits are discussed at the end of the chapter. In this discussion, for simplicity, we refer to outside air leaking in through this or that opening, although of course the flow may be in the other direction, and both directions are important for air sealing.

Large Leaks from Wall Cavity into the Interior

Many of these leaks can be sealed from the outside when the insulation is being blown. Some may remain, however, and will need to be treated from the inside. The large leaks we will discuss are soffited ceilings, dropped ceilings, ducts in interior ceilings or partitions, the space between floor joists, staircases on exterior walls, fireplaces, and pocket doors.

We have already mentioned the case of the soffited ceiling where there is another conditioned space above (see Figure 6-8). If the walls are being insulated, this leakage path should be sealed by tightly packed insulation. If not, it may be sealed from the inside.

Rooms with dropped ceilings (with fiberglass ceiling tiles hung below the normal ceiling) may be located with a heated space above. In this case, the wall leaks are of concern. Moving one or two ceiling tiles out of the way will reveal where leaks might be present and the blower door can be used to determine how important they are. The leaks may be sealed with caulk or, since the space is hidden from view, with foam.

Ducts in interior ceilings or partitions should not matter unless they are dumping air into, or drawing air from, spaces outside the thermal boundary. Supply duct leaks outside the thermal boundary tend to depressurize the house (apart from dumping

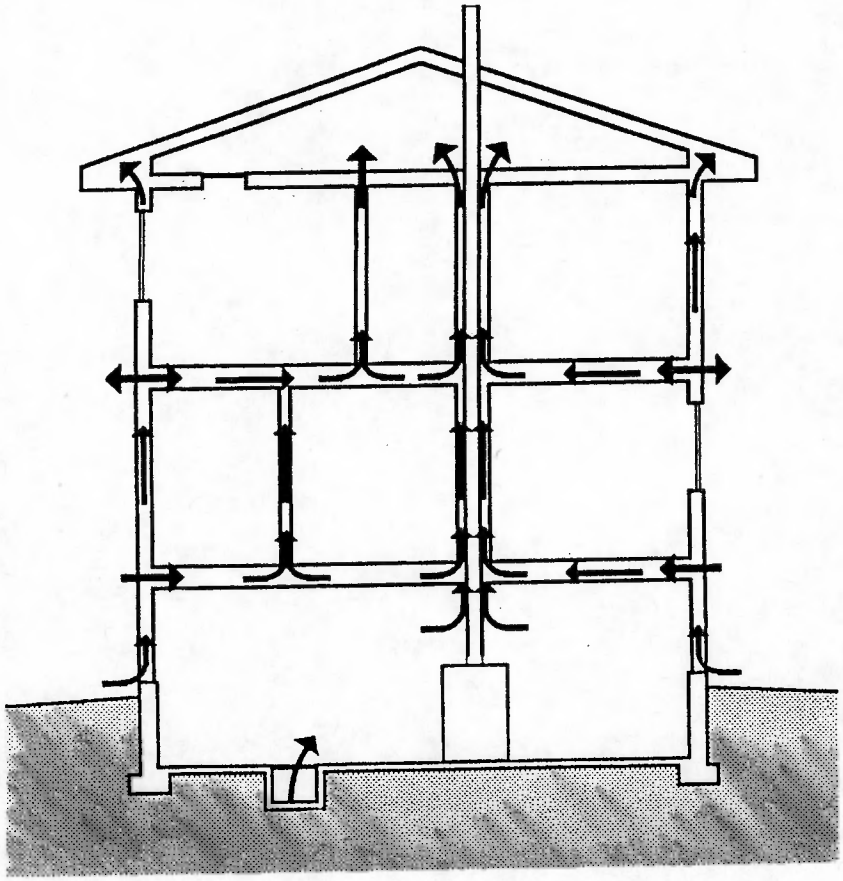


Figure 6-13: Many air leakage paths in houses do not pass through exterior walls.

conditioned air outside) and are important to locate. If such leaks are present, as indicated by the infrared viewer or by smoke movement with the blower door running (with distribution fan off), they will need to be sealed. The best place to seal would be at the thermal boundary (typically an exterior wall or attic floor). For wall penetrations, blowing insulation at the appropriate location from the outside may be the best alternative. If not, access may be possible by removing the register grill, and sealing the opening with foam. Alternatively, a section of the partition or ceiling may have to be removed to gain access. Clearly, the opening will need to be carefully closed up, spackled, and painted.

Hollow partitions for fish tanks, stereos, etc. may be connected to an outside air leak. Again, it will be important to locate where the air leak is crossing the thermal boundary and seal it there, if possible.

The space between floor joists between heated spaces may bring outside air into house interior, where it may leak out between floor boards into the upper story or through ceiling fixtures or other openings into the lower story. This is particularly severe in houses with balloon-frame walls, where the outside wall cavity is usually well connected to the floor joist spaces (see Figure 6-14). The leak is much less in platform construction (Figure 6-15). With the blower door running, leaky floorboards or ceiling leakage is an indication that this leakage path is important. The MWX90 wall insulation procedure should take care of the leak. If insulation is not being added, it may be selectively blown into the outside walls between the floors. Sealing from inside requires drilling into the ceiling near the exterior wall, and blowing insulation in. This method is much more time consuming and extensive patching will be needed afterwards.

Staircases on exterior walls can also hide air leakage paths. The space below the stair treads may be connected into the wall cavity, and again the most effective fix is to blow insulation from the outside. To retain the insulation it may be necessary to put in some fiberglass batt insulation into the cavity first, and then blow the insulation against it. If exterior insulation is not possible, the ceiling below the stairs may be drilled and insulation blown into the space where the stairs connect with the outside wall.

Fireplaces also contribute to house leakage in various ways. The biggest leak is usually the chimney itself, and any attempt to reduce this—tighter-fitting dampers, fireplace doors, etc. — has a big impact on house air leakage. Other leaks are found where the fireplace is installed on the wall. If the fireplace is on an exterior wall, these openings are in the thermal boundary and should be sealed with silicone caulk. If the fireplace is on an interior wall, and the blower door indicates that the joint around the fireplace is leaking, the leak may be connected to an exterior wall or an attic through partition walls. The best place to seal the leak would be at the thermal boundary (the exterior wall or attic). If this is not possible (e.g. because there is a flat roof without access to seal the tops of the partition walls), only then should these leaks be sealed around the fireplace; this sealing would not fix the convective loop problem.

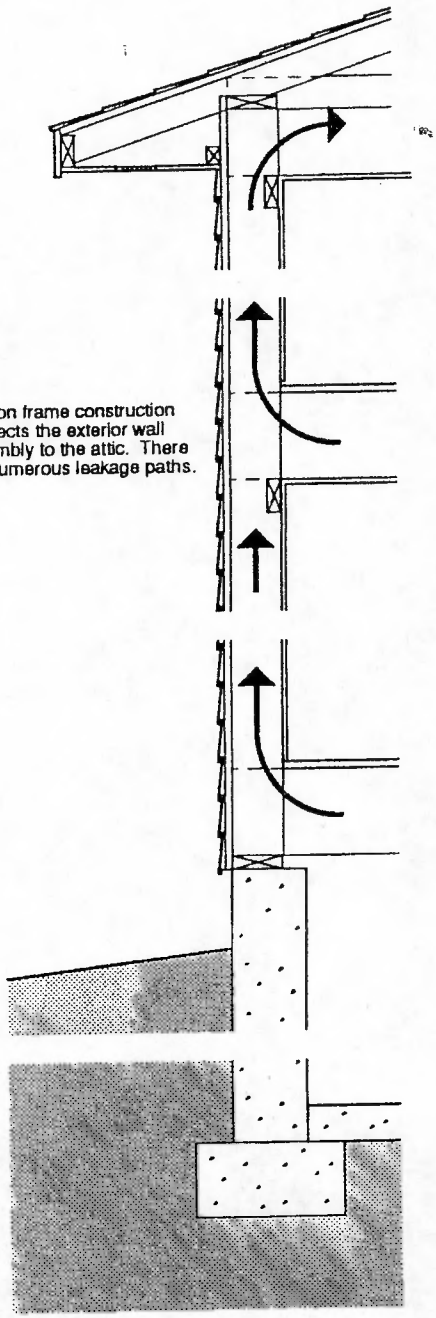


Figure 6-14: Balloon frame construction connects exterior wall cavities to the attic. Sometimes the wall cavity also connects the basement to the attic, leading to large heat losses.

A pocket door installed against an outside wall can be a major air leak that cannot usually be taken care of by wall insulation alone. Typically, the pocket door cavity connects into the wall cavity and any wall insulation blown into the wall cavity passes into the pocket door cavity. This not only reduces the effectiveness of the insulation and does not seal the air leak but also can prevent the pocket door from operating properly. To fix the problem, remove the pocket door (by first removing the stops) and stuff batts of fiberglass into the back of the pocket door cavity, for the wall insulation to be blown against. Make sure the fiberglass does not hinder the movement of the door and then blow the wall cavity tight from the outside. With the fiberglass serving to hold it in place, the insulation can be installed without voids and help seal the air leak at the same time.

Smaller Leaks from the Wall Cavity into the Interior

A number of smaller leaks from the wall cavity into the house interior may be worth fixing depending on their magnitude. These include: floor and ceiling moldings, wall cracks and holes, wall mounted light fixtures, medicine cabinets, plumbing holes into walls under kitchen and bathroom sinks, plumbing intrusions around faucets, shower piping, ceiling and bathroom fans, etc. Even smaller in magnitude (though over-rated because of some erroneous measurements in the early 1970s) are electric light switches and outlets. These openings, located on exterior walls, i.e. on the thermal boundary, may be sealed up with caulk. If the leak is on an interior wall or ceiling, it is a symptom of a leak somewhere on the thermal boundary, and the first attempt should be made to locate this leakage site. Only if it cannot be located, or the boundary is inaccessible (e.g. a wall cavity ending in a cathedral ceiling) should the leak be sealed at the site found.

Straight-through Leaks

Among straight-through leaks, i.e. those that pass directly through the thermal boundary, are leaks around doors and windows as well as kitchen, bathroom, and other exhaust fans. In doors and windows, greater emphasis should be placed on those sites which can be sealed in a durable manner, typically where moving parts are not involved. Moldings around exterior doors may be sealed with caulk; the top of the door which is not normally visible may be the biggest leakage site. The threshold may be leaky, especially at the ends, and can also be caulked. In weatherstripping doors, a resistant material should be used and installed in such a way that the door can be opened and closed without difficulty. In windows, too, the emphasis should be on stationary leaks, e.g. around the molding. Weatherstripping should be a low priority in most cases, except where there is a comfort problem associated with a particular window. Many experiments, including some at Princeton, have shown that good quality weatherstripping can reduce the leakage through the window by 50 percent or more.

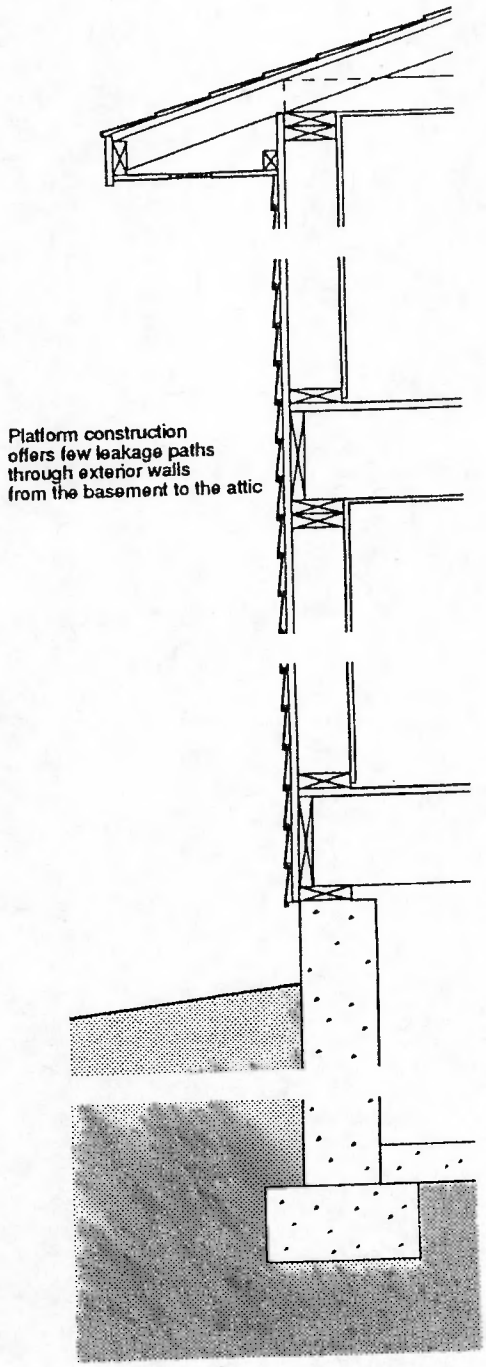


Figure 6-15: Platform construction allows few air leakage paths to the attic from the exterior wall cavities and the basement.

However, since leakage between the movable parts of the window is only a small part of total house leakage, the effect of weatherstripping on reducing whole house air leakage is small, especially in relation to its cost. In windows with pulleys, the pulley hole is a significant, indirect leakage path and may be sealed, for example, using a commercial product such as Pulleyseal.

Recall that the leaks described above should be sealed, guided by blower door measurements of house leakiness. Air sealing should be stopped when either the economic or the airtightness limit to air sealing is reached. These limits are discussed in the last section of this chapter.

STEP 3: SEALING ATTIC BYPASSES

Air leaks from the living space to the attic and convective loops in the attic often account for a significant part of a house's heat losses. Blowing insulation on the attic floor buries these defects but often the bypass heat losses continue. Since the attic floor is not a closed cavity, the air sealing effect of blowing insulation at high density cannot be realized. Blown-in cellulose will effectively seal small openings (up to 1/16-inch-wide, according to Princeton

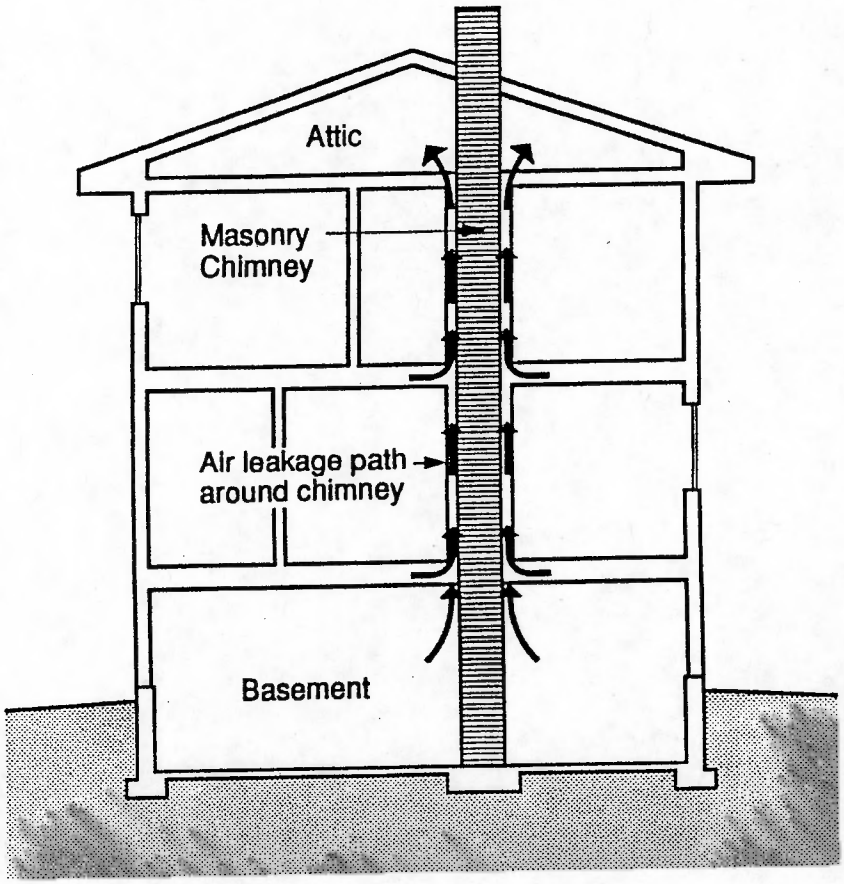


Figure 6-16: The space around a chimney or flue often provides a path that allows basement air to escape through the attic.

SECTION E

Part II

DUCT SEALING AND SYSTEM BALANCING

A. Scope

This practice applies to the onsite evaluation, balancing and repair of existing warm air duct systems in residential housing.

B. General

Excessive energy use, accelerated building deterioration and poor indoor air quality as well as reduced comfort can result from poorly installed, damaged, unbalanced, or non-functioning duct systems.

This practice recognizes that proper evaluation and repair depend not only on the quality of materials used but also on proper equipment for evaluation as well as proper and workmanlike testing and installation.

C. Procedures

Recommended procedures are delineated in "Duct System Location Types, Diagnosis and Repair" by John Tooley of N.F.R., Inc.

SECTION E

Part III

INSTALLATION OF CAULKS AND SEALANTS

A. Scope

These practices apply to the on-site installation of caulks and sealants used to control major air infiltration and exfiltration through building walls.

B. General

Water leakage, air leakage, excessive energy use, accelerated deterioration, and reduced comfort can result from lacking, inadequate or improperly installed caulks and sealants.

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.

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 insulation. With some insulation materials, excessive moisture can also cause the leaching of fire retardants and thus contribute to increased fire hazards.

Apply caulking to the interior with the goal of creating a complete barrier to air flow through the building envelope, often referred to as an air barrier. If there is a water leak it should be treated in an appropriate manner. Exterior caulking is generally an inappropriate treatment. Exterior caulking is recommended on through the wall penetrations only: utility entrances, oil fill and vent pipes, antenna leads, etc., and on the joint between the foundation and the wood frame or sill. Sill caulking may be applied on either the interior or exterior providing the seal is continuous.

Material Specifications - See Weatherization Handbook

Areas Requiring Measures

The major sources of air leakage through the foundation are as follows:

- Cracks in foundation walls
- The joint between the foundation wall and the wood frame
- Windows
- Exterior doors
- Service entrances (gas, electricity, etc.)

- Old openings, such as coal chutes
- Vents and ducts
- Any other openings

NOTE: In addition to air leakage through the foundation, many houses will have air leakage from the basement into the attic via such paths as furnace chimney enclosures and plumbing walls.

The major sources of air leakage through floors over unheated spaces are gaps where pipes, ducts, cables, etc. pass through the floor.

With respect to above grade exterior walls the following are air leakage problem areas:

- Doors and windows
- Gaps between the bottom plate of the wall and the floor
- Electrical receptacles (switches and outlets)
- Major cracks and gaps in the drywall or plaster, including the joint between the wall and ceiling
- Gaps between floor boards where they penetrate the wall
- Joints between trim and interior wall finish material

PRE-INSTALLATION PROCEDURES

1. Identify those areas which require treatment preferably with the use of a blower door.

   a. Cracks or gaps less than 1/8 inch should not require caulking unless they have been identified as sources of air leaks through the use of blower door.

2. Areas to be treated must be free of dirt or other debris that would prevent a proper seal.

3. Ensure that the proper caulking compound has been selected and is compatible with the materials to which it will be applied.

INSTALLATION PROCEDURES

1. Apply the caulk in a continuous, neat bead.

2. "Tool" the bead after application to ensure adequate adhesion and curing.

3. Fill gaps larger than 3/16 inch prior to caulking with backer rod or EPDM gaskets. Fiberglass is not an acceptable filler material.

4. Attic bypasses/basement bypasses - If the penetrations are too large to effectively seal with caulk, use foam sealants and/or sheet metal and high temperature caulk.

POST-INSTALLATION PROCEDURES

1. Ensure that all areas requiring caulking have been adequately addressed.

The major sources of air leakage through ceilings below unheated attic spaces are:

- Gaps at the top of partition walls
- Gaps at the top of exterior walls
- Various holes through and around electrical receptacles
- Holes around electrical cables
- Gaps around vent pipes and plumbing stacks
- Gaps around chimneys
- Gaps around heating duct runs that penetrate the ceiling
- Gaps around the attic hatch

Air leakage areas common to window installations:

- Interior trim
- Window frame and sash
- Deteriorated glass-to-wood joints and through broken or cracked glass

Two points of air leakage are common to doors:

- Door frame, including threshold
- Between the door frame and the surrounding wall

The following are typical areas of heat loss from the building envelope. As it is nearly impossible to accurately guess which areas leak and which don't by visual inspection, MSHA recommends the use of a blower door for all air leakage treatment site selection. (See Fig. 1; Sec. E).

	Type of Heat Leaks:	Where To Look
1.	Joints between floors and outside walls	Baseboards on all outside walls
2.	Interior partition walls without top plates	Attic floor above wall
3.	Uncapped multi-family party wall	Attic
4.	Walls enclosing chimney	Around chimney at attic floor
5.	Attic scuttle hole	Top floor ceiling
6.	Underside and walls of attic stairway	Stairway to attic
7.	Door to attic	Same
8.	Door to unheated space	Door to garage, shed, porch, etc.

	Type of Heat Leaks: (cont'd)	Where To Look (cont'd)
9.	Heating/Cooling ducts	Attic and unheated basement or crawl space
10.	Plumbing stack vent	Locate on roof; then find where pipe passes from heated to unheated space
11.	Outside faucet	Outdoors or in basement sill area
12.	Electric service entrance	Where heavy cable first appears inside house at fuse box
13.	Cable TV antenna entrance	Trace back from TV set; find where cable first enters heated space
14.	Telephone cable entrance	Almost anywhere, but likely in basement where thin white cable penetrates box sill
15.	Electrical outlets and switches	On interior of all outside walls
16.	Recessed light fixtures	On attic floor
17.	Whole house fans	Attic scuttle
18.	Window air conditioner	Outside
19.	Kitchen or stove ventilator	Outside wall or under eave of roof overhang (possibly basement wall)
20.	Bathroom vent	Attic above or wall outside bathroom
21.	Clothes dryer vent	Outside wall or basement window
22.	Fireplace damper	Up inside fireplace

a. With the occupant's permission, unused fireplaces may be permanently sealed.

1) Install a panel, using fire resistant material, i.e., 26 gauge sheet metal to effectively block the fireplace opening. Frame this panel into place and caulk around all edges.

b. If fireplace is used, design a removable plug to friction fit within the flue, effectively blocking the flow of air.

1) Removal of plug can be accomplished with a clearly marked pull tab.

23. Unused mail slots.

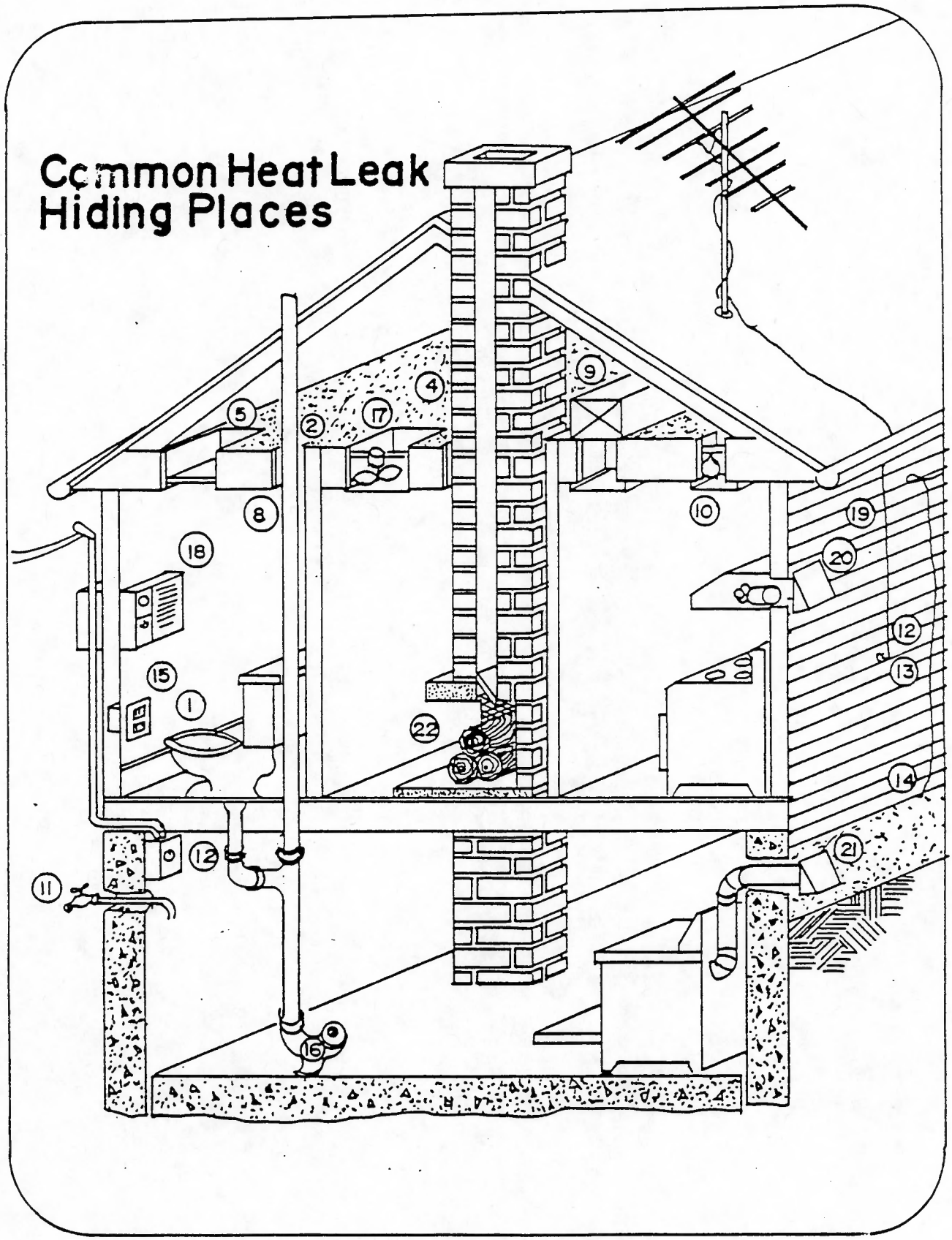

Common Heat Leak
Hiding Places
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Fig 1; Sec E

SECTION E

Part IV

WEATHERSTRIPPING

A. Scope:

Weatherstripping is usually installed on windows and doors, and on cracks around surfaces which move in relation to one another. Where possible, it should be installed so that when the windows or doors are closed, they compress the weatherstripping, rather than rub against it.

B. Material Specifications:

Although the DOE sets the standard for weatherstripping at "commercial availability", the Maine State Housing Authority requires the installation of a permanent weatherstripping product which has a minimum effective life of five (5) years.

C. Requirements:

Windows:

Weatherstrip movable prime windows which separate conditioned from unconditioned space by utilizing a permanent weatherstripping product.

Doors:

Weatherstrip doors which lead from a conditioned to an unconditioned space, such as basements, attics, or unheated hallways.

PRE-INSTALLATION PROCEDURES

1. Windows: Identify all windows requiring weatherstripping and ensure that adequate materials are present and available. (See Fig. 2; Sec. E.)

2. Doors: Identify all doors requiring weatherstripping and/or doorsweeps and ensure that adequate and appropriate materials are present and available.

   a. Address operable mail slots with appropriate weatherstrip.

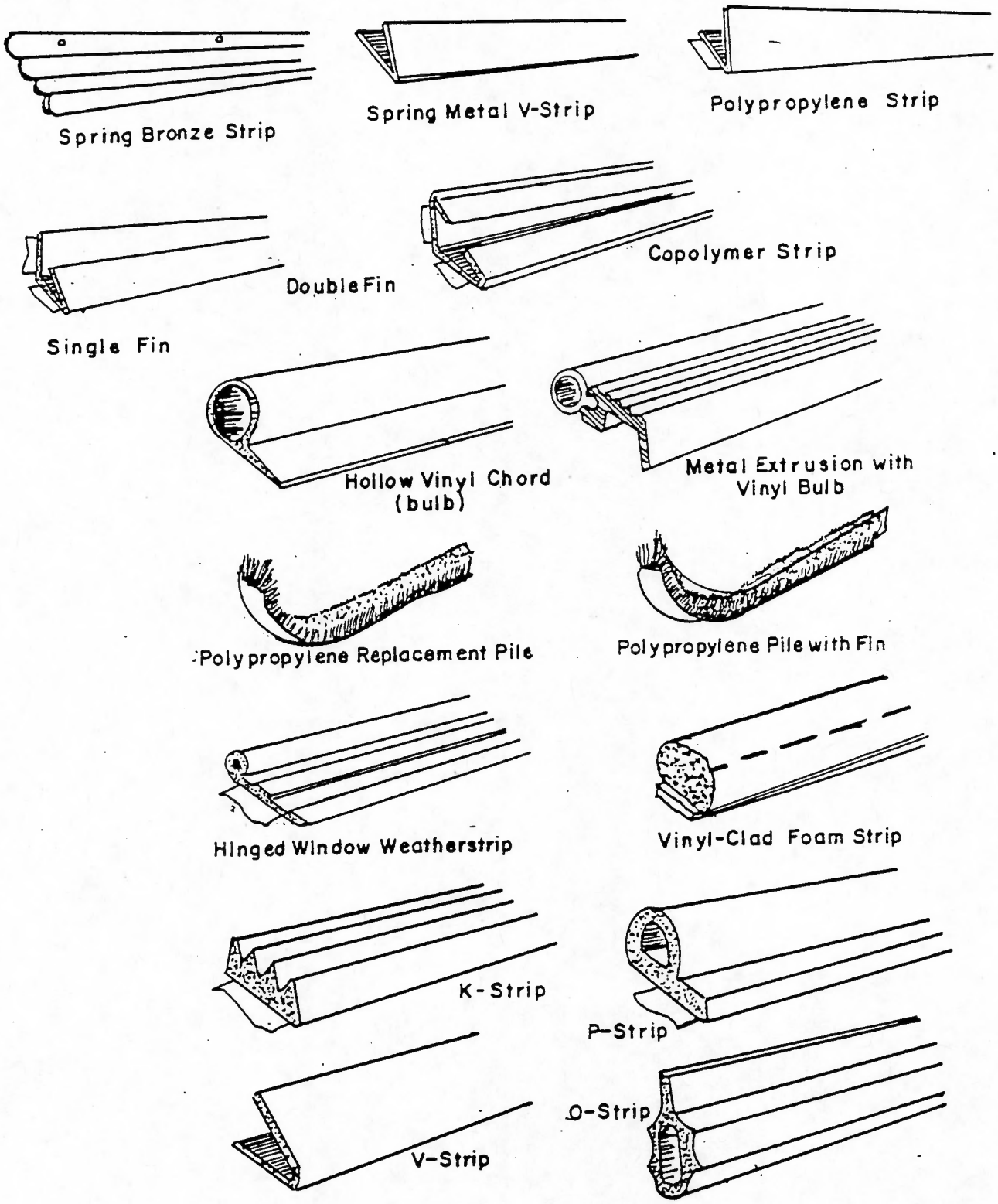
INSTALLATION PROCEDURES - Windows:

1. Double Hung Windows

   a. Weatherstrip the meeting rails.

   b. Weatherstrip the bottom of the lower sash and top of the upper sash.

Window Weatherstripping



Ethylene Propylene Diene Monomer(EPDM) Strips

Fig 2; Sec E

c. If operable sash is loose, weatherstrip the side rails or install jambliners. See Windows Section E (Page 141) for jambliner installation.

d. All weatherstripping must be securely attached with adequate fasteners. Adhesive alone is not acceptable.

2. Casement, Awning and Hopper Windows

a. Weatherstrip the meeting surfaces of the window.

b. Securely attach all weatherstripping with manufacturer supplied fasteners. Adhesive alone is not acceptable.

3. Sliding Windows

a. Weatherstrip the sides and meeting surfaces.

b. Securely attach all weatherstripping with adequate fasteners. Adhesive alone is not acceptable.

4. Exterior Wood Storm Windows

a. Weatherstrip the meeting surfaces. This is the only instance in which felt may be used as a weatherstrip.

INSTALLATION PROCEDURES - Doors:

A. Hinged Doors

1. Weatherstrip the sides and top of hinged doors.

B. Sliding Doors

1. Weatherstrip the meeting surface and top and bottom of sliding doors.

C. Garage Doors:

1. Address the top, bottom and sides of garage doors separating conditioned from unconditioned space with weatherstripping and/or appropriate doorsweep.

D. Doorsweeps

1. Install a doorsweep which provides a uniform flush fit to the threshold on weatherstripped hinged doors.

POST-INSTALLATION PROCEDURES

A. Ensure that door operates freely.

B. Ensure that weatherstripping adequately seals.

INSTALLATION PROCEDURES - Electrical Outlet and Switch Gasket

A. Remove outlet and switch plates and apply a foam gasket prior to replacing the covers.

1. If the wall opening for the electrical boxes does not meet the boxes, seal the gaps to prevent infiltration prior to installing foam gasket.

2. The Maine State Housing Authority recommends the installation of conservation caps on electrical outlets.

SECTION E

Part V

DOOR TREATMENTS

DOOR TREATMENTS - Retrofit

A. Scope:

Weatherstrip; doorsweeps; adjust to close properly; install/adjust lockset/entry set; striker plate; hinges when applicable or replace if necessary; replace broken or cracked glass; repair holes, panels, structural damage.

B. Materials Specifications - See Weatherization Handbook.

C. Requirements:

Door treatments beyond weatherstrips and doorsweeps are appropriate only when excess infiltration/exfiltration potential is documented by blower door testing.

Treat primary doors which separate conditioned from unconditioned space in an appropriate manner so that air infiltration/exfiltration is reduced. Acceptable activities for the treatment of primary doors include weatherstripping, doorsweeps, hinges, locking mechanisms, entry/exit mechanisms, latching mechanisms, striker plates, jamb sets, individual sections of jambs, panels, glass lite replacements, reglazing, interior casing replacement, exterior casing replacement, threshold repair, threshold replacement. (See Fig. 3; Sec. E)

PRE-INSTALLATION PROCEDURES

1. 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 eliminate it, if possible.

2. Examine the existing door frame to ensure that it is sound, free of decay or corrosion, and provides secure anchorage for the existing door.

3. Ensure that the frame contact areas are free of protrusions that would interfere with the proper operation of the door.

4. Measure and plumb the door opening, if appropriate, noting if it is out of square or not in plane.

Exterior Door and Frame Sections

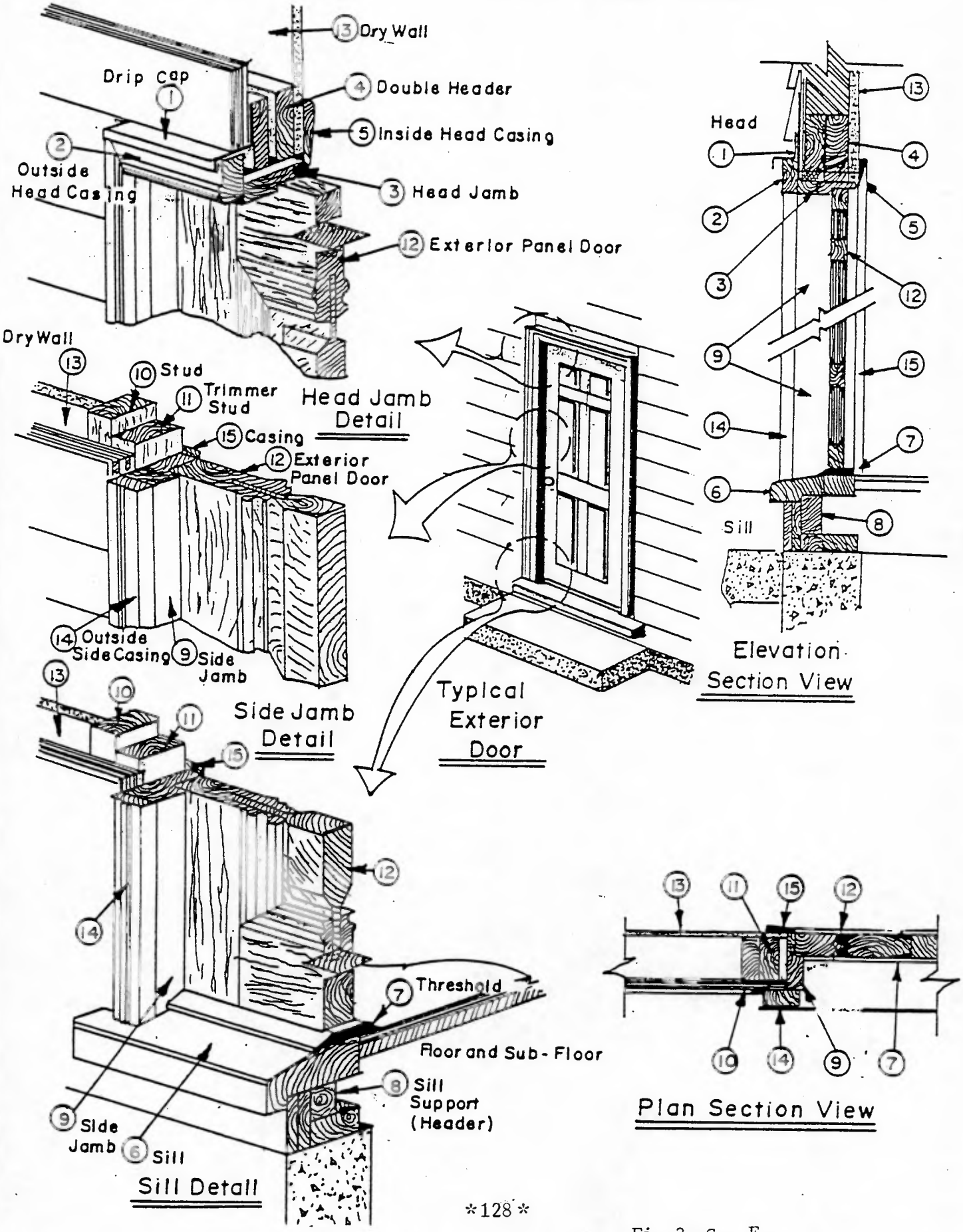


Fig 3; Sec E

a. Ensure that door fits and operates properly, employing the following procedures, as needed:

1) Check all hinges
2) Check all door edges
3) Check hinge screws
4) Check all locking hardware
5) Check all operating hardware, lockset, striker plate, latches, door knobs, etc.
6) Inspect all glass lite and glazing conditions
7) Inspect all door components for structural soundness
8) Inspect all doors for holes, cracks, splits, joint separation, rail separation, stile separation, any component or structural weakness.

INSTALLATION PROCEDURES

1. Shim the existent jambs as necessary to ensure plumb, square and level.

2. If necessary, remove the existing door in a manner that will minimize damage to the remaining construction. Remove all fasteners and hardware from the frame areas.

3. Examine the exposed door jambs, replace unsound material.

4. Adjust all hinges to operate properly.

5. Tighten all loose hinge screws. If screws will not hold, replace with longer screws, or peg holes with wooden filler products, such as small diameter hardwood dowels and wood glue, and attempt again.

6. Space hinge leaves with thin material if necessary.

7. Reset, adjust, reposition, or replace striker plate as necessary to ensure tight, firm, secure closure of door.

8. Reset, adjust or replace lockset/entry set, door knob, or door latch to ensure tight, firm, secure closure of door.

9. Sand and/or plane all door edges, as necessary, until door operates smoothly.

10. Ensure narrow, uniform space between door edge and jamb.

11. Maintain a clearance of at least 1/16 inch between the door and the door opening.

12. Attach weatherstripping to appropriate surface depending upon frame type and weatherstripping type. Weatherstripping shall be securely attached according to manufacturers specifications, and caulked in place. Weatherstripping should be of a type to allow for door movement up to 1/4 inch, and allow for a secure seal of all surfaces.

13. If any portion of door is severely warped, yet overall structural integrity of door does not warrant replacement, cushion spring bronze weatherstripping, or spring loaded expanding and contracting type weatherstripping should be used.

14. Where both the door and jamb are metal, secure a non-metallic, preferably vinyl covered foam, weatherstripping between the door and jamb.

    a. The purpose of the weatherstripping is to provide a thermal break between the metal door and metal jambs. Without the thermal break, frost could build up on the interior surfaces during cold weather. The following materials are examples of acceptable weatherstripping: vinyl, rubber, or high-density polyurethane.

15. Seal exterior joints at jambs and head to resist rain penetration.

16. Attach door weatherseal at bottom crack where door bottom meets threshold or floor, to appropriate surface, depending upon door type and floor or threshold type. Bottom weatherseal must allow for a secure seal of all surfaces.

17. Repair or adjust threshold as necessary, ensure no lateral, vertical or horizontal movement of threshold. Caulk threshold interior, exterior of base, and where threshold meets jambs.

18. Replace broken glass with glass which meets safety glazing standards.

19. Reglaze glass lite.

20. Repair damaged components of panel doors (rail, stiles, panels, corners, cracks, holes) as required by use of wood screws, dowels, L-brackets, beveled panel overlay, bottom metal kick plate. Repair panels using beveled-edge replacement panels or overlays of a compatible material and sealed at all edges and surfaces with two brush coats of water resistant sealant.

21. Repair holes in any part of the surface of wood doors by use of overlay wood panels of a compatible material 1/4 inch thick, set with carpenters glue, fastened with single shaft braces, aligned in a manner which is symmetrical and equidistant from both side (site) edges of the door, and sealed with two brush coats of water proof sealant.

22. Extensive splits or cracks in stile edges of doors in lockset or hinge areas which contribute to structural weakness or improper door operation should be sheathed by shoe-type metal modernization kits (lockset area), or shoe-type, thin gauge metal reinforcers.

POST-INSTALLATION PROCEDURES

1. Ensure that adequate drainage is provided to prevent water accumulation at threshold.

2. Ensure that door operates freely and does not bind when closed.

3. Ensure that door jambs are plumb, square, level and in plane, whenever possible.

4. Ensure that weatherstripping is installed properly and forms a weathertight seal.

5. Ensure that threshold and/or weatherseal is adjusted to provide a tight seal where bottom edge of door meets floor or threshold. (See Fig. 4; Sec. E)

6. Ensure that door catches, handles and latch assemblies properly secure and lock the door.

7. Ensure that all wood surfaces and edges sanded, planed, repaired, replaced are sealed.

SLIDING GLASS DOORS

Sliding glass doors vary in type and style, some being partially or entirely factory weatherstripped or gasketed; some with no weatherstripping at all. Treat a sliding glass door that allows infiltration/exfiltration as if it were a double hung window turned on its side. Often factory installed gaskets become worn or ineffective and may be replaced with manufacturers replacement parts. For doors with one sliding section, treat only the movable section. Install a strip of low profile, wide cushion vinyl weatherstripping, in the side channel that receives the movable door section, and in the top and bottom channels which guide the movable door section. Install a strip of low profile, wide cushion vinyl weatherstripping, or a brush type vinyl doorsweep, along the outer edge of the sliding door, where, when closed, it abuts the stationary stile of the stationary door. Ensure that at least 1/4 inch of the weatherstripping or doorsweep extends beyond the outer stile to provide a secure seal. Weatherstripping should be attached with vinyl-to-metal adhesive. For doors with two movable sections, treat all channels in the same manner as described. For wood units, weatherstripping may be nailed, tacked or screwed in place. Ensure that all locking, latching and operating hardware and mechanisms, rollers, guides, tracks and channels are in proper condition. If not, they may be replaced or repaired as necessary.

DOOR TREATMENTS - Bulkhead (Cellar) Doors

A. DEFINITION: A system component usually site constructed, vertically installed in a frame; normally not used as an entrance/egress and passes through the foundation wall below the sill plate. In some situations, horizontal insulation may be required per estimator's discretion.

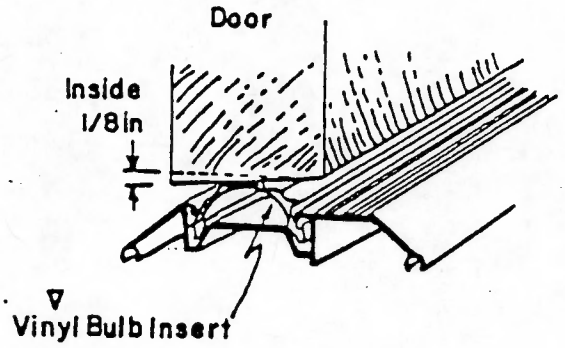
B. Requirements:

1. Do not replace bulkhead (cellar doors) if repair is feasible.

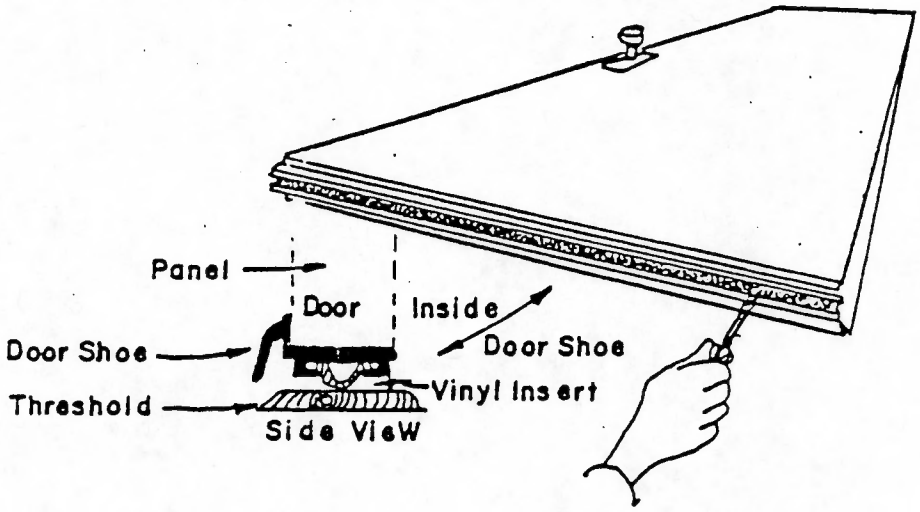
2. Existing bulkhead doors and frames, which can be made airtight or deemed repairable will be sealed with caulk, and weather-stripped in a workmanlike manner.

Thresholds and Door Sweeps

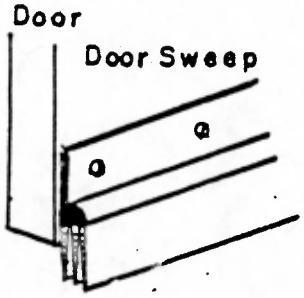
A. Vinyl Bulb Threshold



B. Door Shoe



C. Door Sweeps



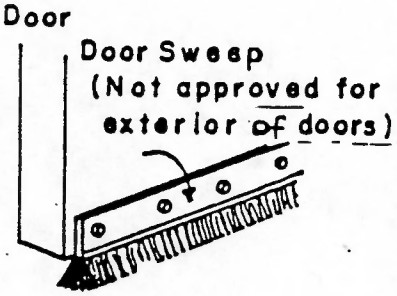


Fig 4; Sec E

PRE-INSTALLATION PROCEDURES

1. Examine the existing door and frame to ensure that it is sound, serviceable, free of decay and will provide secure anchorage.

2. Ensure that the door and frame are free of protrusions that would interfere with proper operability during repair or replacement.

3. Measure and plumb the door opening, including tolerances and provisions for adjustment to out-of-squareness.

4. Ensure that pressure treated lumber is used for any repair/replacement that comes into contact with the ground.

    a. Framing material, door frames should be constructed of rot resistant lumber.

INSTALLATION PROCEDURE

1. If replacement is necessary:

    a. Construct two doors for door opening widths in excess of 36 inches.

    b. Replacement door framing will be constructed of lumber of appropriate dimension. Seal the wood with appropriate sealant.

2. Construct new doors as follows: (See Fig. 5; Sec. E).

    a. Construct a 2 inch by 2 inch frame ensuring a correct fit for existing opening.

    b. Fasten 1/2 inch plywood with rust-resistant screws (no nails) to the outside of the frame.

    c. Fill the door framing with the appropriate thickness fiberglass or foam insulation.

    d. Install a vapor barrier over the fiberglass and attach it to the framing facing the winter warm side of the door.

    e. Install 1/2 inch plywood over the vapor barrier (winter warm side) and fasten with screws (no nails).

    f. Fit the door to existing or replacement frames using:

        1) Three 3 inch butt hinges that are surfaced mounted with screws, evenly spaced, and two 3 inch slide bolts.

    g. Maintain a clearance of at least 1/16 inch around all sides of the door.

h. Ensure that adequate drainage is provided to prevent water accumulation.

i. Liberally brush coat all door surfaces with two coats of the appropriate sealer.

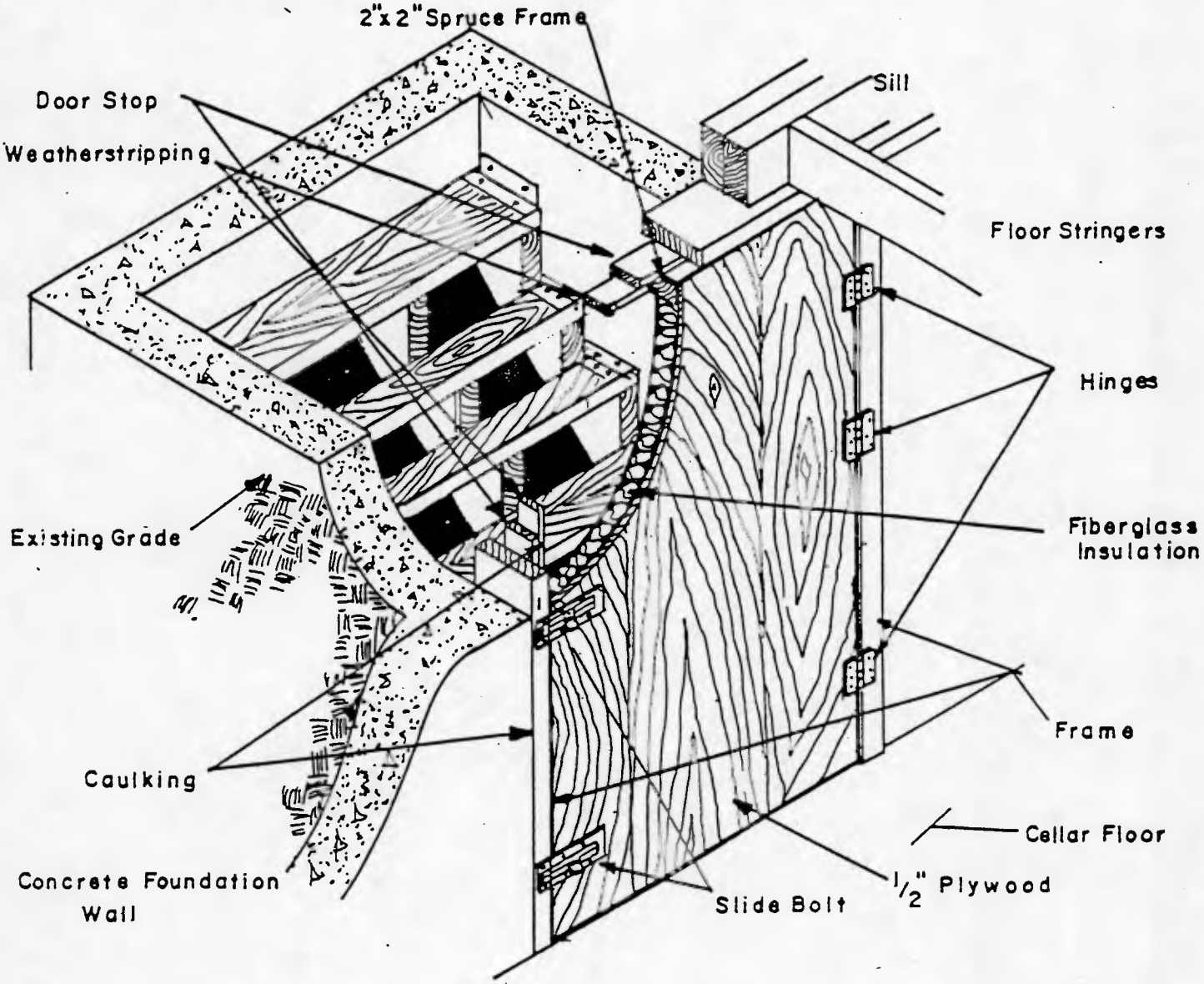
POST INSTALLATION PROCEDURES

1. Ensure that the door operates freely and does not bind when closed.

2. Examine and ensure that weatherstripping, caulking and framing is installed properly and forms a weathertight seal.

3. Ensure that the door hinges, catches, handles, and latch assemblies properly secure.

Bulkhead (Cellar) Doors



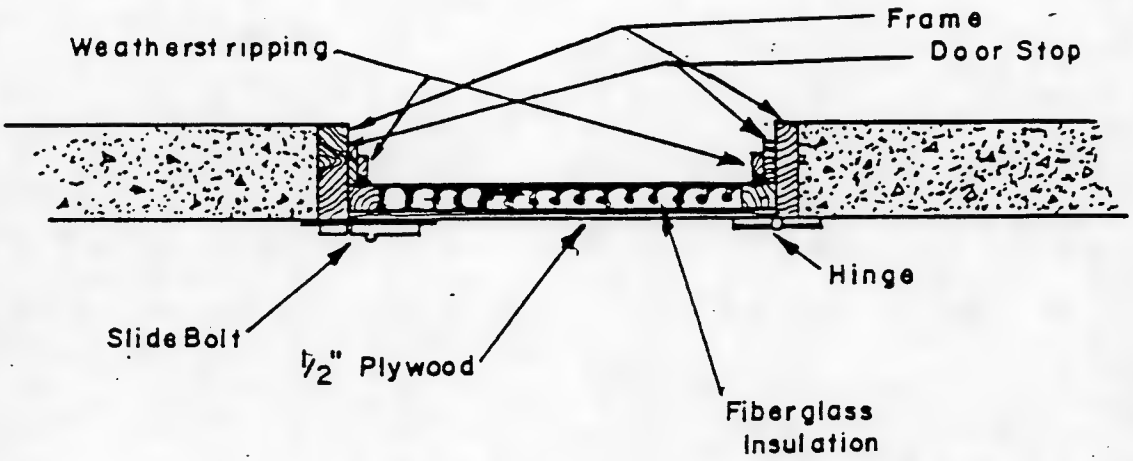


Fig 5; Sec E

SECTION E
Part VI

WINDOW TREATMENTS

Window Treatments - Retrofit

A. Scope:

Weatherstrips; sash locks; pulley seals; jambliners - interior/exterior trim; reglazing; sash/jamb repair; sealing cracked glass; adjusting to close properly; installation or adjustment of hinges when applicable; replacement of broken or cracked glass; repair of holes or structural damage.

B. Material Specifications - See Weatherization Handbook.

C. Requirements:

Window treatments beyond weatherstrips and doorsweeps are appropriate only when excess infiltration/exfiltration potential is documented by blower door testing.

Treat movable prime windows which separate conditioned from unconditioned space in an appropriate manner so that air infiltration/exfiltration is reduced. Acceptable activities for the treatment of primary windows include weatherstripping, pulley seals, locking mechanisms, installation of jambliners, interior/exterior trim, glass lite replacement, re-glazing, sash repair and cracked glass repair.

PRE-INSTALLATION PROCEDURES

Inspect the sash to determine type of window. Each window type will require a different weatherstripping procedure. (See Fig. 6; Sec. E.)

INSTALLATION PROCEDURES

1. Double-hung window - Attach weatherstrip to the bottom rail, one of the meeting rails, and the top rail, unless:

    a. Top sash is painted shut and immovable. If gaps exist between the sash and the wall opening, caulk the gaps with paintable caulk.

    b. Client approves of permanent sealing of upper sash with paintable caulk.

    c. If the sash is loose within the wall opening, such that if shaken side to side there is movement or play, weatherstrip the side rails or install jambliners. (See Jambliner Installation)

2. Casement, Hopper or Awning Windows - Install weatherstrip on the four meeting surfaces.

POST-INSTALLATION PROCEDURES

1. Ensure that the window operates freely by opening and closing several times.

2. Ensure that the weatherstripping does not bind when operating window.

3. The window should fit tightly within the jambs, with a minimal amount of play.

Pulley Seals

A. Requirements: Treat double hung windows with functioning counterweight systems (ropes, weights and pulleys) or inoperative counterweight systems.

PRE-INSTALLATION

Examine the window unit to determine whether ropes and pulleys are intact, or if they have been removed, leaving an oval hole through to the weight pocket.

INSTALLATION

If counterweight system is functional, install a pulley seal cover. Attach the cover to the jamb in two ways. Caulk the cover into place, taking care not to smear the caulk on pulley or rope and use four three quarter inch (4 x 3/4 inch) wood screws to secure the corners. If you suspect deterioration in the jamb, so that it may split when screwing in the cover, pre-drill the holes. Replace the jamb if it splits. If the ropes and pulleys have been removed, seal the hole in such a manner that infiltration/exfiltration is reduced and the opening of the sash will not be impeded.

POST-INSTALLATION PROCEDURE

Is the pulley cover secure? Does the sash and counterweight system operate freely? If the pulley hole has been plugged, does the sash operate freely?

Window Locks

A. Requirements: Secure operable windows separating conditioned and unconditioned spaces with an operable locking mechanism.

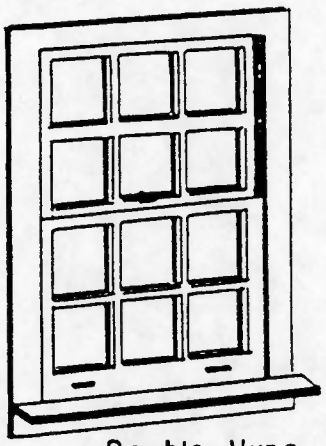
PRE-INSTALLATION PROCEDURE

A. Double hung windows - Examine the unit to determine if the upper and lower sashes' meeting rails fit together and are aligned. (See Fig. 7; Sec. E) If not:

1. Check the top sash to determine whether it has slipped down and no longer meets the head jamb. If so, push the sash back into place and secure it.

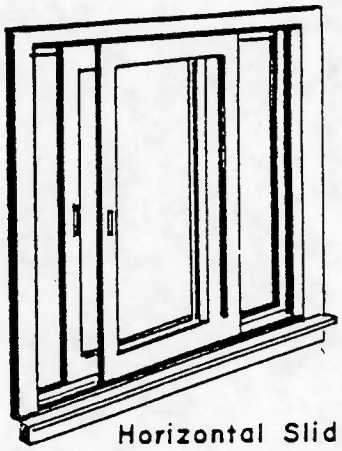
2. Check the bottom sill and ensure that no debris is preventing the lower sash from seating properly. If a utility wire has been run from the exterior to the interior through the window opening, re-route it.

Window Types



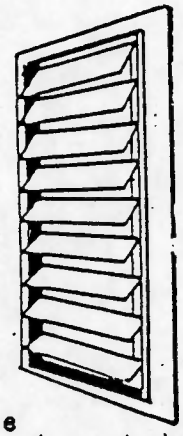
Double-Hung

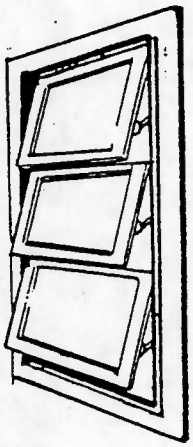
- Sash move vertically, held in desired position by friction fit against the window frame or by various balancing devices.
- single-hung windows are similar with one sash fixed.



Horizontal Sliding

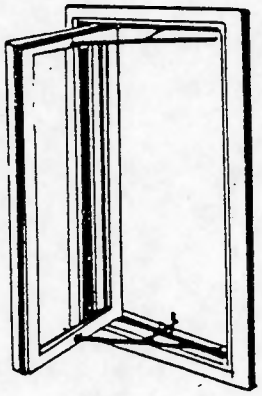
- may consist of 2 sash of which one slides horizontally (50% ventilation) or 3 sash of which the middle is fixed while the other 2 slide. (66% ventilation).





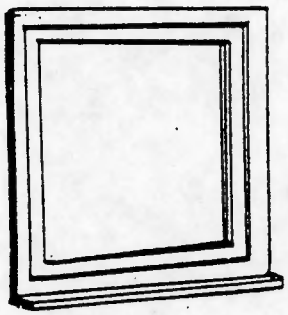
Jalousie
(Large Air Leaks)

- Similar to awining type windows may be opaque or transparent, used generally in warm climates where ventilation is desired along with a flush appearance able to direct ventilation.



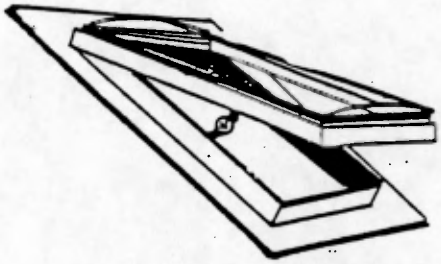
Casement

- Operating sash side-hinged usually swinging outward, pair of operating sash may close on themselves or on a vertical mullion.
- able to direct incoming ventilation.

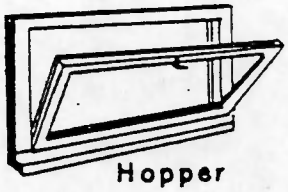


Fixed

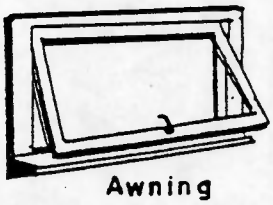
Consist of a frame and glazed stationary sash, when used in conjunction with operable window units, thickness of fixed sash should approximate cross-sectional dimensions of the adjacent operating sash.



Skywindow



Hopper



Awning

- Similar to casement windows but hinged at top (awning type) or bottom (hopper type)
- May be stacked vertically with sash closing on themselves or on meeting rails.
- Able to direct incoming ventilation.

Fig 6; Sec E

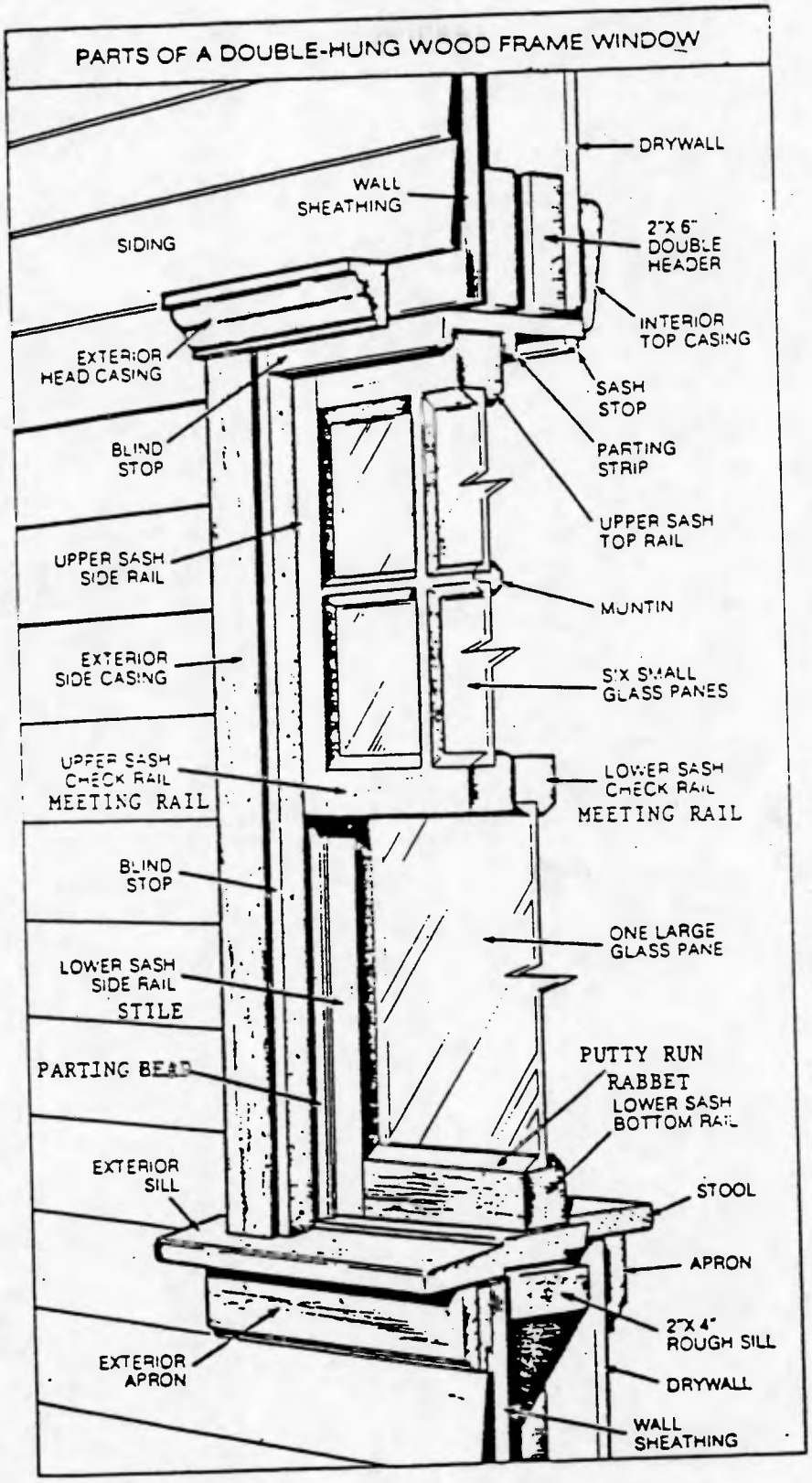

PARTS OF A DOUBLE-HUNG WOOD FRAME WINDOW
DRYWALL
WALL SHEATHING
SIDING
2"X 6" DOUBLE HEADER
INTERIOR TOP CASING
EXTERIOR HEAD CASING
SASH STOP
BLIND STOP
PARTING STRIP
UPPER SASH TOP RAIL
UPPER SASH SIDE RAIL
MUNTIN
EXTERIOR SIDE CASING
SIX SMALL GLASS PANES
UPPER SASH CHECK RAIL
MEETING RAIL
LOWER SASH CHECK RAIL
MEETING RAIL
BLIND STOP
ONE LARGE GLASS PANE
LOWER SASH SIDE RAIL
STILE
PUTTY RUN
PARTING BEAD
RABBET
LOWER SASH BOTTOM RAIL
EXTERIOR SILL
STOOL
APRON
2"X 4" ROUGH SILL
EXTERIOR APRON
DRYWALL
WALL SHEATHING

Fig 7; Sec E

3. If the window unit is too long for the rough opening, and the meeting rails do not align, trim one or both of the sash.

   a. Determine how much will have to be trimmed. If the amount is 1 inch or less, meeting rail alignment can be achieved by cutting the top rail of the upper sash. In order to maintain the structural integrity of the window unit, if the amount exceeds 1 inch trim both the bottom rail of the lower sash and the top rail of the upper.

4. If the window unit is too short for the wall opening, install a "shim" of appropriate size on the head jamb, ensuring true alignment of the meeting rails.

   a. Hopper or Awning Windows - Examine the unit, ensuring proper fit within its frame when closed. Check the hinges, making sure they allow for proper closure.

      1) If the unit binds, trim the meeting surfaces or adjust the hinges.

INSTALLATION PROCEDURES

Double hung windows

1. Top Mount Sash Locks - Install lock or re-position existing lock to hold the sash in a tightly closed manner. Most sash will need one top lock. Install two on larger windows to effectively pull the meeting rails together.

2. Side Mount Sash Locks - Install one lock on each side of the lower sash, attaching the lock to the stop. Optimum performance of side mount locks is achieved if the locks are positioned approximately 1/3 of the distance down from the meeting rail to the sill.

3. Hopper or Awning Windows - Appropriate fastening devices shall be such that the client can easily operate it without the aid of tools. The lock shall adequately keep the window in a closed position.

POST-INSTALLATION PROCEDURES

1. Examine the window in a closed position, using the lock. Check the locking mechanism for ease of operation. If the locking mechanism has two parts (top mount sash lock), ensure that the two parts interlock properly.

2. To test a top mount sash lock on a double hung window, lift the lower sash 2 - 3 inches and insert a dollar bill or a piece of paper between the meeting rails. Close the window and fasten the sash lock. If the lock was installed correctly, it will be difficult to pull the paper out. If the paper slides out with ease, re-position the lock.

Stationary or Fixed Lite Windows

1. Requirements: Treat primary windows between conditioned and unconditioned spaces to reduce infiltration/exfiltration.

PRE-INSTALLATION

Through interview with client, determination will be made that window is fixed.

INSTALLATION

With client approval, caulk the window unit to the interior wall framing.

POST-INSTALLATION

Ensure that a neat, complete bead of caulk has been applied completely around the stationary window.

Jambliner Installation

1. Requirements: Treat primary sash which separate conditioned from unconditioned spaces in an appropriate manner to reduce infiltration/exfiltration.

PRE-INSTALLATION PROCEDURES

1. Ensure that the jambliners are the correct size and type for the sash to be retrofitted.

2. Carefully remove the side stops, setting them aside. Remove the lower sash. Remove both parting beads in a manner that will minimize damage to the remaining framing. Remove the upper sash.

3. Inspect the exposed wall framing members, replacing unsound material if necessary.

INSTALLATION PROCEDURES

1. Fit the jambliners on to each side of the sash, being careful to ensure that upper and lower sash are secure within the appropriate channels.

2. When inserting the entire assembly into the wall opening, place the bottom in first. When the bottom meets the outside stop, tilt the rest of the assembly into the opening.

3. Operate the sash, testing for ease of opening.

4. Securely fasten and caulk jambliners into place, prior to re-installing sidestops. If stops were damaged during removal, replace them.

POST-INSTALLATION PROCEDURES

1. Ensure that the jambliners are air tight to the window casing (window jamb).

2. Ensure that the client shall be able to freely operate the window.

3. The sash shall fit within the jambliners in such a way that infiltration/exfiltration is reduced. The sash shall fit securely within the jambliners so that the tension exerted upon the sash by the jambliners will allow the sash to remain open in whatever position it was lifted to.

Interior/Exterior Window Trim

A. Requirements: Install exterior trim on primary windows to effectively reduce infiltration/exfiltration between conditioned and unconditioned spaces. Install interior trim on said primary windows unless no finished interior wall exists.

PRE-INSTALLATION PROCEDURES

1. Examine the window unit determining whether interior/exterior trim exists. If so, check to ensure that trim is securely attached.

2. Examine the trim to ensure that it forms a continuous seal around the wall opening.

3. Inspect the condition of the trim. Look for signs of wood decay or unsoundness and replace as necessary.

INSTALLATION PROCEDURES

1. New trim shall be compatible with existing trim of the unit.

2. Miter the corners or design according to existing conditions.

3. Prime trim installed on the exterior of the building envelope.

POST-INSTALLATION PROCEDURES

1. Does the added trim adequately match the existing trim?

2. If installed trim will be exposed to the elements, has it been properly sealed?

Sash Repair

A. Requirements: Treat wooden sash, including wooden storm windows, to reduce infiltration/exfiltration. Ensure structural integrity, or soundness, of the sash to effectively prevent infiltration/exfiltration.

PRE-INSTALLATION PROCEDURES

1. Examine the window sash for any separation of corner joints. Determine if joint separation is irreparable deterioration due to wood rot or simply joints drying out and coming loose.

2. The presence of rot can be detected by probing the wood with a knife, or other sharp object. If the blade easily penetrates the wood in several places to a depth of at least 1/2 inch, repair may be feasible.

INSTALLATION PROCEDURES

1. Repair sash using wood screws, L-braces, or dowels. Use these methods singly or in combination to increase the structural integrity of the sash.

   a. If the sash has separated at the corner where the stile meets the lower rail, installation of an L-brace will strengthen the joint. (See Fig. 5; Sec. E)

      1) If L-braces are used, install them on both corners.

   b. If the mortise and tenon joints are intact, pin the joint together using a 1/4 inch dowel.

      1) Careful pre-drilling of the sections is essential to prevent splitting of the wood or glass-lite breakage.

   c. If a muntin has separated from the rails or stiles, re-attach it in the following manner:

      1) Using clamps, secure the window, ensuring that the muntin is properly re-aligned.

      2) Carefully pre-drill the section.

      3) Insert a finish nail, thereby pinning the joint together.

   d. It may be more cost effective to "board up" a cellar sash than to repair and/or replace the sash. Obtain prior client permission.

      1) Provide adequate cross ventilation for moisture control; ensure the presence of at least two functional and operable windows, wherever feasible.

      2) Procedure - Use existing window frame. If necessary, add 2 x 4 inch replacement framing. Secure plywood to the frame in two layers, exterior and interior. Sandwich insulation between the two layers if the above or below grade basement walls will be treated. Seal the exterior panel with primer and caulk into place.

POST-INSTALLATION PROCEDURES

1. Operate the window. Ensure that any repairs undertaken do not impede the operation of the window.

2. Open and close the window several times. Check the repaired sections, ensuring they do not pull apart during operation.

Sash Re-Glazing

A. Requirements: Replace loose or missing glazing compound to reduce infiltration/exfiltration. Reglaze both primary and wooden storm windows as necessary.

PRE-INSTALLATION PROCEDURES

1. Inspect the glazing, noting areas of missing glazing.

2. If loose glazing is suspected, carefully insert a putty knife blade between the glass and glazing, or between the glazing and the rabbett (or putty run). Twist the blade slightly, thereby freeing the section of putty. Continue until all removable glazing has been scraped away.

   a. Be careful when prying loose putty. If too much exertion is imparted, the glass lite will break.

3. If, during the glazing removal, a glazier point that secures the glass is also removed, replace it.

INSTALLATION PROCEDURES

1. Add siliconized glazing to the bare sections. Using a putty knife, bevel the glazing compound between the face of the window frame and the glass lite. Properly beveled glazing will leave no spaces or gaps between the glass lite and the window frame, thereby allowing no moisture to penetrate and damage either the wood or the glazing compound.

2. If siliconized glazing is not used, prime exposed sections of putty run with linseed oil prior to glazing.

3. Prime the finished surface (beveled edge) of the non-siliconized glazing.

4. Clean the excess putty from the glass and the window frame.

POST INSTALLATION PROCEDURES

1. Have all areas requiring glazing been addressed?

2. Has non-siliconized glazing been primed?

Glass Replacement

A. Requirements:

Treat broken glass, including the glass in wooden and combination storm windows, between conditioned and unconditioned areas in the following manner:

PRE-INSTALLATION PROCEDURES

1. Examine the window and determine whether any glass is broken or missing.

INSTALLATION PROCEDURES

Primary and wooden storm windows

1. Seal cracked glass with caulk or glass patch.

2. Replace glass lites as follows:

   a. Remove all the existing glazing compound, using a chisel or putty knife. The glazing can be softened for ease in removal by using a propane torch or an electric putty softening tool. (See Fig. 8; Sec. E)

   b. Remove the existing glazier points.

   c. Carefully remove the existing glass lite.

   d. Scrape the remaining glazing compound from the rabbet, or putty run. Remove all glazing in order to ensure proper fit during glass replacement.

   e. If siliconized glazing is not used, prime the putty run with linseed oil prior to glazing.

   f. Apply a thin bead of glazing compound to the rabbet, or putty run, ensuring a complete application around the panes.

      1) This bead of glazing compound will provide an anti-infiltration seal as well as preventing moisture penetration. It also serves to cushion the glass lite.

   g. Insert glazier points into the wooden window frame to secure the glass lite. Space points a minimum of 4 inches apart and a maximum of 8 inches apart.

   h. Apply siliconized glazing compound around the edges of the glass lite, completing the seal between the glass and the window frame. Using a putty knife, form the glazing compound into a triangular bevel. Leave no spaces or gaps between the glass lite and the window frame.

i. Clean the excess glazing compound from the glass lite and window frame.

j. If siliconized glazing is not used, prime the finished surface (beveled edge) of the glazing.

Jalousie Prime Windows

1. For glass lite replacement, see Mobile Home Section H.

2. Aluminum combination glass lite panels and Marine glazing systems.

   a. In most instances, remove these units and take them to an authorized repair vendor.

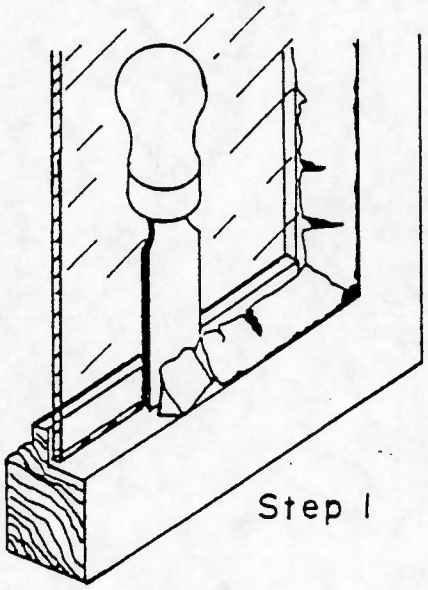
   b. Ensure that the supporting gasket between the frame and the glass lite forms a continuous seal around the glass, thereby preventing air infiltration/exfiltration.

POST INSTALLATION PROCEDURES

1. Have all broken or missing glass lites requiring repair been addressed?

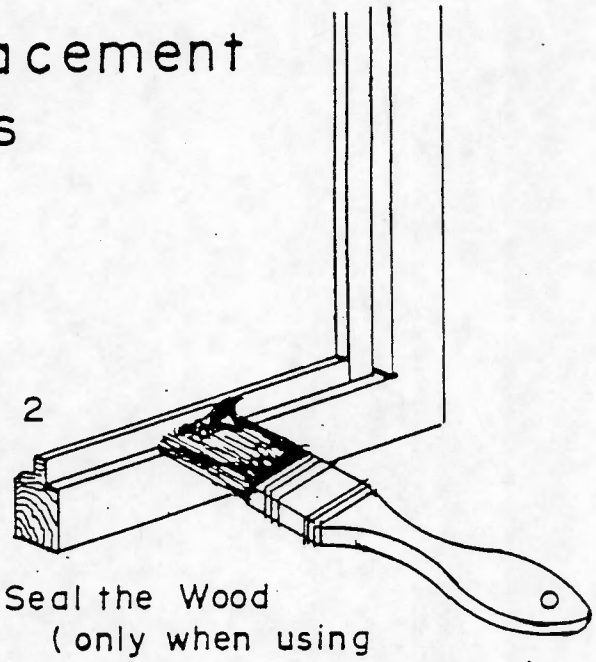
2. Has all non-siliconized glazing compound been primed?

Glass Replacement Steps



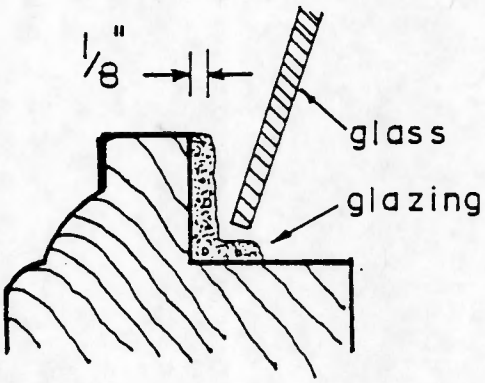
Step 1

Remove the Putty from the Rabbet

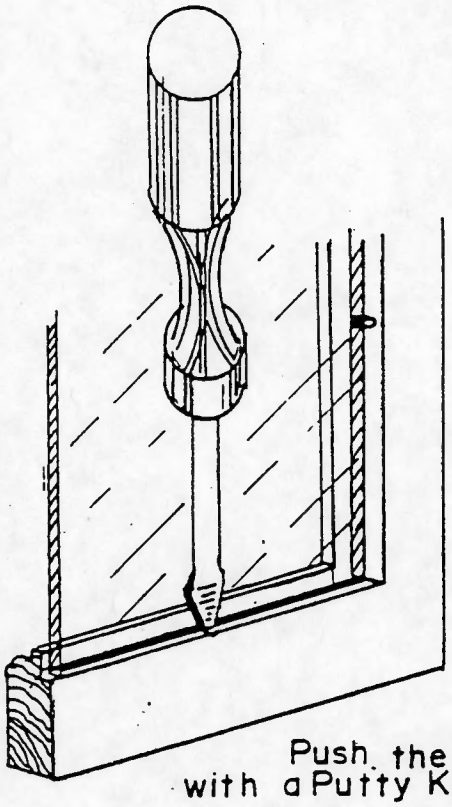


Step 2

Seal the Wood (only when using non-siliconized glazing)

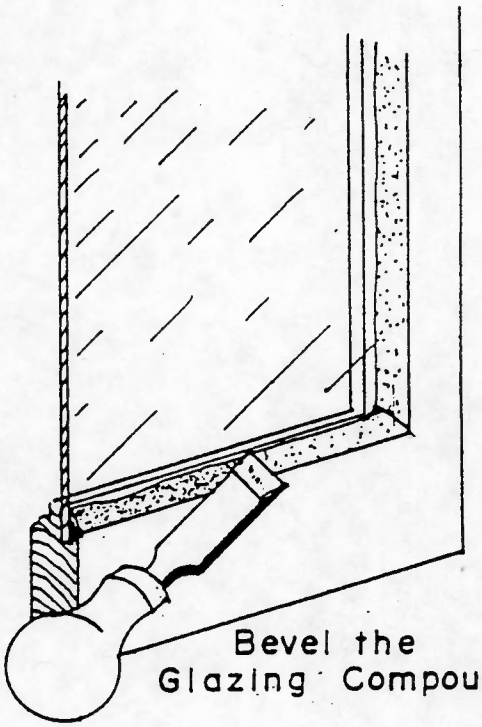


Step 3



Push the Glazier Points in with a Putty Knife or Screwdriver

Step 4



Bevel the Glazing Compound

Step 5

Fig 8; Sec E

SECTION F

STORM DOORS AND WINDOWS

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STORM DOORS AND WINDOWS

STORM DOORS

A. DEFINITION

A storm door is an extra door, installed to the exterior of the primary or ordinary door, that provides greater resistance to heat flow and reduces air infiltration.

B. Material Specifications: See Appendix A

C. Requirements:

General:

1. Storm doors shall be installed only on doors which separate conditioned and unconditioned space, (i.e. doors that are part of the heated envelope).

2. Storm doors shall be installed only after all other activities on a dwelling units priority list are exhausted.

3. Do not install storm doors that would restrict means of egress required by applicable codes and regulations.

PRE-INSTALLATION PROCEDURES

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.

2. Ensure that the frame contact areas are free of protrusions that would interfere with proper installation of the storm door.

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.

4. Ensure that the storm door is the correct size and type for the opening, including tolerances and provisions for adjustments to out-of-squareness.

5. Ensure that the storm door has not been damaged.

6. Ensure that the storm door meets applicable standards for safety glazing.

7. Ensure that adequate weepage is provided on exterior storm doors.

INSTALLATION PROCEDURES

1. Do not install storm door unless the pre-installation preparation has been performed, any identified defects corrected, and their causes eliminated.

2. If required for proper fit, adjust the storm door or its frame to the size and out-of-squareness of prime door frame.

3. Give a liberal brush treatment of commercially available water-repellent preservative to all cut or planed edges of wood storm door.

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.

5. Install the door catches, closers, and chains in accordance with the manufacturer's instructions.

6. Install weatherstripping in accordance with the manufacturer's instructions.

7. Maintain a gap of at least 1/16 inch between the storm door and frame opening, unless otherwise specified by the manufacturer.

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.

9. Do not use excessive force when installing the storm door frame of a pre-hung door into the door opening.

10. Seal the joint between the storm door frame of the pre-hung door and the framed opening to prevent rain penetration.

POST-INSTALLATION PROCEDURES

1. Ensure that adequate drainage is provided to prevent water accumulation at the sill.

2. Ensure that the storm door operates freely and does not bind when closed.

3. Ensure that the weatherstripping is installed properly and forms a weathertight seal.

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.

5. If the storm door includes operable sashes, ensure that the sashes operate properly.

PRE-INSTALLATION PROCEDURES

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.

2. Ensure that the frame contact areas are free of protrusions that would interfere with proper installation of the storm window.

3. Ensure that the storm window is the correct size and type for the opening, including tolerance and provisions for adjustment to out of squareness.

4. Ensure that the storm window has not been damaged during shipping or assembly.

INSTALLATION PROCEDURES

1. Position storm windows to provide a minimum gap of 1/2 inch between the prime and storm glass.

2. 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 frame. The following materials are acceptable spacers: 1/8 inch thick spacers of water-repellent preservative-treated wood; vinyl; rubber; or high-density polyurethane.

3. Secure aluminum storm windows only with aluminum or compatible stainless steel fasteners to avoid galvanic corrosion.

4. Seal interior storm windows to provide greater air tightness than that of the prime window.

5. Treat primary windows as necessary according to applicable window treatment sections.

6. Install interior storm windows according to the manufacturer's instructions.

POST-INSTALLATION PROCEDURES

1. 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.

2. Ensure that weatherstripping is installed properly and forms a weather tight seal.

Exterior Storm Windows, New Installation

A. DEFINITION

A unit of glazing installed in a window opening out side a prime window. (See Fig. 7; Sec. E)

B. Material Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Install exterior storm windows only on window units which separate conditioned and unconditioned space, (i.e. windows that are part of the buildings heated envelope).

2. Do not install window devices that would restrict means of egress required by applicable codes and regulators.

3. Storm windows which are functional after the applicable repairs recommended in Section E Glass Replacement shall not be replaced.

4. Do not install exterior storm windows on primary windows used for bathroom ventilation.

PRE-INSTALLATION PROCEDURES

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.

2. Ensure that the frame contact areas are free of protrusions that would interfere with proper installation of the storm window.

3. Ensure that the storm window is the correct size and type for the opening, including tolerance and provisions for adjustment to out of squareness.

4. Ensure that the storm window has not been damaged during shipping or assembly.

5. Ensure that adequate weepage is provided.

INSTALLATION PROCEDURES

1. Give a liberal brush treatment of commercially available water repellent preservative to all cut or planed edges of wood storm windows.

2. Position storm windows to provide a minimum gap of 1/2 inch between the prime and storm glass.

3. 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 frame. The following materials are acceptable spacers: 1/8 inch thick spacers of water-repellent preservative-treated wood; vinyl; rubber; or high-density polyurethane.

4. Secure aluminum storm windows only with aluminum or compatible stainless steel fasteners to avoid galvanic corrosion.

5. In exterior installed storm windows, seal the joints at jambs and head to resist rain penetration. Do not seal the sill joint.

6. Treat primary window systems as necessary to provide greater airtightness than that of the exterior storm window.

7. Install aluminum or vinyl exterior storm windows according to the manufacturer's instructions.

POST-INSTALLATION PROCEDURES

1. Ensure that all weep holes are clear and provide complete drainage of the sill area.

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.

3. Ensure that weatherstripping is installed properly and forms a weather tight seal.

Terminology of a Typical Storm Window

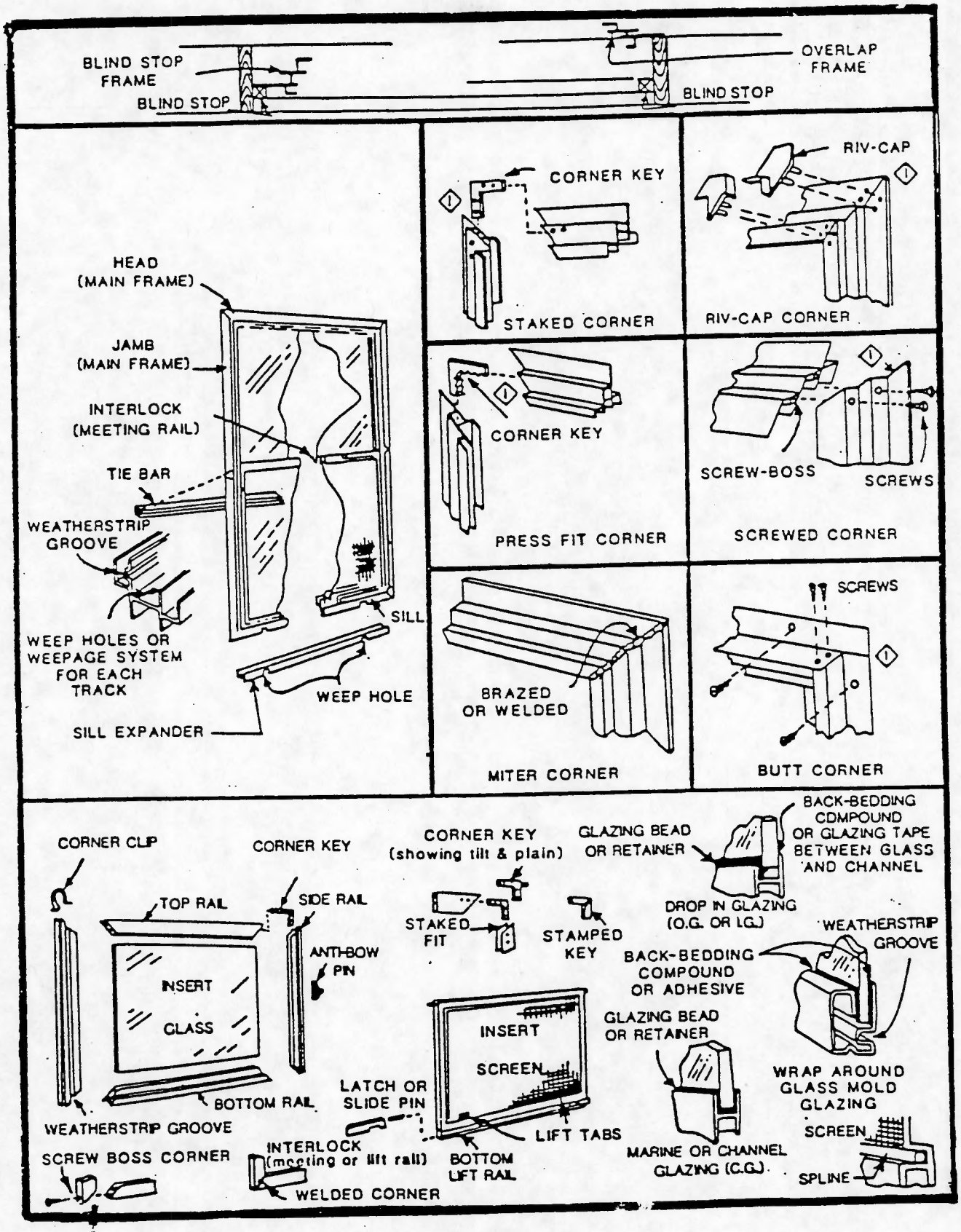

Fig 7; Sec F

SECTION G

REPAIRS

SECTION G

REPAIRS

Roof Repairs

Requirements:

A. Roof repairs include the following:

1. Patching with a suitable roofing material.

2. Installation of drip edge, valley flashing, and step flashing where necessary.

3. The areas to be addressed include chimneys, dormers, additions.

4. Replacement of the roof if deemed necessary to protect installed weatherization materials.

5. Metal roofing: Follow manufacturer's installation instructions.

General Procedures:

1. Maine State Housing Authority (Weatherization) requires that the roof will be stripped if there is more than one layer of existing shingles.

2. All defects will be corrected prior to the installation of new roofing material.

3. Roofs with a slope of 4/12 or greater, except as allowed by BOCA code or manufacturer, will be shingled with asphalt or fiberglass shingles. Each shingle will be attached as per manufacturers instructions will be put down in even and vertically true lines. Every fifth course should have a chalk line snapped to ensure an even application.

4. Roof with a slope less than 4/12 to a minimum of 1/12 will be roofed with double coverage roofing. Double coverage is a 17 inch exposure and 19 inch salvage edge application. All end laps and seams must be cemented to ensure conformance with the manufacturers requirements.

5. "Flat" roofs will be treated as per local code.

INSTALLATION PROCEDURES

1. Check decking under present roof for soundness. Repair if needed with boards or plywood as conditions warrant.

2. Install metal rake and eave drip caps.

3. Check all flashing, valleys, chimney, vent pipes, and replace if necessary. Make sure old shingles are lying flat. If distorted, they should be removed.

4. Apply layer of 15 lb. felt. Do not use a coated sheet, or a heavy felt, which might act as a vapor barrier.

5. It is recommended that horizontal and vertical chalk lines be used to insure good shingle alignment. Cutouts will be accurately aligned horizontally, vertically and diagonally on the roof.

6. The number of nails per strip and the placing of the nails are both vital factors in good roof application. Strip shingles will use a minimum of four (4) nails per strip.

7. Ensure that each shingle is aligned carefully and that no headlap is less than 2 inches from any nail in an underlying course. Nailing should start from the end nearest the shingle just laid, and proceed across.

8. Cap roof by cutting single tab from 3 tab shingle or waste. Apply to ridge with lap facing away from prevailing wind. Bend cap so that it extends an equal distance on each side of the ridge.

9. Hip and ridge applications are best accomplished by following the manufacturers suggested procedures. Never use metal ridging with asphalt roofing. Corrosion may dissolve the roof.

10. The basic flashing of the valleys must be completed prior to roofing. When shingling over a valley flashing, snap chalk lines along the full length of the valley, on each side. The chalk lines should be 6 inches apart at the ridge and spread 1/8 inch per foot as they approach the eaves.

11. Clip off the upper corner of each shingle diagonally to direct water into the valley.

12. Secure each shingle, as it is laid and trimmed, to the valley lining with cement so that a tighter seal is assured. Leave no exposed nails along the valley flashing.

POST INSTALLATION

1. The roof must be cleaned off and free from debris such as nails, extra shingles, board ends and other items generated during the roofing.

2. The valleys and gutters must be cleaned out as a result of the roofing process.

3. Check for proper fastening. Fasteners should not be exposed unless the installation procedures specifically state fastener exposure. This procedure includes asphalt cement and any other adhesive material used during the roofing process.

Siding Repairs

A. DEFINITION

The finish covering of the outside wall of a frame building, whether horizontally or vertically installed material.

B. Material Specifications: See Weatherization Handbook.

C. Requirements

General:

1. Siding shall be installed only when it will serve as a protection for installed weatherization materials.

2. Ensure that siding is installed in accordance with manufacturers instructions.

3. DO NOT leave hammer marks in the siding.

PRE-INSTALLATION PROCEDURES

1. Ensure all nails and sheathing are in place. Waterproof sheathing is recommended for replacement projects.

2. Residing requires that all loose boards are securely fastened. Also, remove old caulking from the corner boards, windows and doors if applicable.

INSTALLATION PROCEDURES

1. Ensure that all sidewalls and base are level and plumb. Use furring strips where necessary.

2. Always use corrosion proof nails or fasteners.

3. Snap chalk line for start strips around the house. Usually it is 1 inch higher than the lowest corner and level around the house.

4. Horizontal application:

   a. The first row of boards or other siding is applied in a level, perfectly straight line.

   b. The bottom of the first row of boards or other siding should be at least 1 inch below the top of the foundation wall.

   c. Starter strip or spacer strip should be removed if they are not covered in the installation.

d. Nails must penetrate 1 inch into the solid wood.

e. 1/8 inch gap for adequate adhesion of caulk is necessary.

5. Vertical Application:

a. Position the starting board or panel so that it is straight and plumb.

b. Vertical siding placed over walls shall be nailed 16 inches o.c. and/or 24 inches o.c. wherever possible.

c. Siding should be fitted to windows, doors and cornerboards in a professional manner.

d. Joints shall be caulked in a professional manner.

POST INSTALLATION PROCEDURES

1. Ensure that all joints are caulked.

2. Check all joints to ensure that they are tight, square and weatherproofed where feasible.

3. Ensure that all corner boards have been installed correctly.

4. Ensure that adequate drainage is provided to prevent water accumulation.

a. Drip caps are recommended.

REPLACEMENT DOORS, NEW INSTALLATION

A. DEFINITION: A door that is intended to replace an existing prime door at the access or egress opening of the building envelope.

B. Material Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Replacement doors shall be installed only at openings which separate conditioned and unconditioned space, (i.e. part of the buildings' heated envelope).

2. Do not install replacement doors if repair is feasible.

3. Door replacement will replicate swing, hand, lite, size and width where applicable, and match appropriate thickness to jamb and stop size.

PRE-INSTALLATION PROCEDURES

1. 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 door will correct the problem.

   a. Water leakage may have been the prime reason for the deterioration of the original door in the first place. Unless the cause of such leakage is eliminated, the replacement door may also deteriorate. Moisture within the wall also reduces the effectiveness of insulation and causes the deterioration of the wall construction.

2. Examine the existing door frame to ensure that it is sound, free of decay or corrosion, and provides secure anchorage for the replacement door.

3. Ensure that the frame contact areas are free of protrusions that would interfere with the proper installation or operation of the replacement door.

4. Measure and plumb the door opening in accordance with the manufacturer's instructions, noting if it is out of square or not in plane.

5. Ensure that the replacement door is the correct size and type for the opening, including tolerances and provisions for adjustment to out of squareness.

6. Ensure that the replacement door has not been damaged or warped.

7. Ensure that door with glass lite meets applicable standards for safety glazing.

INSTALLATION PROCEDURES

1. Prior to hanging door, apply a liberal two-coat brush treatment of commercially available water repellent preservative to all surfaces and edges of wood replacement doors.

2. Shim the existent jambs as necessary to ensure plumb, square and level, if possible.

3. Remove the existing door in a manner that will minimize damage to the remaining construction. Remove all fasteners and hardware from the frame areas.

4. Examine the exposed door jambs, replace unsound material.

5. Anchor the replacement door to the existent frame in accordance with the manufacturer's instructions. Secure steel doors with plated steel fasteners, and aluminum or compatible stainless steel fasteners, to avoid corrosion. Install entry lockset hardware in accordance with the lock manufacturer's installation instructions.

6. Maintain a clearance of at least 1/16 inch between the replacement door and the door opening unless otherwise specified by the manufacturer.

7. Install weatherstripping and doorsweep as required in Section C. Where both the replacement door and jamb are metal, secure a non-metallic, preferably vinyl covered foam, weatherstripping between the door and jamb.

   The purpose of the weatherstripping is to provide a thermal break between the metal door and metal jambs. Without the thermal break, frost could build up on the interior surfaces during cold weather. The following materials are examples of acceptable weatherstripping: vinyl; rubber; or high-density polyurethane.

8. Seal exterior joints at jambs and head to prevent rain penetration.

9. Ensure that door with glass lite meets applicable standards for safety glazing.

10. If the threshold does not seal tightly against the bottom cap of the replacement door, repair or replace the threshold.

POST-INSTALLATION PROCEDURES

1. Ensure that adequate drainage is provided to prevent water accumulation at the threshold.

2. Ensure that the door operates freely and does not bind when closed.

3. Ensure that door and jambs are square, plumb, in plane and level, whenever possible.

4. Ensure that weatherstripping is installed properly and forms a weathertight seal.

5. Ensure that the threshold is adjusted to provide a tight seal against the bottom edge of the door.

6. Ensure that the door catches, handles, and latch assemblies properly secure and lock the replacement door.

7. Ensure that the entire wood door including edges is sealed.

REPLACEMENT OF DOOR FRAME

A. DEFINITION: Finish frame of a door opening, including a head jamb, two side jambs and door stop.

B. Materials Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Install replacement frames only at openings which separate conditioned and unconditioned space to reduce infiltration due to frame unsoundness, deterioration, or failure to properly accommodate existing prime door.

2. Do not replace the frame if repair is feasible.

3. Frame replacement will allow for rehanging of original door, swing, hand, size, width, thickness and locking hardware.

PRE-INSTALLATION PROCEDURES

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.

2. Examine the existing rough framing for signs of decay, corrosion, or other deterioration that would prevent secure anchorage for the replacement frame.

3. Measure and plumb the door opening, and note if it is out of square or not in plane.

4. Ensure that the replacement frame or its parts, or both, have not been damaged.

INSTALLATION PROCEDURES

1. Prior to installing frame, apply a liberal two-coat brush treatment of commercially available water repellent preservative to all surfaces and edges of replacement door frame.

2. Install metal flashing at head jamb and seal to preclude the penetration of water into the wall cavity.

3. 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.

4. Shim frame to provide an opening that is plumb and square, giving particular attention to jamb at lock strike and hinges.

5. Seal the joints between the supporting structure and replacement door frame in accordance with the following:

   a. Fill gaps of 3/16 inch or more with filler materials such as backer rod or EPDM gaskets before installing sealant.

   b. Seal the joints between the rough frame and the replacement frame with any of the sealants approved in Appendix A.

   c. Separate metal frames from any other metal structural members with a non-metallic spacer to prevent galvanic corrosion and to provide a thermal break.

6. Re-hang the door leaf.

7. Replace existent interior and exterior side casing (trim) if undamaged, or replace with matching new trim.

POST INSTALLATION PROCEDURES

1. Ensure that adequate drainage is provided to prevent water accumulation at the sill.

2. Ensure that the replacement frame provides that an opening is plumb and square.

3. Ensure that weatherstripping is installed properly and forms a weathertight seal.

4. Ensure that all parts of a wood frame are sealed.

REPLACEMENT PRE-HUNG DOORS, NEW INSTALLATION

A. DEFINITION: A prefabricated door unit which consists of a door hinged to a finish frame.

B. Materials Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Replacement pre-hung doors shall be installed only at openings which separate conditioned and unconditioned space, (i.e. part of the buildings heated envelope).

2. Do not install replacement doors if repair is feasible.

3. Pre-hung door replacement will replicate swing, hand, lite, size and width where applicable.

PRE-INSTALLATION PROCEDURES

1. Conduct pre-installation preparation according to New Replacement Doors; Pre-Installation Procedures.

INSTALLATION PROCEDURES

1. Conduct installation according to New Replacement Doors; Installation Procedures.

2. Do not use excessive force when installing the pre-hung door unit into the opening.

3. Anchor the pre-hung door unit to the opening in accordance with the manufacturer's specifications.

POST-INSTALLATION PROCEDURES

1. Conduct post-installation procedures according to New Replacement Doors; Post-Installation Procedures.

Window Treatments - Replacement

A. Scope: Treat prime windows which separate conditioned from unconditioned space in an appropriate manner so that air infiltration/exfiltration is reduced.

B. Requirements: Do not replace windows if repair is feasible.

PRE-INSTALLATION PROCEDURES

1 Examine the existing window opening for signs of deterioration or unsoundness.

2. Plumb the window opening in accordance with the manufacturer's directions to ensure that the replacement window can be installed as plumb, square and level as possible.

3. Examine the interior finish surrounding the window opening, checking for signs of moisture damage. If such damage is found, determine whether it is caused by leakage from the exterior.

   Leakage may have caused the original window to deteriorate. Unless such leakage is prevented, the replacement window will also deteriorate.

4. Ensure that the replacement window is the correct size for the wall opening, including tolerances and provisions for adjustments to out of squareness.

5. Ensure that the weatherstripping has been properly installed according to the manufacturer's specifications.

INSTALLATION PROCEDURES

1. Remove the existing window in such a way that damage to the remaining framing is minimized. Clear the frame opening of obstructions or protrusions that would interfere with the proper installation of the replacement window.

2. Correct any defects found in the wall opening framing.

3. Install flashing at the head jamb of the window opening as necessary to prevent water penetration.

4. Seal the wooden replacement window on all sides to prevent moisture absorption.

5. Place the window unit within the wall opening. Shim the unit as necessary to ensure it is plumb, square and level.

   a. When installing fixed lite or stationary window units, it is important to use resilient setting blocks. Such blocks ensure cushioning for the glass and actually bear the weight of the unit. Follow manufacturer's specifications for placement of the setting blocks.

b. If settling or movement of the framing members occur, the glass will not bear the stress and crack.

6. Seal all gaps or cavities exposed when the replacement unit has been positioned.

a. Seal such areas with backer rod, EPDM gaskets, or foam. Fiberglass is not an acceptable air barrier and cannot be used in this application.

b. If expandable foam is used, remember that the objective is to seal the window to the wall opening and not to increase the overall R-value. Therefore, a small bead completely around the unit will be sufficient to prevent infiltration/exfiltration.

7. Re-install the window trim or replace if existing trim was damaged during removal.

POST-INSTALLATION PROCEDURES

1. Ensure that the window operates freely, and that all hardware operates properly.

2. Ensure that window frames are square, plumb and level.

3. Ensure that all manufacturer installed weatherstripping makes full contact with meeting surfaces.

Interior Storm Windows, New Installation

A. DEFINITION

A unit of glazing installed in a window opening inside a prime window.

B. Materials Specifications: See Weatherization Handbook.

C. Requirements:

General:

1. Install interior storm windows only on single glazed window units which separate conditioned and unconditioned space, (i.e. windows that are part of the buildings heated envelope).

2. Interior storm windows shall only be installed as required by the storm window line of each dwelling type priority list.

3. Do not install interior storm windows that would restrict means of egress required by applicable codes and regulations.

4. Storm windows which are functional after the applicable repairs recommended in Section E Glass Replacement shall not be replaced with interior storm windows.

5. Do not install interior storm windows on primary windows used for bathroom ventilation.

SECTION H

MOBILE HOME

SECTION H

MOBILE HOMES

As it would be futile to attempt to create a more comprehensive tract on Department of Energy approved mobile home measures than "Your Mobile Home Energy and Repair Guide", John T. Krigger, 4th edition. MSHA is referencing it in its entirety as part of the Weatherization Procedures Manual.